RIRDC

RURAL INDUSTRIES
RESEARCH & DEVELOPMENT CORPORATION

Feeding Horses in Australia

A Guide for Horse Owners and Managers

Commissioned by
Rural Industries Research and Development Corporation
Equine Research and Development Program

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Disclaimer by Authors

The guidelines and advice given in this publication are intended as a source of information on the nutrition and feeding of horses.
All care and diligence has been exercised in interpreting research findings as the basis for the recommendations and guidelines provided.
Specific circumstances and research findings after the date of publication may influence the accuracy of any recommendations or guidelines.
The authors accept no responsibility and disclaim any liability for any error, loss or unforeseen consequence that may arise from relying on, or adopting, any of the information in this publication.

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FOREWORD

The keeping of horses for leisure is an enjoyment for many and a professional occupation for over 150,000 Australians.

Horse numbers in Australia are increasing, fostered by the world class quality and performance of our racing and equestrian horses, and the desire by many Australians to own or have access to a horse.

RIRDC acknowledges the importance of the Australian horse industry as a major employer and contributor to the Australian economy, and the need to maintain the world competitive status and quality of our horses.

Feeding horses is often regarded as an art, with many owners using traditional diets, and others adopting more scientific feeding methods to get the best out of their horses. Although a great deal of scientific information is available, much of it provided over the years by our own Australian based research and observations, it does not always become readily available in a form that is understood and can be put into practice by horse owners and those feeding and caring for horses.

RIRDC has commissioned this book, in response to a plea from all sections of the horse industry, as a guideline for feeding horses in Australia.

The book provides a balanced and informative approach to feeding horses, highlighting where applicable our special Australian conditions.

Peter Core
Managing Director
RIRDC

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CHAPTER 1

THE PRINCIPLES OF HORSE FEEDING

1.1 Introduction

The need for sound, easy to understand guidelines on feeding horses under Australian conditions was highlighted as one of the major findings of a broad survey carried out in 1996 within the horse industry, under the direction of the Rural Industries Research and Development Corporation (RIRDC). Over the past 20 years, both Australian and overseas research has increased the scientific knowledge of the nutritional requirements of all classes of horses and provided more comprehensive technical information on common feeds and their nutrient values. This research has enabled a greater accuracy in balancing the nutrient content, selected from a wider choice of feeds, when formulating rations. However, much of this information has not filtered down in a form that can be applied by the average horse trainer, owner and breeder.

The increasing popularity of horses for a wide range of sporting and leisure activities has attracted many new horse owners and breeders who have not grown up with horses, or who do not have a rural background or horse keeping experience. Many more horses are now kept on small areas and hobby farms in the urban fringe of cities and towns by owners seeking a semi-rural lifestyle. The volume of grain, hay and prepared feeds destined for horses has doubled in the past 10 years, reflecting the more intensive management and reduced reliance on pasture as the basis of horse feeding.

This book has been commissioned by RIRDC in recognition of the importance of a sound, viable and competitive horse industry to the Australian economy. It provides a review of common horse feeding practices and nutritional management relative to Australian conditions.

The text is presented in a format and style that provides simple, easy to understand guidelines on the nutritional needs of all classes of horses, including ration examples for pastured and hand fed horses.

Although it is not an exhaustive review of horse nutrition and feeding, it aims to provide a summary of the important principles of horse nutrition and feeding, especially for those new to keeping horses. Those intending to purchase their first horse, students of horse management and others involved in the supply of feeds and services to the horse industry should also find the information on feeds and guidelines on feeding specific types of horses of practical interest.

KEYPOINT: In the text of this book, advantages or positive benefits are highlighted by a tick in a box ☑ and disadvantages or adverse effects by a cross in a box ☒ when a particular digestive function, ration, management guideline or feed used for horses is summarised.

1.2 The Rules of Feeding Horses

There are a number of important rules and aspects of horse sense that should be observed when preparing rations and feeding horses.

These should be incorporated into every day feeding practice to ensure that horses maintain optimum health, condition, exercise or reproductive capacity. Many are explained more fully in the various chapters of this book.

1.2.1 Needs of the Horse

- ☑ Good quality pasture, supplemented with hay as required during periods of reduced pasture growth or quality, will supply the needs of resting and lightly worked mature horses, pregnant mares and growing horses over 12 months of age.

- ☑ Supplementary feeding of pastured horses should begin before any horse starts to lose condition, with particular attention being paid to young or aged horses, pregnant and lactating mares.

- ☑ All horses should have an opportunity for free exercise each day, or be exercised as part of their training routine, to ensure best utilisation of their diet and maintenance of health and fitness.

- ☑ It is essential to provide an adequate supply of fresh, clean water at all times, even to horses grazing lush green pasture, and particularly during hot conditions.

- ☑ Horses in yards and stables must be fed as individuals, relative to their body weight, exercise, growth or reproductive needs, appetite, likes and dislikes, metabolic efficiency and desired level of condition.

- ☑ A horse in training on a concentrate ration should always be fed relative to the actual amount of exercise performed during the day, not that planned for the day.

1.2.2 The Ration

- ☑ The ration should contain a balance between roughages (pasture, hay, chaff, bran) and concentrates (grains, protein meals, fats, pelleted or sweet feeds, molasses etc), relative to the horse's needs. (Refer to Chapter 5, Table 5.4, pages XXX to XXX).

- ☑ Horses, which do not have full time access to adequate pasture, should be provided each day with a minimum of roughage as hay and chaff equivalent to1% of their body weight (1kg/100kg body weight), when being fed grains and other concentrates, to ensure efficient digestive function.

- ☑ The effects of the ration should be carefully observed and adjustments made where necessary to ensure that the full ration is consumed, waste is minimised and the horse(s) are maintaining the body weight, condition or well-being and level of performance required, with changes in diet made relative to the training or work load.

- ☑ The ration should be palatable, economical and ideally formulated from a minimum number of readily available ingredients to meet the specific needs of each horse.

- ☑ Horses must be provided with an adequate supply of cool, clean drinking water at all times, situated in a readily accessible, shaded place in a safe trough or

container. The supply or flow of water must be checked at least once daily, especially during hot weather or when horses are being worked or mares are lactating.

- ☑ The feed ingredients that make up a meal should be well mixed to avoid selection and waste. If the ration is to be dampened, it should be mixed freshly for each feed to prevent souring, spoilage and loss of nutrient value.

- ☑ The amount of grain concentrate used to prepare a feed should be measured by weight rather than volume to ensure a more uniform intake of energy and protein.

- ☑ The amount of grain mixed into any meal should not exceed 500g/100kg body weight for any horse to avoid starch overload in the small intestine and digestive upset.

- ☑ Only good quality feeds should be fed, avoiding dusty, mouldy and contaminated feeds. Sweeteners such as molasses should not be used to disguise or improve the acceptance of poor quality feeds.

- ☑ Mineral, electrolyte, trace-mineral and vitamin supplements may be necessary to balance low or inadequate intake in feeds, or meet the elevated needs of growing, working or breeding horses.

1.2.3 Feeding Practice

- ☑ Changes in feed should be gradual, carried out in a step-wise manner over at least 3-5 days for minor changes, and 10-14 days for changes in type of feed, and even longer when increasing the grain content in proportion to the duration and intensity of exercise.

- ☑ Horses in stables or small yards, with limited or no access to pasture should be fed at least twice daily, with horses on high grain diets provided with 3-4 equally spaced feeds during the day and early evening.

- ☑ Stabled horses should be allowed adequate non-interrupted time to eat their feeds, especially young or nervy horses.

- ☑ Aged horses or those with health problems may need special diets and feeding management aimed at ensuring maximum digestive efficiency.

- ☑ Horses that are overweight or losing condition should be fed separately to other horses in a group, to enable individual control and monitoring of the amount of food consumed.

- ☑ Ponies, especially pregnant pony mares, must not be purposely starved to reduce their body weight or denied feed for more than 12 hours. Pony breeds and some other horses, have a high risk of developing a severe metabolic disturbance called Hyperlipaemia if they start to mobilise body fat reserves when insufficient feed is available. (See Glossary term).

- ☑ New horses introduced to a group of horses should be monitored at feedtime to ensure they have access to feeders and that they are being accepted into the social order of the group.

- ☑ The diet should be complemented by good husbandry, including regular worming and teeth care and adoption of careful and considerate training methods.

- ☑ Always ensure that horses are not given “treats” such as lawn clippings, plant trimmings and feed made for other types of animals, as gut disturbances, colic or poisoning may result.

- ☑ A horse should be fed only a small amount of feed or hay just prior to strenuous exercise to avoid working it on a full stomach.

- ☑ Ideally all feed, including hay, should be fed in a bin, tub or trough to minimise wastage, and reduce the risk of contamination of the feed with internal parasite larvae or eggs, or sand ingestion on sandy areas.

- ☑ The intake of cold drinking water should be limited to 1-2 litres for the first 10-15 minutes after hard strenuous exercise to avoid risk of colic and discomfort, with free access to water and feed allowed once the horse cools down.

- ☑ On rest days, the amount of grain based concentrate should be reduced to one third, preferably on the evening before the rest day, and the full ration reinstated over two days following return to full work to help avoid the risk of excitable over energetic behaviour and metabolic problems such as “tying-up” in the muscles.

- ☑ Always dampen dusty feed and hay to reduce risk of airway allergies. Dampening feed will also help to reduce the risk of selection and sifting out of less palatable or new, unfamiliar feeds or supplements.

- ☑ Under drought conditions, grazing horses at pasture should be segregated by age, condition or use, to prevent competition for the feed provided, and to improve the efficiency and economy of supplementary feeding.

- ☑ Ideally the ration should be fed in the same place, and within 60 minutes of the usual time each day, especially where horses are confined for long periods without access to hay or pasture.

1.2.4 The Feeding System

- ☑ Always ensure feeders and watering facilities are kept clean at all times, and are designed and maintained to be safe with no sharp edges.

  Feeders and waterers provided for horses at pasture should be located in a well drained area, ideally in a position that is protected by a windbreak shelter and shade trees.
  In stables or yards they should be in a position that is well lit and allows the horse to see other horses when eating.

- ☑ It is good practice to provide feed in a bin below chest height to all horses, particularly after long distance travel, intense exercise, or when a horse is worked

under dusty conditions. This will facilitate drainage of fluid and inhaled contaminants from the lower airways and lungs.

When feeding a group of horses in a paddock, provide at least 1, 2 or more feeders than the number of horses in the group to reduce competition for feed and the risk of squabbling and injury.

1.3 Feeding Relative to Body Weight

A horse's nutritional needs are influenced by a number of factors, including body size and weight, age, exercise intensity, stage of training, growth rate, reproductive demands, and its individual ability to utilise and get the best out of its ration.

These factors are more fully discussed in Chapters 4 and 5, where nutrient requirements are outlined for each class of horse.

One of the simplest ways to determine how much total weight of feed a horse will require each day is to relate its basic needs and dry feed intake to its body weight, as summarised in Chapter 5, Table 5.4, pages XXX to XXX.

KEYPOINT: Body weight can be related to a horse's condition, breed, type, age and overall body size.

Obviously, the most accurate way of measuring a horse's body weight is to weigh it on a set of scales. Many studs have scales or electronic weighing mats to accurately weigh growing horses to order to map their growth rates, and some racing stables regularly weigh horses in training prior to racing to monitor their condition.

A horse's day to day body weight can also be influenced by the amount of food and water in its digestive tract (gut fill) and fluid levels in its blood and body cells (hydration state) without a visual change in the animal's condition.

KEYPOINT: A horse should be weighed when it is "gut empty", such as early in the morning before it is fed, or at the same time each day to reduce weight variation due to food and water intake.

As most horse owners do not have access to weighing scales or mats, then an estimation of a horse's body weight will need to be made in order to calculate the amount of feed required each day to meet its nutritional demands.

1.3.1 Estimating Body Weight

With experience, most horse owners can appraise a horse's size and condition to estimate its body weight with a 5% error each way, or within 25kg for a 500kg horse.

Being able to estimate a horse's body weight within 5-10% of its actual weight is important when calculating the dose for a worming paste or other therapeutic medications, and in some states, when transporting horses in trailer floats to ensure that the weight being towed does not exceed the legal limit for the towing vehicle.

Up to 80% of horse owners, especially those new to horses, tend to under-estimate a horse's body weight when visually appraising its size and condition. Adult horses and especially ponies, are often estimated to be 10-15% lighter than they actually are, while large breeds are frequently

assessed to be up to 15-20% under their actual weight, especially if they are large framed or are in heavy condition.

✖ Feeding a horse less feed than it requires, if you under estimate its body weight, may result in a loss of performance, vitality and body condition.

✖ Over estimating a horse's body weight and therefore feeding it more energy and feed than it needs, can result in a horse putting on body condition and becoming playful, over energetic, or "hyper" when being handled.

1.3.2 Methods of Estimating Body Weight

There are a number of practical methods to estimate a horse's weight, based on girth, height, and length measurements.

These include using weight tapes available from saddleries, as well as weight estimation equations, standard conversion tables, and nomograms (column calculators) developed on measurements collected from large numbers of horses. These calculations are most accurate for horses of average proportions in moderate condition.

1.3.2.1 Measurement of Girth and Length

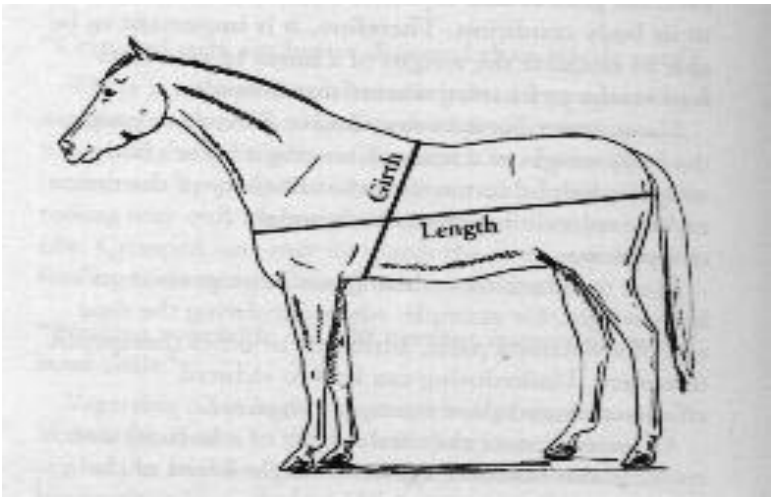
The body weight of a horse can be estimated within 10% of its weight using body girth and length measurements.

The practical methods to estimate a horse's body weight are based on either girth, or a combination of girth and body length measurements.

KEYPOINT: A standard position to measure girth and length must be used to achieve meaningful results.

✓ **The girth of the horse**. Ensure the horse is breathing out when measuring the girth. Position the tape just behind the point of the elbow and encircle it around the body to the rear of the withers area, as shown in Fig 1.1.

✓ **The length of the horse**. Measure the distance from the point of the shoulder, inclining the tape upward in a taut straight line to the rear point of the pelvis or buttock area, as shown in Figure 1.1.



Source: Kohnke (1998)

FIGURE 1.1
Positions to measure girth, length and height

1.3.2.2 Body Weight Tapes and Standard Conversion Tables

An estimate of body weight in proportion to the girth can be made using calibrated girth tapes, or a conversion table. However, because horses vary in shape and build between breeds, variations of between 10-15% are likely in horses with a short wide body, as well as those in either poor or very fat condition.

Girth (cm)	Body Weight (kg)	Girth (cm)	Body Weight (kg)
80	45	140	230
90	70	150	285
100	90	160	345
110	120	170	410
120	150	180	475
130	185	190	545
		200	615

Note: 1. For heavily pregnant mares, add an extra 10% to the estimated weight.
2. For lean, fit horses, subtract 10% from the estimated weight.

Source: Lewis (1995)

TABLE 1.1
Estimating Body Weight from Girth Measurement for Horses in Moderate Condition

Many experienced horse owners use a quick visual appraisal of a horse's height, body size, and relative condition when estimating its body weight. The importance of taking into account a horse's condition is illustrated in Table 1.2, as a weight variation of 170-230kg can occur when height is related to condition score. The method of scoring a horse's condition is outlined in Section 1.4.

Height	CS1 Poor	CS2 Moderate	CS3 Good	CS4 Fat	CS5 Very Fat
	Lean	Fleshy		*Heavy*	*Obese*
12hh	190	210	250	300	360
13hh	240	285	345	375	455
14hh	310	330	400	460	540

15hh	380	420	465	535	600
16hh	420	470	520	575	650

Source: Avery (1996)

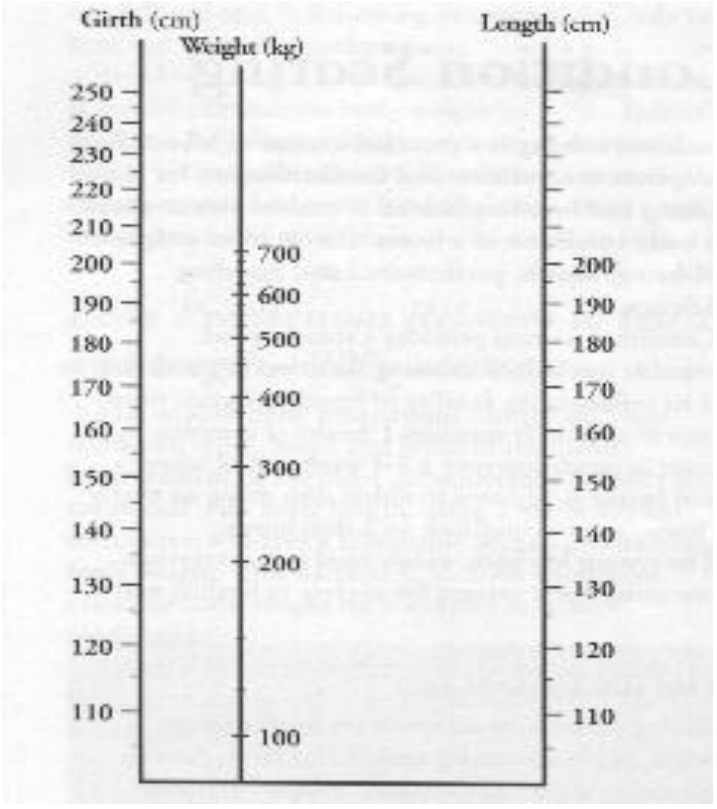
TABLE 1.2
The Influence of Condition Score (CS) Related to Height (hh=hands) When Estimating Body Weight (kg)

1.3.2.3 Weight Calculation Equations and Nomograms

☑ Equation Body weight (kg) = $\frac{\text{Girth}^2 \text{ (cm)} \times \text{Body Length (cm)}}{11{,}880}$

Use a calculator, and remember to square the Girth measurement (ie Gcm x Gcm) (Source: Huntington (1991))

☑ Nomogram The equation above has been used to develop a column calculator, as illustrated in Figure 1.2. Using a ruler or the edge of a piece of paper as a straight edge, join the girth and length measurements to read off the body weight in kilograms (kg).



Source: Huntington (1991)

Figure 1.2 Nomogram for Estimating Body Weight using Girth and Length Measurements

☑ Horse Weight Estimator
A sliding calculator is available from produce stores or Coprice Feeds, Leeton, NSW, which provides both a weight calculator and an illustrated condition scoring system.

When careful measurements are taken of the girth and length, body weight estimations can be within 10% of the actual body weight of an average horse.

KEYPOINT: These methods can over-estimate by 10% or more the body weight of a horse in poor condition, or a horse in training on a high grain ration that has a lower gut bulk and is in light condition. The weight of a lean, fit racehorse or eventer can be over-estimated by between 25-50kg.

As a guide, subtract 50kg from the estimated body weight of a young 2-3 year old racehorse that is in lean, fit racing condition to ensure that you are closer to its actual weight.

1.4 Use of the Condition Scoring System

Condition scoring is a practical method of assessing the adequacy of a horse's diet, as all horses should be fed to maintain them in a suitable body condition relative to their age, athletic use or breeding purpose.

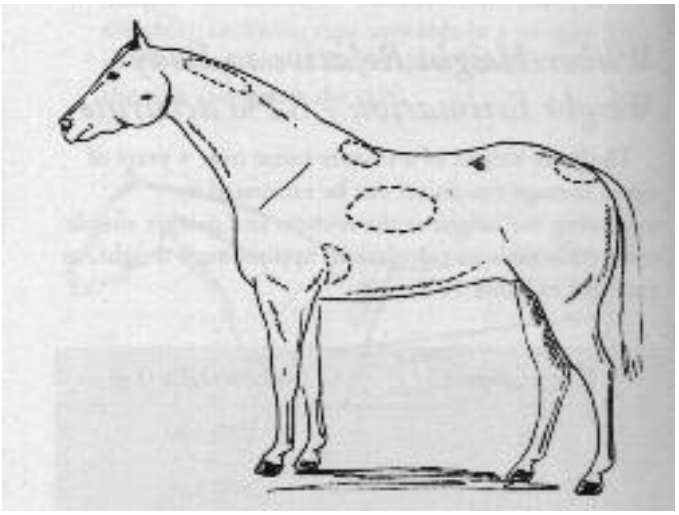
KEYPOINT: Condition scoring is a practical means of evaluating and monitoring the condition of working, show and brood mares to ensure optimum health, athletic performance and breeding efficiency.

In order to standardise the method of condition scoring, a system based on appraising the degree and distribution of body fat was developed in Australia by two veterinarians, Drs. Carroll and Huntington in the late 1980's. Using this method, body condition is scored in a range from O (very poor and bony) to 5 (very fat or obese). An earlier American system, developed in Texas, is used overseas, with a score range of 1-9.

A simple method of condition scoring, adapted from Huntington (1991), is illustrated in Figure 1.4 on page XX. The relative distribution of fat along the neck, withers and shoulders, ribs, back, loin, pelvis, rump/croup and tailhead are evaluated and matched to the descriptions outlined for each condition score. The horse is best viewed from the side initially and then the rear, to make a comparative appraisal of its fat distribution and relative condition. (See Figure 1.3).

KEYPOINT: Up to 10% change in body weight can occur before a large horse will show a visible change in condition score.

Using the Australian system, half points can be scored, as some horses may be in a condition between the whole number score points. (See Figure 1.4 and Table 1.3).



Source: Kohnke (1998)

FIGURE 1.3
Sites of Fat Distribution Used to Estimate Body Condition

A practical guideline for a condition score range that is suitable for each class of horse relative to its age and use is provided in Table 1.3, page XX. Additional comments are included to explain feeding and exercise management that is helpful to maintain a suitable condition score for horses used for a variety of purposes. (Refer to Chapter 5, Section 5.1.1, page XXX).

KEYPOINT: Some racing and equestrian horse owners prefer to maintain their horses at 0.5 of a point score higher than the lowest score suggested in Table 1.3.

A pony grazing on abundant and lush spring pasture or early autumn regrowth after rain should be managed to ensure that it does not exceed a condition score range of 2.5-3.0. It should preferably be maintained between 2-2.5 without developing a ‘cresty’ neck.

Adapted from Huntington (1991)

FIGURE 1.4
Areas to Appraise and Description Relative to each Body Condition Score of a Horse

Class of Horse	SUITABLE CONDITION SCORE	
Breeding Horses		
Non-Pregnant (Dry) Mares for breeding	1.5 - 2 increasing	Increase energy intake during last 6 weeks before breeding. Maintain fat mares in fat condition prior to breeding.
Pregnant Mares - mid term	2 - 2.5	Maintain in a moderate to 'fleshy' condition.
Pregnant Mares last 3 months	2.5 - 3	Ensure some reserves; maintain in a fleshy to good condition, with paddock exercise for fitness.
Lactating Mares – foaling to weaning	3 – 3.5	Maintain in good to heavy condition. Avoid weight loss, as fertility and milk production will be adversely affected.
Stallions (breeding)	2.5 - 3	Maintain in fleshy to good condition. Avoid excessive exercise that may lower libido and interest in mares.
Stallions (off season)	2 - 2.5	Maintain in moderate to fleshy condition. Avoid excess condition.
Equestrian Horses		
Dressage	2.5 - 3	Muscle bulk with rounded appearance relative to breed and build, in fleshy to good condition.
Endurance	1.5 – 2	Some reserve, trim and fit appearance.
Eventing * (Horse Trials)	1.5 - 2	Require fitness, muscle bulk and moderate condition for all phases.
Showjumpers	2 - 2.5	Fit, some reserve, fleshy rather than lean.
Hunters	2 - 2.5	Not fat – moderate with some reserve.
Polo *	1.5 - 2	Some reserve, but not thin, high level of fitness.
Polocrosse *	1.5 – 2.5	Maintain in trim to moderate condition.
Show Horses Ridden Led-in Classes Western Pleasure	2.5 – 3	Well rounded and covered, fleshy to good but not excessively fat. Provide daily exercise even when in yards and stables.
Working Western Horses (Rodeo, Cutting etc.)	2 - 2.5	Maintain in a moderate to fleshy, fit condition.
Leisure/Pleasure Horses		
Horses and ponies ridden on weekends	2 – 3	Moderate to good condition. Avoid heavy condition - feed to exercise level and temperament.
Ponies – grazing spring pasture	2 - 2.5	Avoid a cresty neck, maintain moderate condition by restricted grazing and regular daily exercise to avoid laminitis.
Resting Horses	2 - 3	Monitor regularly - feed to needs, especially aged horses.
Racing Horses – Racetraining		
Arabians *	1.5 - 2.5	Maintain fit, trim to fleshy appearance.
Quarter Horses	2 - 3	Muscle bulk, some reserve, moderate condition, not too heavy.
Standardbreds *	1.5 - 2.5	Trim to fleshy - not too thin, but minimum gut weight.
Thoroughbreds *	1.5 - 2.5	Should have some reserve, sprinters bulkier than longer distance horses, minimum gut weight.
Growing Horses		
Weanling 6 - 12 months	2 – 2.5	No lower than moderately thin - last few ribs outlined. Avoid over condition in growing horses and mineral imbalances in diet.
Yearling 12 - 18 months	2 - 2.5	Moderate to fleshy condition in lead-up to sale, yearlings can have more reserves.

Adapted from Kohnke (1998)

TABLE 1.3
Suitable Condition Score for a Range of Horse Breeds and Uses

* Owners and trainers may prefer to maintain in a moderate condition, with a minimum condition score of 2.
Note: In this table, a condition score of 1.5 is described as 'trim' condition (between poor and moderate), 2.5 as 'fleshy' condition (between moderate and good) and 3.5 as 'heavy' condition (between good and fat)

1.5 Monitoring the Adequacy of a Horse's Diet

As a horse owner, you may wish to evaluate whether the diet that you are providing for your horse is adequate to meet its nutritional needs. Guidelines on the nutritional needs and ration examples for all classes of horses are provided in Chapters 4 and 5.

It is helpful to have a simple assessment method by which you can evaluate and monitor a horse's response to a ration. A check list is provided in Table 1.4 as a guide to how well your horse is doing and performing on its diet when monitored at 7-10 day intervals over a period of at least 2-4 weeks.

Is your horse maintaining its:

- ✓ Bodyweight (all horses)
- ✓ Condition score (all horses)
- ✓ Good overall health (all horses)
- ✓ Vitality and alertness (all horses)
- ✓ Normal intake of feed and its appetite (all horses)
- ✓ Suitable temperament (all horses)
- ✓ Water intake (all horses)
- ✓ Manure and urine colour, consistency and output. (all horses)
- ✓ Coat condition (all horses)
- ✓ Performance and exercise capacity (working horses)
- ✓ A steady rate of growth and development (young horses)
- ✓ Breeding efficiency (mares and stallions)
- ✓ Soundness (growing and working horses)

TABLE 1.4
Check List for Adequacy of a Horse's Diet

If the answer is "yes" to all of these assessment points relative to the type of horse and its use, then the ration you are feeding should be adequate in terms of acceptance, bulk, energy, protein and other major nutrients. Some of the parameters may be modified by

disease conditions, injuries, parasite burdens, the training method and characteristics of the individual horse.

1.6 Summary

There are a number of simple guidelines that should be adopted when feeding horses.

- ☑ Horses are creatures of habit. When given hay or hard feeds, they like to be fed around the same time each day, with good quality palatable feeds and adequate time to eat undisturbed.

- ☑ The ration must be carefully balanced between roughages and concentrates relative to the horse's condition, use and management. Most horses at rest or in light work will do well on pasture, with supplementary hay when pastures are unable to provide their full needs.

- ☑ Horses confined to stables should be fed at least twice daily, and horses on high grain rations, in training, at least 3-4 times daily, in safe feeders at, or below, chest height.

- ☑ Horses with special needs such as growing horses, lactating mares or aged horses, may have to be separated from other horses to ensure they are able to consume their full feeds.

- ☑ An adequate supply of clean, fresh water is essential at all times.

- ☑ Ponies, especially pregnant pony mares, should not be purposely starved to reduce their body weight or denies food for longer than 12 hours as they have a risk of developing hyperlipaemia.

Horses are fed according to body weight and use. It is important that you develop skill in estimating a horse's body weight and condition score so that you can feed to maintain condition and adjust your rations accordingly.

CHAPTER 2

HOW HORSES DIGEST THEIR FEED

The horse has a monogastric (single stomach) digestive structure and well developed grazing habits that are suited to foraging for long periods on a grass dominant pasture. Under free-range conditions, horses selectively browse on shrubs and succulent plants to supplement their diet.

The main dietary base of non-domesticated horses consists of large amounts of cellulose fibre in growing plants that are fermented in the large intestine to provide the majority of their energy needs. The natural grazing diet contains minimal amounts of starch, such as that found in mature grass seeds (cereal grains) and protein as provided by legume plants (clovers and lucerne).

Once the horse was domesticated and provided with pasture and supplementary feed under a more intensive management system, the range and type of feed stuffs which comprise its diet, changed dramatically.

Some of the nutritional problems that can develop in horses are related to these changes in the way domesticated horses are fed.

- ✖ Grazing horses are less able to roam and select a variety of plant types to provide themselves with a natural, balanced diet to meet their specific needs.

- ✖ Horses are often confined to pastures of cultivated grasses and legumes that provide energy and protein intake in excess of their needs, which can lead to excess condition, adverse behaviour and growth abnormalities.

- ✖ Horses are fed a higher starch based diet provided by cereal grains and more protein in legume hays, such as lucerne, in order to increase the energy content and other nutrients for work and growth. These are generally less efficiently digested and utilised by horses and excesses can lead to digestive upset and toxic effects.

- ✖ Horses are provided with supplementary dry feeds with a lower water content and a higher intake of mature plant fibre than provided by growing pasture, which can reduce their digestive efficiency.

- ✖ Horses are confined in groups with increased stocking rates on pasture, resulting in more social interaction and risk of injury, as well as a greater chance of contamination and infection with internal parasites.

KEYPOINT: The horse has the ability to adapt to a large variety of feeds, although its digestive efficiency varies greatly between individual pasture species, grains and hays.

Knowledge of the horse's digestive structure and processes is important when formulating a diet and evaluating its quality and likely utilisation. This understanding will also help to avoid digestive upsets and other metabolic problems in horses fed on grain and hay based diets.

The structural layout, capacity, food transit time and function of each section of the horse's digestive system is outlined in Figure 2.1. This diagram highlights the primary digestive processes of each section of the digestive tract.

2.1 Mouth and Teeth

The horse's lips, teeth and tongue are suited to grazing short, succulent pasture as its primary food source.

KEYPOINT: The strong, mobile upper lip and opposing forward-curved incisor teeth can grasp, shear and tear off small amounts of pasture to enable the horse to selectively graze on shorter, less mature plants. The more succulent, less mature pasture provides it with a diet containing lower starch, higher fermentable fibre and water content suited to more efficient digestion and utilisation.

In practical feeding terms, this means that:

- ✖ The close-cropping grazing habit also increases the risk of sand ingestion on sparsely pastured sandy soils, especially during drought conditions.
- ✖ The selective grazing habit, using the mobile lips and preference for succulent, leafy plants, results in mature, fibrous or unpalatable plants normally avoided by horses being left or becoming more widespread in a pasture.
- ✖ Because horses are able to graze plants to the ground surface, overgrazing can quickly close-crop pastures and reduce plant viability and potential for recovery.
- ✖ Even when pastures are sparse due to overgrazing or poor seasonal conditions, horses will continue to graze and eat out any available palatable pasture species, although supplemented with feeds and hay.
- ✖ When given grains, dry powdered supplements and other feeds, horses are able to sift out feeds they find less attractive by smell, taste or texture. Horses are less selective when provided with a dampened or sweetened feed mix, which they find palatable.

KEYPOINT: When compared to ruminants, horses ingest relatively small amounts of food at each bite and eat at a rate 3-4 times slower than sheep and cattle. Horses crush and grind their food thoroughly between their premolar and molar tooth surfaces (called "cheek" teeth), using the tongue to move and circulate the food mass onto the grinding surfaces until it is thoroughly saturated with saliva and broken down into small particles prior to swallowing.

FIGURE 2.1

Structure and Function of the Horse's Digestive Tract
(Lengths, capacities and retention time for a 500kg horse)

Source: Frape (1997), Kohnke (1998)

A horse chews in a side-to-side movement to bring its teeth into grinding apposition because the upper jaw is wider than the lower jaw. (See Fig 2.2)

Observations indicate that a horse makes an average of 1000 jaw sweeps or chewing cycles per kilogram of concentrates, and from 3000-3500 jaw sweeps when eating a kilogram of dry hay. A horse may take from 30-45 minutes to chew a kilogram of grain and chaff mix, and up to 60 minutes to eat a similar weight of dry hay. Because of its smaller mouth capacity, a pony makes up to 8000 chewing movements for an equivalent amount of concentrates, and countless more for hay. A grazing 500kg horse consumes an average of 35kg of forage per day, using approximately 60,000 jaw movements.

In practical feeding terms, this means that:

✓ Horses should be given adequate and undisturbed time to eat their food to ensure proper and complete chewing and preparation of the food mass for optimum utilisation.

✖ Horses that consume their food quickly (bolt) due to greediness, or when hungry because of irregular feed times may not chew each mouthful thoroughly. They may lose condition or suffer digestive upsets, such as colic or diarrhoea, as they are less able to digest their food efficiently, with longer straws and undigested grains being passed out in their droppings.

2.1.1 Sharp Edged Teeth

The cheek teeth can be more quickly worn away when horses are fed on hard grains and dried hay which require more grinding pressure than when grazing softer, succulent pasture. Because the hard outer enamel coating around the edge of the teeth does not wear away as quickly, sharp edges can develop on the outside edges of the top cheek teeth and on the inside edges of the bottom teeth next to the tongue. The sharp edges that develop can result in abrasion and laceration of mouth membranes as a horse chews its food.

A horse fed on very soft feeds, such as dampened pellets, chaff and bran may chew using smaller jaw sweeps, confining the wear to the central areas of the teeth, which may also lead to the development of sharp-edged cheek teeth.

In practical feeding terms, symptoms of sharp teeth in a horse include:

✖ Increased time to eat a meal due to discomfort when chewing.

- ✖ Reluctance to consume dry fibrous feeds such as hay or chaff that usually require more complete chewing.

- ✖ Dropping or “quidding” of saliva soaked feed clumps that fall out as a horse with sharp teeth adopts a slower more delicate chewing movement due to discomfort.

- ✖ Loss of condition despite an adequate quality and quantity of palatable feed.

- ✖ Tendency to toss the head upwards and pull away when pressure is applied on the bit to control the horse as the sensitive lining of the mouth is pulled back onto the sharp cheek teeth.

- ✖ Large food particles, whole grain and longer fragments of hay (more than 2.5cms long) are passed in the droppings due to the reduced number and completeness of chewing movements, combined with lower grinding forces, when preparing the food mass prior to swallowing.

A horse that fails to improve its condition, despite improved quality and quantity of feed and effective worm control, should have its teeth examined for sharp-edges or other dental abnormalities that can reduce chewing efficiency. This is especially important in both young and aged horses.

FIGURE 2.2

Cross section through the mid nose area of a horse's head illustrating jaw widths and position of sharp points on the cheek teeth.

KEYPOINT: A thorough chewing action is essential to crush and open up the feed structure and increase the surface area of the feed mass to facilitate efficient primary digestion and uptake of short chain carbohydrates (sugars and starches), fats, and protein, as well as minerals and vitamins within the small intestine.

2.1.2 Routine Teeth Care

As part of good feeding management, a horse should have its teeth checked and rasped (floated) to remove any sharp edges whenever the tell-tale signs become apparent, or alternatively, at set intervals during its training or preparation program.

Routine teeth checks and removal of sharp edges by an equine veterinarian or an experienced, qualified equine dentist are recommended at the following times:

- ✓ At yearling age during preparation for yearling sales once the young horse has settled down and can be handled safely.
- ✓ At the beginning of each training preparation or competitive season for all horses, combined with other routine health care such as worming, vaccination and farriery.
- ✓ In young horses in training between 2 and 5 years of age when their deciduous (milk) cheek teeth are being replaced by permanent teeth. For these horses, teeth checks are recommended every 3-6 months to ensure maximum value from their feed and effective control with the bit.
- ✓ Routine teeth checks are recommended for show, leisure and pleasure horses at 12 monthly intervals or more often if the signs become apparent, particularly as the horse ages.

As a horse wears away its pre-molar and molar teeth during mastication, the fully formed adult teeth are pushed out of the bony bottom and top jaws to maintain effective and even apposition as the horse ages. Teeth wear down more rapidly when a horse consumes a diet of predominantly hard grains and dried hay during its lifetime, relative to a horse that is kept primarily on pasture. On average, by 25 years of age, the cheek teeth are worn away to the level of the roots, and become less efficient at grinding.

- ✓ Aged horses should be closely observed for signs that may indicate poor teeth. They should have their teeth checked regularly, with dental work carried out as required, and the diet adjusted accordingly to improve food utilisation.
- ✓ An aged horse, or a horse with poor teeth, will utilise its feed more efficiently when fed on crushed grains and chaff, rather than stemmy hay. Processed feeds, such as extruded or pelleted feeds, are also better utilised by any horse with poor teeth.

KEYPOINT: The most common cause of ill-thrift, weight loss and reduced digestive efficiency in an aged horse is worn away and diseased incisor and cheek teeth.

2.2 Saliva

A horse secretes a relatively large amount of saliva when chewing as compared with other grazing animals. The average volume of saliva secreted by a 500kg horse is between 10-12 litres daily or approximately 1 litre per 4 litres of food consumed. Much higher volumes have been measured when horses are consuming rations of dry hay.

KEYPOINT: The volume of saliva secretion is relative to the amount of feed being eaten, the speed of eating, the moisture content of the food and the taste of the food.

2.2.1 Digestive Function

Saliva is secreted only in response to the chewing action and presence of food in the mouth. It is not stimulated by the smell or sight of feed, as in many other animals. The saliva produced has a high mucus content that serves to saturate and lubricate the food mass to facilitate swallowing. The amount of saliva produced is greatest when a horse consumes dry feeds, such as dried off pasture, hay or chaff.

☑ Sweetening feed with molasses stimulates an increased flow of saliva as a horse eats. Acidic compounds, such as apple cider vinegar and higher amounts of grain also result in a higher saliva output.

KEYPOINT: The saliva of the horse does not contain any digestive enzymes (such as amylase) that normally initiate the breakdown of starch and sugars held in the stomach of other monogastric animals.

Horse saliva contains approximately 50Mequiv./L, or about 3g/L, of bicarbonate which is thought to reduce the concentration of gastric acid in the entrance area of the stomach to allow partial digestive action by microorganisms swallowed with the feed. The relatively high content of bicarbonate in saliva, which is increased in a grain fed horse, may also serve to limit the build-up of lactic acid in the large intestine resulting from fermentation of excess starch overloaded from the small intestine when a horse is fed on a high grain diet. (See page XX)

Because large volumes of saliva containing bicarbonate, sodium, potassium and chloride salts and fluids are secreted when feeding, blood levels of these salts, particularly potassium, (which is low in concentration relative to sodium in the blood fluid (plasma)) are decreased for up to 4-6 hours after feeding. A partial dehydrating effect also occurs due to the fluid loss in the increased volume of saliva produced when a horse consumes large amounts of a dry feed mix and hay.

In practical feeding terms, this means that:

☑ A blood sample should be taken from a horse before it is fed or exercised, such as early in the morning, or alternatively 4-6 hours after feeding, to ensure more representative and accurate values of blood cell counts, plasma protein, and especially potassium and chloride content. Follow-up blood samples should be collected at the same time each day to allow more effective comparison of values.

☑ Dampening dry feed, such as chaff and hay, enables the horse to chew it more easily, with less outflow of saliva and a reduced dehydrating effect, as well as reducing the dust content of the feed.

2.3 Stomach

The stomach capacity of the average adult horse is small when compared to ruminants (sheep and cattle) and other monogastric animals (humans, dogs and pigs) with a volume between 7.5-15 litres or 8-10% of the total digestive tract capacity.

The horse has evolved as a continuous grazing animal and spends up to 16-18 hours each day searching for and selecting feed to meet its needs. Because eating and digestive processes are slow and continuous, the horse requires only a small stomach capacity and lacks a gall bladder in which other animals store bile between large, quickly consumed feeds.

Stabled horses fed three hard feeds and hay will only spend a maximum 8-10 hours in each day consuming their feed rations, which may influence efficient digestive function and give them more leisure time to become bored.

In practical feeding terms this means that:

✓ A horse should be provided with at least two roughage based meals daily when confined to a stable, yard or small paddock, to occupy its time and meet its needs for a continuous supply of feed. When a horse is provided with a diet high in starches or grain in hard training, it should be given 3-4 smaller meals each day to ensure the most efficient digestion and utilisation of the ration.

The suckling foal up to 3 months of age has a stomach and small intestine capacity that is larger in proportion to an adult horse, because a foal has a reduced ability to store and ferment large amounts of fibre in its initially poorly developed large intestine.

A foal has a large intestine volume of 15-20% of its total digestive volume, whereas an adult horse has a large intestine that takes up 64% of the total tract volume.

	Digestive Tract g/kg body weight	Liver Size g/kg body weight	Explanation
Foal First month	35 (3.5%)	35 (3.5%)	The length of the small intestine increases rapidly during first 4 weeks of life. The liver has a large nutrient storage capacity in a young foal.
6 month old - weanling	60 (6%)	12-14 (1.2-1.4%)	The small intestine reaches its maximum capacity at weaning, with less reliance on liver storage.
12 month old - yearling	45-50 (4.5-5%)	10 (1%)	The large intestine capacity increases once pasture and hay is consumed, and the liver serves a metabolic rather than storage function.
Adult	50 (5%)	10 (1%)	

Adapted from Frape (1997), Lewis (1995)

TABLE 2.1
Changes in Digestive Tract Size relative to Body Weight as a Horse Ages

2.3.1 Digestive Function

The muscular stomach has a mixing action with limited digestive function, mainly because the majority of the food mass is retained for only about 30 minutes. However some feed residue may

remain for up to 6 hours after a large meal, relative to the type and consistency of the meal consumed.

KEYPOINT: As the size of the roughage particles entering the stomach are reduced by chopping (chaffing) or grinding hay, as in pellets, the rate of passage through the stomach increases with more of the digestive mass initially passing into the small intestine.

About 50% of the surface area of the stomach wall is lined with non-secretory (squamous) cells. The remainder is covered with a glandular mucosa, forming a separate entrance (fundic) and exit (pyloric) area. The various cell types of the glandular mucosa secrete hydrochloric acid and digestive juices in response to expansion of the stomach as it fills with food. Volumes up to 10-30 litres of gastric acid are secreted daily in a horse on a hay and grain diet. The release of gastric acid occurs more rapidly following a hay meal. There is a delay in its secretion after a grain-based meal, but more is produced and retained in the stomach after a concentrate meal.

When a horse grazes on green pasture, the initial bulk of the food passes quickly into the small intestine. As the stomach fills, more food is retained in the stomach. The majority of water consumed as a horse drinks passes along the curvature of the stomach wall directly into the small intestine. This helps avoid diluting the limited gastric acid and digestive juices, particularly when the stomach is full.

In practical feeding terms, this means that:-

✓ Cereal grain based meals are retained for longer in the stomach than well-chewed forage and higher fibre roughage. This allows more time for the gastric acid to change the starch to a more gelatinous form, which can occur when ground wheat and corn are fed in large amounts. The thick starch residue can reduce the spread of gastric juice and its rate of mixing within the food mass, limiting subsequent digestive activity. The uneven mixing of the acid may encourage more bacterial fermentation of starch within the food mass. Fermentation may produce gas, which can distend the stomach in horses ingesting high starch meals with little roughage, leading to discomfort, colic and risk of gastric rupture.

KEYPOINT: The non-glandular area of the stomach lining may be eroded and become ulcerated by the higher acid level on the surface of the gelatinised food mass when horses are fed on high grain based diets.

Surveys have indicated that up to 70-75% of horses in training on high grain (65-70% by weight) – low roughage (less than 30-35% by weight) diets are likely to develop eroded areas on the stomach wall, which progress to gastric ulcers. Ponies fed on a concentrate ration have an incidence approaching 50% but studies have shown little evidence of gastric ulceration in animals fed on hay or pasture diets. Gastric ulceration can cause loss of appetite and changed eating patterns, with pain and discomfort due to gastric acid attack on the unprotected, ulcerated areas of the stomach wall after each meal. In severe cases, anaemia can develop due to blood loss from the ulcerated area and a risk of perforation of the eroded lining, resulting in peritonitis, severe colic and death.

In practical feeding terms, this means that:-

✓ Horses exhibiting symptoms of gastric ulceration, confirmed by endoscopic examination, should be fed a diet based on roughage, or provided with access to grazing each day so that the ulcerated areas are less irritated and are given an opportunity to heal.

2.4 Small Intestine

The small intestine in the adult horse occupies about 28% of the total digestive tract volume over its 20-25 metre length. The movement of the food mass through the small intestine is relatively fast, with the majority reaching the caecum, or the first section of the large intestine, within 2-8

hours after a meal. The food mass, which is made up of 90% water, is propelled by a muscular squeezing (peristaltic) action at a rate of up to 30cm per minute.

Despite the fast transit time, which is relative to the type, particle size and moisture content of the food, the small intestine is the primary digestion and absorption site for simple sugars and limited amounts of complex polysaccharides or starches, as well as proteins, fats and many minerals and vitamins.

KEYPOINT: The small intestine provides the only opportunity for efficient digestion and uptake of simple sugars, protein, fat, fat soluble vitamins, and the majority of calcium and many other minerals before the food mass reaches the large intestine or hindgut. Factors that interfere with the digestive process in the small intestine have a direct affect on the horse's nutrient balance.

2.4.1 Digestive Function

The rate of passage, the water and fibre content and the bulk of the feed mass can affect the nutrient uptake from the small intestine. A summary of factors that can affect the digestive function of the small intestine is provided in Table 2.2.

Intake of	Direct Effect	Common Nutritional Problem/Symptoms
Lush laxative pasture	High moisture, soluble sugar and laxative bulk increases rate of passage through the small intestine, resulting in loose droppings with high moisture content.	Reduced time for enzymatic digestion of soluble sugars and starch. Excess sugar and starch overloaded into the large intestine is fermented rapidly to D-lactic acid, with a risk of laminitis. * (See page XX).
High grain diets (above 0.5kg of grain per 100kg body weight)	High levels of starch reduces gastric acid and enzyme digestion in small intestine, and not all starch is digested.	Excess starch overloaded into the large intestine is fermented to D-lactic acid resulting in nervous behaviour, diarrhoea and risk of laminitis. *(See page XX).
High protein diets (above 16%) crude protein in a working horse)	Not all the protein is able to be digested by gastric acid and protease enzymes.	Excess protein overloaded into the large intestine may be fermented to heat and ammonia gas, resulting in increased sweating, ammonia in droppings and urine and possible respiratory irritation from ammonia build-up in enclosed stables.
High fat diet (above 10-12% crude fat in a working horse)	Sudden introduction of a fat boosted diet before enzyme digestion can adapt, or too much fat added to diet which cannot be digested.	Excess fat overloaded into the large intestine cannot be fermented or absorbed, interferes with the fermentation process or is passed out in the droppings.
Inflammatory diseases of the Small Intestine (Enteritis)	Faster transit time, reduced digestive efficiency and reduced nutrient uptake.	Excess starches, protein and fat overloaded into the large intestine – see consequences above.
Poorly Chewed Food	Rapid consumption or poor teeth results in whole grain or large particles of starch and protein that cannot be digested by	Reduced feed value – large fibre particles limit the large intestine fermentation activity, resulting in poor condition, often despite

	enzymes in the small intestine.	adequate feed. Whole grain passed out in the droppings.
High oxalate* in tropical grasses, or phytate* in cereal grains, pollard and bran	Chemical binding of calcium results in reduced calcium uptake from the small intestine.	Relative deficiency of calcium with increased resorption of calcium from bone stores, resulting in weak bones. See Nutritional Secondary Hyperparathyroidism (NSH)* page XX.

* See Glossary terms

Table 2.2
Factors Affecting the Digestive Function of the Small Intestine

It is beyond the scope of this book to outline the full physiology and mechanisms of food digestion that occur in the small intestine. However, there are a number of processes that have practical significance relative to the type of diet, or the introduction of new feeds, such as increased grain levels or fat added to a standard diet.

KEYPOINT: There are 4 primary digestive functions in the small intestine that are carried out by the overflow of gastric acid from the stomach, digestive secretions containing enzymes produced by the lining cells, the release of pancreatic juice and bile. In the lower section of the small intestine (or ileum) limited bacterial fermentation of soluble fibres can also occur.

Gastric Acid
Gastric acid provides limited digestion of protein in the stomach, as some is neutralised by bicarbonate and other alkaline compounds in the feed and saliva. Its overflow into the upper section of the small intestine or duodenum is essential to stimulate the release of a continuous flow of pancreatic digestive juice. Studies indicate that the rate of pancreatic juice secretion increases by 4 to 5 times when a meal passes quickly through the stomach into the small intestine. Pancreatic acid secretion ceases if a horse is fasted for more than 48 hours.

In practical feeding terms, this means that:-

✓ Ideally, stabled or confined horses should be provided with an adequate amount of feed split into smaller meals fed 3-4 times daily at equally spaced intervals to ensure more efficient digestive function, especially on grain based diets.

✖ Adding excess amounts of alkaline salts, such as more than 50g (3 tablespoons) of sodium bicarbonate to each feed, may reduce gastric acid activity in both the stomach and small intestine, limiting the release of pancreatic juice to digest sugars and starch in the small intestine on grain based diets.

Pancreatic Juice
The composition of pancreatic juice in the horse is different to other monogastric animals. It has a limited content of the starch digesting enzyme α-amylase and the lipase enzyme required for fat digestion. It has a higher level of peptidase enzyme activity for protein digestion. A horse secretes only 8-10% of the amount of amylase enzyme as compared to the pig, so less starch is digested in the small intestine. The emulsification and digestion of fat is primarily provided by bile and bile salts. Pancreatic juice provides large quantities of fluid and electrolytes, including sodium, potassium, chloride and bicarbonate, although the bicarbonate content does not increase in proportion to pancreatic activity.

The acid buffering capacity of bicarbonate is also increased again in the ileum or lower section of the small intestine, as chloride is reabsorbed in exchange for bicarbonate. This provides a more alkaline environment for fermentation activity in the lower section of the small intestine by *Bifidobacteria* and *Lactobacillus* species prior to the digestive mass reaching the large intestine. The maintenance of alkaline conditions in the small intestine helps to limit the build up of acidity as

volatile fatty acids are produced by fermentation of cellulose and excess starch overloading into the large intestine. (See page XX).

In practical feeding terms, this means that:-

- ✓ Because the production of pancreatic juice and its enzyme activity responds to an increase in starch flow into the small intestine, it is important to commence "graining-up" a horse in a step-wise manner. This encourages more complete digestion in the small intestine and thus avoids the risk of digestive upset by overflow of starch into the hindgut.

  This also applies to the introduction of fat as an energy source to the diet of racing and performance horses. (Refer to Chapter 7, Section 7.1.11.2, page XXX).

- ✓ Blood samples to determine blood electrolyte levels must be taken before a horse is fed (or exercised) because of the drain of electrolytes in saliva and pancreatic juice outflow after feeding. (See also page XX)

Bile

The horse, which has evolved as a continuous grazing monogastric, has no gall bladder in which to store and release bile secreted by the liver in response to feeding. Bile secretion of up to 300mL per hour is continuous as gastric acid stimulates its release from the liver as the food mass flows through the upper part of the small intestine. Bile facilitates digestive activity by emulsifying fats to aid direct enzymatic digestion. It also provides alkaline salts to maintain neutral or alkaline conditions in the small intestine, buffering the pH range between 7.0-7.5 to facilitate efficient digestive enzyme activity.

In practical feeding terms, this means that:-

- ✓ Horses can efficiently utilise limited amounts of supplementary fat mixed well into the ration if introduced in a step-wise manner, because of the continuous flow of bile to aid its digestion. (Refer to Chapter 7, Section 7.1.11.2, page XXX).

Lining Cell Enzymes

The lining cells (brush border) of the small intestine that cover the folds or villi to increase the surface area for contact by the food mass, also secrete enzymes that primarily target the fragmentation of long, branched-chain sugars, the amino acids that make up food protein, and breakdown of fats and oils (lipids) in the diet. The digestion of sugars and starches requires the disruption of the α-D-glucose bonds linking simple sugar molecules, by two enzymes, α-amylase in pancreatic juice, (which is low in grass fed grazing horses) and α-glucosidases produced by the intestinal lining cells. These enzymes fragment disaccharides, such as sucrose, maltose and lactose to glucose, which can then be directly absorbed into the bloodstream to maintain blood sugar and replenish liver and muscle glycogen (a form of carbohydrate energy store) levels.

KEYPOINT: The enzyme, β-galactosidase, commonly known as the lactase enzyme, that digests milk sugar (lactose) is active in foals and young horses. However, as the environment of the small intestine becomes more alkaline on high forage diets, its activity decreases as a horse reaches maturity. Lactase enzyme is not present in the small intestine of horses over 4 years of age.

In practical terms, this means that:-

- ✓ The lactose content in milk powder when fed as a protein supplement above 75g/100kg body weight in adult horses is not digested in the small intestine. It may act to increase the rate of movement of the food mass into the hindgut, contributing to the risk of low-grade diarrhoea.

✓ In young weanling horses, soyabean and canola meal proteins are more economical sources of lysine than milk powder, although growth rates in suckling foals fed milk powder are slightly higher than those fed on the alternative protein sources. (Refer to Chapter 7, Section 7.2, page XXX).

2.4.1.1 Starch Digestion

The small intestine of the horse has limited capacity to efficiently digest the large amounts of starch commonly fed in high grain diets. This is due to a combination of limited pancreatic α-amylase enzyme activity, the compact nature of the starch molecules in raw grain and the relatively fast transit time.

KEYPOINT: Over 50% of the soluble carbohydrate content of the feed passes through the small intestine into the large intestine, where it is fermented by the microbial flora. The total digestibility of starch in both the small and large intestine is greater than 95%, regardless of the type of feed.

The type of ration mix and the degree of processing of the digestive mass can have a direct effect on the efficiency of starch digestion.

✓ Adding up to 3-5% fat to the total diet can promote starch breakdown by stimulating pancreatic juice release that increases enzyme digestion of both carbohydrates and fat.

✓ The degree of processing of hard grain such as grinding corn, wheat or sorghum, or extruding (cooking) the starch, opens up the starch particles to enzyme attack, and increases starch digestibility in the small intestine.

✓ Small amounts of carbohydrate overloaded from the small intestine into the large intestine are efficiently fermented to volatile fatty acids and used as an energy source, with no adverse effect on hindgut function.

Feeding additional cereal grain, which raises the energy density of the ration in an exercising horse, increases the starch content of the diet. A higher proportion of this starch, which is not digested in the small intestine, starts to overflow into the large intestine where it is fermented by the resident microbial populations.

✖ An overload of soluble sugars and starches can occur on high grain diets, or when horses and ponies graze on lush pasture following the break of the season in spring or early autumn when moisture and warm conditions encourage rapid regrowth. In these cases, uncontrolled fermentation in the large intestine of the excess sugar and starch results in build-up of D-lactic acid, which can initiate the physical and metabolic changes that result in “hyper” or over energetic behaviour, “cow pat” diarrhoea, laminitis and founder. (See page XX).

There are a number of actions that can be taken to reduce the risk of overload of excess starch when feeding horses on rations containing more than 40% grain to meet energy demands for exercise.

In practical feeding terms, these include:-

✓ Ensuring a horse's teeth are regularly checked and sharp edges are removed on the "cheek" teeth to improve the efficiency of grinding grains and dry feeds into small particles suited for enzyme attack and digestion in the small intestine. (See page XX).

✓ Limiting the amount of cereal grains to a <u>maximum</u> of 500g/100kg body weight per meal (2.5kg grain in a meal for a 500kg horse) or not exceeding 4g starch/kg body

weight per meal will reduce the risk of the overload of excess starch into the hindgut.

☑ Mixing grain, pellets and sweet feeds with an equal volume of chaff will dilute and help slow the rate of intake of carbohydrates in grain.

However, excessive bulking with chaff may reduce the efficiency of chewing, physically shield the starch particles and increase the rate of transit through the small intestine, thus restricting direct enzymatic attack on the starch particles. In this way, overall digestibility of the starch in the small intestine may decrease.

☑ Processing hard grains such as corn (maize), barley, triticale, wheat or sorghum by cracking, crimping, rolling or grinding can improve starch digestibility in the small intestine by between 5-15%. Reducing the carbohydrate particle size increases the surface area exposed to enzyme attack, so grinding these grains to a coarse powder may be worthwhile to improve digestibility.

KEYPOINT: Processing grains for foals before their teeth are able to chew whole grains efficiently or for aged horses with worn away teeth improves the overall digestibility and utilisation of the starch and protein in the grain.

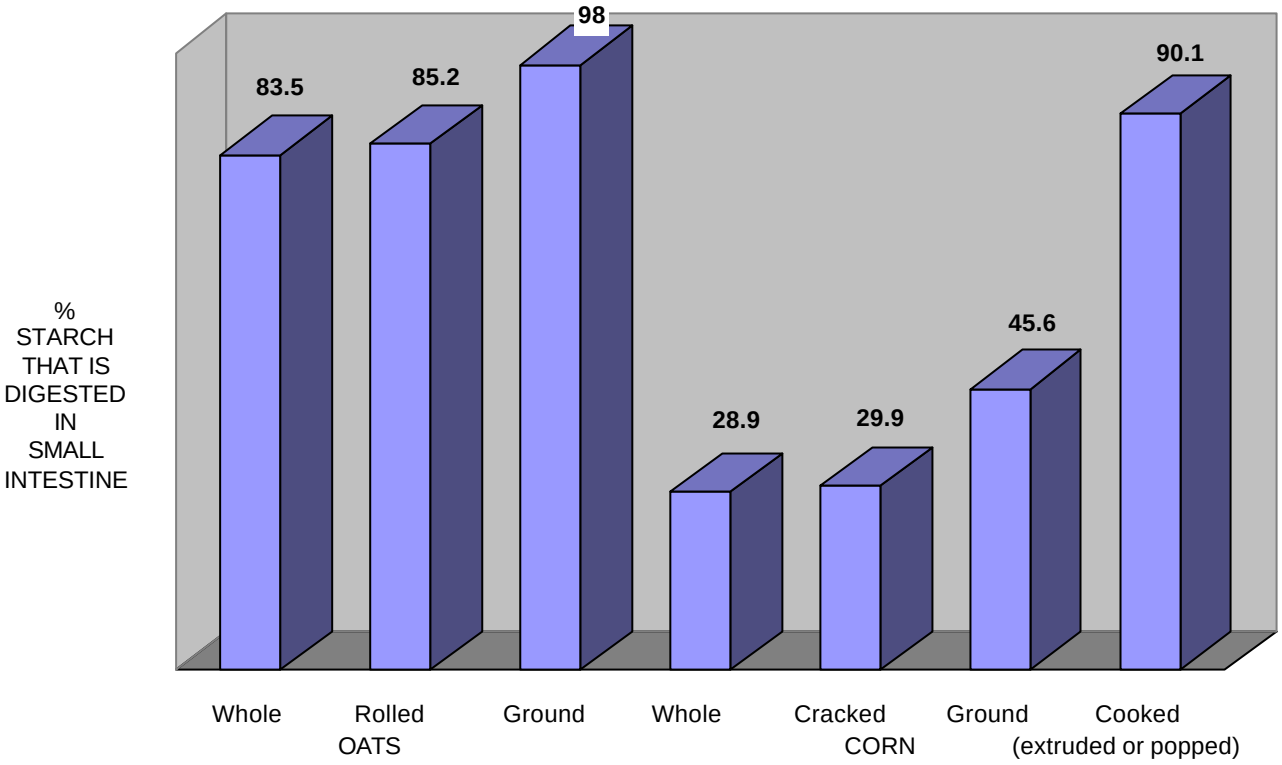
The relative improvement in digestibility in the small intestine gained by various forms of processing of oats and corn is illustrated in Figure 2.3.

Processing oats at standard rates of intake does not significantly increase digestibility of oat starch in the small intestine, provided the horse is able to efficiently chew whole oats in its ration. As the amount of oats exceeds 0.4kg oats/100kg body weight per feed, the digestibility decreases in the small intestine and more is overloaded into the large intestine. (see page XX).

KEYPOINT: Any form of processing increases the dust content of fine particles, as well as the rate of oxidation of fats and vitamins within the opened grain during storage prior to feeding. Processing also raises the cost of the grain.

☑ Cooking the starch by boiling and simmering the grain at 100°C as in boiled barley, or by controlled friction or steam extrusion processing at 135°C, or alternatively by infrared micronisation at 150-160°C, expands the starch particles to form a more open and porous type of granule. This greatly enhances the surface area and hence the efficiency of the enzyme attack on the starch within the small intestine, increasing starch digestibility up to 90% for grains, such as corn (See Figure 2.3). Controlled cooking also improves the digestibility of protein in grains and oil seed meals as well.

KEYPOINT: Careful control of the time and cooking temperatures and rapid cooling to remove retained heat is essential to avoid oxidation of proteins and fats and heat damage to vitamins in cooked feed.



Adapted from Frape 1997, Schoenherr 1996

Note: The above comparisons have been made at equal starch intakes, not volumes or weights of grain. As more oats are added to a feed, digestibility of oat starch is reduced in the small intestine.

% Digestion of Starch in Small Intestine
FIGURE 2.3
Comparison Table of Relative Digestibilities
Of Whole and Processed Oats and Corn
The digestibility of oat starch in the small intestine is higher than starch from corn, barley and sorghum

2.4.1.2 Protein Digestion

The small intestine is the major site of protein digestion into dipeptide and amino acid constituents and their uptake into the blood. The small intestine of a foal can absorb large long chain proteins or immunoglobulins for the first 12-16 hours of life that provide it with protective antibodies against disease. However, proteins in food have to be digested to their constituent amino acids before they can be absorbed into the blood. The amino acids are then recombined into specific body proteins in the horse's liver, blood and tissues.

Protein can be digested either by way of acid hydrolysis using gastric acid or by direct enzyme attack in the small intestine. Gastric acid overflow from the stomach hydrolyses a limited amount of protein until the buffering action of bicarbonate secreted in the saliva and pancreatic juice limits further acid attack. However, whilst acid hydrolysis in the small intestine is three times more active than protein breakdown by acid in the stomach, protease enzymes released in the pancreatic juice digest the greater proportion of protein in the small intestine.

KEYPOINT: The digestibility of protein varies in direct proportion to the amount of protein in the diet, the fibre content of the feed source and the type of the protein relative to its amino acid balance.

Digestibility of protein in grain may be up to 85% in horses fed on concentrate diets containing higher "quality" protein sources, such as soyabean meal.

Studies have shown that the digestibility of protein in low protein (8% crude protein) fibrous grass hay can be as low as 43%, increasing to almost 70% for a 16% crude protein mix of lucerne and concentrates.

Research has indicated that on a moderate protein diet (12-14% crude protein), 75-80% of the protein content of soyabean is digested in the small intestine, with 20% digested in the hindgut and 10% lost in the droppings.

Studies have also shown that protein digestibility of the overall diet and levels of circulating amino acids in the blood can be improved by feeding a small quantity of roughage about 2 hours prior to giving a concentrate meal. In normal feeding practice, concentrates are usually fed first, followed by roughage, which may, in fact, act to reduce protein digestibility in the small intestine.

KEYPOINT: The large intestine does not secrete enzymes that break down carbohydrates, proteins or fats, although the bacterial population produce enzymes during the fermentation process. Diets containing excess protein, which is overloaded into the large intestine, are not efficiently utilised in the large intestine, with significant amounts being passed in the droppings.

Controlled cooking of feed by steam pelleting, boiling, micronization or extrusion increases the efficiency of enzymatic attack on protein as well as starch and improves the digestibility of protein in the small intestine. However prolonged overheating can damage the amino acids in food protein and reduce their efficiency of digestion and reassimilation into protein in the liver and body cells.

Studies indicate that the digestibility of the amino acid lysine in skim milk, fish meal and meat meal can be significantly reduced by overheating during drying and processing.

KEYPOINT: Only very limited amounts, if any, of the excess protein in the diet, which is passed into the hindgut and protein assimilated by bacteria during hindgut fermentation, is absorbed from the large intestine of the horse.

2.4.1.3 Fat Digestion

Fats, or lipids, and long chain fatty acids contained in the feed are primarily digested in the small intestine of the horse. The continuous flow of bile emulsifies lipids (fats and oils) to improve the attack by the lipase enzyme secreted in the pancreatic juice. This helps to efficiently digest limited amounts of fat to its constituent fatty acids and glycerol. Some emulsified fats are absorbed as neutral triglycerides directly through the mucosal lining cells into the lymphatic system. They are then complexed to protein and transported to the liver and cells as lipoproteins. Fats, contained in feeds, also provide the natural fat-soluble vitamins A, D, E and K, which are released during digestion and absorbed into the bloodstream.

KEYPOINT: Studies have indicated that limited amounts of fats are efficiently digested in the small intestine of the horse. However, where the level of added fat exceeds 10-12% of the total concentrate portion, its digestion and utilisation is reduced.

Most forage based diets and concentrate feeds based on grains, fat extracted oil seed meals and hays contain between 2-5% fat. Addition of fat to improve the energy density of the ration has become a popular means of reducing the bulk that needs to be consumed by small framed horses or by horses with a limited appetite. Adding up to 10-12% fat to the concentrate portion of the ration has also been shown to improve the utilisation of carbohydrates as an energy source in hard working horses. (See page XX).

2.4.1.4 Fermentation

The alkaline and enzyme-active environment of the upper small intestine prevents the colonisation of bacteria, although digestive micro-organisms taken in with feed can pass through to become established in the large intestine. The lower section of the small intestine or ileum, before it enters the large intestine, can harbour limited populations of the *Lactobacilli* and *Bifidobacteria* species of bacteria. Once established, these bacteria can ferment a specific type of carbohydrate fibre in feed, known as fructo-oligosaccharides (FOS), which provides volatile fatty acids as an energy source. They also assist by competing with and preventing over-population of other harmful bacteria such as *E.coli*, *Clostridial spp* and *Salmonella spp* that may establish in the lower small intestine and large intestine and lead to digestive upset and diarrhoea.

2.4.1.5 Mineral Uptake

The majority of minerals and trace-minerals contained in feeds and those provided by supplements are absorbed from the small intestine. Minerals such as calcium and iron are complexed to a protein in the small intestine wall prior to uptake into the blood. Between 50-80% of the calcium in the diet and 45-60% of magnesium is absorbed from the small intestine. There is very little uptake of phosphorus from the upper small intestine or duodenum in a horse on a roughage based diet. Limited absorption of phosphorus from a concentrate diet can occur in the lower section of the small intestine.

A high intake of calcium in a feed mix, which is absorbed primarily in the small intestine, does not affect the uptake of phosphate from the hindgut. However, it can lower the uptake of other minerals including magnesium, iron, zinc and manganese in the feed or when these minerals are added to the ration as supplements. (Refer to Chapter 3, Section 3.6.1.2, page XX).

2.4.1.6 Electrolyte Uptake

All the major electrolytes are absorbed as soluble or ionised salts from the small intestine. The uptake of sodium, potassium and chloride, as well as calcium, magnesium and bicarbonate, which are the electrolytes or body salts used in nerve, muscle and metabolic function, is dependent on the acid-base balance and fluid content within the small intestine, its motility and rate of passage of the digestive mass. (Refer to Chapter 4, Section 4.2.3.3, page XXX).

2.4.1.7 Vitamin Uptake

The majority of the fat soluble and water soluble forms of vitamins contained in the feed are absorbed during the digestive process in the small intestine.

2.4.1.8 Water Uptake

Water is absorbed from both the small and large intestine. The digestive mass in the small intestine contains 90% water to promote uptake of soluble nutrients and help maintain its relatively fast rate of passage.

When a thirsty and dehydrated horse has a drink of water, large volumes are absorbed from the small intestine to assist in the rapid replenishment of fluids and electrolytes in the blood and body cells.

2.5 Large Intestine

The large intestine occupies about 64% of the volume, but only 30% of the total length of the horse's digestive tract.

It is a short, voluminous part of the intestine that acts as the horse's "fermentation tank", in a similar way to the rumen or forestomach of ruminant animals.

The large intestine is divided into the **caecum**, a large blind sac hanging directly within the right flank area; the **large colon**, which lies on the floor of the abdominal cavity in 5 "pillow like" segmented sacs, the **small colon**, where the faecal (manure) balls start to form, and finally the **rectum**, which stores the droppings.

The large intestine is often referred to as the "hindgut" because of its size, location and digestive importance. The digestive mass moves slowly through the large intestine, which has a slightly drier consistency than the small intestine, taking from 24 to 60 hours depending on the fibre type, moisture content and bulk of the digestive mass.

2.5.1 Changes with Age

A young foal, during its first month of age, has a large intestine that occupies only 15-20% of the total gut capacity. The low bulk, minimum fibre, milk based diet consumed by a foal is primarily digested in the small intestine.

KEYPOINT: As a young horse consumes more roughage, the large intestine develops its fermentation capacity and expands in volume to accommodate the bulk. As an adult, the large intestine occupies about 64% of the digestive tract volume.

2.5.2 Digestive Function

Large populations of bacterial, protozoal and fungal micro-organisms colonise the warm, watery alkaline and anaerobic (no oxygen) environment of the hindgut. The carefully balanced proportions of micro-organisms or "gut flora" release enzymes to break down the bonds of the large structural polysaccharide compounds that make up cellulose, gums, pectins and other fermentable structural carbohydrates of plants, as well as sugars, starches and proteins overloaded from the small intestine.

The insoluble, indigestible plant component lignin, present in higher concentrations in mature plant stems and grain husks, cannot be digested by bacterial enzymes and passes out in the droppings.

KEYPOINT: An adequate and regular intake of roughage is essential to maintain hindgut contraction movement (motility), balanced micro-organism populations and water reserves and to open up the partly digested food mass to microbial attack as it ferments in the hindgut.

The muscular contractions of the large intestine provide a mixing action to facilitate bacterial fermentation of the fibre in the food mass.

The transit time of the digestive mass through the caecum and colon is influenced by the physical form and size of the food particles, the water content and net rate of uptake of nutrients. Fresh, green succulent forage moves through most rapidly, which can cause watery droppings. Finely ground pelleted feeds move through more quickly than chaff or stemmy hay. Large fragments of forage or hay, more than 2cm long, take up to 7 days to move through the hindgut. Small whole weed seeds have been shown to be retained for 4-13 days in the hindgut, thereby increasing the risk of weed spread on pastures.

KEYPOINT: The hindgut does not secrete digestive juices or enzymes, but it is lined with mucus producing cells to assist the lubrication and movement of the digestive mass through the bowel.

A high indigestible lignin content in feed, or a drier consistency due to inadequate saturation with saliva at feeding or limited water intake, can result in compaction, with reduced digestive activity and a high risk of colic.

In practical feeding terms, this means that:-

✖ Finely chopped mature cereal chaff with a high indigestible lignin content has a higher risk of compacting in the caecum and large colon than similar chaff shredded into longer fragments.

KEYPOINT: The horse is more efficient in utilising sugars, but less able to digest fibre, than the ruminant. Therefore, pasture and hay containing less mature plants, with a higher proportion of cellulose to lignin, are better utilised by the horse.

2.5.2.1 Fermentation

The horse obtains its primary source of simple sugars, protein, fats and some minerals and vitamins from direct uptake and digestive action within the small intestine. However, efficient hindgut fermentation is essential to provide breakdown of structural carbohydrates in cellulose fibres and other structural fibres in plants, to volatile fatty acids, which are a valuable energy source.

The anaerobic buffered alkaline environment of the hindgut provides conditions suited to digestion of fermentable fibres, protein and limited amounts of starch to volatile fatty acids (VFAs). These are chiefly acetic and butyric acids, which are absorbed into the blood stream. These can provide the major source of energy on aerobic oxidation in muscle and other cells in grazing horses, with excess being stored as body fat.

KEYPOINT: Horses resting or performing light work on a pasture based diet obtain 75-80% of their energy from volatile fatty acids produced by hindgut fermentation. In contrast, horses in heavy training on a ration containing grains with less roughage, obtain 70-75% of their energy from starch and fat digested in the small intestine.

Another volatile fatty acid, propionic acid, is produced during fermentation of undigested starch residues. It is absorbed and converted directly to glucose in the liver and utilised as an energy source during anaerobic (fast) and aerobic exercise.

High intakes of lush, rapidly growing grass pasture, or consumption of meals containing large amounts of grain, can overload increased amounts of starch into the hindgut. These substrates increase the fermentation rate, rapidly elevating propionic acid production. Lactic acid producing bacteria also proliferate and accumulate D-lactic acid as a byproduct of starch fermentation, increasing acid levels and reducing the pH of the hindgut. This is termed “caecal or hindgut acidosis”, and high D-lactic acid levels can have a serious effect on digestive function. (See Glossary terms)

KEYPOINT: The production of large amounts of D-lactic acid following overload of soluble sugars into the hindgut is considered to be the mechanism that triggers the onset of laminitis and founder in horses and ponies consuming lush pasture or high grain diets.

The accumulation of D-lactic acid overwhelms the normal buffering efficiency and lowers hindgut pH to below an optimum of 6.5-6.8 necessary to facilitate maximum VFA production and uptake. Observations suggest that when faecal pH falls below 6.4pH units, the higher D-lactic acid concentration stimulates increased motility, which leads to diarrhoea, seen as ‘cow pat’ like droppings, with reduced nutrient and water absorption. If the decline in hindgut pH continues

below 6.4, fermentation activity of the other microbial flora is suppressed and hindgut digestive function is severely compromised.

Studies indicate that up to 16% of horses in training on intakes of more than 5kg total raw (not extruded or cooked) grain daily are likely to develop a low grade form of hindgut acidosis. Other studies suggest that up to 46% of sound racehorses on high grain diets have structural changes within the front hooves, with evidence of downward rotation of the pedal bone consistent with low-grade laminitis. Many of these horses have a history of reduced stride length, symptoms of "foot soreness", widening and deterioration of the white line and increased breakaway around the edges of the hoof wall.

KEYPOINT: If the hindgut pH drops below 6.2 units on high starch diets, large numbers of the resident microbial flora are suppressed and die, releasing toxins that are absorbed into the blood stream.

These circulating toxins are thought to have a direct effect by reducing the vitality of the basement membrane cells in the laminae that provide the structural support within the hooves, as well as reducing the flow of blood into the laminae. This results in devitalisation of the laminae, fluid collection and reduced laminar bonding. If the process continues, devitalisation of the laminae can lead to structural collapse within the hooves and pedal rotation resulting in founder. (See Glossary term).

The fermentation activity and digestive function in the large intestine also contributes a number of other essential byproducts vital to the horse's well being, as detailed below.

2.5.2.2 Heat Production

The fermentation process produces heat from some of the energy stored in the carbohydrates and proteins that are digested in the hindgut. Because cellulose and other complex carbohydrates require prolonged microbial activity to break down their structural bonds, fibrous foods such as roughage from grass, chaff and hay produce more "heat waste" than starches in grains. Together with exercise, the "heat of fermentation" helps to provide heat to maintain body temperature. Excess protein overloaded from the small intestine and fermented in the hindgut also produces approximately 6 times more heat than an equal weight of excess starch fermented in the hindgut.

In practical feeding terms this means that:-

✓ Under cold conditions, feeds with a high fermentable fibre content, such as pasture, good quality hay, and even oats (which is the highest in fibre of the common grains) will assist in maintaining body warmth in grazing horses.

✖ High protein diets, which can result in fermentation of excess protein in the hindgut, can increase the amount of heat that has to be eliminated by sweating and panting in working horses, especially under hot conditions.

2.5.2.3 Water Holding Capacity

Roughages and fibrous foods absorb and hold water within their structure as the digestive mass passes through the large intestine. The hindgut holds 75% of the water retained in the digestive tract, acting as a reservoir of water that can be absorbed to counteract fluid loss from sweating and respiratory evaporation in working horses. Each gram of fibre holds approximately 5 times its weight in water and studies indicate that for every 1kg of dry hay consumed, a horse's body weight can be increased by 4-6kg.

In practical feeding terms, this means that:-

- ✓ Horses that are working under hot conditions are able to maintain higher reserves of fluid to counteract dehydration from sweat loss if provided with dampened roughage 24-36 hours prior to prolonged exercise.

- ✓ Horses that become dehydrated due to inadequate water intake or heavy sweat loss under hot conditions, lose hindgut weight as water reserves are depleted. They can develop an appearance of being "tucked up in the belly", especially if their hindgut capacity is limited by highly concentrated, low roughage rations.

2.5.2.4 Mineral and Electrolyte Uptake

The majority of minerals, electrolytes and trace-minerals are absorbed from the small intestine. Only about 10% of the total calcium is absorbed from the large colon, with a net outflow of calcium from the caecum, large ventral colon and small colon. The majority of the phosphorus is absorbed from the large intestine. Considerable amounts are secreted as phosphates into the large intestine to buffer the acidity resulting from fermentation of cellulose to volatile fatty acids. It is then primarily secreted and reabsorbed, relative to the need for phosphorus and blood phosphate buffering activity from the large intestine.

2.5.2.5 Vitamin Synthesis

The micro-flora and fungi that colonise the large intestine also synthesise (called bio-synthesis) many water soluble B-group vitamins, as well as natural vitamin K, as byproducts of the fermentation process.

In a pasture fed horse, the biosynthesis of these vitamins helps to meet daily needs in excess of those provided in the diet and absorbed during digestive processes in the small intestine. The droppings of a horse contain a higher content of some B-group vitamins than the levels naturally provided in the feed.

KEYPOINT: In horses on concentrated rations with a lower fermentable roughage intake, the biosynthesis of B-group vitamins is reduced. It is also considered that their absorption is limited when horses are exposed to the stresses of training.

In practical feeding terms, this means that:-

- ✓ Horses fed highly concentrated diets in training may benefit from supplementary B-group vitamins in their feed. As B-group vitamins are involved in metabolism and liver function, supplementary amounts may help maintain appetite and assist metabolic recovery from hard exercise. (Refer to Chapter 3, Section 3.7.1.2, page XXX to XXX).

2.5.2.6 Manure Form

The colour, consistency and smell of a horse's droppings reflect the state of its digestive function, water intake and the type of diet that it is consuming on a regular basis.

KEYPOINT: The type and amount of fibre in the diet can affect the consistency, volume and water content of the droppings.

About 50% of the dry matter of the manure consists of microbial cells that are still actively fermenting fibre residues when passed. The content of the rest of the dry matter is relative to the amount of non-fermentable lignin in the diet. Mature pasture and hay diets produce more manure

bulk than lower fibre, growing pasture and concentrated grain based diets. The fibre of cereal grasses and chaff holds more water in its structure than fibre from lucerne hay or chaff and the droppings will often appear to be moister on lucerne based diets. Horses grazing good quality pasture with lower lignin and other residue after digestion normally pass smaller manure balls in their droppings.

KEYPOINT: The water content of the droppings can vary considerably due to the volume of feed consumed, the type of diet and the horse's need for water to replace sweat and lung evaporative losses.

Green pasture diets usually result in droppings with a higher moisture content than dry feed diets. Encouraging water intake by providing salt and electrolytes will often produce wetter manure. When a horse dehydrates from lack of water or heavy sweat loss, its droppings become drier with smaller more compacted manure balls.

KEYPOINT: The efficiency and type of fermentation in the hindgut also influences the smell and consistency of the droppings.

High grain intakes that result in overflow of starch into the hindgut are likely to result in large amounts of D-lactic acid build-up in the hindgut, which lowers the pH of the droppings (see page XX). High D-lactic acid levels also increase the rate of movement of the feed mass through the hindgut, reducing digestion and increasing water content. Affected horses pass "acid" smelling, "cow pat" type droppings after consuming a high raw starch (not cooked) intake in grain based diets that have a less than optimum fibre intake. (See also laminitis page XX and glossary term).

High protein diets can also increase the amount of ammonia in the droppings and urine, as excess protein is fermented in the hindgut.

2.6 Summary

The horse's digestive system has evolved to efficiently use large amounts of fermentable fibre from green growing grass and other succulent plants.

- ✓ The horse enjoys grazing as its natural means of gathering food. It is able to selectively graze close to the ground. A horse selects its feed on smell, taste, texture and moisture content. It must chew and grind its food thoroughly to prepare it for the digestion processes. It normally consumes small amounts of food at each mouthful. Its grinding teeth can develop sharp edges and need regular examination and rasping, especially in horses eating large amounts of dry, hard feed such as whole grain.

- ✓ The horse needs to obtain its protein, fat and major mineral and fat soluble vitamins during the digestive processes in the small intestine.

- ✓ High starch and protein diets cannot be fully utilised in the small intestine and residues of starch that overflow into the large intestine can be rapidly fermented to D-lactic acid, which has adverse effects on digestion.

- ✓ Horses on highly fermentable fibre diets provided by young, growing pasture obtain up to 70% of their energy from volatile fatty acids produced during hindgut fermentation processes, compared to 30% for horses on high starch, grain based diets.

- ✓ Proper and balanced digestive function is essential to maximise the utilisation of the diet and uptake of energy, protein, fat, minerals and vitamins from both the small and large intestine.

☑ The volume, consistency, moisture content and smell of a horse's manure reflects the efficiency of its digestion, type of diet and the amount of water it has taken in with its feed.

CHAPTER 3

THE MAJOR NUTRIENTS IN HORSE FEEDS

Over the past 20 years, largely because of the economic importance of the horse in competitive racing and horse sports, and for pleasure and leisure riding activities, a large proportion of equine research has concentrated on establishing more accurate guidelines on the nutrient requirements of breeding, growing and exercising horses. An understanding of the basic nutrient classes and their importance will enable you to select suitable types of feeds relative to an individual horse's needs. It will also help avoid some of the deficiencies and excesses that can occur if a horse is provided with an imbalance of nutrients because the feeds are blended in incorrect proportions, are of low quality, or are not being consumed because of poor palatability or an individual horse's likes and dislikes.

Most horse owners are familiar with the terms of energy, protein, fat, fibre, major mineral and vitamin needs, because of the mandatory labelling requirements for packaged human foods and prepared "ready-mixed" feeds formulated for horses. The value of a feed is dependent on a horse's ability to digest, absorb and utilise the basic nutrients.

The major nutrient classes, utilisation of feeds and common feed sources are summarised in Table 3.1.

KEYPOINT: The individual contribution of dietary nutrients depends on the types of pasture or feeds provided, the blend and proportion of each in the ration and their quality related to stage of growth, processing and storage.

A discussion of the function of each class of nutrient in the diet is helpful to provide an understanding of its importance and contribution relative to a horse's needs.

In terms of the body's content, daily quantity required, its involvement in digestion and normal physiological and metabolic function, and the amount excreted or secreted from the body, water is the most important of all nutrients in a horse's diet.

NUTRIENT CLASS	PROVIDES A SOURCE OF, OR IS UTILISED FOR	NUTRIENT SOURCES IN FEED	COMMON FEED SOURCES AND RELATIVE CONTENT
ENERGY As Megacalories Mcal Megajoules MJ (MJ=Mcal x 4.185) of Digestible Energy (DE)	Fuel for muscle contraction, body cell metabolism and division in maintaining body function, heat for body warmth, with additional amounts required for growth, exercise, pregnancy and lactation.	Carbohydrates – fibre – microbial fermentation to volatile fatty acids.	Hays and forage (low) 5.6-10 MJDE/kg
		Carbohydrates – starches, sugars.	Cereal Grains (high) 1 15MJDE/kg
		Proteins – 50% of amino acids to energy, excess fermented to heat.	Protein in grains and meals (medium-high) 11.5-14MJDE/kg
		Fats to fatty acids	Fats added to diet (ve high) 37MJDE/kg

PROTEIN g/100g or % (As Crude Protein) (CP)	Amino acid building blocks for body protein in tissues, blood and bones. Extra required for growth, pregnancy and lactation, and exercise.	Crude protein in feed. Quality relative to amino acid content, oil seed meals highest, cereals lowest. Protein produced by microbial fermentation in large intestine not utilised.	Oil seed meals (high) 22-44%CP Lucerne Hay (medium) 15-17%CP Cereal grains 6-12%CP Cereal hay 6-7%CP Amino acids added to diet
FAT g/100g or % (As crude fat)	Concentrated source of energy only and essential fatty acids for body functions, skin condition and muscle and nerve membranes. Fat soluble vitamins.	Saturated Fats, Polyunsaturated oils. Volatile Fatty Acids in feeds produced by fermentation of fibre in large intestine.	Vegetable Oils (very high) 99% Whole Oil Seeds (high) 15-26% Oil Seed Meals (low) 0.5-3% Grains (low) 2-4% Hay (low) 2-3%
FIBRE % (As Modified Acid Detergent fibre (MAD))	Essential for fermentation in the large intestine to provide energy as volatile fatty acids, open the feed mass for efficient microbial action, and hold water reserves in fibrous mass in hindgut.	Fermentable fibre – highest in growing plants. - Celluloses - Hemicelluloses - Pectins, Gums - Lignin – indigestible component increases as plants mature, also in seed hulls.	Oil Seed Meals (medium) 7-22% Oats (high) 17% Corn (low) 3% Barley (medium) 7% Late cut hays (high)40-45% Pre-bloom cut hays 20-30%
MINERALS Major minerals grams (g) Trace minerals milligrams (mg)	Structural content of teeth and bones, involved in metabolic functions, blood formation.	Major Minerals (Macrominerals) Calcium, Phosphorus, Magnesium Trace-Minerals (Micro-minerals) Iron, Copper, Cobalt, Manganese, Zinc, Iodine, Selenium, Chromium.	All common feeds Mineral sources (supplements) Examples: Lucerne : high calcium/low phosphoru Oats : high phosphorus/low calciu
ELECTROLYTES Grams (g)	Nerve and muscle action, acid-base balance, water intake and kidney function.	Sodium, Potassium, Chloride, Magnesium, Calcium (Bicarbonate)	All common feeds Mineral sources (supplements) Lucerne : high in most electrolytes Grains : low in electrolytes
VITAMINS International Units (iu) Micrograms (µg) or	Metabolic functions, tissue health and nervous function, mineral uptake, blood formation, immune response, fertility	Fat-soluble vitamins A,D,E,(K) Water-soluble B-group vitamins and vitamin C	All common feeds vitamin Supplements - high Sunlight on skin – vitamin D

Milligrams (mg)	response, fertility.		vitamin D Hindgut fermentation E group, vit K, vit C in liver.
WATER Litres(L)	Essential to maintain fluid content of blood and tissues, essential for nutrient uptake, kidney function and fluid balance.	Resting, cool weather = 4 litres/100kg daily. Hard exercise, hot weather up to 10-15 litres/100kg daily.	Drinking water Green forages 80% water Dry Feeds 10-16% water Added moisture to fee Metabolic water

Sources: - NRC (1989) Lewis (1995) Frape (1997) Kohnke (1998)

TABLE 3.1

Major Nutrient Classes including Function and Common Sources

3.1 Water

Water held in the digestive tract and as body fluids, accounts for 65-75% of a mature horse's body weight, or approximately 325-375 litres in an adult 500kg horse.

A young foal's body contains from 75-80% water because of the higher proportion of muscle to bone and fat. In the mature horse, the total water content increases as it develops a higher proportion of muscle in training and becomes leaner.

A horse can lose almost all of its fat reserve, and up to 50% of its protein and still remain active although it may be thin and wasted. However, a loss of 6% of body water will severely hamper a horse's vitality, temperature regulation and ability to work efficiently, as well as increase the risk of digestive disturbances and colic. A loss of more than 10% water can lead to severe dehydration, collapse and death. Fluid and electrolyte loss in heavily sweating or hard working horses can result in a progressive loss of performance, combined with an increasing risk of overheating and exhaustion.

3.1.1Need for Water

Water has a number of vital functions in a horse's body. An adequate intake of water is required for:-

- ✓ The metabolic functions of cells that make up a horse's muscles, blood and body tissues. 50% of water in a horse's body is within body cells, 20% between the cells, 5% in the blood as plasma and the remainder in the digestive system.
- ✓ The digestion and absorption of nutrients from the gut and the efficient transport of these nutrients within the body.
- ✓ The elimination of soluble waste products as metabolites and salts in the urine. The non-absorbed nutrients are passed out in the droppings.
- ✓ The control of body temperature (thermoregulation), with efficient heat loss via evaporation of sweat from the skin and exhaled water vapour from the lung surface during respiration. This is an important function in a hot climate, such as exists in Australia, and in a horse exercising over long distances. Each litre of sweat evaporating from the skin is capable of removing approximately 2.43 megajoules (MJ) (2.43 million watts) of heat energy. Evaporative loss in sweat and from the lung surface used in cooling accounts for up to 33% of intake of water during hot weather. During prolonged exercise, urinary outflow is reduced in order to maintain and conserve adequate fluid levels for metabolism and heat loss.
- ✓ Mare's milk contains from 87-89.5% water relative to the stage of lactation. A mare produces from 3-4% of her body weight in milk (15-20 litres in a 500kg mare) daily at the peak of lactation between 4-10 weeks after foaling.
- ✓ It is especially important to provide adequate water to a horse on a dry feed diet and when salt or electrolytes are added to the ration of a working horse.

3.1.2. Factors Influencing Water Requirement

There are a number of factors that influence the daily requirement of water. These are summarised in Table 3.2.

Influencing	Water Requirement/Loss

Factor	
Dietary Influences	Horses need more water to drink when fed on dried hays and grains. Estimated intake is 3.6 litres of water per kg of hay in the diet and 2.9 litres per kg of a combined hay and grain ration.
Environmental Temperature	Under cool conditions (less than 10ºC) a resting horse will consume 2 litres of water per kg of dry feed. Up to 8 litres/kg dry feed may be consumed under hot conditions above 35ºC.
Exercise	A working horse will consume up to 20-30% more water above resting needs due to evaporative sweat and respiratory losses to aid cooling. As body temperature rises during exercise, up to an 800% increase in water loss from the lung surface can occur.
Reproductive	Lactation in mares increases water need by 50-70% above a resting horse. Seasonal cycles in mares result in more frequent urination, increasing urinary water loss by up to 20%.
Growth	Requirements for growth are 10-15% higher than an adult horse of equivalent body size under similar conditions.
Gastro-intestinal Losses	Diarrhoea, especially in foals, can result in substantial loss of water in the manure, along with electrolytes and other feed constituents, leading to dehydration. Foals are less able to concentrate their urine to counteract gastro-intestinal loss and dehydrate more quickly when suffering from severe diarrhoea as compared to adult horses. This can be compounded under hot summer conditions with respiratory and sweat loss.
Urinary Losses	The average 500kg horse excretes about 17 litres of urine per day. Diets high in salt or protein can increase water needs. A higher urinary loss occurs in horses fed on legume diets than those given grain and cereal hay diets.

Source:- NRC (1989) Cunha (1991) Lewis (1995) Frape (1997)

TABLE 3.2

Factors Influencing the Water Requirement and Loss in Horses

KEYPOINT: The daily intake of water does not vary much for an individual horse. Any decrease in water consumption, or change in feed intake, is often a sign of sickness 24-36 hours before symptoms become apparent. A change in body weight, rather than body condition, is a measure of water loss in a sick horse.

A lightly worked horse under cool to moderate temperature conditions loses about 50% of the total water outflow each day in its urine, 30% in droppings and the remainder via sweat and respiratory evaporation. A heavily sweating horse performing moderate work under warm conditions (30ºC) may lose 9-11 litres of fluid per hour in sweat.

3.1.3Sources of Water

A horse obtains its daily intake of water from the moisture content in the feed it consumes, water produced during aerobic energy metabolism in its body tissues and from water it drinks when thirsty.

✓ Moisture in Feeds

Horses grazing fresh, lush pasture and green feed, which contains up to 70-80% water, may not voluntarily drink water under cool conditions. Average green pasture contains up to 65-70% water, dry mature pasture 40% moisture or less and grains and hays from 10-16% moisture. Under drought conditions where limited water and supplementary feed is available, horses will often seek out and consume succulent plants, many of which may be poisonous, to obtain water.

✓ **Metabolic Sources**

The metabolism of carbohydrates, proteins and fats during aerobic (using oxygen) energy breakdown in muscles and other tissues provides a useful source of metabolic water to the tissue and cell environment. Each kilogram of a mixed concentrate feed provides between 350-400mL of metabolic water as the energy is metabolised, relative to its digestibility and fat content.

KEYPOINT: Poor quality, less digestible feeds increase the water requirement in a horse in order to maintain physical digestive flow and offset the reduced contribution from metabolic water production.

✓ **Drinking Water**

A resting horse under cool to temperate conditions (10-25°C) will drink about 4-5 litres of water per 100kg body weight daily, or roughly 2-3 litres per kg of dry feed consumed. If water is available, most horses will drink 3-4 litres per kg dry matter when on a dry feed diet, even though they do not need it.

A study under hot, moderately humid conditions in Queensland indicated that all foals by 6 weeks of age drink up to 4L daily, and by 10 weeks of age 5.5L daily above that provided by milk and moisture in feed.

KEYPOINT: Horses should be provided with a supply of fresh, clean water at all times sufficient to meet their daily needs. They will consume more water and drink more often when water is located near to their feeders. Under hot conditions, horses will drink more readily when the water is cool and in the shade.

Under hot Australian summer conditions, water provided by underground pipes to a self-drinker will help to keep it cool. A volume of at least 50 litres should be provided in a trough or bucket daily under hot conditions to avoid the bulk of water becoming warm and less well accepted.

3.1.4Quality of Water

The quality and palatability of water is critical, not only to ensure a horse will consume it readily, but also to avoid the intake of potentially toxic minerals that could accumulate in its body. Water provided for horses should be clean, fresh and free of chemical tastes or decomposing organic matter.

There is very little specific data on the upper levels of salts or solids in water that will limit its palatability and safety for horses. The recommendations are based on water quality for other livestock and are a useful guideline for horses drinking creek, dam or bore water.

3.1.4.1 Total Dissolved Solid Content

The quality of water is usually expressed as its content of Total Dissolved Solids (TDS), or the total concentration of chemical salts such as chloride, sulfate, carbonate and bicarbonate, and minerals such as calcium, sodium, magnesium, iron and copper that are dissolved or suspended in the water.

The measure of “hardness” of water, which relates to the suspended and dissolved magnesium and calcium salts, can also be used as a guide to water quality. Although individual salts, such as calcium have an Upper Safe Limit (USL) of 500mg/L in water, above which palatability is reduced, a total “hardness” is recommended at 200mg/L. This is because a higher magnesium content in “hard” water is more likely to reduce the palatability of the water than excess calcium.

KEYPOINT: Horses prefer to drink water with a maximum TDS content of up to 1000 ppm (1g/litre), but will consume water containing up to 3000 ppm (3g/litre). Water containing a TDS content of greater than 5000-7000 ppm (5-7g/litre) will cause a reduction in water consumption and can ultimately have an adverse affect on growth rate, athletic performance, milk production and vitality.

In practical feeding terms, this means that:-

✖ The TDS content can be inadvertently increased when electrolyte mixtures, containing concentrated sources of salts, are added to drinking water.

✓ **As a guideline, the maximum rate of adding salt mixes is 60g of an electrolyte (containing at least 50% sodium chloride) per 25 litres of town, rain water or river water.** A smaller amount should be added to water from bores or dams already containing a higher TDS content.

3.1.4.2 Upper Safe Limits of Toxic Minerals

Water drawn from bores or collected in dams and creeks as run off may contain a low concentration of heavy metals and other potentially toxic minerals. The water may be palatable, but the intake of certain minerals may cause them to accumulate in the horse’s blood, liver, kidneys and other tissues, resulting in either acute or chronic toxicity and symptoms of poisoning.

KEYPOINT: The TDS and organic matter content in dams can concentrate during summer due to water evaporation and can result in the water being less palatable when dams are low or almost dry. Alternative sources of fresh water must be provided for horses under these conditions.

The Upper Safe Limits (USL) of potentially toxic heavy metals and other minerals are summarised in Table 3.3.

Mineral Elements	mg/L Upper Safe Limit (USL)
Mercury, Selenium, Cyanide, Manganese	**0.01mg/L**
Lead, Vanadium	**0.1mg/L**
Cadmium, Silver	**0.05mg/L**
Arsenic	**0.2mg/L**
Iron*	**0.3mg/L**
Copper*	**0.5mg/L**
Chromium, Cobalt, Nickel	**1.0mg/L**
Fluorine**	**2.0mg/L**
Nitrite Nitrogen	**10mg/L**
Zinc	**25mg/L**
Nitrate Nitrogen	**100mg/L**
Salt*	**2500mg/L**

* Iron and copper at this level are not toxic, but the palatability of water may be decreased.
** Fluorinated town water contains 1mg fluoride/L

Source: NRC (1989) Lewis (1995)

TABLE 3.3

Upper Safe Limits (USL) of Drinking Water for Horses

3.1.4.3 Water Testing

Water samples can be tested for TDS content and a range of potentially toxic heavy metals by Department of Agriculture Laboratories, or other commercial analytical chemical laboratories. Always collect samples (about 250mL) in clean glass bottles that have been well rinsed with the water being sampled. Samples should be taken 10-15cm below the water surface of a dam, creek or tank.

3.1.4.4 Bacterial and Plant Contamination

Water stored in tanks or run off into dams can also contain excess organic matter and potentially toxic contaminants, such as bacteria and other pathogenic organisms from animal or bird droppings, leaves from poisonous plants and toxins from growth of algae in rivers, creeks and dams.

Although the Upper Safe Limits for bacterial content for horses have not been established, a limit of 50 coliform colonies (*E.coli* bacteria) per 100mL of water is recommended for livestock. Upper safe levels for *Salmonella* species, *Giardia* (protozoa) and *Cryptosporidium* organisms are not known for horses. Consumption of contaminated water may lead to bowel infection, diarrhoea and, in severe cases, may be fatal.

Water that is obviously contaminated with organic matter, or that has an offensive odour, should not be offered to a horse. It is unlikely to accept it anyway and may dehydrate as a result. A compaction colic could develop if the horse refuses to drink the water that is provided.

In practical feeding terms, this means that:-

✓ Water collected into a dam as run off from yards, septic and sullage areas, or other animal holding areas, should not be used for horses. If there is no alternative, samples should be tested for bacterial content if the water collects and the contaminants concentrate in a dam or water hole, particularly as a result of summer time evaporation.

✖ It is unwise to allow potentially poisonous plants, such as Oleander, Yew or Poinsiana (Coral) trees, to overhang dams, tanks or water troughs, where leaves can fall in and rot, releasing toxic chemicals into the water. Troughs should be cleaned regularly to remove residues of food, algae and other contaminants. (Refer to Chapter 9, Section 9.4, pages XXX).

3.1.4.5 Poisoning from Blue Green Algae Contamination

Particular seasonal conditions in eastern Australia, in recent years, have resulted in rapid growth and layering of blue green algae in dams, lagoons and stagnant, slow flowing watercourses. Growth is promoted by a build-up of nitrogen and phosphorus fertiliser residues in these water sources. Under ideal seasonal conditions, heavy growths can become stressed due to overpopulation and inadequate nutrition. The algae die and species of cyanobacteria that co-exist with the algal bloom also die, releasing the very toxic cyanide chemical into the water.

Symptoms of toxicity in horses include sudden death from cyanide poisoning, photosensitisation (sunburn lesions) on non-pigmented skin, muscle tremors, diarrhoea and blood in the droppings and liver damage.

KEYPOINT: There are a number of species of blue green algae which can result in toxicity and samples of algae collected from a water source can be identified by Department of Agriculture advisors in your area.

✓ In the event of an outbreak, remove horses from the water source and report the bloom to the Department of Agriculture or the Environmental Protection Agency. Heavy blooms can be skimmed off and removed manually and transferred to a non-catchment area. The contaminated water should be pumped out onto a non-grazing area. It may be best to test water samples before allowing horses to drink from previously contaminated dams and water holes.

3.1.4.6 Green Algal Growth

Common green algae spores are spread by wind and water, often contaminating creek, dam or tank water used for livestock. The algae grow in troughs and in open tanks exposed to sunlight. The growth of these common algae can be controlled by the addition of copper sulfate (Bluestone – 20% copper) to water at the rate of 5g (1 level teaspoon) per 5000L (about 1200 gallons). Water should be drained out and the source refilled prior to adding more copper sulfate at the recommended rate to avoid affecting the taste and acceptance of the water. It is unwise to add copper sulfate to galvanised tanks as the protective zinc coating may be eroded away more quickly.

3.2. Energy

Of all the nutrients in a horse's diet, energy is the one that is least understood and it is often fed in excess relative to the needs of the average horse. Most horse owners consider starch from grains provide the only source of energy in a horse's diet, but as grazing animals, horses obtain most of their energy in the form of volatile fatty acids from plant cellulose and other structural carbohydrates fermented in the hindgut. (Refer to Chapter 2, Section 2.5.2.1, page XX).

KEYPOINT: A horse requires energy, in the form of **chemical** energy for nerve action, muscle contraction, body processes, organ function and as **heat** energy to maintain body temperature.

Energy need is expressed in Megajoules of Digestible Energy (MJDE) daily. Digestible Energy is used to equate energy needs in horses, which is the total energy in the feed (measured as heat of combustion), <u>minus</u> the energy content of the undigested or waste plant material in the droppings. (See Glossary Term).

3.2.1 Sources of Energy

Forages and harvested feeds contribute varying amounts of energy relative to their carbohydrate, protein, fat and fermentable fibre content. Each feed source has its characteristic content of energy. Comparative levels in feeds are summarised in Table 3.1, Table 5.6 and 5.7 and individual feed content is detailed in Tables 10.1 to 10.4.

✓ Fermentable structural carbohydrates of plants in the form of insoluble non-starch polysaccharides, mostly as cellulose, are converted by microbial fermentation to volatile fatty acids to provide the primary source of chemical and heat energy for grazing horses.

✓ Once a horse is fed on grains to increase the energy density for growth, reproduction or exercise, shorter chain soluble carbohydrates, including sugars and starches, provide a higher proportion of chemical energy.

KEYPOINT: On a high fibre grass and hay diet, up to 60-75% of energy supply is provided by metabolism of volatile fatty acids in a resting horse. Once a working horse is fed up to 50-60% grain to meet its energy and protein needs, only 20-30% of the total energy is provided by volatile fatty acids from hindgut fermentation.

✓ Energy is also obtained from fats contained in feed, which provide 2¼ times more energy than equivalent amounts of carbohydrates and protein. Standard grain and roughage rations contain from 2-5% fat. Small amounts of additional fat, usually in the form of polyunsaturated vegetable oils, provide a convenient, efficient and economical method to boost the energy density of the diet in aerobically exercising horses, such as upper level eventers, show jumpers and endurance horses.

The benefits of feeding additional fat as an energy source are summarised in Table. 3.5. A further discussion on the addition of fat to horse diets is included in Chapter 7, Section 7.1.11.2, page XXX.

✓ The amino acids in protein supplements, such as oil seed meals and excess protein from lucerne hay can also be utilised for energy in working horses. However, protein is an expensive energy source in comparison to

sugars, starches and cellulose in grains and roughages. Hindgut fermentation of dietary protein produces six times more heat and results in a higher urine outflow in working horses, both of which can reduce performance and increase the risk of dehydration in hard working horses, particularly under hot conditions.

3.2.2Factors Influencing Energy Requirement

A daily amount of chemical energy absorbed from food as glucose, or metabolised from fats and volatile fatty acids is required to fuel muscle contraction and other metabolic processes to enable the horse to move around to harvest its food, maintain vitality and body weight. Heat energy predominantly from hindgut fermentation of starch, fibre and protein helps to maintain the body temperature within normal physiological limits.

This is termed the maintenance energy requirement and is proportional to the body weight of the mature horse.

KEYPOINT: Once a horse is required to grow, exercise or reproduce, the needs for energy increase in proportion to the energy expended above normal maintenance requirements.

The requirement for energy for work and other needs is discussed more fully in Chapters 4 and 5.

Low Energy Intake
An inadequate amount of energy in the diet will affect an animal's ability to exercise, grow or reproduce, and if not corrected by increasing the quality or quantity of feed, the horse will lose body weight as fat and protein will be utilised to maintain daily energy needs.

High Energy Intake
If the amount of energy provided is greater than that utilised or expended in exercise, growth or reproduction, the horse will channel the energy surplus into activity, making it "hyper-energetic", "above itself", "fizzy" or more difficult to handle. In a quieter, less active horse, it will be converted to body fat and increase the animal's body weight and condition score.

The major factors influencing energy requirements of exercising horses are outlined in Table 3.4.

Activity	Relative Energy Requirement
Speed of exercise	Galloping expends energy at a rate 6 times faster than a medium trot, and 30 times more rapidly than at the walk over a standard period of time. Galloping expends energy at 2MJDE/min, walking at 4MJDE/hour.
Type and duration of exercise	Light work (walking and trotting) for up to 30-60 minutes increases energy needs by 25%. Moderate work (trotting, some cantering) for 60-120 minutes by 50%, and intense exercise (sustained trotting, cantering, galloping) by 100% above maintenance needs.
Climatic conditions	Cold weather increases the energy needs by 10-15% to maintain body warmth.
Weight of the rider or load pulled	The total amount of energy expended is proportional to the total body weight of the horse and rider during exercise, especially over longer distances, such as endurance riding. In draught horses, as a guideline, maintenance energy needs are increased by 10% for each hour of plough work.
Working surface and terrain	Exercising up hills or under heavy, wet or deep soil conditions increases energy expenditure.
Temperament	Nervy horses expend extra energy in unnecessary self-exercise.
Metabolic efficiency of the horse	Pony and draught horse breeds are generally slower moving and utilise less energy for an equivalent amount of work. Some horses are good "doers" or "easy keepers"; others are "bad doers" or "hard keepers" that are unable to maintain weight on an otherwise adequate ration.

Source: NRC (1989), Lewis (1995), Frape (1997)

TABLE 3.4

Major Factors Influencing Energy Requirement of Exercising Horses

3.3 Protein

Protein is the major structural component of muscles, blood and many other tissues. On a moisture and fat free basis, protein constitutes about 80% of a horse's body weight. Proteins

primarily provide amino acids and nitrogen for tissue growth. Some amino acids contain sulfur as the main dietary source of this essential element.

3.3.1 Sources of Protein

All common horse feeds, except oil or fat, contain protein. Grasses and cereal grains commonly contain a protein content of less than 12% crude protein (CP). Protein levels in grains are much more variable and are influenced by their growing conditions. Oats grown in a wet season is likely to have 6-8% CP, but under dry spring growing conditions, it can contain 11-12% CP. Under Australian feeding practices, lucerne (15-19% CP), used as a roughage base in most rations, provides the major source of protein for all classes of horses often in excess of their needs. Oil seeds range from 23% CP for whole sunflower seeds to 44.5% CP for soyabean meal.

3.3.2 Factors Influencing Protein Requirement

A horse needs a daily intake of protein to maintain, grow and repair tissues. In comparison with energy, which is stored as glycogen or fat, excess protein is not stored in the body. In contrast, breakdown of protein contained in muscle and other tissues occurs in horses on low protein diets. Additional protein is required to replace losses in sweat (1.4g/L) in horses and the protein secreted into the milk of lactating mares (17-25g/L). The urine of a healthy horse does not contain protein. Excess protein in the diet is fermented in the hindgut, producing heat, which adds to the heat load of exercising horses.

KEYPOINT: The protein need of a horse is expressed as Crude Protein in grams required per day. Standard proteins contain 16g nitrogen per 100g (crude protein percentage can be estimated from nitrogen percentage x 6.25). An increased amount of protein in the diet must be provided during periods of growth and development in a young horse, tissue healing, hard exercise, late pregnancy and lactation in mares. Horses recovering from blood loss due to heavy worm burdens, stomach ulcers and severe haemorrhage benefit from an increased amount of protein in their diet.

The requirement for protein related to work and other needs is discussed more fully in Chapters 4 and 5.

3.3.3 Quality of Protein

Proteins are composed of amino acids, and each plant source has a different combination of amino acids that forms its protein content. There are approximately 22 amino acids that make up plant proteins. Of these, 10 amino acids cannot be synthesised during the digestive processes, or in the horse's liver, and these are termed "essential" or "indispensable" amino acids.

KEYPOINT: The essential amino acids must be supplied in adequate amounts in the diet otherwise tissue repair and growth will be limited. The other amino acids can be synthesised by transamination processes in the liver and tissues. They are not required to be supplied in the diet and are referred to as "non-essential" amino acids.

The essential amino acids required in a horse's diet are listed and described in Table 3.5.

Amino Acid	Action Role in Metabolism	Common Sources Protein Meals, Milk Powder and Lucerne grams/kg
Arginine	Promotes release of metabolic hormones – insulin, growth hormone. Involved in the immune response. Component of the urea cycle, ammonia in blood increases in deficiency of arginine.	Cottonseed 45g, Peanut 37g, Soyabean 28g, Linseed 26g, Canola 24g, Lucerne 9g, Milk Powder 9g
Histidine	Essential for growth. Involved in carnosine and haemoglobin synthesis.	Cottonseed 11g, Canola 9g, Soyabean 8g, Milk Powder 7g, Lucerne 3.5g
Isoleucine	Branched chain amino acid. Metabolised in	Soyabean 25g, Linseed 17g, Cottonseed

	muscle – involved in protein metabolism and energy production.	13g, Canola 13g, Milk Powder 13g, Lucerne 9g
Leucine	Branched chain amino acid. Metabolised in muscle – regulation of protein synthesis, energy metabolism.	Soyabean 38g, Milk powder 25g, Cottonseed 19g, Lucerne 15g
Lysine	Required for growth and optimum nitrogen balance in tissues. The major amino acid that is used as a standard for dietary content in growing animals.	Soyabean 28g, Milk powder 25.4g, Canola 17g, Sunflower seeds 16.8g, Lupins 16g, Cottonseed 16g, Linseed 11.6g, Lucerne 8g, Copra 5.4g
Methionine	Sulfur containing amino acid. Essential for optimum growth and nitrogen balance. Provides methyl groups for choline synthesis. Methionine can be partly replaced by cystine, a non-essential amino acid, supplying up to 50% of the methionine requirement, but not vice-versa.	Canola 7g, Soyabean 6g, Milk Powder 6g, Cottonseed 5g, Linseed 4g, Lucerne 3.3g
Phenylalanine	Essential for nitrogen balance in tissues. Phenylalanine can be partly replaced by tyrosine, a non-essential amino acid, in phenylaninine deficient diets, but not vice-versa.	Peanut 27g, Soyabean 22g, Cottonseed 22g, Peas 20g, Lucerne 10g, Canola 7g
Threonine	Required for optimum growth, feed conversion and nitrogen balance in tissues.	Soyabean 20g, Peanut 14g, Cottonseed 13g, Linseed 11g, Milk Powder 10g, Lucerne 8g
Tryptophan	Essential for growth. Involved in synthesis of Niacin (vit B3).	Soyabean 6.5g, Lucerne 4.6g, Cottonseed 4g, Milk Powder 4g, Canola 3.6g
Valine	Branched chain animo acid. Metabolised in muscle – energy metabolism and protein synthesis.	Soyabean 20g, Cottonseed 18g, Canola 17g, Milk Powder 17g, Lucerne 10g

Sources:- NRC (1989) Frape (1997), Feedstuffs Annual (1989 – values)

TABLE 3.5
Essential or Indispensable Amino Acids in Horse Diets

KEYPOINT: The quality of a protein source, or the amounts and ratios of the essential amino acids it contains, has an important influence on its contribution during protein synthesis for tissue growth, liver function and metabolism.

The “high quality” protein sources, which include legume and oil seed proteins, contain the 10 essential amino acids, although lysine, an important amino acid, may be lower in some legume species. Lysine is used as a standard to compare the quality of protein sources.

In practical feeding terms, as an example:-

✖ Linseed meal has a lower lysine content than soyabean meal, canola meal or milk powder. Linseed meal is not regarded as a suitable protein source for growing animals, especially if the other meals are readily available.

✖ Milk powder has a slightly lower protein and lysine content than soyabean meal. (See Table XX on page XX). However, it has been demonstrated to enhance growth rate in foals as compared to soyabean meal because of its better overall balance of essential amino acids and higher digestibility and utilisation in young foals. The expense of milk powder as a protein supplement in weanlings and older horses, if required, makes it less economical compared to soyabean, cottonseed, or canola meals.

✖ Cereal grass and cereal grain protein sources have inherently lower levels of the three essential amino acids required for growth – lysine, methionine and tryptophan, and often threonine. These are regarded as “poor quality” protein sources for growing horses.

KEYPOINT: Threonine has been demonstrated to be an amino acid that is often low in pasture and hard feeds not supplemented with protein meals. Lack of this amino acid may limit growth in young horses. A deficiency of threonine has been identified in young growing horses grazing grass dominant pastures in southeast Queensland.

3.3.4 Protein Digestibility

The digestibility of protein is related to its source and quality, as well as the amount in the diet. Proteins are digested and the resultant amino acids are absorbed from the small intestine. Excess protein is overloaded into the hindgut, but cannot be utilised as a protein source. (Refer to Chapter 2, Section 2.4.1.2, page XX).

Studies have indicated that digestibility of low (8%) crude protein (CP) grass hay may be as low as 43%, while it may be as high as 69% on a 16% CP lucerne-concentrate mixture. Other research has shown that protein digestibility can be increased to 70-75% when the concentrate to hay ratio is increased above 50%.

Many ready-mixed feeds contain good quality proteins, such as soyabean meal, which can help to improve their overall protein digestibility. Studies indicate that when the amount of concentrate relative to hay by weight exceeds a 3 to 1 ratio, protein digestibility is reduced.

KEYPOINT: Protein digestibility can be reduced by heat processing of feeds that damages the amino acid structure and complexes them to fat, resulting in decreased utilisation of the amino acids from the diet.

- ✖ The temperatures used during the spray drying of milk powder and those generated during poorly controlled extraction of oil seed meals can result in reduced availability of amino acids such as lysine and consequently less than satisfactory growth in young animals.

- ✖ Some protein sources, such as raw soyabeans, contain an anti-nutritional factor that prevents the activity of trypsin, a major protein digesting enzyme in the small intestine. These factors are inactivated by controlled heat processing, making the protein more readily digested and utilised. (Refer to Chapter 8, Section 8.3, page XXX).

3.3.5 Non-Protein Nitrogen (Urea)

Nitrogen, which is primarily supplied by proteins and amino acids, is also a constituent of urea.

Although overseas studies suggest that urea may have benefit as a nitrogen source to horses on low protein diets, recent research in Queensland found there was no benefit at all to be gained from routinely adding urea to horse feeds and that there was a risk of toxicity.

- ✖ When added to feed, urea is quickly absorbed from the small intestine and excreted before it reaches the hindgut in an adult horse.

- ✖ High levels of urea in the blood can be converted to ammonia before it is excreted, which can affect performance, promote nervous behaviour and cause toxicity in large amounts.

- ✖ Although excess urea could be converted by hindgut microorganisms into protein if it reached the hindgut, this bacterial protein is not absorbed from the large intestine of the horse.

Studies indicate that mature horses can tolerate up to 4% (about 500g) of urea in their daily diet but a single dose of 500g of urea was reported to cause severe illness and death in ponies.

KEYPOINT: A horse is slightly more tolerant than a ruminant to the addition of up to 4% of urea to its diet. There is no benefit from feeding urea boosted cattle feeds to a horse. There is a risk of toxicity if the urea is poorly mixed, and a horse consumes more than it can tolerate.

Note: Cattle and poultry rations may also contain low levels of Monensin®, a growth promotant, which is toxic and fatal to horses at rates as low as 1mg/kg body weight. Do not feed prepared feeds intended for these animals to horses.

3.4 Fat

On average, a standard diet based on pasture contains 0.5% fat, and a mixed ration of grain and hay contains 2-5% fat.

Fats are chemically a combination of one unit (molecule) of glycerol (5% of the fat) and three units (molecules) of long chain fatty acids, which after bile emulsification and lipase enzyme digestion in the small intestine, yields high-energy shorter chain fatty acids that are absorbed into the blood. Body fat stores can also be drawn upon during prolonged hard exercise, such as endurance riding. They are broken down to free fatty acids, which are then aerobically metabolised to energy in the working muscles. Fats cannot be converted to glucose and used during fast anaerobic exercise in athletic horses.

3.4.1 Function of Fat

Fat in the diet serves several important functions, including:

- ✓ Providing and assisting the absorption of the essential fat soluble vitamins A, D, E and K contained in the feed or added to the diet in a supplement. (Vitamin K can also be synthesised by microorganisms during hindgut fermentation of fibre).
- ✓ Supplying essential fatty acids for stability and protection of cell membranes and health of the skin.
- ✓ Increasing the energy density of a ration when added in small amounts as an energy source to a working horse and reducing the bulk of the ration that needs to be consumed.
- ✓ Improving the palatability of the ration, particularly if a horse becomes accustomed to the taste of a particular fat (eg canola oil) added to its diet.

KEYPOINT: The energy requirements for extended work can be met by the aerobic breakdown of glucose and boosted by the mobilisation and oxidation of body fat stores. Metabolic adaptation to efficiently use added fat as an energy source in the diet of a working horse may take up to 3 months.

In practical feeding terms, this means that:-

- ✓ Because fat is primarily absorbed directly, or following enzymatic digestion in the small intestine, it may provide a useful form of slow release of energy during aerobic exercise, making it a suitable “cool” energy supplement for hard working or nervy horses.
- ✓ During hard training, the release of natural cortisone hormones in response to stress leads to more efficient breakdown and oxidation of body fat to fatty acids, providing sustained energy during prolonged endurance type exercise.
- ✓ Fat is not fermented to heat in the hindgut and does not contribute to the “heat waste” in hard working horses. Under hot Australian summer conditions, replacing part of the energy supplied by grain in the diet by vegetable oil may help reduce the total amount of heat that needs to be lost from the body during hard exercise. (See Table 3.6).

A summary of the practical advantages of feeding increased amounts of fat in the diet of a horse is provided in Table 3.6

Benefit of Added Fat	Practical Advantages
Concentrated energy source	Fats provide 2¼ times more energy on digestion than carbohydrates or protein. Small amounts can boost the energy density of a ration, requiring less bulk to be consumed in a small framed horse, or a horse in hard work that has a reduced appetite.
Increased energy utilisation	Studies indicate that oils have a digestibility ranging from 76-94% when supplemented at a rate up to 6-8% to replace 20% carbohydrate in a ration. Exercising horses require less total energy when fat is aerobically digested during extended exercise. It may take up to 3 months for a horse's metabolism to adapt to fully utilise added fat as energy.
Higher glycogen levels and slower depletion of muscle glycogen	Studies have found that heart rates were slower to increase during medium intensity exercise and galloping horses were able to work harder and longer when 10% fat was substituted for grain energy. A diet containing 12% energy as fat increased resting blood glucose content by 26%. Over a 2-3 month period, a similar intake of fat increased muscle glycogen content by 16%, but diets above 16% fat decreased muscle glycogen storage. During extended exercise, aerobic metabolism of fatty acids can delay blood glucose and glycogen depletion, resulting in higher muscle reserves being retained at the end of exercise and lower lactic acid accumulation and delay onset of fatigue.
Reduction in gut fill	Fat substituted for cereal grains reduces gut fill and hindgut weight, which may increase speed and reduce fatigue in racing horses working over distances greater than 1600 metres.
Decreased hindgut heat waste under hot conditions	Fats are absorbed from the small intestine and the excess is not fermented in the hindgut to heat, which is an advantage in horses working under hot climates or over long distances.
Supply of metabolic water during metabolism	Fats provide almost double the amount of metabolic water during aerobic metabolism (107g water /100g fat) compared to carbohydrates and protein, making fats useful for horses performing for extended times by partly counteracting fluid loss from the cells and blood.
Skin health and coat conditioning affect	Most horse rations contain from 10-30 times the requirement of α-linoleic acid and therefore are not deficient in this fatty acid necessary for the production of skin oils that shine the coat. Adding oils rich in α-linoleic acid, such as safflower oil (78%), sunflower oil (69%), corn oil (70%), soyabean oil (54%), or oil blends at the rate of 15mL/100kg body weight is a popular supplement to aid coat condition in horses, but it may have little if any benefit to horses on good quality diets.
Reduced dust in feed	Adding 1% vegetable oil (10g/kg) to a mixed feed will help reduce dust in the feed and risk of airway allergy from inhaled dust as a horse eats.

Sources: Lewis (1995), Pagan (1996), Frape (1997).

TABLE 3.6
Practical Benefits of Added Fat to Horse Diets

3.4.2 Sources and Quality of Fats

The most common sources of additional fat as a supplement to a horse's diet are oil seed meals, whole oil seeds and rendered meat fat, or tallow. The quality of fats is related to the blend and the types of fatty acids in the oil or fat used and the degree of oxidation (rancidity) during extraction, processing and storage. A more detailed discussion on the sources and quality of fats commonly used in horse feeds is included in Chapter 7, section 7.1.11, page XXX as it relates to the selection and use of fats and oil.

Practical guidelines on the use of fats are also provided in Chapter 7, Section 7.1.11.

3.5 Fibre

An adequate intake of fermentable fibre is essential for efficient gut function and nutrient supply for all horses. The horse has a well developed, voluminous hindgut structure with a slow flow rate and wet digestive mass that allows micro-organisms (bacteria, protozoa and fungi) to digest (ferment) soluble plant fibres, as well as limited amounts of excess sugars, starches and proteins overflowing from the small intestine. Lignin, a structural component of plants, which increases as plants mature, cannot be fermented and is passed out in the droppings.

Note: The fibre content of plants and other feeds is traditionally stated as a % or grams/kg of crude fibre, which is the fibre residue left after removing the fat with solvents and successive treatments with set concentrations of boiling acid and alkaline solutions to remove the starch and protein (nitrogen) content. The crude fibre contains cellulose, hemicellulose and lignin, some of which is lost during the acid and alkaline treatment. It does not include the full nutritional value of the other fermentable structural components of feeds such as gums, pectins and resins.

A more accurate measure of total fermentable and non-fermentable fibre content is now universally accepted as the Modified Acid Detergent (MAD) process. The MAD fibre value includes the total fermentable cellulose and lignin content, which reflects a more accurate estimation of the energy digestibility of the feed. The MAD fibre value is higher than the crude fibre value for feeds containing a greater content of lignin and other structural carbohydrates. In this book, the values for fibre are expressed both as crude fibre and MAD fibre % (where available), or on a grams/kg basis for fibre content.

3.5.1 Functions of Fibre

Fibre has a number of important functions, which include:-

- ✓ To open up the digestive mass and trap water to aid soluble nutrient uptake.
- ✓ To facilitate controlled fermentation to provide volatile fatty acids for energy synthesis of B-group vitamins, and generation of heat during fermentation to maintain body warmth. (Refer to Chapter 2, Section 2.5.2.2, page XX).
- ✓ To store a reserve of fluid in the hindgut that can be absorbed as a horse dehydrates due to sweat, respiratory and urinary losses.

KEYPOINT: A horse needs at least 1% of its body weight fed as roughage (chaff, hay, pasture), or **not** less than 30% by weight of roughage in its diet for efficient hindgut function.

The majority of common feeds, except oils, contain fibre. The fibre content varies, being highest in the stems of plants and lowest in the seeds of dehulled grain. The quality of fibre, which relates to its digestive utilisation, is relative to the source and maturity of the grazing plant or hay at harvest.

- ✓ The lowest fibre content, with a higher proportion of cellulose and other fermentable fibres, is found in young growing plants.
- ✖ Older, mature plants that have bloomed and lost their leaf coverage as well as husks of grains and seeds contain a higher ratio of non-fermentable lignin to fermentable cellulose. Mature, woody and stemmy plants are also hard to chew and horses find them less palatable.

KEYPOINT: Horses are selective feeders and often stemmy mature plants in a pasture will be avoided or hard, stalky hay will be rejected as the softer leaves and less mature parts are consumed.

3.6 Minerals

Minerals play an important structural and co-factor role in many metabolic processes within the body. There are a total of fourteen chemical elements grouped into minerals, electrolytes and trace-minerals that are required in a horse's diet. Minerals must be provided in a balanced form and at an adequate level. A resting adult horse is able to obtain the majority of its mineral requirements from an adequate intake of good quality pasture, or from supplementary hay during periods of poor pasture quality or availability.

KEYPOINT: The mineral content of pasture and harvested feeds can be influenced by soil deficiencies, stage of growth, natural imbalances in plants and availability and uptake of individual minerals following release during digestive processes.

A further discussion on soil mineral and trace-element content in Australia is given in Chapter 6.

Note: Trace-minerals are often referred to as trace-elements in older books, but the term trace-element is now used to refer to elemental chemicals in the soil, while trace-minerals refer to elemental chemicals found in feeds.

Supplementation with minerals and trace-minerals may be required to meet elevated demands during growth, late pregnancy, lactation or work to combat low or inadequate levels provided by the diet, or to counteract higher losses in sweat, urine, and milk.

The minerals that have an important role in the body are summarised in Table 3.7.

MACRO-MINERALS & ELECTROLYTES(✷) (Required in amounts exceeding 1g daily for a 500kg horse)	MICRO-MINERALS OR TRACE-MINERALS (Required in amounts less than 1g daily for a 500kg horse)
Calcium	Zinc
Phosphorus	Iron
✷ Potassium	Manganese
✷Sodium	Iodine
✷Magnesium	Selenium
✷Chloride	Copper
✷Bicarbonate	Cobalt
Sulfur	Molybdenum
(Silicon)	Fluorine
	(Chromium)
	(Boron)

The minerals in brackets do not have an established dietary requirement in horses. However they are regarded as being of possible benefit if added to the diet.

TABLE 3.7
Macro-Minerals, Electrolytes and Trace-Minerals Required by Horses

3.6.1 Function of Minerals

The function, metabolic regulation, deficiency and toxicity symptoms and common feed sources of individual minerals, electrolytes and trace-minerals are reviewed in brief in Tables 3.8 and 3.9 below, and the contents of all feeds in Tables 10.1 – 10.4.

3.6.1.1 Macro-Minerals

Note: The content of a mineral element in a mineral source is expressed as grams of mineral per 20mL (one level metric tablespoon) as a convenient common measure.

Calcium (Ca)

Function	Structural component of bone (35%), 98% found in bones and teeth. Binds to a protein for uptake and transported in blood as an ionised salt or electrolyte in blood and tissue fluids. Nerve and muscular function, blood clotting, hormone and enzyme action, inter-related to phosphorus status.
Metabolic Regulation	Vitamin D and phosphorus status in the diet.
Major Losses	Sweat 300mg/L, milk 800-1200mg/L, urine average 3600mg/L.
Bioavailability from Feeds	Mainly absorbed from small intestine. Range 45-70%. Young horses 70%, mature horses 50%. Low P or Vitamin D reduces uptake. High phosphorus levels decrease its uptake.
Dietary Interactions	High oxalate content in tropical grasses and phytic acid in bran and pollard can reduce uptake and lead to Nutritional Secondary Hyperparathyroidism (NSH) – "Big Head". (See Glossary term).
Deficiency Symptoms	Bone deformities/skeletal weakness, joint problems and rickets in young animals. Low blood calcium may lead to muscle weakness and conditions such as "tying-up", and the "thumps", in heavily sweating, exhausted horses.
Toxicity Symptoms	Increased calcium deposition in bones especially if Vitamin D is high. Calcium can be fed at 5 times its daily requirement, if adequate phosphorus is available in mature horses. Excess calcium may reduce uptake of iron, zinc, magnesium and manganese from the diet or supplements of these trace-minerals added to the diet.
Common Feed Sources	Limestone 7.8g/20mL, Dicalcium Phosphate 4.6g/20mL, Dolomite Limes 4.4g/20mL, Lucerne Hay 12g/kg, Milk Powder 12.8g/kg.

Phosphorus (P)

Function	Structural component of bone (14-17%) 85% in bones and teeth. Energy transfer, synthesis of phospholipids and phospho-complexed compounds in liver and tissues. Phosphate used as acid-base buffer in blood and gut.
Metabolic Regulation	Vitamin D and calcium status. Optimum Ca:P Ratio 1.2-2.0:1.0 in growing horses, adults can tolerate up to 4:1.
Major Losses	Sweat 25mg/L, milk 350mg/L.
Bioavailability from Feeds	Range 30-55%. Low/high calcium or low Vit D reduce uptake. Majority absorbed from large intestine as phosphate buffer.
Dietary Interactions	High calcium intake depresses phosphorus uptake. Phosphorus bound up in phytic acid in bran.
Deficiency Symptoms	Inadequate bone formation, retarded growth, poor appetite, infertility and poor conception, lowered milk production. Phosphorus is often inadequate in diets.
Toxicity Symptoms	Decreased uptake of Ca, depleted Ca in bone, bone weakness due to Nutritional Secondary Hyperparathyroidism (NSH) – "Big Head" (See Glossary term).
Common Feed Sources	Dicalcium Phosphate 3.6g/20mL, Bran 11.4g/kg with 2g/kg bioavailable, Milk Powder 10.2g/kg, Lucerne Hay 2.2g/kg, Grains 3.0g/kg average.

Sodium (Na)

Function	50% of body sodium is in bone. Electrolyte essential for acid-base balance. High levels in blood fluids, low in cell fluids.
Metabolic Regulation	Osmotic regulation in cells and water balance.
Major Losses	Sweat 3.7g/L, milk 161-364mg/L, urine 1g/L. Heavy sweating horses up to 100g salt/day.
Bioavailability from Feeds	Up to 95% in salt, but variable from feeds relative to potassium content.
Dietary Interactions	High potassium can aggravate a deficiency of sodium.
Deficiency Symptoms	Decreased appetite, rough coat, reduced water intake, skin dehydration and in severe cases, incoordination of muscles, and collapse. Horses will lick objects to obtain salt.
Toxicity Symptoms	High water intake, excessive urination and diarrhoea – may occur in salt starved horses if given access to salt.
Common Feed Sources	Salt – (Sodium chloride) 9.8g/20mL, Lite Salt 6.5g/20mL, Grains 0.3-0.5g/kg, Lucerne Hay 0.8g/kg, Milk Powder 16g/kg, Molasses 16g/kg.

Potassium (K)

Function	Nerve and muscular function. High levels inside body cells, acid base balance, enzyme activation, protein synthesis and carbohydrate metabolism.
Metabolic Regulation	Osmotic regulation with sodium in cells and blood fluid.
Major Losses	Sweat 1.4g/L Milk 15g/L Urine 0.7-1g/L.
Bioavailability from Feeds	52-74%. Foals require higher intake than adult horses.
Dietary Interactions	High magnesium intake increases potassium uptake.
Deficiency Symptoms	Reduced appetite, retarded growth, weight loss, weakness, dehydration. Most common due to diarrhoea.
Toxicity Symptoms	Unlikely as rapidly excreted in normal diets – unlikely to consume high chloride feeds.
Common Feed Sources	Hay 15-25g/kg, Grains 3-5g/kg, Potassium Chloride 11.2g/20mL, Lite Salt 5.2g/20mL.

Chloride (Cl)

Function	Closely inter-related to sodium in acid-base balance and extra-cellular fluid osmotic regulation. Contained in bile and gastric acid.
Metabolic Regulation	Osmotic regulation in cells and water balance.
Major Losses	Sweat 6.2g/L. Milk 250mg/L.
Bioavailability from Feeds	Up to 100% from salt. Unknown in feeds. Table salt has silica to make it flow easily, reduces sodium uptake.
Dietary Interactions	High potassium may reduce chloride uptake, high bicarbonate increases excretion.
Deficiency Symptoms	Heavy sweat loss results in alkalosis or high bicarbonate level in blood. Low dietary intake results in appetite loss, lower milk production and dehydration.
Toxicity Symptoms	Nervous signs, similar to sodium excess – unlikely to consume high chloride feeds.
Common Feed Sources	Rock Salt 12.2g/20mL, Potassium Chloride 8.8g/20mL, Lite Salt 8.3g/20mL, chlorinated water 1mg/L (insignificant).

Magnesium (Mg)

Function	60% of Mg in body in bone (0.75% Mg) with Ca and P. Electrolyte in muscle contraction, body fluids and metabolic enzymes.
Metabolic Regulation	Adrenal, thyroid and parathyroid hormones.
Major Losses	Sweat 140mg/L, milk 45-90mg/L, urine 100mg/L.
Bioavailability from Feeds	Range 40-60%, 70% from chemical sources. Very poor from dolomite and reduced by phytate in bran and grains.
Dietary Interactions	Reduced uptake from high Ca and P diets, oxalates in tropical grasses, high potassium intakes.
Deficiency Symptoms	Causes hypomagnesemia – nervous signs, muscle tremors, incoordination, rapid breathing, sweating, collapse, death. May occur in transported horses.
Toxicity Symptoms	Horses can tolerate 8.6g/kg diet – excess may cause nervous depression.
Common Feed Sources	Lucerne 3.0g/kg, Grains 1.1-1.4g/kg, Canola Meal 5g/kg, Soyabean Meal 2.7g/kg, Bran 5.6g/kg (poorly available), Milk Powder 10g/kg, Magnesium Oxide 10.6g/20mL, Magnesium Carbonate 5.6g/20mL, Magnesium Sulfate (Epsom Salts) 2g/20mL, Dolomite (Dolomite limes) average 2g/20mL.

Sulfur (S)

Function	A horse's body contains 0.15% sulfur by weight. Constituent of the sulfur containing amino acids methionine, cystine and cysteine, also in insulin, Co-enzyme A, keratin in hooves and hair.
Metabolic Regulation	Not known – regulated by body needs for sulfur containing compounds.
Major Losses	Milk 200mg/L.
Bioavailability from Feeds	Organic sulfur taken in with feeds. Little inorganic sulfur absorbed in small intestine. Some converted to amino acids during hindgut fermentation but poorly absorbed.
Dietary Interactions	High intake of sulfur may reduce copper uptake in ruminants, but no evidence in horses.

Deficiency Symptoms	Not described in the horse. More likely to be associated with a protein deficiency.
Toxicity Symptoms	Horses given 200-400g flowers of sulfur (99% sulfur) become lethargic, colicy, laboured breathing. 2 out of 12 horses died after convulsions.
Common Feed Sources	Amino acids methionine and cystine in diet. Lucerne Hay 2.6g/kg, Grains 1.1-2.0g/kg. Flowers of sulfur 16.6g/20mL. Magnesium sulfate (dried) (Epsom salts) 4.6g/20mL.

Sources: Tyznik (1982), NRC (1989), Caple (1991), Cunha (1991), Lewis (1995), Frape (1997)

TABLE 3.8
Macro-Minerals Required in the Diet of Horses

3.6.1.2 Micro-Minerals or Trace-Minerals

Note: The content of a trace-mineral in mineral sources is expressed as milligrams of mineral per 5mL (one level metric teaspoon) as a convenient common measure. As the daily amounts required are less than 1g daily, trace-minerals are best included in the diet by way of a commercial supplement.

Iron (Fe)

Function	A horse's body contains 33g iron /500kg bwt. Incorporated into haemoglobin (60%), muscle myoglobin (20%), and storage forms (20%), muscle oxidative enzymes (0.2%).
Metabolic Regulation	Iron uptake increases with elevated needs, and decreases with excessive intake of cadmium, cobalt, copper, calcium, manganese and zinc.
Major Losses	Sweat 21-25mg/L, milk 1.3mg/L at foaling, decreasing to 0.5mg/L at 4 months. Urine 10mg/L relative to supplementation.
Bioavailability from Feeds	15-18% from feeds, higher from mineral sources, highest from soluble iron sources and micronised iron.
Dietary Interactions	High levels of iron depress blood and liver zinc levels. High calcium decreases iron uptake. Vitamin E and Vitamin C destroyed by contact with iron in damp feeds.
Deficiency Symptoms	Small red cell and low haemoglobin anaemia – lack of stamina, laboured breathing, tire quickly. Deficiency is most common due to blood loss from Strongyle worms.
Toxicity Symptoms	Excess iron toxic in young foals – do not supplement milk diets. Risk of overdose 25 times less in adult horses. Iron overload can occur with injectable iron and high feed supplementation – limit supplementation to 400mg daily in feed.
Common Feed Sources	Lucerne Hay 140-205mg/kg, Oaten Chaff 350mg/kg, Wheaten Chaff 200mg/kg, Grains usually less than 100mg/kg. Horses rarely deficient in iron. Iron (ferrous) sulfate 1000mg/5mL. Iron carbonyl 4900mg/5mL. Iron amino acid chelates and bioplexes range from 250-650mg/5mL..

Copper (Cu)

Function	Required for development of bone, joint cartilage, elastic connective tissue, uptake and utilisation of iron, and copper containing metabolic and tissue anti-inflammatory enzymes.
Metabolic Regulation	Many minerals can affect copper metabolism and relative needs. Copper can be stored in the liver as a reserve.
Major Losses	Sweat 4mg/L. Milk 0.10mg/L.
Bioavailability from Feeds	Range 5-50%, decreasing uptake as dietary levels increase.
Dietary Interactions	High molybdenum may reduce copper uptake. High zinc intakes may depress copper uptake in foals.
Deficiency Symptoms	Reduced cartilage formation in foals – big joints, lameness in growing horses. Anaemia in severe deficiency, yellowing of haircoat in grazing horses.
Toxicity Symptoms	Horses can tolerate higher intakes than cattle. Maximum tolerated level 800mg/kg diet.

Common Feed Sources	Lucerne Hay 9-16mg/kg, Corn 3.4mg/kg, Oats 12.6mg/kg, Barley 5.3mg/kg. Copper sulfate (Bluestone) 1300mg/5mL. Copper carbonate 2800mg/5mL.

Cobalt (Co)

Function	4% cobalt incorporated into structure in Vitamin B12, which is involved in haemoglobin formation and metabolism.
Metabolic Regulation	Cobalt utilised by hindgut microorganisms to synthesize cyanobobalamin (Vitamin B12).
Major Losses	Milk 0.05-0.07mg/L.
Bioavailability from Feeds	Not known.
Dietary Interactions	Low copper may reduce cobalt uptake.
Deficiency Symptoms	Not common in horses as require lower levels than ruminants. Cobalt deficiency results in a Vitamin B12 deficiency – anaemia, rough coat, poor appetite.
Toxicity Symptoms	Upper safe limit of 10mg/kg of feed may be tolerated.
Common Feed Sources	Lucerne Hay 0.21-0.36mg/kg, Oats 0.06mg/kg, Corn 0.13mg/kg, Barley 0.14mg/kg, Wheat Bran 0.07mg/kg, Cobalt oxide 3550mg/5mL, Cobalt carbonate 2500mg/5mL, Cobalt sulfate 1000mg/5mL

Manganese (Mn)

Function	Carbohydrate and fat metabolism and formation of chrondroitin sulfate in cartilage of joints. Essential for optimum fertility in mares and stallions.
Metabolic Regulation	Regulated by manganese stores in body and relative requirement.
Major Losses	Sweat 0.2mg/L. Milk 0.25-1.5mg/L. Inter-related to selenium storage in body.
Bioavailability from Feeds	Range 40-47%.
Dietary Interactions	Absorption decreased from high calcium diets, bound up by phytic acid in bran.
Deficiency Symptoms	Symptoms not reported. Joint cartilage and bone formation reduced in low Mn diets – large hocks and knuckling over of joints, brittle bones. Embryonic loss and death at birth. Irregular “season” cycles.
Toxicity Symptoms	Excess intake may cause anaemia and infertility. Neurotoxic. May lead to aggressive behaviour.
Common Feed Sources	Lucerne Hay 32-55mg/kg, Corn 5mg/kg, Barley 16mg/kg, Oats 38.2mg/kg. Manganese carbonate 2250mg/5mL, Manganese oxide 3500mg/5mL, Manganese sulfate 1250mg/5mL.

Zinc (Zn)

Function	Co-factor in over 200 enzymes in metabolism, essential in bone, cartilage and hoof formation and health of skin.
Metabolic Regulation	Regulated by the zinc status in the body.
Major Losses	Sweat 20-21mg/L. Mare’s milk 1.8-3.2mg/L.
Bioavailability from Feeds	Range 5-10%, mineral sources 50-60%.
Dietary Interactions	High phytate intake in bran may depress zinc uptake.
Deficiency Symptoms	Reduced appetite, retarded growth, dry, thickened skin and hair loss in severe deficiencies.
Toxicity Symptoms	Symptoms of anaemia, enlarged joints and lameness in foals.
Common Feed Sources	Lucerne Hay 23.24mg/kg, Barley 26mg/kg, Corn 19mg/kg, Oats 23.8mg/kg. Zinc sulfate 1200mg/5mL, zinc oxide 4000mg/5mL, zinc carbonate 2800mg/5mL. Amino acid chelates and bioplexes 500mg/5mL.

Selenium (Se)

Function	Required in small amounts as a trace-mineral in the structure of the enzyme, glutathione peroxidase and in combination with vitamin E, acts as an antioxidant to prevent polyunsaturated fatty acid oxidation to toxic radicals that damage muscle and cell membranes. Also part of an enzyme that regulates thyroxine hormone activity.
Metabolic Regulation	Marginal selenium deficiency widespread in Australian soils (see page XXX).
Major Losses	Lost in sweat in small amounts.
Bioavailability from Feeds	77% from supplements – chelated or organic forms higher in diets boosted with vegetable oil for energy.
Dietary Interactions	Vitamin E and selenium are inter-related. In selenium deficient areas, vitamin E will provide some antioxidant protection, but not replace selenium. Increasing manganese to 50mg/kg diet may help retain more selenium in blood.
Deficiency Symptoms	Poor muscle development and pale, weak muscles (White Muscle Disease) in foals on deficient diets. Poor performance in racing horses, may predispose to 'tying-up', lower fertility in mares.
Toxicity Symptoms	Cumulative if over dosed – toxic effects can not be reversed. Over supplementation of selenium causes loss of hair of mane and tail, bent legs in foals, lameness and hoof separation.
Common Feed Sources	Lucerne Hay 0.5mg/kg, Corn 0.12mg/kg, Barley 0.18mg/kg, Oats 0.21mg/kg. Selenium yeast 4mg/5mL, sodium selenite 2300mg/5mL – banned as a source in many countries.

Iodine (I)

Function	Incorporated into the hormone thyroxin in the thyroid gland, which regulates the metabolic rate.
Metabolic Regulation	Thyroid gland regulation related to needs.
Major Losses	Not known.
Bioavailability from Feeds	Up to 60% from mineral supplements.
Dietary Interactions	High nitrogen fertilisers may reduce plant uptake and lead to iodine deficiency in unborn foals.
Deficiency Symptoms	Deficient in soils in Tasmania. Iodine deficiency critical in pregnant mares last 2 months of pregnancy - foals born weak or dead. Goitre in mature horses. Reduced metabolic rate and exercise tolerance.
Toxicity Symptoms	Can cause congenital goitre in foals, infertility and abortion in mares, most commonly due to excess seaweed meal as a natural feed supplement. Foals can develop enlarged joints and contracted tendons if excess is fed. Maximum tolerated level 0.1mg/kg body weight.
Common Feed Sources	Lucerne Hay 0.15mg/kg, Barley 0.04mg/kg, Oats 0.11mg/kg. Iodised salt 350µg/5mL, potassium iodide 3200mg/5mL, kelp up to 7.2mg/5mL (see warning page XX)

Fluorine (F)

Function	Incorporated in bone and teeth structure to increase hardness only during formation.
Metabolic Regulation	Not known.
Major Losses	Not known.
Bioavailability from Feeds	Not known.
Dietary Interactions	High calcium and magnesium may reduce fluorine uptake.
Deficiency Symptoms	Not a common problem in horses consuming fluorinated tap water.
Toxicity Symptoms	Not to exceed 20mg/kg diet. Cumulative toxicity. Common causes are rock phosphates and limestone supplements. Discoloured teeth, ill-thrift, lameness.
Common Feed Sources	Fluorinated tap water 1-2mg/L, Forages 1.7- 14.6mg/kg, grains 0.9-2.7mg/kg. Limestone 25-50mg/5mL.

Chromium (Cr)

Function	Involved in carbohydrate metabolism and activity of insulin hormone. Benefits of supplementation include less fat to muscle ratio, increased energy metabolism, reduced stress and lactic acid accumulation during fast exercise.
Metabolic Regulation	Associated with glucose tolerance activity, in conjunction with niacin (Vitamin B3).
Major Losses	Not known.
Bioavailability from Feeds	Barley contains highest level of grains.
Dietary Interactions	Not known.
Deficiency Symptoms	Not known.
Toxicity Symptoms	Trivalent chromium III is relatively safe. Dichromates are very toxic. Concentrates in brain, aggressive behaviour.
Common Feed Sources	Brewers Yeast 1.0mg/20mL, Barley 6mg/kg, Chromium Yeast 40mg/5mL

Silicon (Si)

Function	Incorporated into joint cartilage and essential for bone formation, collagen synthesis.
Metabolic Regulation	Not known.
Major Losses	Not known.
Bioavailability from Feeds	Not known.
Dietary Interactions	Depressed by high molydenum and aluminium.
Deficiency Symptoms	Reduced bone formation and cartilage/collagen strength.
Toxicity Symptoms	Not known.
Common Feed Sources	Silicon dioxide 1500mg/5mL.

Sources: Tyznik (1982), NRC (1989), Caple (1991), Cunha (1991), Lewis (1995), Frape (1997)

TABLE 3.9
Micro-Minerals or Trace-Minerals Required in the Diet of Horses

3.6.1.3 The Requirement of Minerals

The daily mineral and trace element requirements are listed for each class of horse relative to their body weight range in Chapter 6, Table 6.2, page XXX.

3.6.1.4 Soil Deficiencies in Australia

A map of the soil deficient areas that are known to lead to low or inadequate levels of selenium, zinc, copper, manganese, iodine and molybdenum is included in Chapter 6, Table 6.3, page XX. More detailed information relative to your own locality can be obtained from the Department of Agriculture Soils or Agronomy Sections in each State.

3.7 Vitamins

Vitamins are essential for many metabolic processes as co-factors in energy, protein and fat utilisation as antioxidants, uptake of minerals and their balance, production of hormones and regulation of many other vital body functions. Vitamins in feeds are classified into **fat soluble**, which include vitamin A, vitamin D, vitamin E and vitamin K, and **water soluble** which includes B-group vitamins and vitamin C.

3.7.1 Function of Vitamins

The function, metabolic regulation, deficiency and toxicity signs, as well as sources of individual vitamins in feeds are summarised in table format below. Certain vitamins, such as vitamin A from carotene, vitamin E and vitamin D in horses confined to stables without adequate exposure to sunlight, have to be provided in the diet. Pasture contains a wide range of vitamin precursors and vitamins. Many vitamins can be synthesised in the horse's body to supplement dietary intake. These include vitamin D (production in the skin stimulated by sunlight); vitamin K and B-group vitamins (produced during hindgut fermentation) and vitamin C, produced in the liver.

3.7.1.1 Fat-Soluble Vitamins

The function, symptoms of deficiency or excess and common feed sources of the 14 vitamins required in a horse's diet are outlined in Table 3.10 and 3.11 below and the content of all feeds in Tables 10.1-10.4.

Note: The vitamin content of sources other than feeds is expressed as units of vitamin per 20mL (one level metric tablespoon), which is a convenient measure.

Common Name: Vitamin A
Technical Name: b-carotene (feeds) Retinol (fats/oils supplements)

Function	Fat soluble natural vitamin essential for growth processes. Required by visual pigments in eyes, bone remodelling, tendon strength, health of skin and mucus membranes.
Metabolic Regulation	β-carotene converted to Retinol in gut, stored in liver, then released to blood and tissues. Conversion: 1mg Retinol is equivalent to 3333iu Vitamin A.
Major Losses	50% loss of β-carotene in hay in 7 months, 66% in 12 months, 90% in 24 months. Rapid loss in hay that is rained on when curing. Paraffin oil binds vitamin A in feeds. Pasture levels of β-carotene relative to plant maturity, seasonal conditions, sun curing and storage time of hay.
Dietary Interactions	Liver has 2 months reserve on a deficient diet. Excess excreted in urine. β-carotene destroyed by heat, light and oxidation in stored feed. Heavy metals in supplements.
Deficiency Symptoms	Progressively poor night vision, loss of appetite, poor growth, infertility in mares (older mares more affected), reduced tendon strength, higher risk of respiratory infections.
Toxicity Symptoms	Ill-thrift, rough coat, weakness, depression, anaemia, maximum safe limit 16,000iu (4.8mg) per kg dry feed per day.
Common Feed Sources	Vitamin A equivalent. Green pasture 120000-240000iu/kg. Lucerne hay, early bloom 50000iu/kg, mid bloom to full bloom 24000iu/kg. Oaten Hay 10000iu/kg, Barley 800iu/kg, Corn 2100iu/kg, Oats 44iu/kg, Cod Liver Oil 18666iu per 20mL.

Common Name: Vitamin D
Technical Name: Ergocalciferol (D2) Cholecalciferol (D3)

Function	Essential fat-soluble vitamin required in diet, with extra synthesised in skin by sunlight. Regulates calcium and phosphorus uptake, maintains optimum balance and controls excretion.
Metabolic Regulation	Converted to metabolically active form with hormone-like action on the small intestine, bones and kidneys along with parathyroid hormone in controlling Ca:P levels. Summer blood levels of active forms are higher due to sunlight synthesis in skin. Conversion 1μg vitamin D3 is equivalent to 40iu vitamin D.
Major Losses	Synthesis in skin of vitamin D – 20 mins sunlight over whole body required daily. Storage losses in prepared feeds 7.5% per month. Feed stored for more than 1-2 years may be deficient in vitamin D. Horses kept indoors may develop low vitamin D levels.
Dietary Interactions	Vitamin D destroyed by heavy metals and alkaline components of feeds.
Deficiency Symptoms	Calcium uptake is depressed by a Vitamin D deficiency. Abnormal gait, stiffness and lameness, weak bones with risk of fracture, swollen joints, loss of appetite, low blood levels of calcium and phosphorus. Slow closure of growth plates in bones and reduced growth rate in young horses.
Toxicity Symptoms	Promotes increased uptake of calcium, especially when phosphorus is in excess. Increased calcification of tissues, including blood vessels and heart, kidneys and gut lining. Decreased exercise tolerance, loss of weight, appetite, elevated resting heart rate (55-80b/min). Maximum safe level 2200 iu/kg diet for longer than 60 days, higher levels tolerated for shorter periods.
Common Feed Sources	Ergocalciferol is a less active source in hay. Sun cured clover or lucerne hay 1500iu/kg. Oaten Hay 1400iu/kg, Cod Liver Oil 1920iu per 20mL. Vitamin D supplements increase calcium and phosphorus uptake in horses – do not over supplement.

Common Name: Vitamin E
Technical Name: a -tocopherol

Function	Essential fat-soluble vitamin - α-tocopherol found in tissues. d-α-tocopherol = natural source vitamin E. dl-α-tocopherol = water soluble synthetic vitamin E. Antioxidant activity to protect against oxidation of compounds in food, and within fats in membranes of muscles and body tissue. Supplementation at high dose rates enhances the immune response. Supplementary intakes of 2000iu daily for 3 months improved track performance in racehorses.
Metabolic Regulation	Inter-related to trace-element selenium in protecting fats against oxidation to harmful, inflammatory compounds. Vitamin E is stored in muscle and body fat, and liver levels can take 7 weeks to be depleted on a deficient diet. Conversion: d-α-tocopherol (natural) 826iu equivalent to 1000iu (mg) dl-α-tocopherol (synthetic).
Major Losses	Fats in feeds after processing are prone to oxidation and loss of naturally protective Vitamin E content. Losses accelerated under moist, hot storage conditions. Fresh lucerne contains an antagonist that binds vitamin E.
Dietary Interactions	Vitamin E intake should be increased to protect added fats used as energy boosters in performance diets. Vitamin E in supplements destroyed on contact with iron and copper – do not mix together in damp feeds. More vitamin E is needed when selenium is deficient.
Deficiency Symptoms	Inter-related to selenium – signs may be related. Weight loss, subcutaneous swellings, fluid collection under chest and belly, stiff gait, muscle weakness, rough coat, "wobblers" due to brain nerve damage. (EDM) (See Glossary).
Toxicity Symptoms	High levels of vitamin E, unlike the other fat soluble vitamins, are not toxic. Maximum safe limit suggested is 1000iu/kg dry feed daily.
Common Feed Sources	Vitamin E loss is highest in moist feeds and processed grains. Green forage 100-450iu/kg, Lucerne Hay 10-30iu/kg, Cereal Grains 5-30iu/kg, Wheat Germ 2.1mg/20mL, Yeast 0.5mg/20mL. Recommended supplementation 1000iu daily in racing and performance horses.

Common Name: Vitamin K
Technical Name: Phylloquinone (Vit K1) in plants

Menaquinones (Vit K3) synthesised in hindgut by bacteria

Function	Fat soluble vitamin not required in diet. Adequate amounts synthesised by hindgut micro-flora to satisfy basic daily requirements. Converted to active form in liver. Essential for activation of blood clotting factors in conjunction with calcium, as well as other proteins in the body.
Storage Losses Synthesis	Synthesis inadequate in foals up to 2 weeks of age as hindgut fermentation function is not active – may be stored in liver.
Dietary Interactions	Because vitamin K is synthesised by hindgut microbial fermentation, extended treatment with sulphonamide drugs for infections will reduce vitamin K production.
Deficiency Symptoms	A deficiency can develop in 1-3 weeks on a deficient diet, where hindgut synthesis is suppressed by antibiotics or when liver utilisation is reduced by acidosis or severe diarrhoea, as little is stored in the body. Plants, such as sweet clovers, containing dicoumarol anti-clotting agent can affect vitamin K action, leading to haemorrhage.
Toxicity Symptoms	Excess intake from plants appears to be safe because it is not all absorbed. However, injectable vitamin K can be toxic. High doses cause depression, kidney pain and kidney failure, blood in urine, loss of appetite and laminitis (founder).
Common Feed Sources	Upper maximum limit set at 1000 times dietary need daily. Adequate levels in most forages and hays, supplemented by hindgut synthesis. In healthy horses, vitamin K supplementation is not warranted.

Source: Hintz (1982), NRC (1989), Cunha (1991), Lewis (1995), Frape (1997)

TABLE 3.10
Fat Soluble Vitamins Required in the Diet of Horses

3.7.1.2 Water-Soluble Vitamins

Note: The vitamin content of sources other than feeds is expressed as milligrams of Vitamin per 20mL (one level metric tablespoon) which is a convenient measure.

Common Name: Vitamin B1
Technical Name: Thiamine (Vitamin F or Aneurine)

Function	Water-soluble B-group vitamin. Role in carbohydrate metabolism, nerve transmission.
Metabolic Regulation	Provided in feeds and also synthesised in hindgut during microbial fermentation, of which about 25% is absorbed.
Major Losses	Losses in processing of grain, 5% loss each month in feeds. Sensitive to heat, light, low acid pH in liquid supplements.
Dietary Interactions	Thiamine destroyed by thiaminase enzyme in bracken fern – consuming 15kg new fronds daily for 3-4 weeks.
Deficiency Symptoms	Reduced growth rate, loss of appetite, abnormal heart beat, muscle tremors, incoordination and stiffness in limbs, lung fluid build-up. Bracken fern poisoning in horses results in nervous excitement.
Toxicity Symptoms	Considered safe at high intakes of up to 2000iu/kg bwt, as it is water soluble and excreted quickly. High dosages commonly used to settle and calm nervy horses – often anecdotal observations.
Common Feed Sources	Lucerne Hay 3mg/kg, Oats 6mg/kg, Corn 4mg/kg, Brewers Yeast 2mg/20mL, Wheat Germ 0.5mg/20mL. In supplements, thiamine mononitrate more stable than thiamine hydrochloride. (Refer to Chapter 6, Table 6.1, page XXX).

Common Name: Vitamin B2
Technical Name: Riboflavin (Vitamin G)

Function	Water soluble B-group vitamin. Involved in the metabolic function with two co-enzymes used in aerobic energy production. It has a distinct yellow colour in concentrated form.
Metabolic Regulation	Riboflavin is carried in protein in the blood, and the higher the intake, the less absorbed, excess is rapidly excreted in urine, making the urine more yellow in colour.
Major Losses	Feed loss about 3% per month. Reasonable resistance to heat, light and moisture in feeds.
Dietary Interactions	Riboflavin not compatible with vit B1 in liquid supplements and is destroyed.
Deficiency Symptoms	Little storage in body so deficiency symptoms can develop quickly on a deficient diet. Reduced growth rate, dull dry coat and flaky skin loss, hindgut inflammation and diarrhoea.
Toxicity Symptoms	Not a common cause of toxicity – not reported in horses.
Common Feed Sources	Cereal grains 1-3mg/kg. Buttermilk powder 31mg/kg. Milk powder 17mg/kg. Brewers yeast 0.7mg/20mL.

Common Name: Niacin (Formerly Vitamin B3)
Technical Name: Nicotinic acid, Nicotinamide, Vitamin PP

Function	Nicotinic acid in feeds is converted to nicotinamide in the gut lining. Nicotinamide in the tissues is involved in the metabolism of carbohydrates, fats and amino acids to energy – higher requirement in exercising horses.
Metabolic Regulation	Nicotinamide is synthesised during hindgut fermentation and from the amino acid tryptophan in body cells.
Major Losses	Feed losses are 4-5% per month. Little is stored in the body and excesses are rapidly excreted in the urine, up to 90% in 24 hours.
Dietary Interactions	Nicotinamide, the active form, is one of the more stable of the B-group vitamins, and is less affected by heat, oxidation and light during storage.
Deficiency Symptoms	Symptoms have not been reported in horses, but in other animals, a deficiency can lead to mouth ulcers, skin inflammation and diarrhoea.
Toxicity Symptoms	High intakes are well tolerated in horses, and upper maximum limit of 350mg/kg bwt is suggested for animals over extended times.
Common Feed Sources	Pasture and good quality hay contain reasonable levels, but in cereal grains, it is less available. Lucerne hay 35mg/kg, Brewers yeast 9.5mg/20mL, Wheat Bran 200mg/kg.

Common Name: Pantothenic acid (Formerly Vitamin B5)
Technical Name: D-calcium pantothenate used in supplements

Function	It is a constituent of many co-enzymes involved in metabolism of carbohydrates, proteins and fats to energy.
Metabolic Regulation	Pantothenic acid is synthesised by microbial fermentation in the hindgut, which combined with feed intake should meet daily needs in most healthy horses.
Major Losses	Feed losses estimated at 2.4% per month. Little is stored in the body, and excess intake is rapidly excreted in urine.
Dietary Interactions	Pantothenate is less stable under high moisture conditions in damp feed mixes.
Deficiency Symptoms	Symptoms not observed in horses or cattle, but in other animals slow growth, dermatitis, gut ulcers and diarrhoea have been reported.
Toxicity Symptoms	Regarded as non-toxic to horses.
Common Feed Sources	Pasture and good quality hay contain adequate levels, but grains are generally low. Lucerne Hay 15mg/kg, Oats 9mg/kg, Bran 27mg/kg, Brewers Yeast 2.2mg/20mL, Peanut Meal 50mg/kg.

Common Name: Vitamin B6
Technical Name: Pyridoxine

Function	Converted to an active form in the body, requiring both niacin and riboflavin for conversion. Involved in energy production and blood formation.
Metabolic Regulation	Although synthesised by hindgut microbial action, it is not absorbed well, with majority of uptake from small intestine.
Major Losses	Feed losses are about 4% per month.
Dietary Interactions	Affected by light and alkaline salts in a damp feed mix. Body storage is minimal, excess intake is eliminated in urine.
Deficiency Symptoms	A low level of niacin or riboflavin can affect vitamin B6 conversion, and reduce its activity, but symptoms of a deficiency not reported in horses.
Toxicity Symptoms	Not reported in horses, although nervous signs and incoordination reported in other animals.
Common Feed Sources	Levels in pasture and grains are generally low at 3-6mg/kg. Lucerne 5.5mg/kg, Brewer's Yeast 0.6-1.0mg/20mL.

Common Name: Vitamin B12
Technical Name: Cobalamin, Cyanocobalamin in supplements

Function	Required in much smaller amounts than most other vitamins. Involved in methionine synthesis, folic acid activity and propionic acid to energy.
Metabolic Regulation	Synthesised by micro-organisms in hindgut fermentation processes. Contains the trace-mineral cobalt in its structure, and although a low intake of cobalt in ruminants results in low vitamin B12 and deficiency signs, horses are less affected.
Major Losses	Stable in feeds with losses about 1.4% per month. Early weaned foals may benefit from supplementation whilst adapting to a pasture diet.
Dietary Interactions	Vitamin B12 rapidly excreted if repeated injections given on a weekly basis, with little retention and excess rapidly excreted in urine.
Deficiency Symptoms	Although not reported in adult horses, it is widely used in performance horses to avoid anaemia, aid the appetite, complement iron supplementation and promote recovery after heavy worm burdens.
Toxicity Symptoms	Not reported in horses, as high intakes are rapidly excreted.
Common Feed Sources	Vitamin B12 is only synthesised using cobalt by microorganisms – not in pasture or feeds as vitamin B12. Milk powder 50µg/kg, Buttermilk powder 20µg/kg, Brewer's Yeast 0.02µg/20mL.

Common Name: Folic Acid
Technical Name: Folacin

Function	Associated with vitamin B12, which is necessary for conversion to its active form. Involved in blood cell production in conjunction with vitamin B12.
Metabolic Regulation	Higher blood levels are reported in pastured horses than permanently stabled horses. Synthesised by microbial fermentation in hindgut.
Major Losses	Feed losses 5% per month. Moderately affected by storage conditions, particularly moulds in feeds. Stored in liver as a reserve, which may be depleted when horses have reduced access to pasture. Excesses are excreted mainly in the bile into droppings.
Dietary Interactions	Adequate intake of methionine in good quality protein can offset a lower intake of folic acid. Synthesis is decreased when sulphonamide drugs are given.
Deficiency Symptoms	Not reported in horses, but anaemia is observed in other animals. Supplementation if they have little access to pasture. Folic acid may be of benefit to horses in hard training, often in conjunction with vit B12 and iron.
Toxicity Symptoms	Not observed in horses. Intramuscular injections do not increase blood levels for more than 24 hours. Supplements are best added to feed. (See Chapter 6).
Common Feed Sources	Green pasture provides 0.3-1mg/kg when grazed, Lucerne Hay 1-1.3mg/kg, Brewer's Yeast 0.2mg/20mL, Cereal grains 0.2-0.6mg/kg.

Common Name: Biotin
Technical Name: D-Biotin (Vitamin H)

Function	Involved in co-enzyme activity during synthesis of glucose and formation of fats, RNA and DNA in cells.
Metabolic Regulation	Synthesised by hindgut fermentation.
Major Losses	Feed losses about 4% per month.
Dietary Interactions	Biotin contained in wheat, barley, sorghum and bran is not available, due to phytate binding but good uptake from pasture, clovers, corn and soyabean meal.
Deficiency Symptoms	Not reported in horses. Responses have been reported in improving the hardness, growth rate and quality of the hooves and laminae strength with calcium at rate of 15mg/horse each day for 4-6 weeks.
Toxicity Symptoms	Not observed in horses.
Common Feed Sources	Lucerne 0.25mg/kg, Brewers Yeast 5mg/kg, Soyabean Meal 0.32mg/kg. Concentrated feed supplements of synthetic biotin are required to provide 15mg/day for improving hoof hardness, as feed sources are not sufficiently concentrated. (Refer to Chapter 6, Section 6.3.1, page XXX).

Common Name: Vitamin C
Technical Name: Ascorbic Acid

Function	Provides important antioxidant action by removing excess oxygen to protect fats and proteins in cell membranes, enhances bone and collagen formation, and utilisation of some amino acids. Aids utilisation of folic acid and iron uptake in gut wall.
Metabolic Regulation	Synthesised in the tissues from glucose. Sources are poorly absorbed, but longer term daily supplementation can increase blood levels.
Major Losses	Feed losses 30% or more per month. Calcium and sodium ascorbate salts more stable in feeds and wax coated vitamin C is more stable.
Dietary Interactions	Affected by light, heat moisture and oxidises easily. Unstable when mixed into damp feeds containing iron or copper in a supplement.
Deficiency Symptoms	Horses do not require vitamin C in their diets. Horses under stress have lower blood levels, but doses of 20g daily to racehorses had no reported beneficial effect on performance or well-being. Older mares have lower blood vitamin C levels than young mares, but supplementation does not improve fertility in mares or stallions. Stress may reduce normal synthesis.
Toxicity Symptoms	Not reported in horses and up to 1g vitamin C/kg body weight in feed daily is regarded as safe.
Common Feed Sources	Pasture contains variable levels.

Sources: Tyznik (1982), NRC (1989), Caple (1991), Cunha (1991), Lewis (1995), Frape (1997)

TABLE 3.11
Water-Soluble Vitamins Required by Horses

3.7.2 Requirements of Vitamins

Vitamins are required in very small amounts, compared to minerals and trace-minerals. Deficiencies can occur due to low feed intakes or more commonly as a result of vitamin breakdown by oxidation and hot conditions during harvesting, storage and processing of grains and hays. Deficiencies can occur on pasture and on dry food diets. Excesses are mostly due to over supplementation with specific vitamins. Supplementation of certain vitamins in horses with little access to high quality pasture, or those subjected to the stress of training, may be beneficial for optimum health and performance. The requirements for vitamins relative to a horse's needs are summarised in Chapter 6, Table 6.3, page X XX.

3.8 Summary

The horse requires an adequate and balanced supply of nutrients, which it can obtain from various feed sources.

- ☑ An adequate supply of cool, clean water is essential for all horses, especially growing, lactating mares and horses working under hot conditions.
- ☑ A horse can use a variety of energy sources depending on its diet, the amount it requires and its rate of use of energy.
- ☑ Protein is contained in most feeds, except fat. Good quality protein is required for growing foals and lactating mares.
- ☑ The fat content of most feeds is low. Fat is a high energy source that is suited to working horses under hot Australian conditions.
- ☑ All horses need at least 30% of their diet by weight as roughage to maintain optimum gut function, hold water reserves, to facilitate fermentation to provide natural B-group vitamins and to produce heat to maintain body warmth under cold conditions.
- ☑ Minerals are important in the formation of bone, to maintain nerve and muscle function and in digestive and metabolic functions.
- ☑ Vitamins are required in small amounts, but their function in a wide range of metabolic processes and their inter-relationships with each other and with many minerals, requires an adequate daily supply. Vitamin A and vitamin E must be provided in the feed, vitamin D is provided in feed, and via skin synthesis in outdoor horses, whilst other vitamins are synthesised within a horse's body. Excess of vitamin A and D can lead to serious toxic effects.

Chapter 4

NUTRIENT REQUIREMENTS OF HORSES

The nutrient requirements of horses are much more varied than most other animals because of the use of the horse as an athletic and reproductive animal and the range of size and types.

KEYPOINT: A horse must be provided with a palatable diet it enjoys eating, that is adequate and balanced to satisfy its nutritional needs and maintains it in an optimum condition and at a suitable energy level for its purpose.

The major nutrient requirements of a horse are influenced by the following factors:

- ✓ **The age and maturity of the horse.**
  A young horse requires more energy, protein and minerals for growth. An aged horse requires a higher level of calcium and protein in its diet because of reduced utilisation.

- ✓ **Whether the horse is resting or working and if working, the intensity, duration and frequency of exercise.**
  All nutrient needs increase relative to the stage of training, speed and duration of exercise, with maximum needs for intense and prolonged exercise.

- ✓ **The stage and rate of growth.**
  A foal requires a higher intake relative to body weight, reducing through weaning to yearling age. Higher rates of growth require increased needs.

- ✓ **The stage of pregnancy and lactation in mares.**
  Needs increase in late pregnancy as the unborn foal rapidly develops, with at least a 50% increase in all nutrients during lactation.

- ✓ **The environmental and management conditions.**
  Cold weather increases energy needs. Hot weather elevates fluid and electrolyte requirements. Grazing horses use more energy searching for food when pasture is sparse or shorter. Younger horses at pasture exercise more than older horses.

Individually, the needs of a horse are relative to:

- ✓ **Its body weight, and in a large horse, its size.**
  Most requirements are related to body weight. Large horses over 600kg need less energy on a body weight basis because they do not self-exercise as much.

- ✓ **Its individual digestive and metabolic efficiency.**
  Some horses are “good doers” or “easy keepers” and readily put on condition. Others are generally “poor doers” or “hard keepers”, despite an adequate diet.

- ✓ **Its appetite, including its likes and dislikes.**
  Small-framed horses may not be big eaters and need a more concentrated diet with less bulk. Appetite can be suppressed by work, requiring a higher density of energy in the ration.

- ✓ **Its temperament, and often the characteristics of its breed.**
  Some are suspicious eaters, others are nervy and active and need more energy to maintain condition. Some breeds are generally more active and “hyper” than others.

- ✓ **Its general health, including parasite burdens, injury or stress related needs.**
  Heavy worm burdens sap nutrients, physical stress increases energy and other nutrient needs.

In order to provide a comparative review and practical guidelines on the nutritional requirements and management for different classes of horses, the needs of the following classes of horses are outlined.

Resting horses.
Working or exercising horses.
Breeding horses.
Growing horses.

KEYPOINT: The nutrient requirements used as a guideline in this book are based on the recommendations provided in the "Nutrient Requirements of Horses" published in 1989 by the National Research Council, Washington DC, USA

Specific needs related to the common feeds used in Australia and influences of seasonal conditions, locality or management practices as well as any new research findings have been incorporated into the guidelines. The daily requirements of the major nutrient classes, as outlined in Chapter 3, will be discussed for each category.

4.1 Requirements for Resting Horses

The term "maintenance" is used to describe an adult horse at rest under temperate conditions (15-30ºC) that is not worked on a regular basis or required to perform any demanding activity.

DEFINITION: Maintenance is defined as the intake of sufficient nutrients to fuel and provide for vital processes and exercise related to feed gathering activities so as to maintain a constant body weight and condition score, and good health and vitality.

A mature horse that has retired, or one that has no regular work demand, can usually maintain itself on good pasture for most of the year. Supplementary feed, as good quality hay, is usually only required when pasture is sparse, short, or of poor feed value.

There are two exceptions to this general guideline in pastured horses:-

✖ Horses grazing tropical grass pastures in Queensland and Northern Australia containing oxalate chemicals which can bind calcium to prevent its uptake from the small intestine, may require supplementation with calcium. (Refer to Chapter 7, Section 7.4.7, page XXX).

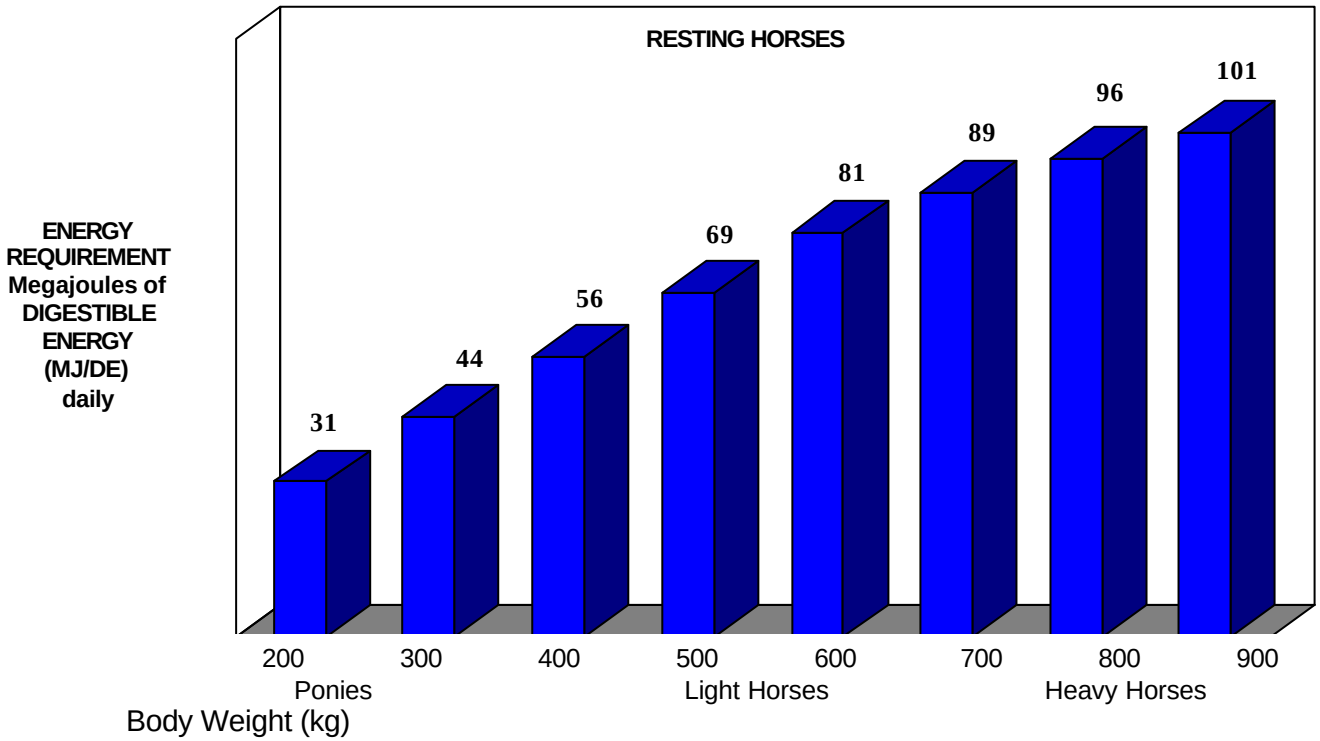
✖ Pasture intake may have to be restricted in ponies or overweight horses during lush periods to avoid risk of laminitis and founder. (Refer to Chapter 5, Section 5.1.1.1, page XXX).

KEYPOINT: A grazing horse on green pasture needs to consume approximately 5-7% of its body weight, or from 5-7kg/100kg body weight to meet its major nutrient needs each day to maintain itself. This can be satisfied by 4-5 hours of grazing on good pasture, but may require up to 18-20 hours of grazing on shorter, less nutritious pasture.

4.1.1 Energy

A mature horse requires a daily supply of energy to fuel body processes, maintain its condition and body warmth and enable it to gather food and perform voluntary self-exercise to maintain its fitness, health and vitality.

✓ In most cases, where a resting horse is turned out on pasture, it should be able to obtain all the major nutrients to meet its needs if adequate pasture is available for it to eat.



Source: NRC (1989)

Theoretical Need:

An adult resting horse requires from 13-15 Megajoules DE per 100kg body weight, or an energy density of 7.5 Megajoules of DE per kilogram of dry feed consumed, to maintain its condition and vitality.

KEYPOINT: Regular appraisal of body condition and vitality in an otherwise healthy horse is a practical means of evaluating the adequacy of its energy intake.

The daily requirement of energy for maintenance, as illustrated in Figure 4.1, increases roughly in proportion to body weight, but for horses over 600kg, the increase in energy requirement is lower, as heavy horses do not move around as actively and expend less energy when exercising and working at slower speeds.

Dietary Ration Intake:

A resting horse, based on an average energy content in hay, containing an average 10% moisture, needs to consume from 1.5-2.0% of its body weight in dry feed daily, to satisfy its energy need and appetite with the bulk it consumes.

As an example, a 500kg horse would need to consume from 7.5kg to 10kg of dry feed each day, depending on its energy content. In simple terms, its daily energy need would be satisfied by approximately 7½kg of lucerne hay or alternatively up to 10kg of grass hay if there is no pasture available, such as when a horse is confined largely to a day yard or in a small eaten out paddock.

✓ A horse that is a "good doer" will be able to maintain its condition on a smaller amount of food and its diet may need to be bulked out with lower energy roughage, such as cereal chaff, to satisfy its appetite but avoid it putting on extra condition.

A resting horse on a diet slightly deficient in energy will normally take 2-3 weeks to show a loss of condition. This commonly occurs when pasture dries off after the flush of the season, or is eaten out and supplementary hay or other feed is not given early enough to make up the shortfall in energy.

KEYPOINT: As pastures are grazed down or dry off, it is important to regularly monitor a horse's condition and the time it spends grazing to help decide when a resting horse requires a supplement of hay.

✓ A horse will normally increase its food intake during cold weather, often seeking additional roughage to occupy its time and in doing so provide extra fermentation heat to help keep it warm.

✓ A thin horse needs more energy to maintain body heat and once body condition is lost by energy drain it is often difficult to regain, especially in an older horse.

✖ Many owners who keep horses on small areas start to supplementary feed as soon as pastures dry off or are grazed down in the hope that this will save the pasture. Most horses will eat the hay and continue to graze the pasture bare as well. It is best to shift the horses off the pasture if possible, confining them to yards with supplementary hay and limiting their access to pasture under these conditions. This will allow the pasture to regrow rather than being eaten out. When pastures are eaten out, weed growth is encouraged because plant competition is reduced.

KEYPOINT: An excess intake of energy relative to daily needs can make a horse over-energetic and hard to handle, but if it is a quiet lazy type, it is more likely to put on condition, often compounded by a reluctance to self exercise as it gains more weight.

A resting horse supplemented with hard feed and hay during the mid to late spring period when pasture would easily meet its needs, will normally put on extra body condition. Resting horses and ponies do not have the ability to limit their energy intake and will continue to graze and gain weight under plentiful pasture conditions. A horse in work will normally only consume sufficient energy to meet its need for exercise.

4.1.2 Protein

An adult horse at rest that is grazing on abundant pasture will obtain sufficient protein to meet daily needs. Even on a low protein grass pasture, if a horse is able to eat enough to provide adequate energy to maintain its body weight, sufficient protein is usually consumed in the bulk of feed to meet maintenance needs.

A resting horse requires an intake of 130-150g of crude protein per 100kg body weight daily, or roughly 7-8% crude protein in its diet as fed. Most grass based pastures provide this content of protein without supplementation.

✖ Where lucerne hay (15-17% crude protein) is used as a roughage and supplementary feed to meet energy needs during periods of reduced pasture value, such as under dry, hot summer or wet, cold, wintry conditions, it will provide protein in excess of maintenance needs. Although not harmful in terms of oversupply of protein to a resting horse, feeding lucerne hay to appetite demand will often provide an energy excess that is likely to result in a weight gain. The increased fibre intake may lead to a "hay belly" as the hindgut expands to digest the bulk of hay.

4.1.3 Other Nutrients

Fat and fibre needs should be provided by pasture or supplementary hay. An adult horse at rest needs the lowest intake of minerals, trace-minerals, electrolytes and vitamins relative to its body weight. (Refer to Chapter 6, Tables 6.2 and 6.3, pages XXX to XXX).

The requirement for water is approximately 3 litres/100kg body weight daily, but often less is consumed when a horse is grazing green pasture under cool conditions. Up to 6 litres per 100kg body weight daily may be required by a resting horse fed on a dry feed diet or under hot conditions.

KEYPOINT: Good quality pasture should satisfy the major nutrient needs for resting adult horses especially if the pasture contains a blend of at least 20-25% legumes (lucerne/clovers) mixed with cereal grasses. Extra roughage as supplementary meadow or lucerne hay should be provided at critical times.

4.2 Requirements for Working Horses

Once a horse is put into training, or is exercised purposely on a regular daily basis, its nutrient requirement on a body weight basis will increase in proportion to the type, intensity and duration of the work effort expended, the ambient temperature, and its temperament. For example, a "hyperactive" horse will require a higher energy intake relative to other nutrients to maintain its condition.

KEYPOINT: As the intensity of exercise increases, the bulk of intake may be limited by a reduction in appetite, so an increase in the density of the major nutrients in the ration may be necessary to maintain body weight and work capacity in hard working horses.

4.2.1 Energy

The adequacy of the energy intake in a working horse can directly influence a horse's performance, vitality and the maintenance of an optimum body condition.

KEYPOINT: The majority of horses in work will only eat sufficient to meet their needs in comparison to horses at rest. A resting horse will invariably consume more feed and energy than it requires to satisfy maintenance requirements.

The requirements for energy are usually classified into **light**, **moderate** and **intense** exercise and effort levels.

4.2.1.1 Light Work

It can be difficult to provide meaningful guidelines on the nutrient needs for a horse in light work, because many horse owners have varying estimates on the amount of effort expended and the actual length of time they work their horses each day.

DEFINITION: Light work is defined as up to 30-60 minutes daily exercise, consisting of walking, trotting and some cantering.

✓ The majority of pleasure, basic dressage, show horses and working ponies are included in this category.

Theoretical Need:

Approx Energy Requirement: 17-18 Megajoules DE per 100kg body weight daily, or an energy density of 9.2 Megajoules DE per kilogram of dry food consumed. A

500kg horse at the walk uses 4MJDE per hour increasing to 42MJDE per hour at the canter and half-pace gallop.

Dietary Intake:

A horse in light work needs to consume from 1.5-2.5% of its body weight in dry feed (10% moisture) each day. Therefore a 500kg horse in light work would need to consume from 7.5 to 12.5kg of feed each day, or an average of 10kg daily to meet exercise demands and maintain its condition and vitality.

✓ The needs of many horses that are worked from the paddock can be supplied by day time grazing and 0.5kg/100kg body weight of hay or mixed chaff overnight.

✓ If a horse is totally "hand" fed, then, to limit excess bulk of feed, a diet of approximately 65% roughage and 35% concentrate feed, by weight, will be adequate to meet its needs. (Refer to Chapter 5, Table 5.4, page XX for full guidelines).

KEYPOINT: Energy to meet the needs of light work can usually be provided by an adequate intake of good pasture, with supplementary hay as required during leaner or colder periods of the year.

✓ Many weekend pleasure and pony club horses receive only light work on a sporadic basis as time and weather conditions permit. A pasture-based diet is often adequate during spring to mid summer under normal seasonal conditions in most parts of Australia.

✖ Ponies and their crossbreds may need to have their access to grazing lush, spring pastures restricted to avoid excessive weight gain and risk of laminitis, which can develop into the condition of founder if the pedal bone rotates due to devitalisation of the structural laminae. (Refer to Chapter 5, Section 5.1.1.1, page XXX).

✓ Show horses are also lightly worked, but require good body and coat condition for competition. Show horses are usually stabled overnight and confined to yards during the day with only restricted access to pasture to limit self-exercise that may lead to injury or drain energy and condition.

Show, pleasure and leisure horses may not be worked regularly and for the same duration each day, especially during the winter months because of shorter daylengths or cold or wet conditions.

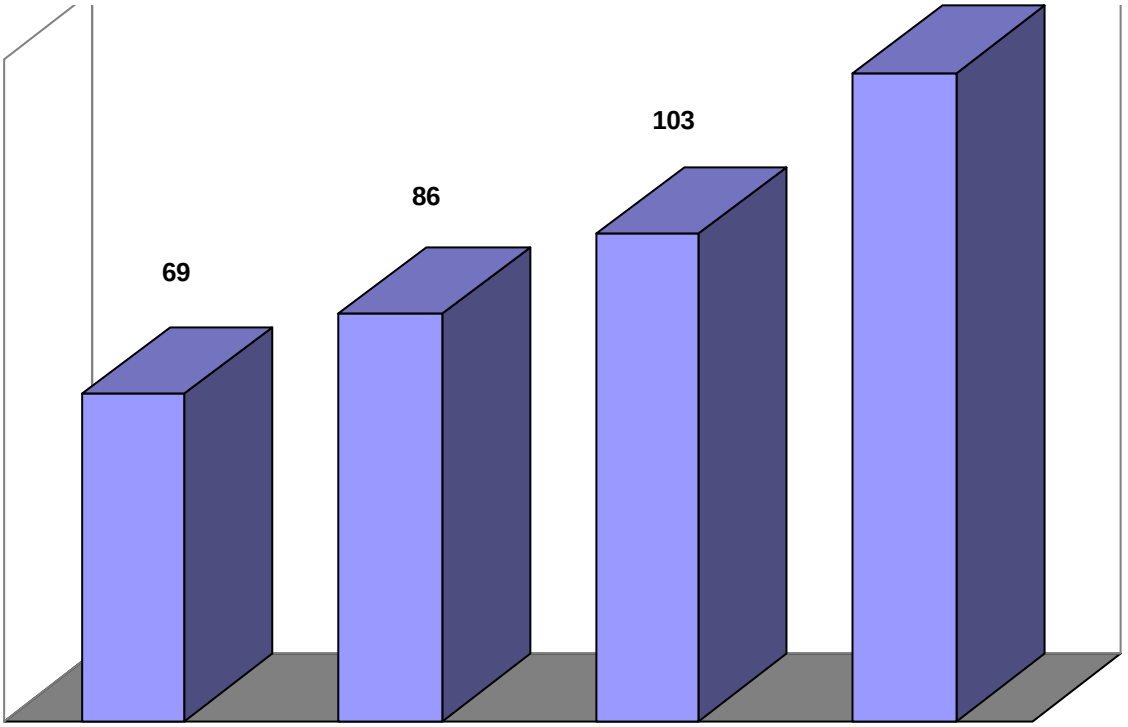
The amount of energy in the feed provided each day should be relative to the work effort and duration to ensure that a horse does not put on extra body condition. Excess energy will also increase the risk of a horse becoming "fizzy" or over-energetic, especially when provided with a set amount of feed sufficient for 30-60 minutes of light exercise and little or no exercise is given for one or more days.

✓ Ration adjustments must be made during the weekdays for pleasure horses that are regularly ridden only on the weekends.

ENERGY REQUIREMENT MEGAJOULES OF DIGESTIBLE ENERGY MJ DE DAILY

KEYPOINT: Adjustments to the dietary energy intake must be made relative to the actual amount of work performed each day, rather than the work planned for an individual horse on a particular day.

A reduction to one third of the concentrate feed to no more than one third on very light work or rest days, or withdrawal of the concentrates in the next feed if a horse is not worked on a particular day due to lameness, sickness or injury will avoid risk of over-energetic, 'fizzy' behaviour and typing up in susceptible horses.



WORKING HORSES
500kg body weight

4.2.1.2 Moderate Work

The increased energy requirements for moderate work performed on a regular basis require a more energy dense ration in a bulk that a horse is able to fully consume. Often horses at this level of work are confined to small paddocks, yards or stables and have less reliance on pasture as a source of energy and other major nutrients.

DEFINITION: Moderate work is defined as 30-120 minutes daily exercise at walk, trot and canter, with some galloping.

☑ **Advanced dressage, showjumpers, polocrosse, one day event horses and racehorses in early to mid training are included in this category.**

Theoretical Need:
Approx Energy Requirement:
21-23 Megajoules DE per 100kg body weight daily, or an energy density of 10 Megajoules DE per kilogram of dry food consumed.

The energy intake will be related to the speed and intensity of the work effort. At the slow trot (200 metres/min) a 500kg horse will use approximately 13MJDE per hour, increasing

to 28MJDE per hour at the fast trot (300 metres/min) up to 42MJDE per hour at the half pace gallop.

Dietary Intake:
A horse in moderate work needs to consume from 2.0-2.5% of its body weight of dry feed (10% moisture) each day. If the horse is totally "hand" fed, it would need a ration containing an average of 50% roughage and 50% concentrate feed by weight to meet its needs in a bulk that it is able to consume. (Refer to Chapter 5, Table 5.4, page XX for full guidelines).

✓ A small framed horse, or one with less than normal appetite, may require a less bulky ration with a higher energy and protein density to ensure it is able to eat enough to meet its needs.

This is normally achieved by reducing the amount of a bulky grain, such as oats, and replacing it with a smaller portion of steam rolled barley, corn, or even fat, as these contain more energy in a smaller volume of feed. (Refer to Chapter 5, Table 5.6, page XXX for Energy Substitution Rates).

4.2.1.3 Intense Work

Horses subjected to heavy or intense work on a daily basis require a ration with increased density of a wide range of nutrients to meet their elevated needs in a bulk of ration that can be consumed relative to their appetite.

The majority of these horses are stabled full time to limit energy loss by self-exercise and maintain low gut weight, with little or no reliance on pasture.

A survey carried out on a large group of horses in 50 Thoroughbred and Standardbred racing stables in the Sydney area by Dr. Louise Southwood and co-workers in 1992 found that energy intakes were similar to that recommended by the NRC (1989), although a variety of grain and feed blends were used.

Definition: Intense work collectively includes 30-60 minutes sustained trotting, cantering and galloping, or short high intensity galloping in race competition.

✓ **Horses in advanced race training, polo and upper level event competition and endurance riding over distance are included in this category.**

Theoretical Need:
Approx Energy Requirement: 28-30 Megajoules DE per 100kg body weight, or an energy density of 10.7 Megajoules DE per kilogram of dry feed consumed.
A 500kg horse at half pace gallop (8-10 metres/sec) uses 42MJDE per hour, and 2MJ per minute at the full gallop (12 metres/sec).

Dietary Intake:
A horse in intense work needs to consume 2.5-3.0% of its body weight of dry feed (10% moisture) each day. In a fully confined horse, a ration containing 30-40% roughage and 60-70% concentrate feed will meet requirements in a bulk that a horse can consume. (Refer to Chapter 5, Table 5.4, page XXX for full guidelines).

☑ Horses with a large frame and good appetite may consume up to 3.0% body weight, but most horses in intense training will only be able to eat a maximum of 2.5% of their body weight in weight of feed. Often the appetite of horses in a race training is depressed by hard work. To improve their competitiveness, gut fill and hindgut weight can be minimised by part substitution of oats with corn, barley or with limited amounts of vegetable oil. (Refer to Chapter 5, Table 5.6, page XXX).

☑ Some of the more nervy or "hyperactive" horses, or ones that fail to "do well" when confined to a stable or yard, are often best trained from the paddock, especially in outer urban or country areas. A "hard" feed is normally provided morning, evening and overnight in a sheltered outside yard, with pasture grazing during the day.

4.2.2 Protein

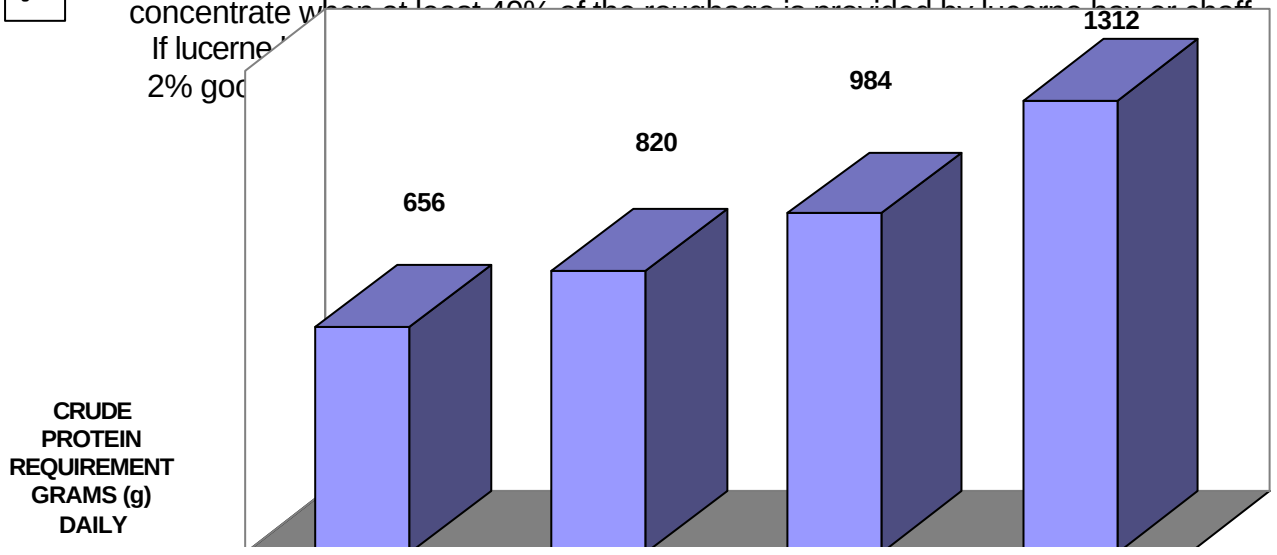
Studies have shown that horses in work require approximately 9.5-10g crude protein per Megajoule of Digestible Energy consumed each day. The estimated protein requirement, related to energy intake for light, moderate and intense exercise, is illustrated in Figure 4.3.

Light Work	170g crude protein per 100kg body weight daily, or a ration containing 8.5-9.0% crude protein.
Moderate Work	190-200g crude protein per 100kg body weight daily, or a ration containing 9-10% crude protein.
Intense Work	260-270g crude protein per 100kg body weight, or a ration containing 10-12% crude protein.

A survey of the rations and feeding practices of 50 Sydney and provincial thoroughbred racing stables by Dr. Louise Southwood and colleagues in 1992 found that on average, the amount of protein consumed when a horse is fed a lucerne based ration was between 12 - 24% in excess of NRC (1989) suggested daily requirements. In some stables the protein intake was elevated even more by the routine but often unnecessary addition of oil seed meals as a protein supplement. Protein intake in excess of 50% above the horse's needs can lead to higher heat waste from fermentation, elevated heart and respiratory rates and may have an adverse affect on athletic performance.

The quality of protein in providing a range of essential amino acids for blood, bone and muscle development and maintenance, such as lysine, is important in horses on higher grain diets because the protein in grain is often relatively deficient in lysine and other amino acids. (Refer to Chapter 10, Tables 10.1 – 10.4, pages XXX - XXX)

☑ Adequate protein for adult horses in training will be obtained from a grain based concentrate w[illegible] at least 40% of the roughage is provided by lucerne hay or chaff. If lucerne [illegible] 2% goo[illegible]



☑ Young horses in training that are less than 3 years old, horses in lighter condition, and those with poorly developed muscle, may benefit from an additional 2% crude protein provided by an oil seed meal during the first 6-8 weeks in training.

In practical feeding terms, this means that:
To provide an additional 2% or 200g crude protein in a 10kg daily ration intake with minimum lucerne hay, 450g (approx 2 cups (500mL) of soyabean meal (44.5%CP), or alternatively 530g (approx 3 cups (750mL) of canola meal (36%CP) or alternatively 720g (approx 4 cups (1000mL) of crushed tick beans (25.5%CP), would need to be included because of the varying crude protein content of each protein source. (Refer to Chapter 5, Table 5.7, page XXX for substitution rates).

4.2.3 Other Nutrients

The requirement for minerals, trace-minerals, electrolytes and vitamins are related to the intensity of exercise, sweat output and the stress of repeated work. The important minerals are calcium and phosphorus and electrolytes lost in sweat including sodium, potassium, chloride and magnesium, as illustrated in Table 4.1.

	Minerals and Electrolytes					
Work	**Body Weight (kg)**	**Calcium (g)**	**Phosphorus (g)**	**Sodium (g)**	**Potassium (g)**	**Magnesium (g)**
Maintenance Resting	400	16	11	6.7	20	6.0
	500	20	14	8.2	25	7.5
	600	24	17	9.7	30	9.0
Light Work	400	20	15	20.5	25	7.7
	500	25	18	25.1	31	9.4
	600	30	21	29.7	37	11.2
Moderate Work	400	25	17	23	31	9.2
	500	30	21	27.8	37	11.3
	600	36	25	32.9	44	13.4
Intense Work	400	33	23	28.2	41	12.3
	500	40	29	34.5	50	15.1
	600	47	34	40.8	59	17.8

Source: NRC (1989)

TABLE 4.1
Comparative Daily Major Mineral and Electrolyte Requirements for Working Horses ranging from 400 to 600kg Body Weight

4.2.3.1 Calcium

Calcium requirements increase with exercise, as calcium is an important co-factor in metabolism and muscle contraction. Bone stores of calcium are also being "turned over" as bones repair and strengthen themselves when subjected to hard exercise. In addition, calcium is lost when horses sweat.

A survey by Dr. Ivan Caple and co-workers in the early 1980's of Thoroughbred racehorses in training in Melbourne found that 40% of horses did not receive adequate calcium in their diets based on NRC (1978) recommendations. An inadequate calcium intake was most likely when high grain diets contained little or no lucerne.

✓ A minimum of 3kg of lucerne chaff and hay (12g calcium/kg) as a roughage base, combined with grains in a concentrate feed, should meet the daily requirements for calcium and protein in a horse performing up to a moderate work level.

✓ A horse subjected to hard training requires up to 4kg of lucerne roughage (hay and chaff) daily to meet its calcium needs without calcium mineral supplementation.

Analysis by Dr. Louise Southwood and colleagues in 1993,of the rations fed by 50 Sydney trainers found that 32% of Thoroughbred diets and 24% of Standardbred diets required supplementation with calcium to bring them up to NRC (1989) levels.

✓ Supplementation with 60g (3 tablespoons) of calcium carbonate daily, providing approximately 24g calcium, to horses in Hong Kong fed on a 70% grain ration mixed with cereal and lucerne roughage lowered the incidence of vertebral fractures by 35% over a 3 month period.

Horses performing at an intense level of exercise, such as racing, eventing and endurance horses, being fed on a 30% roughage to 70% concentrate ratio by weight, may not be able to consume sufficient bulk of lucerne to meet calcium and protein needs without supplementation with a mineral source of calcium and protein meals. Some racehorse trainers feed little or no lucerne and, in this case, calcium and protein supplementation is essential to meet the daily needs of horses in training.

KEYPOINT: Where the ration of racing and other hard working horses contains less that 2 kg daily or no lucerne hay or chaff, calcium and protein supplementation is essential to meet the daily needs of horses on grain based diets.

✓ Recent evidence suggests that endurance horses, or horses working for extended periods on a regular basis, should be provided with adequate, but not excessive intake of calcium during training to meet needs and replace sweat losses. It is considered that high intakes of lucerne provide excess calcium, which suppresses parathyroid gland function and the subsequent mobilisation of calcium from bone stores during a ride when sweat output depletes blood calcium. Reduced blood calcium can result in muscle weakness and a risk of 'tying up'.

✓ Horses between 18 months and 3 years of age in race training also require supplementation with calcium because calcium requirements are elevated by active bone modelling to increase bone strength and density in response to increased skeletal loading during exercise. In addition, horses that sweat heavily under hot conditions will require extra calcium.

4.2.3.2 Phosphorus

Phosphorus is required for metabolism and as phosphate in maintaining the acid base balance of the blood during and after exercise. The 1993 survey of racehorse feeding practices in Sydney by Dr. Louise Southwood and colleagues found that the intake of phosphorus was adequate on standard racehorse diets containing 5-6kg grain (average 3g phosphorus/kg) and up to 4kg lucerne chaff or hay (average 2.2g phosphorus/kg). In this survey, the intake of phosphorus in Thoroughbreds ranged form 70-230% of NRC (1989) requirements and Standardbreds ranged from 81-209%. Although bran is added as a source of phosphorus, much of it is in phytate form, which reduces phosphorus availability during digestion in the hindgut. Calcium supplements based on limestone (calcium carbonate) do not provide phosphorus.

On a low grain, high lucerne diet, a supplement containing phosphorus, such as dicalcium phosphate (also called DCP or calcium hydrogen phosphate) [calcium 4.6g, phosphorus 3.6g per 20g (level metric tablespoon)] provides a suitable source of available phosphorus. The addition of extra phosphorus to balance the calcium:phosphorus ratio is important in horses on high lucerne diets already receiving an excess of calcium relative to phosphorus each day.

4.2.3.3 Electrolytes

During exercise, 80% of the energy metabolised during muscle activity is given off as heat, which is dissipated largely by evaporation of sweat secreted from the skin surface during and after exercise to cool the body.

The survey of Sydney Thoroughbred and Standardbred trainers by Dr. Louise Southwood and colleagues in 1992 found that commercial electrolyte supplements were used by 44% of trainers but the majority fed salt as well.

KEYPOINT: Fluid and electrolyte loss in sweat during exercise is relative to the speed and duration of work, the environmental conditions and the training status and fitness of a horse.

- ✓ Sweat rates of 4-5 litres per hour have been measured during moderate exercise under cool conditions (20ºC), increasing by 30-35% under warm conditions (30ºC) and doubling to 10-11 litres per hour under hot conditions (35ºC). An endurance horse can lose up to 60 litres of sweat during a 160km endurance ride under warm and humid conditions.

- ✓ A high relative humidity does not increase sweat output, but reduces the efficiency of evaporation of sweat from the skin surface. Hot, humid conditions prolong sweating time during recovery from exercise, as the evaporation of sweat is less efficient, especially under conditions with little or no air movement.

- ✓ As a horse becomes fitter, it expends less heat energy during exercise, and improves its efficiency of heat loss from the skin surface, reducing sweat loss by up to 30%. Up to 30% of the accumulated heat in the muscles, blood and gut contents is eliminated via the highly vascular, large surface area of the lungs as a horse pants after hard exercise.

- ✓ The concentration of sodium, potassium and chloride in sweat increases as a horse sweats more heavily. The concentration of sodium in most feeds is lower than potassium and chloride.

KEYPOINT: Each 1 litre of horse sweat contains approximately 3.7g sodium, 1.4g potassium, 6.2g chloride, 0.75-1.24g protein, 140mg magnesium, 300mg calcium, 25mg phosphorus, 21-24mg iron, 20-21mg zinc, 4mg copper, 0.2mg manganese and small amounts of selenium.

Supplementation with coarse rock salt (sodium chloride) will replace the higher sweat losses of sodium and chloride and maintain water intake in light to moderately sweating horses.

✓ Heavily sweating horses should be supplemented with sources of potassium, magnesium and calcium when worked on a regular basis. Although pasture and hay contain a much higher content of potassium relative to sodium, the speed and degree of depletion of blood fluid (plasma) potassium level during exercise is much greater than the reserve in the blood or the rate of potassium replenishment from digestion of feed.

A potassium source, such as Lite salt (a 50:50 mixture of sodium and potassium chlorides) or potassium chloride, or alternatively a commercial electrolyte replacer containing higher levels of potassium (at least 20% potassium ion), is recommended for heavily sweating horses. This will help maintain fluid and electrolyte acid-base balance and replace lost potassium and chloride, in addition to the sodium and chloride provided routinely in salt.

4.2.3.4 Trace-Minerals and Vitamins

Exercise increases the requirement for many trace-minerals that are involved in metabolism and those depleted by sweat loss. Many B-group vitamins that are essential for the action of metabolic enzymes are also required in increased amounts relative to the work intensity as illustrated in Table 4.5.

		Trace-Minerals			Vitamins		
Type of Work	**Body Weight Kg**	**Manganese Iron Zinc (mg)**	**Copper (mg)**	**Cobalt Iodine Selenium (mg)**	**Vitamin A iu**	**Vitamin D iu**	**Vitamin E Iu**
Maintenance	400	268	67	0.7	12,000	2010	335
	500	328	82	0.8	15,000	2460	410
	600	388	97	1.0	18,000	2910	485
Light Work	400	273	68	0.7	18,000	2051	547
	500	335	84	0.8	22,500	2510	669
	600	396	99	1.0	27,000	2969	792
Moderate Work	400	303	76	0.8	18,000	2275	607
	500	371	93	0.9	22,500	2785	743
	600	439	110	1.1	27,000	3294	878
Intense Work	400	376	94	0.9	18,000	2821	752
	500	460	115	1.2	22,500	3453	921
	600	545	136	1.4	27,000	4084	1089

Source NRC (1989)

TABLE 4.5
Daily Trace-Mineral and Essential Vitamin Requirements for Working Horses ranging from 400 to 600kg body weight

In most cases, the increase in the amount of feed consumed to provide energy for exercise will meet the elevated demands for essential trace-minerals.

✓ Variations in feed levels of copper, zinc and manganese and the possible deficiencies of selenium and iodine in feeds grown in certain localities may be avoided by providing a supplement of these trace-minerals at 50% of NRC (1989) recommended intakes. (Refer to Chapter 6, Table 6.4, page XXX).

✓ The elevated needs for vitamins A, D and E may not be provided by high grain diets that are often inherently deficient in fat-soluble vitamins or where losses during long term storage of feeds reduce their natural content. Supplements of these vitamins are recommended for horses performing moderate to intense exercise. (Refer to Chapter 6, Section 6.3.1, page XXX).

The requirement for B-group vitamins, many of which are involved in metabolic pathways for energy production during exercise, has not been fully established.

KEYPOINT: The hindgut synthesis of B-group vitamins by digestive fermentation may be suppressed on high grain, minimal fibre diets that are fed to horses in hard work and uptake of these vitamins may be further reduced under stress.

✓ The NRC (1989) recommends an increase in vitamin B1 (thiamine) from 2.7 to 4.5mg/kg of dry feed for working horses, although the requirement for vitamin B2 (Riboflavin) remains at 1.8mg/kg dry feed.

✓ Studies indicate that supplementary vitamin B12 (cyanocobalamin) may be beneficial as an aid to improving the appetite of horses on high grain diets. (Refer to Chapter 6, Section 6.1, page XXX).

✓ One survey in Australia by Dr. Malcolm Roberts in 1983 indicated that blood levels of folic acid were decreased in stabled horses as compared to horses grazing pasture, suggesting that folic acid supplements may be beneficial to maintain adequate levels of this vitamin in stabled horses. (Refer to Chapter 6, Section 6.3.1, page XXX).

✓ A requirement for vitamin C (ascorbic acid) has not been demonstrated in horses, even those subjected to intense work. Studies have shown that a dose of more than 4.5g daily was required to increase blood levels in working horses. Feed supplements providing up to 20g of vitamin C daily had no discernible beneficial effect on racing performance or the general well-being of horses in intense training.

4.3 Requirements for Breeding Horses

The impact of inadequate nutrition on the fertility, conception and foaling rate of mares and its influence on subfertility in breeding stallions has received much more attention over recent years.

To provide the breeder with an economic return, a mare at stud should produce a foal in each season she is mated. Although fertility and rate of conception decrease in mares as they age, careful attention to nutrition and a well planned feeding program leading up to breeding will help ensure optimum fertility.

✖ Horse breeders tend to over-feed pregnant mares and stallions relative to their needs and often under-feed dry mares and lactating mares kept under paddock conditions.

✖ The drain of lactation on a marginally under nourished mare with a foal at foot can result in less than optimum fertility and a reduced chance of getting the mare back in foal.

✖ If the drain of lactation on a mare is not compensated for by an increased energy and major nutrient intake, her milk fertility, followed by a reduction in milk production, and finally a loss of body condition will be apparent.

KEYPOINT: The level of nutrition and feeding management has a major influence on the fertility and reproductive success of both the mare and stallion.

✓ A study in south east Queensland by Drs. Jim Gallagher and Neil McMeniman in 1985 and by Dr. Robyn Martin in 1986 indicated that pregnant mares grazing improved pastures containing mixed grass and clover received an adequate intake of energy and protein during the majority of the year.

✖ Dr. Jim Gallagher in an earlier survey concluded that, under seasonal pasture conditions in southern Australia, where pastures dry-off during the late summer and early autumn period, mares are unlikely to obtain an adequate nutrient intake unless they are supplemented with hay or "hard" feed to maintain their condition. Supplementation is also required where low winter pasture growth rates limit the availability of feed.

KEYPOINT: Of all the nutritional factors that influence fertility and maintenance of pregnancy, the adequacy of energy and protein intake is critical to breeding success.

4.3.1 Non Pregnant Mares

Definition:

A non-pregnant mare includes a Dry Mare (not lactating) or a Wet Mare (lactating mare with a foal at foot) that is to be bred again in the current season. In overseas literature, a non-pregnant mare is often referred to as an "open" mare.

Regular evaluation of body condition prior to breeding as well as during pregnancy and lactation is a practical way of matching feed intake to changing nutrient requirements.

KEYPOINT: The use of the standardised Condition Scoring system provides a comparative appraisal and a standard by which to monitor and to maintain optimum condition and breeding success of broodmares.

A method to evaluate and score a horse's body condition, and guidelines for an optimum condition range in breeding and other horses is outlined in Chapter 1, Section 1.4, page XXX.

4.3.1.1 Energy

A maiden mare or a mare in poor condition under semi-drought conditions or an older dry mare most commonly will suffer a shortfall of energy in their diet prior to breeding.

A filly normally begins to cycle by 12-15 months of age provided she has received sufficient energy in her diet to yearling age to reach a "target body weight" necessary to initiate ovarian activity and "oestrus cycles". Studies of young fillies that are bred before 3

years of age show a need for higher energy intake to ensure optimum fertility and meet the needs for growth and pregnancy.

✖ Up to 46% of young mares that are not fully mature will abort their foals before full term if they are not fed enough to meet their total needs.

KEYPOINT: Energy intake and the maintenance of body weight or condition score, are interrelated in stimulating the oestrus (seasonal) cycle, success of conception and the maintenance of early pregnancy in the broodmare.

✖ A dry mare over-wintering at pasture with a less than optimum intake of energy on slow growing pasture, compounded by energy loss under cold conditions, is likely to have a negative energy balance. This will lead to a further loss of body weight, prior to breeding early in spring, particularly if she is already in a thin condition,

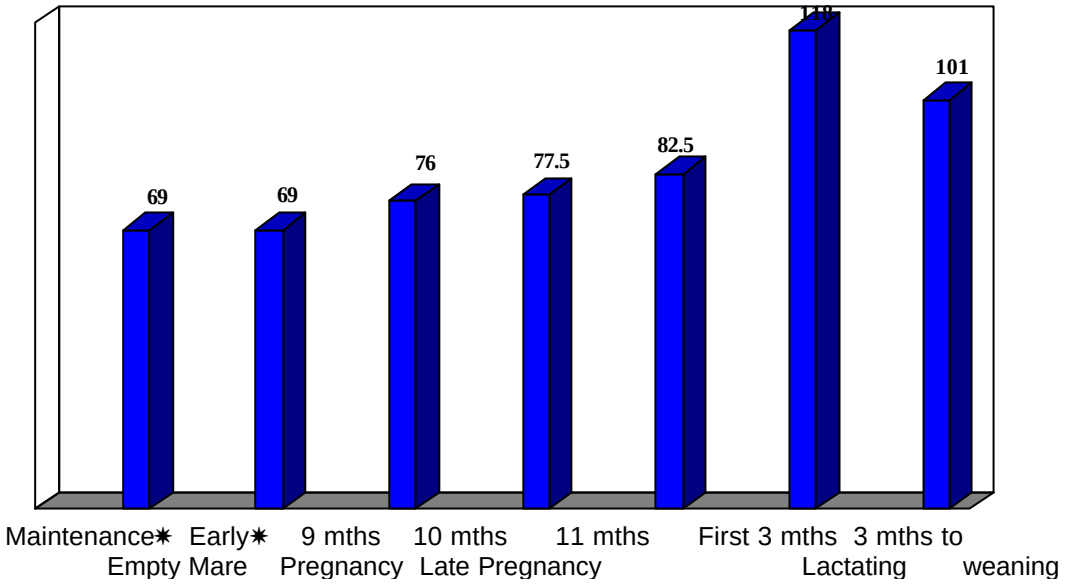
✖ A fat mare that loses weight immediately prior to the breeding season will suffer a delay in the onset of her oestrus cycles with an elongated period between each cycle.

✖ Although a dry mare is classified as requiring an energy intake of feed similar to a resting horse on a maintenance diet, as illustrated in Fig 4.4, feeding to maintain her at a body condition score of less than 2.0 can reduce her overall fertility.

Nutrient	Effect on Fertility	Type of Mare Often Affected
Low Energy	Condition score less than 2.0-2.5 – delayed onset of oestrus cycle, irregular cycles, more cycles to conception, reduced conception rate and less likelihood of maintaining pregnancy.	Maiden mares – poor social adjustment to the herd. Lactating mares in thin condition under drought conditions.
Reducing Energy	Weight reduction in well-fed or fat mares will retard onset of oestrus, and may increase oestrus cycle intervals.	Maiden mares out of race or sport training. Mares as pastures dry off or are grazed off in late summer. Mares during drought conditions.
Increasing Energy	Thin mares put on a higher energy intake – will increase oestrus intensity and regularity, and improve their conception rates.	Thin mares given extra feed starting 4-6 weeks before breeding. Thin lactating mares given extra feed to maintain increasing milk production to lactation peak..
High Energy	Overwintering in heavy condition, or a condition score greater than 4.0. Excess energy intake results in over weight and heavy condition. Shorter time to first season cycle in spring, ovulate earlier when “in season”	Fat or heavy conditioned mares – leave fat mares fat for breeding.
Low Protein	A low protein intake, even with adequate energy, can delay onset of oestrus, lower ovulation rates although the mare may exhibit normal cycle length and “season” behaviour.	Drought conditions. Lush, grass only, pastures in spring without supplementation with lucerne hay or 10-12% crude protein hard feed.

Source: Lewis (1995) Avery (1996) Frape (1997)

TABLE 4.6
Relationship of Energy and Protein Intake to Condition Score and Fertility In Broodmares



Source: NRC (1989)

FIGURE 4.4

Daily Needs of Digestible Energy for a 500kg Empty, Pregnant and Lactating Mare

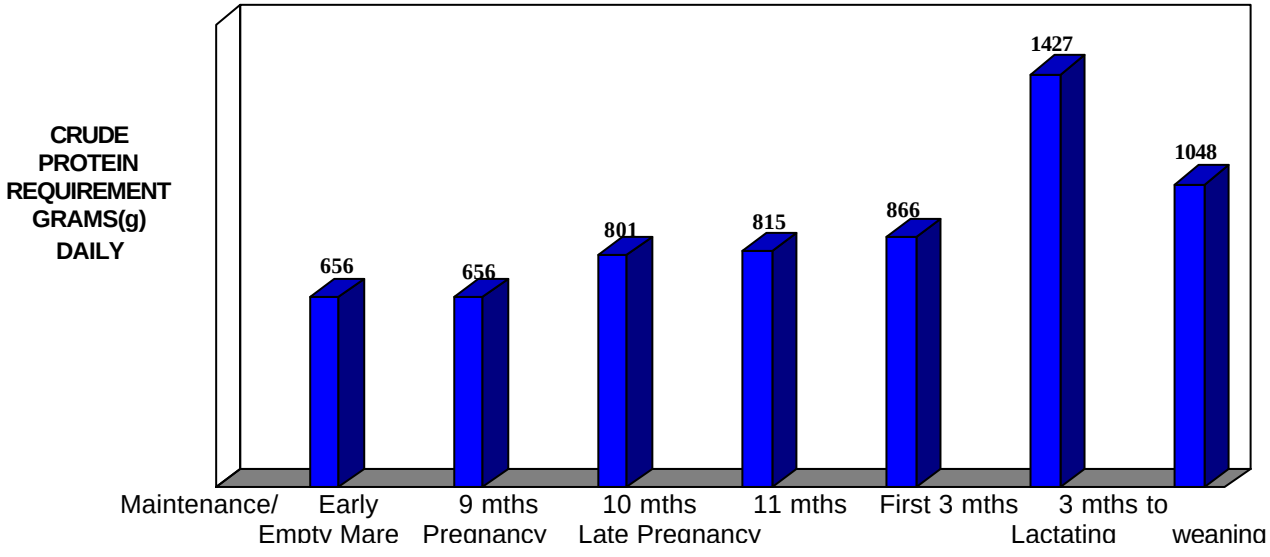
✷ *The energy need of a resting mare and a pregnant mare are similar, but a thin mare must be fed to maintain and improve her body condition score to at least 2.0 before mating. Energy requirement increases during the last 3 months before foaling. Energy requirements are increased by 50% during the first 3 months of lactation. (See also Table 4.7 page XX)*

A summary of the influences of energy and protein intakes on the fertility of mares is provided in Table 4.6.

KEYPOINT: The body condition (Condition Score) of a mare should be monitored during the late autumn and winter period prior to mating so that ideally the mare does not fall below a condition score of 2.0.

☑ If a mare is in poor condition, providing supplementary feed to increase her energy and protein intake will help to improve her fertility and chance of conception, and ensure that she is able to maintain her pregnancy during the first 3 months.

☑ A mare's condition should be evaluated at least 4-6 weeks prior to breeding, and adjustments made to the dietary intake to ensure the mare is receiving an adequate ration to reach and maintain an optimum condition score of 2.0 prior to breeding.



KEYPOINT: A mare in thin condition that is fed to gain weight in the 4-6 weeks prior to breeding has a 60% greater chance of conception than an underfed mare.

4.3.2 Lactating (Wet) Mares to be Bred

4.3.2.1 Energy

The energy and protein drain of lactation in a mare may affect her chances of cycling and conceiving when she has a "foal at foot".

A simple way to remember that an adequate energy intake is essential for optimum breeding performance is that the letter 'E' is in the words OESTRUS, FERTILITY, CONCEPTION, PREGNANCY AND EMBRIONIC HEALTH.

Any mare in thin condition has less chance of getting back in foal as reserves are drained by the onset and increasing demands of lactation.

✖ A mare with a low condition score below 2.0 at foaling is likely to suffer a delay in onset of her oestrus cycles after foaling, exhibit an increased number of cycles per conception, and have a lower rate of conception.

✓ A mare that is in heavy condition (condition score above 3.5) at foaling, but suffers a loss of weight after foaling, will have a similar level of fertility as would a moderate to well conditioned mare (condition score at 2.5-3.5) which maintains or gains weight during lactation.

✖ A thin mare at the peak of lactation between 4 to 10 weeks after foaling has less chance of cycling normally and becoming pregnant, particularly if she missed during the first month after foaling.

The comparative energy needs for pregnant and lactating mares are illustrated in Table 4.7.

Stage of Pregnancy	Digestible Energy		Crude Protein CP		Calcium (Ca)		Phosphorus (P)		Lysine (L)	
	Energy MJ DE* Daily	% Increase over a Resting Horse	CP (g) daily	% Increase over a Resting Horse	Ca (g) daily	% Increase over a Resting Horse	P (g) daily	% Increase over a Resting Horse	L (g) daily	% Increase over a Resting Horse
Non Pregnant	69	-	656	-	20	-	14	-	23	-
First 8 months of Pregnancy	69	-	656	-	20	-	14	-	23	-
Early 9th month of Pregnancy	76	8%	801	21%	35	75%	26	85%	28	22%
10th month of Pregnancy	77.5	10%	815	23%	35	75%	26	85%	29	26%
11th month of Pregnancy	82.5	17%	866	31%	37	85%	28	100%	30	30%
Early Lactation	118	70%	1427	116%	56	180%	36	157%	50	117%

)-3 months										
.ate .actation 3 months to veaning	101	46%	1048	58%	36	80%	22	57%	37	60%
Stallions Breeding Season)	86	23%	820	20%	25	25%	18	29%	29	26%

*MJ DE = Megajoules Digestible Energy

Source: NRC (1989)

TABLE 4.7

Major Daily Nutrient Requirements for 500kg Brood Mare and Stallion (Breeding Season)

KEYPOINT: A thin lactating mare, without reserves, that is not receiving an adequate intake of energy, is likely to suffer a reduction in fertility initially, then in milk production, prior to losing body weight and noticeable condition.

The rate of early embryonic loss in lactating mares bred soon after foaling is around 17%, as compared to 6.3% for non-lactating mares. The high rate of early embryonic loss may be related to the retention of uterine fluids, or influenced by the increased energy and protein demands to fuel increased milk production for the first 6-8 weeks after foaling. Lactation represents a heavy drain on energy stores in thin mares with a condition score below 2.

✓ Overseas studies suggest that weaning the foal at 3 months of age off a thin mare and then providing her with a higher energy ration will greatly improve her chances of getting back in foal in the same breeding season.

✖ Studies in southeast Queensland by Dr. Robyn Martin and Dr. Neil McMeniman in the early 1990's concluded that a mare in thin condition (condition score below 2.0) with a foal at foot at lactation peak about 2 months after foaling may not receive enough energy to maintain optimum fertility and condition, even on good pasture.

KEYPOINT: A mare that foals late in the season onto grazed down or dry pastures must be provided with sufficient supplementary feed to maintain her condition and ensure she has the best chance of breeding, conceiving and maintaining her pregnancy.

The condition of a lactating mare must be monitored regularly. If she is thin or losing condition, then she must be provided with extra supplementary feed, preferably twice daily, to ensure she at least maintains or ideally gains condition to a moderate condition score of between 2.0-2.5 before she is bred again.

4.3.2.2 Protein and Other Nutrients

Generally, if the intake of energy is sufficient to maintain an adequate or rising plane of nutrition in a mare prior to breeding, then the diet will contain adequate protein to meet the needs of a dry mare and a mare during early pregnancy.

KEYPOINT: Feeding a diet containing more than 9% crude protein has no direct benefit in improving the fertility of mares that have an adequate intake of energy.

✖ A low protein diet, which can be a problem when mares are grazed on grass dominant pasture, even with an adequate intake of energy, can delay the onset of oestrus. Subsequent fertility may be reduced by a failure to ovulate, even if the mare exhibits normal cycle length and 'in season' behaviour.

As illustrated in Table 4.7, the energy and protein needs are significantly increased during the last month of pregnancy and for the first 3 months of lactation. An adequate intake of balanced pasture mix containing 60% grass and 40% legumes will generally provide a sufficient quantity and quality of protein without limiting important amino acids for a lactating mare.

KEYPOINT: The quality of protein, related to the lysine and other essential amino acid content, is important in pregnant and lactating mares.

Although an adequate and balanced intake of vitamin A and vitamin E has been shown to be essential for optimum fertility and conception in a mare, especially on dry pastures, supplementation with either vitamin alone unless there is a significant deficiency may not improve the overall fertility of a mare.

Studies have shown that a deficiency of phosphorus, magnesium, manganese, iodine and selenium may reduce the overall fertility in mares at pasture and supplementation with these minerals and trace-minerals may improve the conception rate in grazing mares. However, excessively high phosphorus intakes (at 50g phosphorus/100kg body weight) have been found to cause abortion in mares.

4.3.3 Pregnant Mares

A pregnant mare should be maintained in a condition corresponding to a Condition Score between 2½-3. In most cases, an adequate amount of good quality pasture will meet the needs of a pregnant mare. It is important that she maintains her condition, especially during the critical times of the year in late autumn and over winter when she is in the late stage of pregnancy. Regular monitoring of her condition at 10-14 day intervals with the provision of additional hay or hard feed when required, will ensure she maintains an adequate intake of energy, protein and other nutrients.

KEYPOINT: There is a tendency for owners and breeders to overfeed a pregnant mare with hard feed and hay, even when adequate pasture is available.

In most cases, lucerne hay provides a suitable balance of energy, protein, calcium and other nutrients, although it may be low in phosphorus, to help maintain a pregnant mare in optimum condition during critical times of the year.

The nutritional requirements and management of a pregnant mare is traditionally divided into two stages.

✓ Early pregnancy – conception to 8 months

✓ Late pregnancy – 8-11 months.

4.3.3.1 Early Pregnancy

Generally, during the first 8 months of pregnancy, a mare requires an intake of energy, protein and essential nutrients, equal to a resting horse of similar build and condition. Studies indicate that mares grazing low quality grass based pastures may have a higher rate of early embryonic abortion in the first month of pregnancy. This may be prevented by feeding a higher energy and protein diet, based on lucerne hay, soon after conception. A fall away in condition, particularly in a thin mare and an aged mare, must be avoided.

The comparative requirement for energy and protein during early and late pregnancy and lactation is illustrated in Table 4.7.

✓ Studies have shown that, during the first 3 months of pregnancy, a mare that is not provided with an adequate intake of energy to maintain condition has a higher risk of early embryonic death, compared to a mare kept at a constant body weight during the first 90 days of pregnancy.

✖ A rapid loss of weight in a pregnant mare will retard the growth rate of the embryo and developing foetus and in severe cases, increase the risk of early to mid-term abortion.

✓ A pregnant mare that is in heavy condition (Condition Score of 4.0 or above) can be put onto a gradual weight loss program without affecting the viability or birth weight of her foal after the first 3 months of pregnancy. This can be achieved by reducing the energy content of supplementary feed, while maintaining the bulk and vitamin and mineral level in the ration and the opportunity for daily exercise.

KEYPOINT: A mid-term pregnant mare should not be purposely restricted in feed intake or fed on poor quality feeds that risk vitamin and trace-mineral deficiencies that may lead to abnormal limb development in the unborn foal in an attempt to reduce her condition prior to foaling.

4.3.3.2 Late pregnancy

There is a corresponding increase in the energy, protein and mineral needs, as the unborn foal develops rapidly to double its size and increases its weight by 60% during the last 3 months of pregnancy.

✓ It is important that a mare in late pregnancy is fed so that she can build-up reserves not only in preparation for lactation, but also for re-breeding as soon as possible after foaling. Generally, a small loss of condition in a pregnant mare will not affect the birth weight of her foal at full term.

✓ A heavily pregnant mare grazing slow growing pasture during the winter months, which provides an overall lower intake of nutrients, should be given extra hard feed and hay to ensure she maintains her condition during late pregnancy and especially after she foals.

KEYPOINT: It is best to segregate heavily pregnant mares during the last 3 months of their term from other mares, particularly if pasture intake starts to fall short of satisfying requirements in late winter in southern Australia. These mares may need to be provided with supplementary feed away from other horses to cater for the increased demands of late pregnancy.

✓ An increase in the amount of concentrate and hay of approximately 10% per month from the 8th month of pregnancy will meet the energy and protein needs where pasture supply is limited.

✓ A ration containing 12-14% crude protein, based on good quality lucerne hay, should counteract the lower protein content of unimproved grass pastures, especially during the cold dormant winter months in southern Australia. Providing a higher protein ration may also be of benefit in mares over 15 years of age where protein utilisation may be less efficient.

✓ It is essential to ensure an adequate intake and balance of calcium and phosphorus to meet the increased needs of the rapidly developing foal. (See Table 4.7). Additional calcium will normally be provided by a supplement of good quality lucerne hay sufficient to maintain condition.

✓ Studies by Dr. Ron McKenzie and co-workers in the early 1980's concluded that mares grazing on abundant tropical grass pastures in Northern Australia and Queensland, or lush fertilised kikuyu in subtropical coastal areas in spring, must be provided with a supplement of calcium each day to counteract the calcium binding effect of oxalate chemicals. (Refer to Chapter 7, Section 7.4.7, page XXX).

KEYPOINT: A deficiency of phosphorus may retard the skeletal development of the unborn foal and lower a mare's milk production and fertility after foaling.

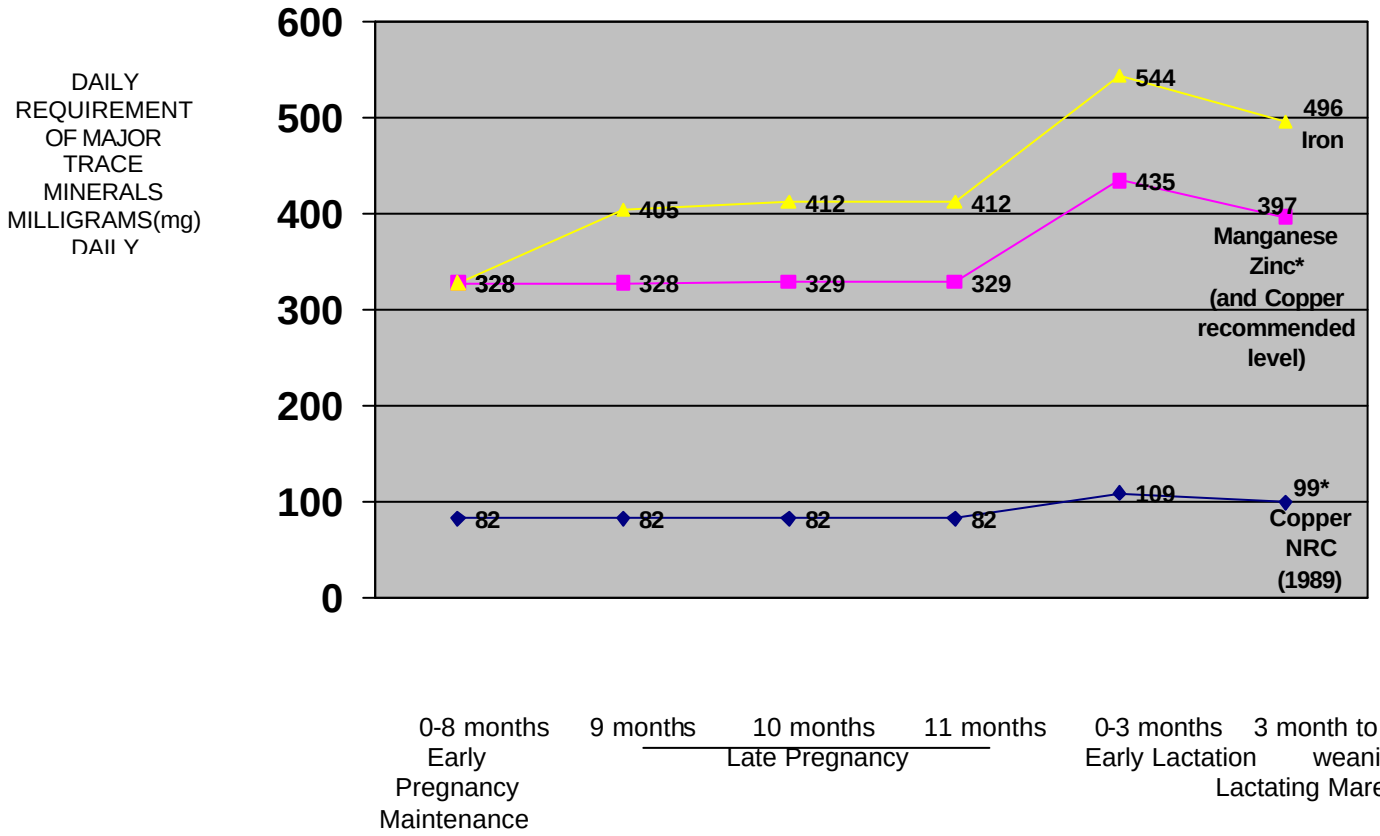
✓ Phosphorus can be provided in part by a grain-based concentrate or both calcium and phosphorus may be supplemented by the addition of 10-15g/100kg body weight of dicalcium phosphate (DCP) to the 'hard' feed mix.

The requirements for trace-minerals in pregnant and lactating mares are illustrated in Figure 4.6.

The increased amount of feed consumed to provide for late pregnancy and lactation will meet the requirements for the majority of trace-minerals, with the possible exception of manganese, copper and zinc. The increased incidence of bone and joint abnormalities over the past two decades, associated with Developmental Orthopaedic Disease (DOD) in newly born foals and growing horses, has led to a recommendation for increased copper and zinc intake in heavily pregnant and lactating mares. Higher supplementary levels added to the mare's feed will ensure that adequate blood levels in pregnant mares are available to the unborn foal. However, supplementation will not increase the normal concentration in mare's milk, which is naturally lower than that needed by the suckling foal.

KEYPOINT: As mare's milk contains insufficient copper and zinc to meet the young foals requirements, it is essential that the foal builds up sufficient reserves during the last 3 months of gestation to meet its requirements during the first few months of life.

Copper and zinc supplementation at 30-50mg per kilogram of 'hard' feed is recommended for pregnant and lactating mares to ensure that marginal deficiencies that are linked to joint cartilage and bone growth abnormalities are corrected. In practice, it is wise to provide a supplement of vitamins and trace minerals if pasture quality and availability falls short of energy and protein needs.



Source NRC (1989)

MAINTENANCE AND EARLY PREGNANCY

The requirements for vitamin A increase by 50% and vitamin D by 199% over maintenance during the last three months of pregnancy.

KEYPOINT: A mare grazing on good quality pasture should obtain an adequate intake of vitamin A from pasture and vitamin D from skin synthesis in the outdoor sun and sun cured hay.

All other major vitamin needs will be met from pasture and a supplement of lucerne hay as required. Feeding at least 500g/100kg body weight of sun-dried lucerne hay daily, or a supplement of 600iu/100kg body weight of vitamin D daily, will help ensure that vitamin D needs are satisfied during pregnancy and lactation.

Exercise

Pregnant mares at pasture will normally self-exercise themselves sufficiently when grazing to maintain adequate physical fitness for foaling. Heavily pregnant mares in the last month prior to foaling will be less active, particularly if they are over-conditioned. Undulating country and separating feed and watering points at opposite sides of a paddock will encourage exercise.

4.3.4 Lactating Mares

Although mares are not selected for their milk production and only have two relatively small milk glands (udders) with limited storage capacity, they produce a volume of milk each day comparative to grazing beef cows. Foals nurse up to 105 times daily for about 1½ minutes at each drink during the first week of life, reducing in frequency to up to 65 times daily as lactation develops, and 35 times daily by 2 months of age. Regular and frequent suckling helps stimulate an increased production of milk to satisfy the foal's demands, prevents overload of the digestive tract and bathes the gut with protective local IgA antibodies against bacterial and other diseases during the first 3 weeks of a foal's life.

KEYPOINT: Milk yield in mares is influenced by the mare's genetic ability for milk production, feed intake during the late stage of pregnancy, and by availability of water and intake of energy and protein during lactation. The growth rate of her foal at foot is relative to the milk yield of the mare.

An adequate supply of good quality water is critical to maintain milk production in mares, especially during hot weather under Australian summer time conditions. Research by Dr. Robyn Martin in South East Queensland has shown that a 500kg mare may drink up to 50 litres or more daily when grazing dry pastures at her lactational peak. Dr. Robyn Martin and co-workers found that Stockhorse foals also consumed up to 4.4 litres of water daily by 6 weeks of age and 5.5 litres daily from 10 weeks to weaning. Under colder Northern hemisphere conditions, observations have found that only 50% of foals drank water up until the time they were weaned.

4.3.4.1 Energy

An adequate intake of energy is essential to maintain milk production and fertility in a lactating mare.

KEYPOINT: Studies by Drs. Jim Gallagher, Neil McMeniman and Robyn Martin in South East Queensland have shown that when there is sufficient pasture to provide an adequate nutrient content; a mare should be able to meet her lactation demand on pasture alone during mid spring to early summer periods under Australian conditions.

In many cases, the grazing lactating mare, especially one that foals late in the season when pasture is drying off, is often underfed in relation to her needs for energy, protein, calcium, phosphorus and vitamin A in early lactation as milk production peaks between 4-10 weeks after foaling.

Theoretical Need
Mares under 300kg **28-29 MJ DE per 100kg body weight daily.**
Mares between 300-900kg **21-24MJ DE per 100kg body weight daily.**

Each litre of milk produced daily requires 3.3MJ DE to be consumed by the mare and each litre of milk provides the foal with about 1.8 MJ DE.

The relative increase in energy need after foaling is illustrated in Table 4.7.

KEYPOINT: A lactating mare at the peak of lactation at 4-10 weeks after foaling requires about the same amount of energy, but a higher protein, calcium, phosphorus and Vitamin A intake each day, as a similar sized horse performing moderate to intense work for up to 60 minutes daily.

Practical Guidelines

✓ A lactating mare should receive an adequate intake of energy to maintain a fleshy to good condition score of 2½-3.0. The total energy intake must provide energy to ensure optimum fertility and best chances of getting back in foal, produce an adequate supply of milk to feed her foal, as well as meet the increased expenditure during exercise when she has a foal at foot.

A lactating mare may produce up to 4% of her body weight equivalent as litres of milk each day at the peak of lactation (or about 18-20 litres in a 500kg mare) and consume up to 3-3½% of her body weight in dry feed (or about 15-17½ kg feed in a 500kg mare) when pasture is poor.

✓ Where there is limited grazing, a ration containing 30-33% roughage, and 65-70% concentrate feed may be required to meet energy and other nutrient needs at peak of lactation (Refer to Chapter 5, Table 5.4, page XXX).

KEYPOINT: The condition of a lactating mare should be monitored at weekly intervals and supplementary hay or hard feed provided if necessary to maintain her condition, especially as the pasture dries off or is grazed down.

4.3.4.2 Protein

KEYPOINT: A lactating mare requires a diet containing adequate energy and between 10-12% crude protein to meet the elevated needs of milk production.

✓ Research in Queensland by Dr. Robyn Martin and co-workers in the late 1980s indicated that a lactating mare can produce an adequate volume of milk on an ad lib diet containing 9% crude protein, provided she consumes enough energy from pasture and hay supplements to meet her requirements.

The quality of protein in the diet can affect the protein content of a mare's milk. An increase in milk protein occurs when higher quality soyabean protein constitutes 50% of the protein intake, with a corresponding increase in the growth rate of suckling foals.

However, supplementing with an excessively high protein concentrate feed above 24% crude protein may reduce pasture intake in grazing mares. It was also shown that mares and growing foals grazing mature grass based pasture may receive adequate energy, but may be marginally deficient in protein, including the amino acid threonine, to satisfy the needs of heavy lactation and growth.

KEYPOINT: A diet containing less than 8% crude protein in a mare grazing grass dominant pasture can result in a 20% lower body weight of her foal at three months of age.

Under late spring and summer conditions in Southern Australia, good quality lucerne hay or chaff as a roughage base to a daily 'hard' feed provides 15-17% crude protein to boost protein intake in heavily lactating mares. Although lucerne is lower in essential amino acids than oil seed meals such as soyabean and canola meal, in the amounts fed, it helps make up the major shortfalls of lower protein pastures as they dry off in late spring and summer. Lucerne contains 8g/kg of threonine, or roughly half that in the common oil seed protein supplements, such as soyabean and canola meal. (Refer to Chapter 3, Table 3.5, page XX).

✓ An intake of 0.75kg/100kg body weight or more of lucerne hay daily will satisfy the needs of threonine and many other essential amino acids in mares grazing on grass dominant pastures.

KEYPOINT: As a guideline, any supplementary 'hard' feed given to a lactating mare to maintain her body weight, when pasture intake falls short of needs, should contain 12-14% crude protein to meet protein and amino acid requirements.

4.3.4.3 Minerals and Vitamins

There is limited information available on the effects of low or inadequate intakes of mineral or vitamins on fertility and breeding performance of mares. A dietary deficiency of phosphorus, as well as manganese, iodine and selenium has been associated with less than optimum fertility in breeding mares. The requirements for important trace-minerals are illustrated in Figure 4.6 and in Table 6.2 in Chapter 6.

The major minerals of calcium, phosphorus and the trace-minerals copper, zinc and manganese have been identified as essential nutrients required in the ration of heavily pregnant and lactating mares to ensure optimum bone and joint cartilage development in unborn foals and young growing horses.

A survey of studs by Dr. Ivan Caple in Victoria in the early 1980's found that calcium and phosphorus was not provided in adequate amounts during winter and spring when low calcium grasses dominated the pasture mix. Supplementary calcium and protein, either as good quality lucerne hay, or in a hard feed, should be provided under these conditions.

Dr. Ron McKenzie and co-workers concluded that broodmares grazing tropical grass pastures in Queensland or fertilised, rapidly growing kikuyu grass in temperate areas, will require supplementation with calcium and phosphorus, particularly during late pregnancy and lactation when mineral requirements are elevated. High oxalate levels in these pastures inhibit calcium uptake. (Refer to Chapter 7, Section 7.4.7, pages XXX).

4.3.5 Stallions

Under the warmer southern hemisphere and Australasian seasonal conditions, stallions are usually turned out to pasture during the non-breeding season and then more intensively fed and managed when being used on a regular basis during the breeding season.

4.3.5.1 Non Breeding Season

A stallion should be fed to maintain a fleshy to moderate condition, (condition score 2-2½) for most of the year.

Access to pasture may need to be restricted if a stallion is becoming too heavy in condition (above a condition score of 3 – 3 ½), particularly in pony stallions and their crossbreds that are prone to developing laminitis when grazing abundant lush spring or autumn flush pastures.

KEYPOINT: The condition of a stallion turned out onto pasture should be evaluated on a regular fortnightly basis during the "off season" when he is not breeding, so as to avoid extremes of condition.

Supplementary feed, as good quality hay or limited amounts of hard feed, should be provided relative to the amount and quality of the pasture. As stallions are usually kept as solitary animals in an allocated pasture, feeding management is much easier to control than for groups of horses in which the competitive "peck-order" can have a significant influence on a horse's intake.

Stallions must also be provided with an opportunity to exercise, either as free-range paddock exercise when grazing, or controlled lungeing or walking exercise to help maintain fitness and a suitably conditioned physique during the off-season. Any loss of condition will need to be regained before the start of the breeding season otherwise the stallion's fertility and libido may be less than optimum.

KEYPOINT: The nutritional needs of the non-working stallion will be satisfied by a diet suitable for a horse in very light work, with regular appraisal of condition and assessment of fitness and supplementation with hay or 'hard' feeds relative to the seasonal conditions.

4.3.5.2 Breeding Season

A working stallion has similar nutritional needs to a horse in light to moderate work and should be fed to maintain a fleshy to good body condition, complemented by a reasonable degree of physical fitness without an excessive and tiring exercise program. An adequate and balanced diet, based on good quality roughage, is important to maintain optimum fertility, vitality and libido (serving vigour) in the working stallion.

KEYPOINT: Over feeding a stallion is a common practice that can adversely affect his libido, reduce his lifespan, and increase the risk of colic and laminitis.

✓ An adequate level of energy must be given to maintain vitality and body condition, ideally between a fleshy to good condition. (Condition score 2½-3.0).

✖ An excessively overweight stallion is likely to suffer from reduced libido and, while maintaining sexual interest, may be reluctant to mount and serve mares.

✖ An overly fat stallion will also feel the effects of hot weather and may tire more easily when required to serve 1 or 2 mares on a daily basis late in the breeding season under Australian summer time conditions.

✖ An over fed stallion may also become "over energetic" and with his weight and strength, become difficult to handle if he is not given light exercise on a regular basis.

KEYPOINT: The condition of a stallion should be evaluated about 4-6 weeks prior to the start of the breeding season and, if he is in a less than optimum condition, he should be fed on a rising plane of nutrition to meet the desired condition standard.

When a stallion is not serving mares on a regular day to day program, then the amount of concentrate must be cut back by 20-30% and the bulk made up with good quality chaff or hay.

KEYPOINT: There is no benefit to fertility, ability to maintain sperm counts or libido in providing a diet containing more than 16% crude protein to a working stallion. An adequate energy intake to maintain body condition and vitality is much more beneficial in maintaining libido, sperm counts and motility and serving vigour than a high protein diet.

✓ Stallions must be provided with an adequate intake of minerals and vitamins, especially calcium for older stallions or when lucerne hay is restricted, as well as vitamin A, vitamin D and perhaps vitamin E for stallions fed on dry feeds or dry lucerne based diets with little opportunity for paddock grazing.

KEYPOINT: A working stallion should be maintained in a physically fit condition, without being over-exercised during the breeding season.

Studies indicate that an excessively tiring exercise program may have an adverse affect on a stallion's serving efficiency. A tired stallion may have reduced serving libido and less sexual interest in mares.

A program of careful feeding and regular appraisal to avoid excessive condition, complemented by regular light exercise, such as controlled exercise at the slow trot on the lunge for 5-10 minutes twice weekly relative to the stallion's fitness and serving frequency, will help maintain adequate stamina and vitality during the breeding season.

✖ A stallion that has access to pasture may tire himself "running the fencelines" in search of, or at the sight of, mares. He may also lose condition and risk fence injuries and damage to joints and limbs.

If a stallion is "running with the mares", he will usually only exercise himself as the need arises when individual mares come into season.

4.4 Requirements for Growing Horses

The nutritional needs of growing horses have been a focus for research over the past two decades. These studies have provided better guidelines with which to formulate rations to achieve optimum growth and steady controlled development in athletic breeds of horses.

✖ Overfeeding, in an attempt to produce well grown young horses in good condition for sale, and with sufficient development for training as 2-3 year olds, can lead to rapid growth rates. This has been associated with an increase in limb abnormalities and unsoundness of young horses.

KEYPOINT: The combination of adequate, rather than excessive nutrition, and opportunity for free exercise each day are the two most important factors that influence limb development and soundness in young horses.

The growth phases of a young horse can be divided into 3 main stages relative to its age and body development.

1. The foal from birth to weaning
2. Weaning to yearling age
3. Yearling to 18 months of age.

4.4.1 Foal-Birth to Weaning

It is important that a newly born foal receives an adequate intake of colostrum of at least 750-1000mL/100kg body weight during the first 12-16 hours of life. Colostrum provides both essential antibodies to give the foal immunity and protect the developing gut against infection during the first 2-3 weeks of life, as well as energy, protein and other nutrients to meet its needs during the first few days of life.

It is beyond the scope of this book to include recommendations for feeding colostrum or for the nutrition and care of an orphan foal. A number of books, listed in the suggested reading section at the end of this book on page XXX, provide practical reviews and recommendations or your local equine veterinarian can be consulted.

KEYPOINT: The growth rate of a young foal can be monitored by the increase in body weight, height at the withers and overall development of body proportions.

When consuming an adequate amount of milk and grazing to meet its needs, a foal will double its birth weight in the first month, and double it again by 3 months of age. After 6 months, usually at about the time of weaning, the growth rate slows down until adult body weight is achieved by 4½-5 years of age, relative to the breed. Pony breeds normally mature 6 months earlier than light horse breeds and warmblood horses. Draught horses reach adult proportions by 5½-6 years. The average daily body weight gain and growth rate relative to age are illustrated in Figure 4.6 for a growing horse maturing to 500 kg body weight.

4.4.1.1 Energy and Protein

Mare's milk contains sufficient energy, protein and other major nutrients to meet the needs of the young foal during for the first 4 weeks of its life. The growth rate of the foal is dependent on the milk yield of the mare during the first 2 months of life.

KEYPOINT: A light horse foal maturing to 450-500 kg body weight requires approximately 9 kg milk for each kilogram increase in body weight at 7 days of age, 13 kg at one month of age and 15 kg at 8 weeks of age. These intervals correspond to the peak of lactation of a mare.

Studies by Drs. Robyn Martin and Neil McMeniman in Queensland found that thoroughbred and stockhorse sized foals drank up to 18 kg of milk daily and required an intake of 16.4 kg of milk per kg of liveweight gain at 8-10 weeks of age. They also drank 5.5 litres of water daily at 10 weeks of age.

After Lactation Peak

After the peak of lactation, which occurs from 4-10 weeks after foaling, the energy and protein content in a mare's declining milk production is unable to meet the foal's needs for growth, although adequate calcium, phosphorus, trace-minerals and vitamins will normally be provided in the milk.

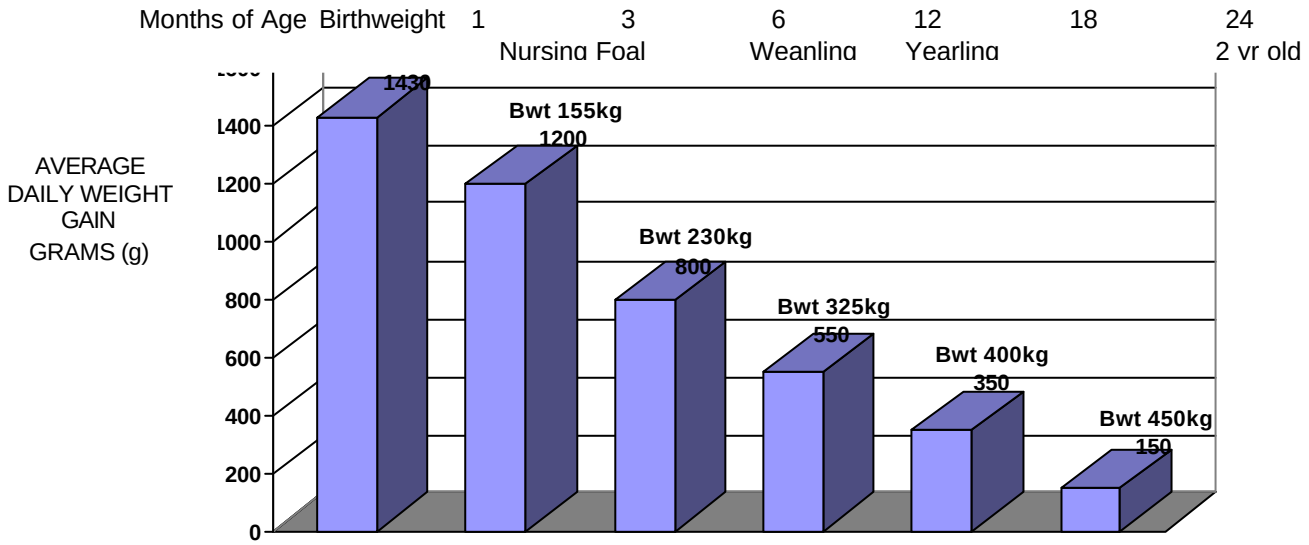
KEYPOINT: Good quality green pasture, containing 9-10% Crude Protein on a dry matter basis, will help make up the shortfall in energy and protein as growth needs in a young foal exceeds that supplied by milk.

As pastures dry off, or are grazed down in early to late summer, the studies in Queensland indicated that a supplementary concentrate feed was necessary for both the mare and her foal to enable the young foal to maintain an optimum rate of growth. This need would apply to other areas of Australia when pastures become less productive during the summer months.

Studies by Dr. Robyn Martin in Queensland have shown that a supplementary creep feed, containing 16-18% crude protein (with an energy density of 13-14MJ/kg, in a pelleted feed, or a mix containing crushed or extruded grains), will make up shortfalls in energy and protein intake required by young growing foals. The concentrate should contain at least 20-25% by weight of a high quality protein meal, such as soyabean, canola meal, or skim milk powder for young foals to meet protein, lysine and other essential amino acid requirements for growth. (Refer to Chapter 5, Table 5.2, page XXX).

KEYPOINT: A 12-14% crude protein feed based on pellets, crushed or extruded grains to a mare and her foal to share, will help to meet the increased nutritional demands of the foal as milk production by the mare declines towards weaning time.

The higher energy content of the supplementary ration will also help ensure the mare maintains an optimum body weight and the chances that she will be able to breed and support the critical 90 days of early pregnancy. Any weight loss caused by the drain of lactation must be avoided, particularly during mid to late summer when pastures dry off.



Source: Hintz (1978)

FIGURE 4.7

Average Daily Weight Gain and expected Bodyweight relative to age for a Foal Maturing to 500kg Adult Weight

4.4.1.2 Other Nutrients

It is important to evaluate and monitor a foal's rate of growth and development to achieve an optimum and steady, rather than a maximum or rapid rate of growth. The incidence of limb deviations and enlarged growth plates on joints associated with Developmental Orthopaedic Disease (DOD) is largely influenced by diet and exercise in the young growing horse from 3 – 9 months of age. (See DOD glossary term).

KEYPOINT: Controlled feeding of a diet containing adequate, but not excessive, energy, good quality protein and balanced mineral and trace-mineral intake, complemented by the opportunity to exercise daily, in the period from 3 months to yearling age, is essential to avoid limb abnormalities.

- ✖ Selenium deficiency in young foals prior to weaning that are grazing on selenium deficient pastures can result in White Muscle Disease, which is characterized by poor muscle development, weakness and inability to exercise normally. (See Glossary term).

KEYPOINT: A plentiful supply of clean, good quality water must be provided for mares and nursing foals under warm conditions.

Dr. Robyn Martin and co-workers in studies in southeast Queensland, found that under hot, humid conditions, foals will consume almost 4 litres of water daily at 6 weeks of age and 5.5L at 10 weeks of age. A supply of good quality water, located in a suitable safe and low trough to allow foals to drink, is important under warm Australian conditions. In colder overseas countries, observations indicate that only 50% of foals drink water on a regular basis before weaning.

4.4.2Weanling to Yearling Age

At weaning age, a young horse should have achieved almost 50% of its mature body weight and reached 85% of its height at the wither.

The majority of young horses maturing to 500kg mature weight should have an Average Daily Gain (ADG) of about 800g at weaning age, decreasing to 550g by yearling age, as illustrated in Figure 4.6. An ADG above this range, promoted by an excess intake of energy, in conjunction with a deficiency of key trace-minerals, can increase the risk of limb abnormalities associated with Developmental Orthopaedic Disease.

4.4.2.1 Developmental Orthopaedic Disease

Over the past 20 years, there has been concern over the high incidence of bone and joint disorders in growing foals and weanlings. These include skeletal abnormalities such as acquired angular limb deformities (bent legs at the knee or hock), epiphysitis (enlarged joint growth plate regions with "big knees" or "apple joints") and cervical vertebral malformation ("wobbler" foals and weanlings) due to abnormal bone growth plate development of long bones, formation of poor quality cartilage on joint surfaces, and lack of adequate calcification and strength of bones. (See Glossary term).

KEYPOINT: The highest incidence of DOD related limb abnormalities that affect the future soundness of a young horse occur from weaning age onwards.

There are many predisposing causes that can increase the risk of DOD, which have been classified into

- ✖ Low risk factors (including growth rate and body size, mechanical stress and injury)
- ✖ Medium risk factors (associated with genetic and hormone influences and joint infection)
- ✖ High risk factors (caused by excess dietary energy and protein, imbalanced or inadequate calcium phosphorus and trace mineral nutrition and exercise).

KEYPOINT: The High Risk Factors that predispose to DOD are related to nutrition and exercise, both of which are influenced by the feeding and paddock management of young growing horses.

A full discussion of the predisposing factors and recommendations for reducing the risk of DOD are included in the RIRDC publication by Janine Aldred (See Suggested Reading List, page XXX).

Extensive overseas and Australian research by Dr. Kate Savage of Melbourne University in the late 1980's indicated that the nutritional influences that increase the risk of DOD are associated with a combination of a number of inter-related factors, which include:

- ✖ Excessively high energy intakes rather than too much protein in the diet.
- ✖ Low calcium, high phosphorus, low copper and high zinc intakes.
- ✖

High energy intakes with low calcium, high phosphorus, or vice-versa.

✖ Low copper, either in the diet, or induced by high calcium or high zinc intakes.

✖ Low zinc, low manganese and low copper may all contribute individually, or in combination, to increase the risk of DOD in young growing horses.

The research in Australia by Dr. Kate Savage indicated that from weaning onwards, energy intakes of greater than 128% of the NRC (1989) recommended levels, combined with high phosphorus, low dietary copper and zinc and an excessively low or high calcium intake can increase the risk of DOD limb and joint disease.

The mineral and trace-element content of the diet, including calcium, phosphorus and magnesium for bone development, copper; zinc and manganese for cartilage formation, iodine for metabolic control and selenium for optimum muscle development, must be adequate and balanced to achieve optimum development whilst ensuring a minimal risk of DOD lesions.

Ensuring a young growing horse has an opportunity for self-exercise for a minimum of 2 hours each day will reduce the incidence of DOD, even when fed a ration that is imbalanced, but not deficient, in major nutrients.

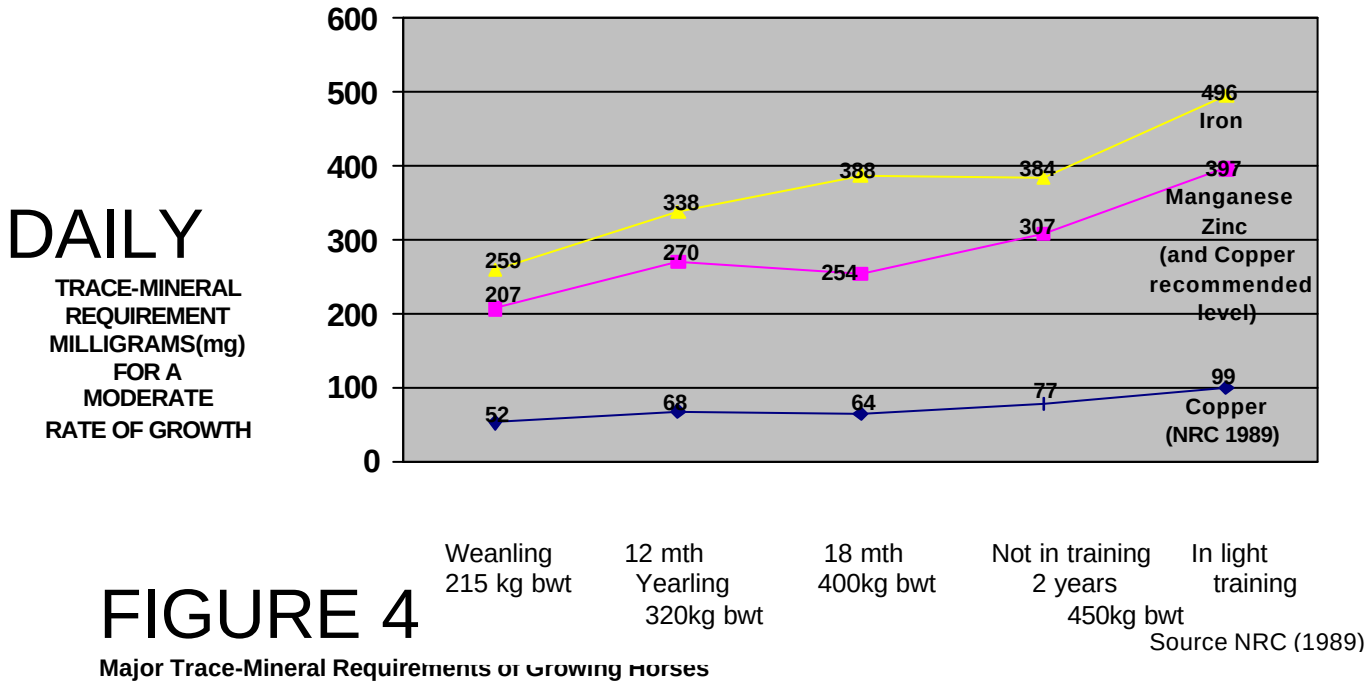
Recommendations for dietary intakes of minerals, trace-minerals and Vitamins A, D and E in growing horses are given in Chapter 6, Table 6.2 and 6.3 on page XXX.

KEYPOINT: To minimise the risk of DOD in young growing horses, their diet should:

- promote an optimum, steady growth rate;
- contain adequate, but never excess energy;
- contain the correct calcium:phosphorus ratio (1.2-2.0 parts Ca: 1 part P);
- maintain an adequate intake and balance of the trace-minerals copper, zinc and manganese, as well as sufficient iodine and selenium.
- Young horses must be given the opportunity for free exercise for at least two hours daily.
- Avoid breeding from mares or stallions that have produced a number of DOD affected foals.

4.4.3Yearling to 18 months

The growth rate and therefore the demands on a body weight basis for energy, protein, lysine and other nutrients, are reduced once a young horse reaches the body proportions and 80% of the adult level of development at or soon after yearling age.



Source NRC (1989)

FIGURE 4

Major Trace-Mineral Requirements of Growing Horses Maturing to 500kg body weight

Most horses in this age group can meet their demands from pasture in the spring following their birth and during the summer period in summer rainfall areas. If pasture is inadequate, then good quality lucerne hay will be able to satisfy the energy and protein needs to supplement grazing. Where yearlings have had a setback, or are being produced for sale, then the proportion of concentrates may be increased to provide up to 45% of the total daily intake. However, the mineral balance of calcium to phosphorus, and the trace-element requirements for copper, zinc and manganese, including iodine and selenium, must still be satisfied to ensure development of sound bones and joint cartilage.

KEYPOINT: The risk of DOD related bone and joint problems is reduced from yearling age onwards, but excessive growth targets with oversupply of energy and/or trace-mineral deficiencies can still have an influence on soundness of young horses in early training.

4.5 Summary

Horses require an adequate, palatable and balanced diet with sufficient bulk to satisfy their appetite and meet their specific needs relative to exercise, growth or reproductive demand.

- ✓ Resting and lightly worked horses can meet their needs from pasture for the majority of the year, with supplements of good quality hay to make up shortfalls when pastures are slow growing or dried off and are inadequate to meet dietary requirements.

- ✓ Once a horse is required to expend more energy during training and in competition, it may not be able to consume sufficient bulk to meet its needs and the energy and nutrient density of the ration must be increased by providing grains and other concentrates relative to its specific requirements.

- ✓ Generally, if adequate energy is provided to maintain condition and exercise capacity, diets based on grains, with lucerne hay or chaff, will provide sufficient protein to meet the elevated needs of exercise.

- ✓ Working horses require an adequate and balanced intake of calcium, phosphorus and electrolytes, as well as trace-minerals such as iron, manganese, iodine and selenium, and essential fat soluble vitamins A, D and E, with increase in requirements relative to the intensity and duration of exercise.

- ✓ Body Condition Scoring is a practical and standardised method of appraising condition to help ensure optimum fertility and reproductive success in broodmares and stallions.

- ✓ Breeding mares must be fed to maintain a fleshy to moderate condition to ensure optimum fertility and maintenance of early pregnancy. Thin mares should be fed on a 'rising plane' of nutrition, starting 4-6 weeks prior to breeding, to improve their chances of fertile cycles and conception when bred.

- ✓ Mares in late pregnancy should be fed to achieve a moderate condition score and to provide extra nutrients in the last month of pregnancy to meet elevated needs and ensure adequate reserves prior to lactation. An adequate intake of calcium and phosphorus, complemented by the trace-minerals copper, zinc, manganese, iodine and selenium may need to be provided in a supplement to ensure optimum birthweight and sound musculo-skeletal development in unborn foals.

- ✓ The peak of lactation in a mare occurs from 4-10 weeks after foaling. Mares, at this stage, can consume up to 3% of their body weight in dry feed. This must contain adequate energy and other nutrients to meet the requirements for lactation, maintentance of condition and to ensure that the mare can be bred successfully in the same season.

- ✓ Young foals have a rapid rate of growth which, after one month of age, cannot be sustained by milk alone. Shortfalls must be made up by pasture or hard feeds, depending on the quality, availability and suitability of the grazing pasture.

- ✓ The most critical time in a young horse's growth and development is from 3 to 9 months of age, during which any shortfall or imbalance in mineral or trace-mineral nutrition or an over-supply of energy or restriction of exercise will increase the risk of limb abnormalities and unsoundness.

- ✓ The diet of a growing horse must contain energy and protein levels, which will promote optimum, <u>but never excessive,</u> rates of growth. In addition, it should provide a balanced intake of calcium and phosphorus, critical

trace-minerals including copper, zinc and manganese for cartilage growth and iodine and selenium for muscle and tissue development.

☑ Young horses must have the opportunity for at least 2 hours free paddock exercise on a daily basis.

CHAPTER 5

FORMULATING RATIONS

Horses in Australia are kept under a variety of feeding and management systems, ranging from full time pasture grazing to being stabled and fed on grains and chaff (hard feeds) with long stem roughage as hay.

KEYPOINT: The majority of resting, growing, breeding and lightly worked stock and pleasure horses can be kept outdoors, relying on pasture as their main feed source to meet their energy and other nutrient needs for the greater part of the year.

Over recent years, supplementary feeding of horses with prepared mixes, chaff and hay has become a widespread practice. This has led, in many cases, to pastures being under utilised as a valuable feed source for horses. The increase in numbers of horses being kept on small semi-urban areas has expanded the need to hand feed for a significant part of the year in order to preserve limited areas of pasture and prevent overgrazing. There is also a trend towards feeding complicated mixtures containing a number of ingredients, when more simple formulations would easily meet a horse's needs.

There are 5 broad categories related to the feed type and management system that influence the need to formulate and provide additional supplementary rations to meet nutritional requirements.

The major categories for formulating rations are outlined under the following sections:-

5.1 Resting and Lightly Worked horses reliant on pasture
5.2 Lightly and Moderately worked horses on pasture with supplementary feeding
5.3 Breeding horses on pasture with supplementary feeding
5.4 Growing horses on pasture with supplementary feeding
5.5 Stabled or confined horses on hard feed without access to pasture.

5.1 Resting and Lightly Worked horses reliant on pasture

If possible, horses should be kept at pasture as this is their preferred and natural feed source. In Australia, the majority of retired horses, horses resting from training, breeding mares, growing horses and ponies are predominantly pasture fed.

Horses that are turned out to pasture without regular work and training demands, including many adult horses used for stock work, weekend pleasure riding or pony club activities, should be able to meet their needs from grazing. Supplementary feeding may only be required to maintain body weight and work capacity during critical periods of the season when pasture production falls short of providing the total bulk and nutrient needs.

The common seasonal variations that result in variable feed availability (as a "feast or famine") under Australian conditions are summarised in Table 5.1 and illustrated in Chapter 7, Figure 7.2 and 7.3 on pages XXX and XXX).

Pasture **Productivity/ Availability**	**Seasonal Conditions, Yield and Quality and Locality**	**Type of Nutritional Stress on Grazing Horses and Supplementary Feed Type**
Short, succulent pastures dominated by unfertilised winter growing grasses	Wet cold late autumn and winter conditions. Low yield and variable quality pasture. Southern states and southern highlands.	**- Semi feast -** High water content and reduced bulk to satisfy appetite and gut fill. Good quality hay will usually make up dietary shortfalls.
Short, slow growing pastures – all pasture	Dry, cold winter conditions. Low yield but quality generally	**- Semi famine -** Low bulk to satisfy appetite.

species	good on available pasture. Winter period in most southern localities.	Good quality hay and minimal concentrates may be required for breeding, growing and working horses.
Semi-lush, fast growing pasture – ideally balanced between grasses (70%) and legumes (30%).	Warm early autumn, spring and summer conditions with adequate moisture. High yield and high quality of pasture. Warmer weather in most states when the rainfall is adequate.	**- Feast -** Adequate bulk and energy for full-time grazing. May have to limit access to avoid weight gain in all horses, limb abnormalities in growing horses, and laminitis or founder in horses and ponies. No supplementary feeding is usually required. Pasture may need to be slashed to maintain in optimum phase of growth and maintain quality.
Dry, mature pastures	Late summer or dry autumn conditions in most states. Fibrous, mature and less digestible plants reduce quality and utilisation.	**- Semi-famine -** Bulk intake adequate but quality reduced. May need concentrates to boost energy, protein and mineral intake in breeding and growing horses.
Dry, short or grazed out pasture – mini-drought periods, hot dry summer conditions in low summer rainfall areas	All localities under dry summer conditions, or unseasonally dry conditions. Low yield and low quality dry pasture. Heavy rainfall on dry grass stands can rapidly reduce quality and quantity. (Most of southern Australia).	**- Famine -** Low bulk, poor quality and risk of overgrazing and stress on pasture. Supplementary hay and concentrates – may need to hold horses in smaller areas to prevent widespread overgrazing. Higher risk of sand colic when pasture is short on sandy soils.

Source: Avery (1996)

TABLE 5.1

FEAST OR FAMINE PERIODS
Horses on Dryland Pastures in Australia

KEYPOINT: Supplementary feeding with hay or with minimal amounts of prepared or "hard" feed may be required during the critical times of the year when pasture growth is limited, or of poor quality, to meet the total requirements of the pasture fed horse.

✓ The highest nutritive values are present in early growth or regrowth pasture, with a reduction in energy, protein digestibility and phosphorus content as plants mature.

✖ Do not allow pastures to be eaten down to ground level, which then allows weeds to dominate and increases the risk of soil damage and erosion.

Often horses on semi-rural and grazing properties have to compete with sheep or cattle for available pasture.

Both horses and sheep graze close to the ground, so horses sharing a pasture with sheep may be disadvantaged under more competitive conditions when there is reduced pasture growth or availability.

Cattle tend to eat the longer, less palatable and more mature plants selectively avoided by horses, whilst horses concentrate on the shorter pastures that they are able to harvest on their selected grazing areas.

KEYPOINT: Horses may require supplementary feeding at a much earlier time when grazing with sheep than when sharing pasture with cattle.

Pasture walks, at regular 7-10 day intervals, are useful to evaluate and monitor the height and maturity of the pasture stand and the grazing pressure that the horses are placing on their preferred grazing areas. Once horses are confined to a pasture for a period of 2-4 weeks, the available grazing area must be monitored more carefully because their selective grazing habits start to create "lawns" and "roughs" . (See Glossary term).

✖ Often with months of set grazing, up to 50% or more of the grazing area can be lost to roughs, bare areas and camping areas, depending on the stocking rate, the type of pasture and its resistance to grazing and the seasonal conditions.

KEYPOINT: Regular appraisal, at 7 – 10 day intervals, of a horse's body condition along the ribs and backline as well as comparative belly size will help monitor the adequacy of the energy intake and relative bulk the animal is consuming. The Optimum Body Condition Score for a working, breeding and growing horse is given in Chapter 1, Table 1.3, page XX.

5.1.1 Conditions of plentiful pasture

Under ideal warm seasonal conditions with adequate moisture pasture, a well covered grazing pasture will normally provide excess energy and bulk. A resting or lightly worked horse or pony, grazing on plentiful pasture, is likely to gain body condition and develop a "grass belly" from the high bulk consumed.

KEYPOINT: Pastures growing at a rate faster than the horses can harvest and maintain in an active growth phase may have to be slashed or rotationally grazed to maintain optimum growth, competition and vigour and delay maturity by encouraging regrowth under suitable conditions. (Refer to Chapter 7, Section 7.4.4, page xx)

✖ When grazing rapidly growing, high yield grass and legume pastures, many ponies and their crossbreeds that are 'good doers' are prone to developing laminitis and the more serious internal structural damage within their hooves associated with founder.

KEYPOINT: The danger periods for laminitis are early to mid spring, or during a wet warm autumn following a summer dry period, when the combination of warm weather, suitable day length and moisture levels encourages rapid regrowth of a previously dormant or heavily grazed pasture.

Resting horses and in particular, cresty ponies at pasture should be managed during 'flush' or 'feast' periods so they only have access to pasture sufficient to maintain a moderate to good condition (Condition Score 2 ½ - 3). Grazing may need to be restricted by removing them from the pasture overnight and providing a small quantity of hay in a yard to keep them occupied. Light exercise under saddle or by lungeing will also help to reduce excess weight and maintain fitness.

✖ Rapid spring regrowth of pasture that has been slashed to curb weeds or even out "roughs" can also become a high-risk grazing area within 7-10 days under suitably warm and moist conditions. A nitrogen or other fertiliser blend applied after slashing will promote rapid pasture regrowth under ideal moisture conditions.

✖ Horses hungry for a green pick will often consume excessive amounts of laxative, lush pasture, with a high soluble starch and sugar content, resulting in overload of highly fermentable carbohydrates into the hindgut and the development of hindgut acidosis. If intake is not controlled, onset of laminitis and founder and often irreversible internal hoof changes can occur. (Refer to Chapter 2, Section 2, page XX and Glossary term).

Guidelines to Reduce the Risk of Laminitis (Founder)

It is important that controlled grazing management be adopted to reduce the risk of laminitis in ponies and "good doers" that are turned out onto rapidly growing pasture during flush periods.

✖ Do not allow a "good doer" or cresty horse to graze overnight on dense, lush pasture, or fresh pasture regrowth. Rapidly growing pasture has a higher soluble sugar and starch content in the late evening as plants store carbohydrate produced from daytime photosynthesis. Lush plants may be partly wilted from the warm conditions, thus concentrating highly fermentable sugar and starch in the leaves.

✓ Restrict the time allowed for grazing to short periods of one hour at a time and, if possible, increase the amount and regularity of exercise to maintain the animal in a moderate to good body condition. (Condition Score 2-3).

✓ Where a pony or a horse has had a history of seasonal 'grass' founder in previous years, or has a developing 'cresty' neck, restrict its time spent grazing before the animal starts to show signs of discomfort when walking.

KEYPOINT: Do not forceably exercise any horse or pony exhibiting signs of lameness due to early stage founder, as it will increase the degree of discomfort and risk of serious and permanent damage to the internal structure of the hoof.

✓ A high fibre, low energy feed can be mixed from 80% cereal chaff and 20% lucerne chaff, sweetened with a 20mL per litre volume of a 50:50 mix of molasses and water to dampen and encourage acceptance.

The horse or pony can be given a meal of this feed mix to 'fill it up' before turning it out for a limited grazing period each morning and evening. It will be less likely to graze continuously and the fibrous feed mix will help dilute the intake of pasture.

✓ Ensure the animal's front hooves, which are more likely to develop long toes and white line separation, are trimmed at regular intervals of no more than 4 weeks apart, rather than letting them grow out. Long toes will increase the risk of a higher downward rotational force on the pedal bone and increase the separation of devitalised internal laminae in the hooves.

✓ A daily supplement of a product containing virginiamycin, especially formulated and approved for horses in Australia, will help suppress the rate of hindgut lactic acid accumulation when fed as directed during critical periods when there is a high risk of laminitis and founder. (Refer to Chapter 2, Section 2.5.2.1, pages XX and Glossary term).

✖ Do not starve a pony with founder, or feed a low protein diet solely based on cereal chaff or hay during recovery from founder. The addition of a protein supplement such as 15% soyabean meal by weight or 20% canola meal or alternatively 35% lucerne chaff will provide amino acids for protein synthesis as well as calcium and trace-minerals. These nutrients are essential to promote the regrowth of laminae and the hoof wall.

KEYPOINT: It is unwise to starve a pony because the more serious and often fatal condition of hyperlipaemia may result. (See Glossary term for more details).

5.1.2 Conditions of Reduced Pasture Availability

The nutritional needs of an adult resting horse are outlined in Chapter 4, Section 4, page XX. Provided that a horse is maintaining condition and vitality, the energy intake from pasture is likely to be adequate to meet its needs, unless it is in very poor condition. In most cases, when the pasture is eaten out, or only the less palatable plants and weeds remain, a daily supplement of hay will make up the shortfall to meet maintenance needs.

The nutritional value and utilisation of hay can vary relative to the stage and method of harvest, plant blend and contamination with weeds and other less palatable plants, as well as the care taken and standard of the curing process. Horses that are well fed are more selective in utilising hay and will leave parts they find unpalatable. However, if a horse is hungry and losing condition because pasture is well short of its needs, it will usually become less selective. It may be forced to pick-over and consume plant material it would normally avoid in order to obtain enough bulk to satisfy its appetite.

5.1.2.1 How much hay should be fed?:

It is often difficult for horse owners to determine how much hay a horse will require to meet its needs in terms of energy, because most horses will look for more if they cannot satisfy their appetite and need for bulk from pasture.

KEYPOINT: Horses enjoy eating to pass the time and resting horses will eat palatable hay and supplementary feed even if their energy and other nutritional needs are already satisfied by pasture.

✓ Scientific calculations can be carried out to estimate the pasture intake and the relative shortfall of energy. The amount of hay required, relative to its quality, can be calculated to make up the shortfall in energy. This type of calculation is beyond the resources of most horse owners. Some feed companies are able to provide this type of advisory service.

✓ A 'feed and see' method is a simple way to evaluate the need for supplementary hay. A horse at rest will normally consume 1.5-1.75% of its body weight of dry feed (or a total feed intake of approximately 1.5-1.75kg/100kg body weight) each day.

When the pasture is unable to provide sufficient to satisfy a horse's hunger, it will start to actively search for feed by cropping the 'lawn' areas of the pasture even more closely and selectively grazing the 'rough' areas. Once the pasture becomes overgrazed, the horse will not be able to eat enough, even though it spends most of its time grazing and fossicking for pasture, to obtain sufficient energy and nutrients to maintain a satisfactory body condition.

Before the horse starts to visibly lose body condition or the pasture is showing signs of being heavily grazed, commence feeding meadow hay at the rate of 1.0kg per 100kg bodyweight, or alternatively lucerne hay at 0.5 – 0.75kg per 100kg body weight, as an evening feed initially. As a guide, a 100mm (4 inch) thick biscuit of good quality lucerne hay weighs approximately 2kg. Monitor the horse's intake and relative appetite each day and check its condition at 7-10 day intervals.

KEYPOINT: Even when horses at pasture are provided with hay or other supplementary feed to prevent over-grazing of palatable pasture species, they will still intensively graze and eat-out any available pasture. Overgrazing is most

common under dry seasonal conditions, drought, or when there are more horses than can be sustained on the available pasture area.

Once the pasture is eaten down below 5cm in height, or grazed out areas begin to appear as bare patches, then the amount of hay should be increased.

To avoid long term damage to the pasture or soil erosion, it is best to take the horses off the pasture and confine them to large yards once the pasture is grazed down below 5 cm in height. Supplementary hay and hard feed should be provided with only limited daily access to the pasture to allow exercise without risk of overgrazing until the pasture regrows.

On average, 10% of the hay provided to pastured horses by feeding it out on the ground is wasted by trampling, being blown away by wind, or spoiled. It is best to provide hay in a safe feed bin or trough to reduce wastage, as well as to minimise intake of dirt, worm eggs and larvae that occurs when hay is fed from the ground.

5.1.2.2 When should 'hard' feed be fed?

Generally, horses at rest or those in light or occasional work, do not require a 'hard' feed unless suitable quality hay is not available, they are unable to utilise hay due to poor teeth or old age, or extra energy is required to gain condition in preparation for being brought back into work.

Cold, winter conditions

- ✓ During cold winter conditions, hay will provide adequate energy and other nutrients, as well as additional heat from hindgut fermentation to help maintain body warmth.

Under these conditions, a mixture of whole oats and chaff provides a simple, economical and suitable "hard" feed base. The oats fed at a rate of 0.25kg per 100kg body weight should be mixed with at least an equal volume of either cereal or lucerne chaff, or a 50:50 mixture of each chaff to help satisfy the horse's hunger. To provide bulk, feed either meadow hay at 1kg of hay/100kg body weight or lucerne hay at a rate of 0.75kg/100kg body weight. Monitor the horse's appetite and body condition at 7-10 day intervals and adjust the supplementary feed to maintain the desired condition.

Aged Horses

- ✓ Aged horses that have poor teeth can be given either a dampened mix of crushed oats or alternatively a prepared feed such as a rolled muesli or stud mix or a pelleted or preferably extruded feed containing 10-12% crude protein, at the initial rate of 0.25-0.5kg/100kg daily. This can be mixed with an equal volume of chaff as a single evening feed, or preferably divided between two feeds. Good quality leafy dampened lucerne hay at 1kg/100kg body weight provides additional roughage if the horse is able to chew it efficiently. Alternatively, a 50:50 mix of lucerne and cereal chaff at a similar dose rate, dampened with 50:50 molasses in water, if necessary, will encourage acceptance in aged horses with poor teeth.

An appropriate dose of a multi nutrient mineral and vitamin supplement can be provided on a daily basis to make up any minor shortfalls of a range of minerals and vitamins. Alternatively, a mineral block or lick can be placed in the paddock feeder for a resting or lightly worked horse to consume at will.

5.1.2.3 Evaluation of the adequacy of the ration

The adequacy of the ration can be evaluated using the following criteria:

- ✓ **Monitor the horse** to check if it is consuming all the hay or supplementary feed provided and is maintaining a suitable condition score, good health and vitality. The horse may also be looking for more to eat, but if it is in suitable condition, any additional feed should be a low energy, bulky feed, such as cereal chaff or grass hay.

- ✓ **Check if there any left-overs** – if there are, adjust the quantity at the next feed accordingly and monitor the animal's eating habits, amount of wasted feed and time spent consuming the meal.

- ✓ **If the horse is losing weight and condition** despite being provided with an adequate and palatable ration, **check the horse's teeth and worm the horse** to improve its digestive efficiency.

✓ **Be prepared to change the amount of supplementary feed offered relative to changes in pasture growth after rain**. Rapidly growing, lush regrowth of grasses and legumes may increase the risk of laminitis and founder in ponies within 10-14 days after soaking rain in the warmer conditions during spring, summer and early autumn.

KEYPOINT: Supplementary feeding and restriction of grazing by confining horses to yards should be continued for 10-14 days after the break of season to allow the pasture to respond and be able to withstand the pressure of grazing. If a horse is turned out on lush pasture for more than 3-4 hours each day, it may develop low grade diarrhoea as a result of over consumption of laxative green pick. Restriction of grazing will also help to reduce the risk of laminitis and founder in susceptible ponies and horses.

✓ In a group of horses, the **competition for feed should be monitored**, especially under drought conditions. Horses that are not receiving an adequate share relative to their needs may need to be segregated out and fed separately in an adjoining yard.

✓ Always ensure an **adequate supply of fresh, clean water** is available at all times.

5.2 Lightly and moderately worked horses on pasture with supplementary feeding

Many owners of pleasure horses used for stock work, polocrosse, one-day eventing and endurance riding, often keep their horses at pasture and train them from the paddock. A supplementary 'hard' feed may need to be provided in the paddock once a day to meet the increased energy and nutrient demands of moderate exercise when pasture intake falls short of requirements. For higher levels of competition or more intense training, a horse is best stabled or yarded overnight with an evening "hard" feed given with hay. A morning feed may be provided before the horse is worked, prior to turning the horse out for daytime grazing.

5.2.1Assessing the Contribution from Pasture

KEYPOINT: Well managed pasture can provide the basis for an adequate and low cost diet for many horses in light to moderate work.

Horses that are well cared for are often provided with more supplementary feed than they actually require. Extra feed may be given because a horse always appears to be hungry and searching for food, or to prevent horses from eating shade trees in yards or small paddocks.

Horses in moderate work being trained from the paddock are likely to be subjected to a "feast or famine" on a pasture based diet. However, in many cases supplementary feed is provided as a matter of routine, rather than necessity, even during periods when pastures are able to provide sufficient nutrient to meet exercise needs.

KEYPOINT: Where the area of pasture or its nutritional value is limited, then it is best to provide the major dietary needs of competitive horses in training by a twice daily ration of 'hard' feed and hay.

The pasture productivity can be evaluated, in terms of dry matter produced, the stage of growth, the types of plants being selectively grazed and the rate that the pasture is being eaten off, by a walk through the pasture at intervals of 7-10 days.

The value of pasture to the total diet can also be monitored by the duration of time a horse has access to it. As well, the horse's appetite and ability to consume the full hard feed provided as well as any amount of feed left-over after a meal whilst still maintaining its body weight, condition, ability to work and recover during training should be considered.

KEYPOINT: A horse trained from the paddock is more likely to fill itself up on lush, green pasture and reduce its 'hard' feed intake when allowed unlimited day time grazing, than when the pasture is dry, less palatable and has a lower energy content.

✓ On good pasture, a horse can consume sufficient bulk and nutrients to maintain itself in 4-5 hours grazing. On short, sparse or poor quality pasture, a horse may need to graze for 18-20 hours a day to maintain its body weight.

✓ The time spent grazing may need to be monitored and limited relative to the intensity and stage of the training program in order to avoid excess hindgut size and weight that may reduce a horse's competitiveness.

The increase in popularity of horses for equestrian competition and for leisure and pleasure activities has resulted in many more horses being kept on smaller areas around the urban fringe and on semi-rural hobby farms. The higher level of care, regular work output and quest for a higher body condition for the horse has reduced the reliance on pasture as a

major component in the diet of many equestrian and leisure horses. The move from a pasture based diet to hand feeding is also influenced by high stocking densities, limited grazing area and the inability to rotate and rest pastures.

✖ Prolonged wet weather and winter conditions, where pastures do not dry out, further accelerates the risk of pasture damage in small paddocks. The degree of pasture and soil damage is relative to the type of soil and stocking rate. Horses that are shod are likely to cause more soil and pasture damage, especially during wet weather compared to unshod horses. Access to pasture may need to be limited or denied during wet weather for this reason. Shifting horses into daytime yards and providing them with "hard" feed or hay will help to reduce pasture degradation, soil erosion and overall spoilage of pastures where the grazing area is limited.

✓ Daily access to pasture often benefits as a form of relaxation and to aid recovery after training. It provides a recreational role with free exercise, an opportunity to stretch, roll and move more naturally as well as socialisation with other horses.

✓ Access to green pasture is helpful to maintain the appetite, provide additional fluid in the feed consumed and a source of natural minerals and vitamins.

✖ As pastures dry off, or are eaten down, the nutritional contribution from grazing is reduced.

Practical Guideline:

A starting point to estimate the energy and other nutritional intake from pasture and the relative need for supplementary feed can be based on the following general guidelines:

✓ 50 - 60% of dietary needs should be provided by full daytime grazing on growing, well established pasture ranging from 5-15cms in height.

✓ Only 25 - 30% of the dietary needs each day will be provided when horses graze shorter, less productive pasture.

✓ Only 10-15% of the dietary needs should be allowed for when calculating the amount of "hard feed" if a horse in training is turned out only for 3-4 hours grazing each day on less than a half a hectare (about 1 acre) of moderate pasture.

5.2.2 How much hard feed should be fed?

The amount, blend and completeness of the supplementary 'hard' feed required is relative to:

✓ **The availability and stage of growth of the pasture**.
If the pasture is actively growing and of high quality, a horse will often prefer to graze pasture than eat hay or other supplementary dry feed provided in the paddock. However, to ensure an adequate energy intake is consumed in a limited bulk to meet exercise demands, and to avoid a 'grass belly' and excess hindgut weight for competition, the horse may need to be turned out to graze only for a limited time once or twice daily.

✓ **The duration and intensity of the exercise carried out on a daily basis**.
An adult horse will require, above its maintenance diet, about 500g of hard feed (30-35% grain and 65-70% mixed chaff) per 100kg body weight for each 60 minutes of light exercise (walking and trotting). Approximately 750g – 1kg of the same hard feed per 100kg of body weight is required for each 60 minutes of moderate work (trotting, cantering and some galloping). If the horse is not worked, then the amount of hard feed should be reduced and the bulk made up with hay or more time allocated to grazing if pasture is available.

✓ **The condition score suited to the horse's use or purpose**.

(Refer to Chapter 1, Table 1.3, page XX for a guideline on optimum condition scores). Often the horse's build, size and stage of training will influence its intake and appetite. For example, the energy density of the ration may need to be increased by substituting some of the oats in the ration with less bulky, higher energy grains such as corn, barley or even vegetable oil to ensure the horse maintains a suitable level of condition, vitality and ability to work. (Refer to Table 5.6, page xx for substitution rates).

✓ **The nutrient value of the roughage base that is provided in the supplementary feed**.
Cereal (white) chaff provides only 80-85% of the digestible energy, 50% of the crude protein, 20% of the lysine, 25% of the calcium and 50% of the phosphorus as compared to an equal weight of lucerne (green) chaff. The energy, protein and mineral content of the supplementary feed may need to be varied relative to whether cereal, lucerne or a blend of chaff (or hay) provides the roughage base.

KEYPOINT: The dietary guidelines given in Tables 5.4 and 5.5 on pages XXX to XXX for various levels of training and competition for a totally hand fed horse can be used as a starting point for a horse with access to limited pasture grazing, relative to the quality and amount of available pasture.

✓ A horse in early training, that is turned-out for the majority of daylight hours on good pasture, can be provided with an evening feed at 0.25-0.5kg/100kg body weight of roughage to concentrate ratio as recommended in Table 5.5. The amount offered is dependent on the horse's condition, appetite and work load. This will provide the basis for a supplementary feed to meet the requirements for energy, protein and other nutrient needs. The concentrate feed can be based on a home mixed grain feed or prepared feed, mixed with an equal volume of cereal, lucerne chaff or a 50:50 blend of each.

An overnight supply of good quality meadow hay at 0.75kg/100kg body weight, or alternatively lucerne hay at 0.5kg/100kg body weight will provide adequate fibre and bulk to provide food for the horse to consume and keep it occupied overnight.

The horse can either be given hay at a rate of 0.25kg/100kg body weight in the morning before being turned-out, or worked first and then given hay when turned out to pasture.

✓ For a horse in more advanced training, it is important to limit gut weight by restricting the time spent grazing to 2-3 hours daily and feeding a more energy dense ration. A grain or prepared feed mix at the recommended grain to concentrate ratio in Table 5.5 fed at 0.75-1.0kg/100kg body weight should be divided between morning and evening meals and mixed with an equal volume of mixed or lucerne chaff. This would provide a starting point for a hard feed. Approximately 1.25kg/100kg of meadow hay, or 0.75-1.0kg/100kg body weight of lucerne hay should also be fed overnight to appetite.

If a horse is in heavy training, a supplement of salt (sodium chloride) at the rate of 10g/100kg body weight daily, split between evening and morning meals, should be provided. Where a horse is worked for an extended time of more than 60 minutes daily, particularly under hot conditions, an electrolyte mix containing at least 20% potassium at the same dose rate will help replace electrolytes lost in sweat. (Refer to Chapter 6, Table 6.1, page XXX for guidelines).

✓ A multi-vitamin and mineral supplement may be added to the evening meal to meet the elevated needs of a working horse.

✓ An adequate supply of fresh, clean water must be provided at all times.

KEYPOINT: Regular monitoring of body weight, condition, gut fill and performance will help to determine the adequacy of the ration so that appropriate adjustments can be made where necessary.

5.3 Breeding Horses on pasture with supplementary feeding

In Australia, the temperate climate provides suitable conditions under which the majority of our breeding and growing horses can be kept at pasture for the greater part of the year. The criteria for the evaluation of the contribution from pasture and the amount of hard feed as outlined on pages XXX and XXX for resting and working horses also apply to breeding mares. The appraisal of body condition using the standardised method of condition scoring outlined in Chapter 1, Section 1.4, page XX provides a practical means of monitoring breeding mares to ensure optimum fertility and milk production.

KEYPOINT: The quality and seasonal growth of pasture can have a direct effect on the fertility and breeding success of a mare sent to stud.

The nutritional requirements of breeding mares have been outlined in Chapter 4, Section 4.3, pages XXX to XXX.

KEYPOINT: Feeding to improve condition by providing a rising plane of nutrition in a thin mare will increase her fertility and conception, but extra feeding in a well conditioned mare grazing on good pasture will have little or no benefit.

✖ Often pastures in late winter are short and less able to meet the energy and protein needs of a mare to be bred in the spring.

A thin mare, with a condition score less than 2, should be supplemented with additional good quality hay. Alternatively, a concentrate feed once a day, at the concentrate to roughage ration recommended in Table 5.5, increasing in a stepwise manner by approximately 0.1-0.5kg feed/100kg body weight at weekly intervals (ie. 500-750g for a 500kg mare) will achieve a “rising plane of nutrition” within the 4-6 week period prior to breeding.

KEYPOINT: In a good season, the natural flush of pasture in Spring will provide a corresponding increase in energy and overall nutrient intake. This will improve body condition to the level necessary to initiate the breeding cycle in a mare to be bred or to maintain lactation in a mare with a foal at foot.

- ☑ Extra feed, such as good quality meadow or lucerne hay at 0.25 – 0.5kg hay/100kg body weight, should be provided to a mare under cold conditions during late winter to ensure that she does not fall away in condition prior to breeding.

- ☑ A heavily conditioned mare must be provided with a sufficient amount of feed daily so that she maintains condition, as any loss of condition will reduce her fertility and chances of conception.

KEYPOINT: It is important to feed to maintain the body condition of a mare, even an overly fat mare, for the first 90 days of pregnancy, as any reduction of energy that results in weight loss can increase the risk of early embryonic abortion.

A well-fed mare in good condition, or one straight out of race or upper level training, sent to stud may lose condition due to insufficient energy intake when grazing on less than adequate pasture. This is typical of the November to January period in southern Australia, when pastures dry off after the spring flush. Additionally, in larger groups of mares, the "peck order" dominance for feed often denies newly introduced mares an adequate intake of supplementary feed to help maintain their energy intake and body condition.

- ☑ A maiden mare introduced to a group of older and 'socialised' mares must be carefully managed to avoid loss of condition prior to breeding. If the mare is 'bullied' away from the feeders, it is best to locate two or more feeders a short distance away from the main feeding area so that mares low in the 'peck order' have less interruption when feeding.

KEYPOINT: A maiden mare out of training should ideally be let down over a period of 3 months to allow her to adapt to paddock feed and the social stress of the mare group.

It is not always possible to gradually let down a mare in work as she may be sent to stud at short notice, particularly toward the end of the breeding season.

A maiden mare, in training on a high-energy ration that is retired to stud during the breeding season, is best maintained on an equivalent level of energy in the stud ration as provided during training to avoid weight loss. Often it is wise to keep a young mare in training on full feed and breed her when she comes into season. This is preferable to turning her out onto less than adequate pasture or forcing her to compete for feed in a large group of mares, thereby causing a loss of condition and fertility.

Alternatively, in the early part of the breeding season, plan to let the mare down over a 2-3 month period before sending her to stud. This is best done by reducing the energy content of her ration by 5-7% each month in a step-wise program over the 2-3 month period. This will avoid any reduction in energy and protein intake that may effect her fertility as the mare adjusts to a maintenance diet.

- ☑ An older mare may be unable to maintain condition during the winter months unless she is provided with supplementary feed so that she can achieve a suitable condition for breeding. If an older mare is below an optimum condition for breeding

(a condition score less than 1.5-2.0), it is often a slow process to achieve an adequate condition score which she will be able to maintain prior to and after breeding. In this case, the mare should be wormed out, have her teeth checked, and rugged if necessary. This will help to improve her overall feed utilisation and reduce the energy drain, so that she can obtain maximum benefit from the improved diet.

5.3.1 How much hay and hard feed should be fed?

Good quality pasture in an active growth phase (Refer to Chapter 7, Fig. 7.3, page XX) should be able to meet the nutritional needs of a pregnant and lactating mare. A stocking rate of two pregnant mares, or one lactating mare for each 1 – 1 ½ hectares of good quality pasture cover is a useful guide.

KEYPOINT: Regular monitoring by pasture walks at intervals of 7-10 days to evaluate the volume of pasture production and feeding value, combined with appraisal of the condition of grazing mares, is a practical way of determining the adequacy of the pasture.

As pastures dry off, or are grazed off, with a corresponding decline in energy and protein content, then supplementary feeding must be commenced before the mares start to obviously lose condition. This will prevent a negative energy balance in both empty and lactating mares prior to breeding.

Many larger studs provide clover or lucerne hay in hay racks for ad-lib consumption by mares to help offset variation in pasture quality and quantity and to ensure mares are maintained in an optimum, but not excess, body condition. Depending on seasonal conditions, supplementary hard feed may also be provided, particularly to mares during the first 3 months of lactation when nutrient demands are highest.

KEYPOINT: It is important that a lactating mare is maintained in a suitable condition so that she can be bred successfully with a foal 'at foot'.

Non Pregnant and Early Pregnant Mares

✓ Lucerne and clover hay are suitable roughages to provide additional energy and protein to counteract the decline in the quality of grass based pastures as they dry off or are eaten down. A feeding rate of lucerne or clover hay at 0.5-0.75kg/100kg body weight daily is a good starting point as the pasture stand declines to below 5cm in height and more closely cropped (lawn) areas become obvious.

✓ A combination of whole oats or 10-12% crude protein mare pellets or cubes fed at a rate of 0.25-0.5kg/100kg body weight should be mixed with double the volume of lucerne and cereal chaff and given as a single feed once a day. This is a suitable starting point to supplement the energy and protein intake of a non-pregnant mare and a mare during early pregnancy. The amount of oats or mare pellets may have to be increased to maintain body condition as the pasture becomes less productive or is eaten out.

Heavily Pregnant and Lactating Mares

✓ During the last 2 months before foaling, a pregnant mare can be supplemented with whole oats, mare pellets or cubes at 0.5-0.75kg/100kg body weight daily in a single feed, mixed with a double volume of lucerne chaff to provide additional energy and protein up until foaling.

✓ A lactating mare during the first 3 months can be provided with oats, pellets or mare cubes at 0.75-1.0kg/100 kg body weight daily as a starting point, divided between 2 feeds at the higher rate.

Studies in Queensland have shown that pregnant and lactating mares can be given a supplement of molasses up to 400g/100kg body weight daily as a lick to provide additional energy when pastures dry off. (Refer to Chapter 7, Section 7.1.12, page XXX).

Good quality lucerne hay provided ad-lib in a hay rack, or hand fed at a rate of 1.0kg/100kg body weight daily (about 2½ biscuits for a 500kg mare) will provide the additional energy and bulk required.

✓ As pasture dries off, the total amount of dry feed may need to be increased to 2.5-3kg/100kg body weight to meet the needs of the lactating mare at the peak of lactation between 4-10 weeks. Often a foal will eat concentrates (co-feed) from its mother's feed bin from 4-6 weeks of age.

- ✓ A ration containing a minimum of 14-16% crude protein, consisting of 50% crushed oats or preferably extruded grain, 20% cracked corn and 10% soyabean meal mixed with 20% by weight of lucerne chaff can be fed at a rate of 2-2.5kg/100kg body weight for a lactating mare. Her foal will be encouraged to share the feed if it is sweetened with molasses.

Alternatively, 15% canola meal or skim milk powder by weight may be substituted in the mix for 10% soyabean meal to provide a high quality protein source with lysine and other amino acids required for growth. Skim milk powder may initially be added at 15% for foals up to 6 weeks of age. Milk powder may be better accepted in young foals sharing their mother's feed than soyabean or canola meal. Alternatively, a creep feed for foals may also be provided. (Refer to Table 5.7 for protein substitution rates and Section 5.4.1, pages XXX for information on creep feeds).

The concentrate should be based on a low dust lucerne chaff base, with 1% (10g/kg) added salt and 3% (30g/kg) added Dicalcium phosphate to meet requirements for salt, calcium and phosphorus.

- ✓ A commercial pelleted, mixed or extruded feed may be provided at a rate recommended by the manufacturer.
- ✓ A multi-vitamin and mineral supplement, may be included when the intake of green pasture is limited as it dries off in mid to late summer. This supplement must contain adequate calcium, phosphorus, copper, zinc, manganese, iodine and selenium as well as vitamin A, D and E to meet the needs of a lactating mare sharing her feed with her foal. (Refer to Chapter 6, Figure 6.3, page XXX, for localities where soil trace-element deficiencies are known to occur in Australia).
- ✓ An adequate supply of clean, fresh water must be provided for lactating mares and foals when pastures dry off and during hot weather. A 500 kg lactating mare can drink at least 50 litres of water daily and a foal can consume 5.5 litres or more of water after 10 weeks of age. (See Chapter 4, Section 4.4, page XXX).

KEYPOINT: Regular weekly appraisal of the body condition of the mare and daily observation of the young foal to check if it is drinking sufficient milk and gaining weight is the basis for monitoring the nutritional adequacy of a ration for a lactating mare.

5.4 Growing horses on pasture with supplementary feeding

With few exceptions, the majority of growing horses are kept outdoors on a pasture based diet under Australian conditions. Several studies have indicated that in a good season in most parts of southern and eastern Australia, pasture can provide sufficient energy and other nutrients to meet the needs of growing horses for a major part of the year. In some cases, in a good season with late summer rainfall, continued pasture growth from February to April can help reduce the risk of a setback in development of the young horse at weaning. Studies in Australia by Dr. Ron Leng and colleagues at Armidale in the late 1970's suggested that if young horses had sufficient energy in their diet combined with an opportunity for free-range exercise, they could grow and develop satisfactorily on an 8% crude protein diet, provided they were able to consume an adequate amount of feed to meet their exercise requirements.

Most young horses will exhibit some compensatory growth when provided with better quality pasture or feed after a period of slower growth on poor pasture. Any growth spurt must be limited by careful monitoring of feed intake to avoid the risk of limb abnormalities associated with DOD.

Breeders of racing and performance horses often set a standard that requires their horses to reach almost adult proportions by 12-15 months of age for sale purposes.

There is a tendency to overfeed young horses to achieve a rapid rate of growth and development, often by the provision of higher energy grain based feeds with less reliance on pasture as a major nutritional source. Overfeeding carries a potentially high risk of limb and joint abnormalities in young horses, as discussed in Chapter 4, Sections 4.4.1 to 4.4.3, pages xxx to xxx.

5.4.1 Foals

Foals up to weaning age may benefit from supplementary feeding in order to maintain a steady and adequate rate of growth. Under dry seasonal conditions, or when the stocking rate increases the intensity of competition for available pasture, supplementary feeding is essential to ensure that lactation in mares and optimum growth rates in their foals at foot can be achieved.

KEYPOINT: Foals that become accustomed to eating a supplementary feed from 2-3 months of age are less likely to suffer a nutritional setback at weaning.

During poor seasons, concentrate feeds provided in a separate “creep” feed may help to maintain optimum growth. Care must be taken to avoid over feeding of free-choice 'creep'concentrates because excess energy intake is one of the predisposing high risk factors associated with limb and joint abnormalities in young horses from 3-9 months of age. (Refer to Developmental Orthopaedic Disease (DOD) Chapter 4, Section 4.4.1 to 4.4.3, pages XXX to XXX and Glossary term).

- ✓ Controlled access to a creep feed helps to provide additional energy and nutrients to foals after the peak of lactation at 8-10 weeks of age, especially under dry pasture or overstocked conditions.
- ✓ Excessive consumption of creep feeds by dominant or already over-developed foals will increase the risk of limb abnormalities associated with DOD due to excess energy intake or an imbalanced or inadequate intake of copper, zinc, manganese, iodine or selenium.
- ✓ Most younger foals will learn to feed with their mothers, which helps develop their grazing and eating patterns. A good quality concentrate ration providing 14-16% crude protein and containing a balanced and adequate calcium to phosphorus content and copper, zinc, manganese, iodine and selenium as major trace-minerals will help maintain bone and muscle development. A 'hard' feed given once a day to mares and foals is a practical way of developing good eating habits and patterns, which will accustom the young foal to eating concentrates in preparation for weaning.

Many good quality commercial feeds for foals and growing horses are available and the majority are well balanced in the ratio of energy to crude protein, minerals, and trace minerals.

A home mixed ration may be prepared as outlined in Table 5.2.

Feed	Feed Amount in Weight
Energy Source	
Crushed Oats or alternatively Steam Rolled Barley	1kg
Cracked (or preferably extruded) Corn	1.6kg
High Quality Protein Source	
Skim Milk Powder	300g
Soyabean Meal	800g
Calcium & Phosphorus Source	90g
Dicalcium Phosphate	100g
Minimal Fibre Source	
Lucerne chaff or Bran	½ cup mixed with ½ cupful of warm water
Sweetener	
Molasses	20g
Trace Mineral, Electrolyte and Vitamin Source	250iu The final hard feed mix should contain 30-50mg/kg of elemental copper, zinc & manganese, & 0.1mg/kg of iodine and selenium.
Salt	
Vitamin E (optional)	
Trace-Mineral and Vitamin Supplement Foal Dose	

Feeding Rate: 1.0-1.5kg/100kg body weight daily as a supplement to milk intake after one month of age.

Adapted from Kohnke (1998)

Note: If a foal gains excessive weight, the intake should be reduced to 0.75-1.0kg/100kg daily until growth rate and condition are within accepted limits. The calcium, phosphorus, trace-mineral and vitamin content must be maintained by adding the same amount as provided in the initial full volume of feed. (See page XX).

Mixing Details: **(1)** Mix fresh each day, add molasses just prior to feeding.

(2) Soyabean meal may need to be introduced in a step-wise manner over 7-10 days to ensure acceptance.

(3) Milk powder can be replaced by 200g soyabean meal once foals reach 10-12 weeks of age..

(4) Once foals reach 12 weeks of age, add 1kg lucerne chaff to provide additional fibre and bulk.

TABLE 5.2
Creep Feed for Young Foal

8 weeks to weaning

- ✓ Monitor the growth rate and development at regular 10-14 day intervals and restrict access to the creep feed before foals become overweight or start showing signs of epiphysitis (enlarged growth plates).
- ✓ Ensure adequate opportunity for daily free paddock exercise, for a minimum of 2 hours and preferably full time access to pasture.
- ✓ Provide access to a plentiful supply of clean, fresh water at all times, especially under warm or humid summertime conditions.
- ✓ Regular worming and hoof care are important routine management procedures to ensure that optimum growth and health are maintained.

5.4.2 Weanlings

The period from weanling to yearling is one of the most critical periods of a young horse's life. The combination of adequate and balanced nutrition and exercise has a major influence on the long term development and soundness of a young horse as it develops to maturity.

Note: An overview of the interrelationship between nutrition and exercise, and management to avoid limb and joint abnormalities associated with Developmental Orthopaedic Disease (DOD) is presented in Chapter 4, Section 4.4.2.1 on pages XX to XX.

Under colder autumn and winter conditions in southern Australia, or dry winter periods in sub-tropical and tropical areas, weanlings on slow growing pastures may suffer a nutritional set back, unless supplemented with good quality hay or a prepared concentrate ration.

Although lucerne hay contains adequate calcium and protein to make up shortfalls in the diet, often young horses will not readily consume the dry hay provided for them when lush pasture is available.

KEYPOINT: The ration intake must be adequate, complemented by an opportunity for daily paddock exercise to maintain an even rate of growth.

As a guideline, the prepared ration must be formulated to provide;

- ✓ Adequate but not excessive energy from a feed containing 30% roughage, with a maximum of 70% concentrate. (See Table 5.4).
- ✓ A range of 14-16% crude protein in a hard feed for weanlings grazing on grass based pastures or 12-14% for those grazing mixed grass and legume pastures.
- ✓ 6-7g elemental calcium and 4-5g elemental phosphorus per kg of total ration, a balanced calcium to phosphorus ratio of 1.2-2.0 calcium to 1.0 phosphorus;
- ✓ 30-50mg/kg of elemental zinc, copper and manganese and 0.1mg/kg of iodine and selenium in the concentrate mix.

There are many well-formulated commercial feeds now available for weanlings and yearlings as a supplement to pasture during critical periods.

Weanlings grazing abundant tropical grass pastures containing a high oxalate content must be provided with supplementary feed each day containing additional calcium and phosphorus to offset the calcium binding effect of oxalate chemical in the small intestine, as well as the essential trace-minerals as outlined above. It is best to provide the concentrate feed in a yard to ensure the calcium and trace-mineral supplement is consumed.

In most cases, a growing mixed pasture under moist conditions that is withstanding the stocking rate and showing adequate regrowth will provide sufficient energy and protein for growing

weanlings. A small hard feed of lucerne chaff with added calcium, phosphorus and the trace-minerals as outlined above, may be supplied once a day to meet the needs for these essential nutrients for optimum bone and joint development.

A suitable ration mix for a weanling is outlined in Table 5.3.

Feed	Feed Amount in Weight
Primary Energy/Protein Source	2kg (3kg if corn not used)
Crushed Oats or alternatively Steam Rolled Barley	1kg
Cracked (or preferably extruded) Corn	400g (600g)
High Quality Protein Source	300g
Soyabean Meal (or alternatively Canola Meal)	300g
Roughage Source	200g
Cereal Chaff	½ cup mixed 50:50 with warm water
Lucerne Chaff	60g
Bran (optional)	30g
Sweetener	20g
Molasses	250-500iu
Calcium & Phosphorus Source	The final feed mix should contain 30-50mg/kg of elemental copper, zinc and manganese, 0.1 mg/kg of iodine and selenium, & 2000iu vitamin A, 1000iu vitamin D & 50-100iu vitamin E per kg of feed mix
Dicalcium Phosphate	
Calcium Carbonate	
Trace Mineral, Electrolyte & Vitamin Source	
Salt	
Vitamin E (optional)	
Mineral and Vitamin supplement – Weanling Dose	

Feeding Rate: 1.25-1.5kg per 100kg body weight daily, monitored regularly once a week relative to pasture intake to maintain an even, steady growth rate. Regularly increase the amount fed in proportion to body weight as the young horse grows. For light horse and racing breeds, increase intake by 0.5kg per month as the young horse develops from weaning depending on the intake from pasture, Good quality lucerne or clover hay at 1-1.5kg/100kg body weight can be provided daily, or on an ad-lib basis, relative to the availability and quality of pasture.
Feed once daily if pasture is available for grazing, divide into two daily feeds if pasture is poor or grazed off. During the colder winter months, more good quality roughage may be provided to increase the bulk of the ration.

Mixing Details: Mix fresh each day, add molasses just prior to feeding.

Adapted from Kohnke (1998)

TABLE 5.3

Ration For Weanling
5-9 months of age

✓ Monitor the growth rate and development at regular 10-14 day intervals and adjust the intake of concentrate to maintain a steady rate of growth. A steady growth rate of 500-550g daily. A condition score of 2-2 ½ with the outline of the last few ribs and pin bones is desirable for a young horse maturing to 500kg body weight.

✓ All young horses must be provided with the opportunity for at least 2-3 hours of free-exercise each day, preferably full time access to a large, safe paddock.

✓ Regular worming and hoof care are important routine management measures.

✓ Regular daily appraisal of general health, vitality and soundness, and inspection for injuries is an essential management routine for young horses..

Management of DOD Limb Abnormalities

If a young horse is gross in proportion and overweight, with evidence of limb and joint abnormalities associated with Developmental Orthopaedic Disease (DOD), then limiting its access to pasture and gradually reducing the intake of energy is recommended. The grain content in its supplementary feed should be reduced by 30-50% whilst maintaining the bulk of the ration by adding more cereal and lucerne chaff or hay over a 10-14 day period. When maintained at this lower energy level its body weight and condition score can be trimmed to a more acceptable standard.

KEYPOINT: Whenever a restriction in dietary intake is used to control excessive growth, only the energy level of the ration should be reduced by decreasing the grain content or access to lush pasture. The intake of protein as well as calcium, phosphorus and trace-minerals including copper, zinc, manganese, iodine and selenium should be maintained at the required daily supplementation levels.

5.4.3 Yearlings

Most young horses should have reached 90% of their mature height and 65-70% of their mature body weight by 12-15 months of age.

KEYPOINT: The rate of growth starts to slow down by yearling age and many yearlings can maintain an optimum rate of growth and development over the spring and summer period on pasture alone.

A supplement of hay or hard feed may be necessary as pasture dries off, or is grazed down.

✖ Lucerne hay is a useful supplement to provide energy, reasonable quality protein and minerals to grazing yearlings in late summer through winter where pasture is limited or of reduced nutritional value. However, although lucerne provides excess calcium to phosphorus, other important trace-minerals essential for development of bone and joints may be relatively deficient when grazing yearlings are fed on a lucerne based supplementary feed.

This may be overcome with a small supplementary feed, offered on a 100kg body weight basis, containing 200g oats (optional), 100g cereal or lucerne chaff (for bulk) and 15g Dicalcium Phosphate (DCP) sweetened with molasses to avoid sifting and ensure acceptance, as well as a commercial trace-mineral and vitamin supplement at a yearling dose rate. Many good quality commercial feeds formulated for yearlings are also available.

✖ Yearlings grazing abundant tropical grass pastures containing oxalate chemicals, which bind calcium and reduce its uptake, can be provided with a similar blend as a once daily supplementary feed. Mix 2 parts calcium carbonate (ground limestone) and 1 part dicalcium phosphate (DCP) at a rate of 20g per 100kg body weight into 70% lucerne chaff and either 30% oats alternatively or 200g/100kg body weight of molasses. (See Chapter 7, Section 7.4.7 page XX for additional details).

On many larger stud farms, yearlings are provided with supplementary feeds prior to yearling sales to offset any shortfalls in pasture and ensure an adequate mineral and trace-mineral intake is provided.

The ration guideline outlined in Table 5.3 for weanlings can also be used to supplement yearlings at critical times, bulking it out with 50% more lucerne chaff to reduce the energy density. This ration can be fed at the rate of 1.0-1.25kg per 100kg body weight daily. The calcium and phosphorus sources and a trace-mineral and vitamin supplement should be added relative to the amount of hard feed consumed on a daily basis.

5.4.4 Young Horses 18 Months or Older

The requirements of young horses after yearling age, by which time the growth rate has slowed to about 60% of the average daily gain for a yearling, can usually be satisfied by good quality pasture, supplemented where necessary as outlined for yearlings.

Evaluating the Adequacy of the Pasture and Ration

The regular monitoring of condition score and overall development at 7-10 day intervals can provide a benchmark on which to base the feeding program for weanlings and yearlings. Many larger studs have weighing scales to monitor average daily gains (ADG) in growing horses, adjusting where necessary to maintain an even, steady rate of growth related to age and height. (See page XXX).

Key points for appraisal of a young horse 18 months or older are:-

- ✓ Is the young horse maintaining a steady, even rate of development, with a condition score between 2.0 –2.5, with flesh covering over the ribs and backline?
- ✓ Is the animal exercising freely? Does it have straight limbs and no evidence of joint enlargement or epiphysitis? These are signs of Developmental Orthopaedic Disease (DOD) (see Glossary term). If there are signs of DOD apparent, adopt the management measures as outlined under weanlings.
- ✓ Does the young horse appear fit and healthy with a good coat condition?

If the growth rate is within an optimum range of 300-350g daily for an 18 month old horse maturing to 500kg body weight, then the pasture is providing adequate energy and crude protein for development. Regular appraisal of the young horse is vital to ensure an adequate and balanced growth rate. Pasture walks every 7-10 days will assist in monitoring the adequacy of the pasture and the need for supplementary feed, especially as the pasture dries off or is eaten down.

KEYPOINT: It is important that young horses receive adequate energy, crude protein and the correct balance of calcium, phosphorus, copper, manganese and zinc in their diets to achieve an optimum growth rate with a low risk of limb and joint abnormalities.

5.5 Stabled or confined horses on hard feed without access to pasture

Pleasure and show horses in semi-urban areas on small 'hobby' farms of up to 2.5 hectares, often have to be hand fed during the winter months when pastures dry off. Horses in race and upper level equestrian training, when confined to stables and outside yards, usually have little access to pasture. Both these groups need to be provided with 'hard' feeds of grains and meals, with roughage as chaff and hay to meet their nutritional needs.

KEYPOINT: Daily access to pasture is often considered to be a nutritional bonus to help maintain the appetite and provide an opportunity for free-exercise and relaxation after training. If pasture is not available, stabled horses are often given a "green pick" on the lead, or hand fed green feed on a daily basis to help maintain their appetite and provide relief from boredom when confined to stables.

There are three main methods by which a suitable hand fed ration can be devised for horses that are confined largely to yards and stables when in training.

- ✓ Formulate a home mixed ration from available ingredients using grains, meals, chaff and roughage to meet the requirements relative to the exercise level, appetite and likes and dislikes of each horse.
- ✓ Commission a feed manufacturing company to carry out a computerised formulation of a specific ration, based on the feeds available, the locality and soil influences and the specific needs of the horses in training.
- ✓ Purchase a ready-mixed or prepared commercial feed as the energy, protein, mineral and vitamin base. Chaff and hay roughage can then be added as recommended on the bag label. This is an option that many racing and performance horse owners and trainers find convenient and timesaving. In some cases, prepared rations may prove to be a more costly option than a home mixed ration, particularly in country areas and during seasonal oversupply of grain.

  The advantages and disadvantages of ready-mixed or prepared feeds are discussed in Chapter 7, Section 7.5, page XXX.

5.5.1 How to Formulate a Ration

The nutritional requirements of all types of horses have been discussed in Chapter 4.

Rations can be formulated from simple ingredients to meet nutritional needs. The acceptance of the ration is influenced by a horse's eating habits, including its appetite, individual likes and dislikes and the relative degree of physical and mental stress it is subjected to during training and competition. Some horses become more selective and less willing to accept a standard ration, as they lose their appetite when worked hard or competed on a regular basis.

KEYPOINT: It is best to measure feeds by weight rather than volume to ensure consistency relative to quality and nutrient content, especially of grains.

Most horse owners measure feeds by volume rather than weight. Initially, a check on the weight per standard volume measure used (eg a scoop, dipper, ice-cream container) should be made, and any new batch of grain, in particular, checked by weight if you sense a difference in quality or weight when measuring it out. Only good quality feeds should be used for horses. (Refer to Chapter 7, Sections 7.1-7.7 for guidelines).

Ready mixed feeds are generally uniform in weight to volume from batch to batch, so that the volume measures recommended can be used when making up a feed.

There are a number of steps that must be followed when formulating a ration for a particular class or type of horse.

These have been summarised in the following step by step method in conjunction with the guidelines given in Tables 5.4 – 5.8. Two practical examples of the steps involved in formulating a home mixed ration using this method are provided on the adjacent page.

- ✓ You will need to weigh or estimate the body weight and decide on an optimum condition score for your horse. (Refer to Chapter 1, Sections 1.3 – 1.4, pages XX to XX for guidelines).
- ✓ You will need to use a calculator when formulating or checking the ration.
- ✓ Consult the guidelines for overall ration formulation suited for each type of horse, as provided in Table 5.4.
- ✓ Although the formulation of a ration is based on guidelines which consider as many variables as possible, adjustments may need to be made to satisfy the specific needs, appetite and likes and dislikes of an individual horse.
- ✓ The prepared ration may need to be adjusted by substitution of different feeds to either increase or reduce the energy density to satisfy a horse's appetite or the bulk of food it can consume without waste of left-overs.
- ✓ The rules of feeding horses, outlined in Chapter 1, Section 1.2, must be observed to ensure full benefit and avoid digestive or metabolic upsets.

Formulating a Hard Feed Ration - Guidelines

How Much to Feed

Guidelines

1. Feed intake is related to body weight for each level of exercise, stage of reproduction and age and rate of growth of young horses. This is summarised for working horses in Table 5.4, and for all classes of horses in Table 5.5.
2. Consider the horse's condition score, height and frame size, appetite, eating habits and temperament.
3. The amount of feed relates to dry feed (10% moisture as fed) for common grains, meals, chaffs and hay.

Method

Refer to Table 5.5

- Using Column 1, select the level of exercise or other use applicable to your horse.
- Using Column 2, calculate the total dry feed intake that a horse should be able to consume in kilograms each day relative to your horse's body weight, using Table 5.5.
- **Note:** If you use a calculator, round off amounts to nearest 0.25kg, as illustrated in Table 5.6.

Select the Required Balance between Roughage and Concentrates

Guidelines

1. The amount of roughage and concentrate are calculated on weight (kg) rather than volume (litres) in Table 5.5, Column 3

Method

Refer to Table 5.5

- Using Column 3, select the relative balance as a % by weight of roughage and concentrate that should meet your horse's specific requirement. You may need to reduce the concentrate intake for a horse that is either a 'good doer' or is not being worked on a regular basis at a consistent level of exercise, or a horse with a nervy temperament.

Select the Roughage Base

Guidelines

1. Plan to feed approximately 75% of the roughage as hay, and 25% as chaff by weight mixed into the concentrate feed.
2. The most common hay used in Australia is lucerne or clover hay.
3. Lucerne or cereal chaff or a mixture of both can be used.

Method

Refer to Table 5.5

- Using Column 3, calculate the total weight of roughage required to meet your horse's requirements.
- Calculate the amount of roughage by weight based on 70 - 75% of the roughage as hay, and 30% as chaff.

Note:

1. If lucerne or clover hay is available as the major long stemmed roughage, use cereal chaff or alternatively a mixture of 50-70% cereal chaff and 30-50% lucerne chaff, as a roughage or fibre base in the grain mix to avoid excess intake of protein and calcium in lightly worked horses.
2. If meadow or grass hay is available as the major long stemmed roughage, use lucerne chaff in the ratio of 50-70% lucerne to 30-50% cereal chaff. Meadow hay is lower in protein and calcium than lucerne hay and a greater volume of lucerne chaff will provide extra energy, protein and calcium to horses in work.

Formulating a Hard Feed Ration – Practical Examples

How Much to Feed

Ration Example 1

Horse: 7 year old Thoroughbred gelding in training for 3 day eventing
Work: 45-60 mins intense work daily
Bodyweight: 475kg
Condition Score: 2.5 (fleshy)
Height: 16.1 hands, medium frame
Appetite: Average, reduces with work
Nervy temperament
Refer to Table 5.5 Column 2
Total Intake: 2.5%bwt in dry feed
Refer to Table 5.6 for calculation
475kg bwt x 2.5% of bwt = 12.0kg daily

Ration Example 2

Horse: 6 year old Warmblood mare in training for elementary level dressage
Work: Light work up to 60 minutes daily
Bodyweight: 550kg
Condition Score: 3.0 (Good)
Height: 16.2 hands, large frame
Appetite: Good.
Quiet temperament
Refer to Table 5.5 Column 2
Total Intake: 2.0% bwt in dry feed
Refer to Table 5.6 for calculation
550kg bwt x 2.0% of bwt = 11.0kg daily

Select the Required Balance between Roughage and Concentrates

Refer to Table 5.5, Column 3 and the calculations above
Total Feed Intake: 12.0kg daily
Roughage: (hay, chaff) 40%
Concentrate: (Grains, meals, oil, pollard) 60%
Note: Considering this horse's nervy temperament, the concentrate has been limited to 60%

Refer to Table 5.5, Column 3 and the calculations above
Total Feed Intake: 11.0kg daily
Roughage: (hay, chaff) 70%
Concentrate: (Grains, meal, oil, pollard) 30%
Note: This horse has a large frame and a good appetite, so 70% roughage is suitable

Select the Roughage Base

Refer to Table 5.5 Column 3 in the calculation above
Total Feed Intake: 12.0kg daily
Roughage: 40% of total intake
Lucerne hay is available
Total Roughage Intake:
12.0kg x 0.4(40%) ≅5kg daily hay/chaff
Lucerne Hay 70% = 5 x 0.70 = 3.50kg
Chaff 30% = 5 x 0.30 = 1.5kg
Because lucerne hay is the roughage base, more cereal chaff should be fed.
Lucerne chaff 30% = 0.5kg
Oaten chaff 70% = 1.0kg
Total chaff = 1.5kg

Refer to Table 5.5, Column 3 in the calculation above
Total Feed Intake: 11.0kg daily
Roughage: 70% of total intake
Good quality meadow hay is available
Total Roughage Intake:
11.0kg x 0.7 (70%) ≅ 7.75kg daily hay/chaff
Meadow hay 75% = 5.75kg
Chaff 25% = 2.0kg
Lucerne hay is selected as the chaff because meadow hay is the main roughage base
Lucerne chaff = 2.0kg

Add the Concentrates

Guidelines

1. Concentrates include grains, protein meals, oils, pollard.
2. If the ration contains over 50% roughage as lucerne hay and chaff, a protein meal need not be added for working horses.
3. Other protein sources can be substituted on a crude protein basis relative to the crude protein content of soyabean meal using Table 5.8.

Method

Refer to Table 5.5

- Calculate the total weight of concentrate required as % of the ration in kilograms (kg).
- Select one or two grains as an energy source.
- Concentrates can consist of all oats or rolled barley, but no more than 50% corn in the total concentrated mix by weight. Grains can be substituted using the guidelines in Table 5.7.
- Select a protein meal if the total ration contains more than 50% grain based concentrate, or less than 50% lucerne as roughage by weight. Add a protein meal at rate of 50g crude protein for each 1kg of grain in the total ration. Using soyabean meal (44.5% crude protein) as the protein meal selected, this equates to approximately 100g soyabean meal (½ cupful (125mL)) per kg of grain. If soyabean meal is not available, substitute another protein source by weight for the soyabean meal, such as canola, lupins or tick beans so as to provide the equivalent amount of crude protein using the substitution rates in Table 5.8.

Divide the Hard Feed Ration into Meals and Allocate the Hay

Guidelines

1. The 'hard' feed mix includes the grain concentrate and chaff as the bulking agent.
2. For simplicity, feed equal amounts of feed in the morning and evening feeds.
   60% of the morning feed by weight may be made up of grain, but no more than 2.5kg of grain in each feed for a 500kg horse.
3. Where 3 hard feeds are given daily, split meals into 40% by weight for the early morning feed, 20% for midday and 40% for evening meal. For a horse that is stabled full time in training, 4 feeds daily are usually provided, with the mid afternoon feed being made up from a portion of the midday and evening feed.

Method

- Divide the total grain and chaff into 2-3 meals for stabled horses.
- Up to 4 equally spaced feeds may be provided to racing horses confined to stables.
- **Feed no more than 500g of grain/100kg body weight in an individual feed.**
- For each kilogram of grain or other concentrate fed, mix in at least 200g chaff, or alternatively mixed chaff, as bulk to provide fibre and dilute the grain.
- Feed 40% of the hay during the day, as one meal, or alternatively split between 2 meals
- Feed 60% of the hay overnight to help maintain a supply of feed for best digestive function and to reduce boredom.
- Dampen the hay if necessary if it is dry and brittle to reduce dust, leaf loss and wastage, as well as improve palatability. Spray the hay until it is damp with fresh, clean water, letting it absorb the moisture for 30-60 minutes before feeding.

Add the Concentrates

Refer to Table 5.5 and the calculations above
Concentrate: 60% of total intake.
You may select two grains for a horse in heavy work, with one energy dense grain, such as corn to reduce ration bulk for horses with reduced appetite when worked hard.

Total weight of concentrate:
12.0kg x 0.6 (60%) = 7kg daily
Select 70% whole oats
30% cracked corn
Total weight of oats = 7kg x 0.70 = 5.0kg daily
Total weight of corn = 2.0kg daily
For this horse, a protein meal is not required because lucerne contributes over 80% of the roughage. (ie. 4.0kg in 5kg of hay/chaff)
Note: You may wish to calculate the crude protein contributed by each ingredient in Tables `10-1- 10.3, compared to the daily requirements in Table 5.5 to obtain accurate

Refer to Table 5.5 and the calculations above
Concentrate: 30% of total intake
Select one grain for a lightly worked horse, as generally only a minimum amount is required to provide energy relative to that contributed by the roughage base of the diet

Total weight of concentrate:
11.0kg x 0.3 (30%) = 3.25kg
Select 100% steam rolled barley
Total weight of barley = 3.25kg daily
For this horse a protein meal is not required because meadow hay and lucerne chaff combined should provide adequate protein for light work.

Note: You may wish to calculate the crude protein contributed by each ingredient in Tables `10-1- 10.3, compared to the daily requirements in Table 5.5 to obtain accurate

guidelines for supplementation

guidelines for supplementation

Divide the Hard Feed Ration into Meals and Allocate the Hay

Total Ration Formulated:

Lucerne hay		3.5kg
Lucerne chaff	0.5kg	
Oaten chaff	1.0kg	
Whole oats		5.00kg
Cracked corn		2.00kg

Check total Feed = 12.0kg per day

As an example, 3 feeds daily could be divided as follows:

Morning feed	Whole oats	1.75kg
	Cracked corn	0.75kg
	Cereal chaff	0.5kg
Midday feed	Whole oats	1.5kg
	Cracked corn	0.5kg
	Lucerne chaff	0.3kg
	Lucerne hay	1.0kg
Evening feed	Whole oats	1.75kg
	Cracked corn	0.75kg
	Cereal chaff	0.5kg
	Lucerne chaff	0.2kg
Lucerne hay (overnight)		2.5kg
	Total:	**12.0kg**

Total Ration Formulated:

Meadow hay	5.75kg
Lucerne chaff	2.0kg
Steam Rolled Barley	3.25kg

Check total Feed = 11.0kg per day

As an example, 2 hard feeds per day with hay at midday, could be divided as follows:

Morning feed	Steam rolled Barley	1.75kg
	Lucerne chaff	1.0kg
Midday feed	Meadow hay	2.5kg
Evening feed	Steam rolled Barley	1.5kg
	Lucerne chaff	1.0kg
Meadow hay (overnight)		3.25kg
	Total:	**11.0kg**

Add a Sweetener if Required

Guidelines

1. If the 'hard' feed is dry, it may be dampened with water or alternatively molasses mixed with hot water. If oil is added as an energy source it will also help to reduce dust.

Method

- Sweeten the meal with ½ cup of molasses mixed in ½ cup hot water per 10 litre volume of feed. (ie. a 20 litre (5 gallon bucket) of feed would be sweetened by 1 cupful of molasses blended into one cupful of hot water).
- Thoroughly mix the molasses into the feed at the time of feeding. Do not store sweetened feed for more than 4 – 6 hours under hot, humid conditions.

Check the Bulk of the Ration

Guidelines

1. A horse can consume roughly 4-5 litres of total hard feed per 100kg body weight in each meal.
2. If the bulk (volume) of the meal is more than 5 litres/100kg body weight, the volume the horse has to eat can be reduced by substituting with higher energy dense grains and vegetable oil, using Table 5.7.

Method

- Mix each of the feeds you have formulated, weighing out each ingredient.
- Check that the chaff base is at least equal in volume to the concentrate mix.
- Determine if the horse should be able to eat the bulk of feed, or roughly a limit of about 4 – 5 litres of hard feed per 100kg body weight. If the feed is too bulky, substitute some of the oats with barley, cracked corn or vegetable oil using the substitution rates in Table 5.7. If up to 10% oil by weight of concentrate mix, such as canola oil, is used for a hardworking horse or a small framed horse with a limited or poor appetite, add up to one cup per meal, removing an equivalent amount of grain. For example, 1 cup (250mL) of oil replaces 1.5 litres of oats in a ration - refer to Table 5.7 for substitution rates.
- **Note:** Refer to Chapter 7, Section 7.1.11.2, page XXX for guidelines for introducing oil in a ration as an energy supplement. A small amount of oil mixed into the ration is helpful in reducing dust.

Add Supplements

Guidelines

1. If 50% of the ration is lucerne, supplementary calcium will usually not need to be included for adult horses, but additional phosphorus would be beneficial to balance the calcium to phosphorus ratio. (Refer to Chapter 6, Table 6.1, page XXX for guidelines).
2. Add one tablespoon (20mL metric spoon) salt for each 2kg of concentrate in the feed of hard working or heavily sweating horses. (Refer to Chapter 6, Table 6.1 page XX for guidelines).

3. Add a vitamin and mineral supplement if necessary. (Refer to Chapter 6, Tables 6.2 and 6.3, pages XX and XX for guidelines).
4. Vegetable oil may be added at a rate of 15mL/100kg body weight to help ensure coat condition for show horses, although evidence of its benefit is largely anecdotal.

Add a Sweetener if Required

As an example:
Morning and midday feeds - dry or dampened with water
Evening meal 1 cup molasses mixed with 1 cup hot water

As an example:
Morning feed: ½ cup molasses mixed into half a cup hot water
Evening meal ½ cup molasses mixed into half a cup hot water

If the horse loses its appetite, then the morning meal may be sweetened with molasses.

Check the Bulk of the Ration

Make up each of the feeds, weighing out each ingredient and mixing them carefully.
Check that the chaff base is at least equal to or more than the volume of the grain added to each feed.

If not, add more chaff – usually it may require only 1 – 1 ½ litres as chaff is bulky but light in weight, ranging from 120g (cereal chaff)-150g (lucerne chaff) per litre volume

A horse should be able to consume up to 4-5 litres per 100kg body weight of a hard feed mix of chaff and concentrates.
If one particular feed is too bulky, consider evening out the meals by removing or topping up with chaff.
The bulk of the ration may be reduced by substituting some of the oats or barley with a feed that has a higher energy density, such as corn, oil, rice pellets or an extruded feed using the guidelines in Table 5.6. This may be required in horses that lose their appetite when worked hard on a regular basis in advanced training.

Add Supplements

Total ration weight: 12.0kg
Total weight of lucerne hay and chaff: 4kg
This ration will require a calcium and phosphorus supplement.
Approx. 40g of dicalcium phosphate daily.
(See Tables 5.4 and 6.1 for guidelines).

Total ration weight: 11.0kg
Total weight of lucerne hay and chaff: 2.0kg
This ration will require a calcium and phosphorus supplement.
Approx. 60g of dicalcium phosphate daily.
(See Tables 5.4 and 6.1 for guidelines).

Note: Calculation of the calcium and phosphorus content in each ingredient can be made using Tables 10.1 – 10.3 compared to daily requirements in Table 6.2 to obtain accurate guidelines for supplementation.

A vitamin and mineral supplement may be included.
Salt should be added and an electrolyte supplement may be included if the horse is a heavy sweater, as recommended in Table 6.1.

A vitamin and mineral supplement may be included.
Salt should be added and an electrolyte supplement may be included if the horse is a heavy sweater.

Method

- If less than 50% of the ration is lucerne, add a calcium and phosphorus supplement. (See Chapter 6, Table 6.1, page XX for guidelines)
- Mix salt, electrolytes and other supplements well into each feed.

Observe and Monitor the Results

Guidelines

1. Feed the ration for 7-10 days initially, or longer if possible.

Method

- Observe the acceptance (palatability), appetite and condition of the horse, and evaluate the feed to the performance result you want from the ration.
- Adjust if necessary.
- Remember to cut grain back to one third on the evening before rest days in working horses by replacing the weight of grain removed with hay, and reinstate to full grain over 2 days once work is resumed to help avoid excitable and playful behaviour and reduce the risk of tying-up in susceptible horses.

Observe and Monitor the Results

Over a 7-10 day period, observe the horse's acceptance of the ration, its appetite and whether it is 'licking the feed bin clean' and looking for more food.
If the horse is still hungry – add more white chaff or hay to increase the bulk of the feed.
Monitor the horse's condition score and performance.
Adjust the bulk or ingredient ratio if necessary.
Cut the grain back on rest days.
Note: The above ration examples are formulated to provide the basic needs. Other grains and meals can be substituted using the guidelines in Tables 5.7 and 5.8.

Use/Type of Horse	% Roughage(R) to %Concentrate(C)	Energy Need and Density **Energy Density and Cool Feeds (See Glossary)**	Crude Protein (CP) % Requirement **(% in total ration)**	Calcium (Ca) and Phosphorus (P) **(See Table 6.3)**	Electrolytes **Sodium Na Potassium K Magnesium Mg Chloride Cl**	Trace-Minerals **Iron, Copper, Zinc, Manganese, Iodine, Selenium, Chromium**	Vitamins **Vitamin A, D, E Vitamin B group Vitamin C**
Thoroughbred Racehorse (Thb) 450-500kg bwt **Racing Quarter Horse 500-550kg**	Early Training 50-55% R to 45-50% C Fit and Racing 40-45% R to 55-60% C (Minimum 30-35% R)	Early Training Adjust to condition and work intensity/duration Fit and Racing Increase energy density in concentrates to reduce volume if appetite is limited. Substitute some or all oats with corn, barley 5% oil or extruded feeds (See Table 5.6)	Early Training 12-14% CP including 2% protein meal. (See Page XXX) Use guidelines in Table 5.6 for selecting protein meal. Fit and Racing 10-12%CP If less than 2kg lucerne, provide 12-13%CP in concentrate	Early Training Add Ca for bone modeling and bone strength Fit and Racing Add Ca to low lucerne diets, add P to high lucerne diets (See Table 6.3)	Early Training Salt Alkaline salts Light sweat mix Fit and Racing Salt Potassium for heavy sweat loss Heavy sweat electrolyte mix in hot, humid weather	Iron and copper to assist blood generation Full range of trace-minerals at 50%NRC (1989) including selenium. Chromium for muscle mass (optional)	Vitamin A for blood and tendon strength if low suncured hay and calcium supplement Vitamin E for antioxidant and muscle function (include selenium) Vitamin B group for appetite/vitality Biotin to improve hoof quality (optional)
Standardbred Trotting/Pacing Horse 425-450kg bwt **Racing Arabian Horse 400-450kg**	Early Training 50-55% R to 45-50% C Fit and Racing 35-40% R to 60-65% C (Minimum 30-35% R)	Early Training As for Thb Fit and Racing As for Thb Small framed horses – higher energy density in lower concentrate bulk	As for Thb	As for Thb Ensure adequate intake of calcium for heavily sweating horses	Early Training As for Thb Fit and Racing Heavy sweat output – salt and heavy sweat electrolyte mix	As for Thb Heavy sweating horses may benefit from supplementary iron	As for Thb
Polo Horses 425-475kg	Early Training As for Thb Fit and Competing As for Stb	Early Training As for Thb Fit and Competing Smaller framed horses that are worked hard - as for Stb	Early Training As for Thb Fit and Competing As for Thb	Early Training As for Thb Fit and Competing As for Thb	Early Training As for Thb Fit and Competing As for Stb	As for Thb	As for Thb
Dressage	70-75% R to	Require energy,	10-12% CP is	Young horses –	Regular daily	Provide balanced	Provide balanced

body weight dependent on build and breed 500-650kg bwt	25-30% C Up to 35% C if in advanced levels and heavy Thb/Warmblood crosses	muscle bulk and controlled temperament. "Cool" sources of energy include extruded feeds, 3-5% oil, copra meal, rice pellets	adequate based on 3kg lucerne daily hay/chaff daily Excess protein can increase sweating.	ensure adequate Ca for bone development. When fit, as for Thb.	training Salt Heavy sweat electrolyte mix in hot, humid weather or hard work	trace-mineral and vitamin supplement. Chromium for muscle bulk (optional).	trace-mineral and vitamin supplement when no access to pasture. Vitamin E (optional)
Show Hacks Western Pleasure Pleasure Horses 450-600kg	<u>Early Training</u> 75-80% R to 20-25% C <u>Regular Competition</u> Above ratio but adjust to work and temperament	As for dressage. Often perform well on minimal grain. Cool sources as for Dressage but smaller concentrate volumes.	Generally 9-11% CP would be adequate, limit high lucerne intake to avoid excess protein if in heavy condition	Growing horses may require additional Ca and P. 30% lucerne as roughage would supply adequate for competition	Salt Heavy sweat electrolyte mix if hot humid weather and competing	Balanced trace-mineral and vitamin supplement for competition horses	As for Dressage at competitive levels
Pony Club and Riding Pony activities 300-400kg depends on breed and type	Concentrate intake relative to pasture and training frequency and intensity. Base ration on hay and mixed chaff. Avoid excess concentrates at all times.	Generally as for show hacks but must be adjusted to daily work effort. 'Cool' sources of energy required in 'nervy' types.	<u>Light Work</u> 8-10% CP <u>Regular Competition</u> 10-12% CP based on 30% lucerne adequate	Pasture and 30% lucerne as roughage would supply adequate levels	Salt Heavy sweat electrolyte mix if hot , humid weather and competing	As for hacks	Pasture should provide adequate vitamins for lightly worked ponies. As for Dressage at competitive levels
Endurance (Arabian or part-bred) 425-500kg bwt	<u>Early Training</u> 55-60% R to 40-45% C <u>Fit and Competing</u> 40-45% R to 55-60% C	Arabian and their crossbreds may perform well on lower grain intake	<u>Early Training</u> As for Thb <u>Fit and Competing</u> Avoid excess lucerne intake in training (Refer to page XXX)	All horses are mature. Provide Ca and P during 'legging up' training. Provide balanced and adequate Ca and P when fit. Limit Ca from high lucerne intake during training. (Refer to page XXX).	Prolonged Endurance exercise requires full range of electrolytes to replace sweat loss. Salt and heavy sweat electrolyte mix in hot, humid weather.	As for Thb. Iron supplements may not be necessary. Ensure adequate trace-minerals provided in a balanced supplement.	As for Thb. Biotin to maintain hoof quality may be worthwhile in long term training.
Eventing Horses 3 Day Events	<u>Early Training</u>	<u>Early Training</u>	<u>Early Training</u>	<u>Early Training</u>	<u>Early Training</u>	As for Thb	As for Thb

One Day Events 500-550kg	As for Thb Fit and Competing 45-50% R to 50-55% C Adjust C% to daily work effort. Refer to comments for Dressage horses in all columns	As for Thb Fit and Competing Increase energy density relative to workload and appetite limit. May benefit from cool energy sources, including extruded grains, 3-5% oil, copra meal, rice pellets.	As for Thb Fit and Competing As for Thb	As for Thb Fit and Competing As for Thb Older horses require adequate Ca to maintain bone strength	As for Thb Fit and Competing As for Thb One Day Eventers as for Dressage	One Day Eventers As for dressage	One Day Eventers As for dressage
Show Jumpers 500-600kg	Early Training 65-70% R to 25-30% C Fit and Competing 50% R to 50% C	Early Training As for Thb Fit and Competing As for Eventers but with less grain	Early Training As for Thb No additional protein meal usually required. Fit and Competing As for Thb	Early Training As for Thb Fit and Competing As for Eventers	Salt Heavy sweat electrolyte mix and salt in hot, humid weather	As for Thb	As for Dressage. If worked hard, as for Thb.
Polocrosse Campdrafting Stock Horses 450-500kg	Early Training 60-65% R to 35-40% C Fit and Competing 50% R to 50% C Adjust relative to pasture intake and training effort	Early Training As for Thb Fit and Competing As for eventers but less grain	Early Training As for Thb but no additional protein meal Fit and Competing As for Thb	Early Training As for Thb Fit and Competing As for Thb. Older horses require adequate Ca to maintain bone strength	Early Training As for Thb Fit and Competing Salt Heavy sweat electrolyte mix and salt in hot, humid weather	As for Dressage Top grade as for Thb Need relative to pasture intake	As for Dressage. Top grade as for Thb. Need relative to pasture intake.

Table 5.4
Ration Formulation Guidelines for Racing, Horse Sport and Equestrian/Pleasure Horses

Note 1: The feeding guidelines in this table have been compiled from the recommendations given in Table 5.4 relating to the relative intake of roughages and concentrate based on a % body weight bases using values of feed as fed (10% moisture).
Note 2: The function of individual minerals, trace-minerals and vitamins are discussed in Chapter 3, Section 3.6 and 3.7. Guidelines on recommended concentrations required in the diet related to amount per kilograms of feed (as fed) are summarised in Chapter 6, Table 6.4, page XXX.
Note 3: On rest days or lightly worked days, the concentrate intake should be reduced to a maximum of one third on the night before a planned rest day, or the next meal when planned work was not carried out. The full concentrate intake should be reinstated over the following 2 days.

HOW MUCH FEED DOES A HORSE NEED EACH DAY?

Horses should be fed on a body weight basis relative to their specific needs. Roughage, as hay or pasture, must form the foundation as the fibre source of all diets, at a minimum rate of 1kg/100kg body weight for all horses, with concentrates added in proportion to exercise or other needs. Horses in training, or those confined to stalls, require a blend of hay and concentrate to supply the major nutrients required in an adequate bulk that they can consume. These guidelines are provided for horses with limited or no access to pasture.

An adequate supply of fresh, clean water must be available at all times.

Feed Intake to meet Energy, Protein and Fibre needs

COLUMN 1	COLUMN 2	COLUMN 3		COLUMN 4	COLUMN 5
		Balance of roughage and grain/concentrate Required relative to needs			
Type and Duration of Exercise. Classes of Horses, Reproduction and Growth Needs	**Total Daily Feed intake to meet Energy, Protein and Fibre Requirements Weight "as fed" of hay and grains (10% moisture)**	**Roughage** (e.g. Hay, Chaff, Sunflower Hulls, Bran) % by weight* *Assuming an average energy density of 7.5 MJDE/Kg, 10% moisture as fed.	**Concentrates** (e.g. Grains, Protein Meals, Fats (Oils), Raw or cooked (extruded) grains) % by weight* *Assuming an average energy density of 12.4MJDE/Kg, 10% moisture as fed	**Energy Megajoules (MJ) Digestible Energy (DE) (MJDE) Daily**	**% Crude Protein (CP)** In Ration
Working Horses:					
Idle/Resting Horses Maintenance Diet	1.5–2.0% body weight (Average 1.75% body weight) **(1.75kg/100kg body weight)**	**80–100%** Resting horses can usually be maintained on 100% pasture, with roughage as required.	**0–20% maximum** Resting horses on short or sparse pasture may require concentrates in cold weather, or if body condition starts to fall.	13-15MJ DE/100kg body weight Approx. 7.5MJDE per kg of feed	• Resting 7-8% CP (70-80gCP per kg of dry feed) Lysine 0.25% of feed
Light Work 30-60 minutes daily walking, trotting, some cantering. - **Pleasure, basic dressage, show horses, working ponies.** - **Early sport horse training**	1.75-2.25% body weight (Average 2.0% body weight) **(2kg/100kg body weight)**	**65–75%** (average 70%) Good pasture with hay to maintain body weight	**25–35% maximum** (average 30%) • Feed in proportion to exercise. • Reduce grain to one-third on idle/rest days, replace weight with hay. • Nervy horses – feed minimum grain, or extruded feeds, or 5% fat for energy.	17-18MJ DE/100kg body weight Approx. 9.2MJDE per kg of food	• Lightly worked horses 8.5-9.0%CP (85-90gCP per kg of dry feed, or 170gCP per 100kg bwt). • Early sport horse training 10-12% CP Lysine 0.32% of feed

Moderate Work 60-120 minutes walking, trotting, canter, some galloping · **Advanced Dressage, Jumping, Hunters, Polocrosse, One Day** Horse Trials, (Eventers) **Racehorses – early training**	2.0-2.5% body weight. (Average 2.25% body weight) **(2.25kg/100kg body weight)**	**50%** (average 50%) Roughage bulk may limit intake to meet energy needs in small framed horses or naturally "poor doers".	**50% maximum** (Average 50%) • Feed in proportion to exercise. • Reduce grain to one-third on idle/rest days, replace weight with hay.	21-23 MJDE/100kg Approx. 10 MJDE per kg of feed	• All horses 9-10%CP (90-110gCP per kg of dry feed, or 190-200gCP/100kg bwt) • Harder work 10-12%CP. Lysine 0.35% of feed
Intense (Heavy) Work 30-60 minutes sustained trotting, cantering, galloping or short, intense, stressful exercise. • **Advanced race training, Polo,** • **Upper Level Horse Trials (Eventers)** · **Endurance riding**	2.5-3.0% body weight (Average 2.75% body weight) **(2.75kg/100kg body weight)** Hard worked horses may not be able to consume more than 2.5% body weight on a regular basis. The energy density of the ration may need to be increased by adding more grain or fat (see % grain comments).	**30-40% absolute minimum** (average 35%) 30% roughage by weight of total ration as hay and chaff is the absolute minimum to ensure efficient digestive function and hindgut water holding capacity in working horses.	**60-70% absolute maximum** (average 65%) Racing horses up to 60-65% grain – limit bulk by substituting high energy density grains (corn, barley, sorghum) and 5% fat (up to 10% fat in endurance horse diets). If low fibre grains such as corn replace more than 50% of oats in a ration, limit grain:roughage to 50:50 ratio by weight. Feed in proportion to exercise, reduce grain to one-third on idle/rest days, replace weight with hay.	28-30MJ DE/100kg Approx. 10.7 MJDE per kg of feed	• Hard working horses 10-12%CP. (120-140gCP per kg of dry feed, or 260-270gCP/100kg bwt) Very heavy work, 12-14%CP may be provided. Lysine 0.36% of feed
Breeding Horses					
Mares Early Pregnancy **Non pregnant mares fed as for resting horses.**	1.5-2.0% body weight (Average 1.75% body weight) **(1.5-2kg/100kg body weight)**	**80-100%** Pasture will normally satisfy needs, with hay during critical times.	**0-20%** maximum Grain, such as oats, may be fed during cold weather or when pasture is sparse, to maintain condition.	13-15MJ DE/100kg body weight Approx. 7.5MJDE per kg of feed	8-10%CP, or if adequate feed, mixed pasture will meet needs. Lysine 0.25% of feed
Mares Late Pregnancy 9-11 months	1.75-2.25% body weight (Average 2.0% body weight) **(2kg/100kg body weight)**	**80%** reducing to **70%** in last month to allow for reduced hindgut capacity due to almost full size foal.	**20% - 30%** Increasing in last month to provide extra reserves for milk production.	17-18MJ DE/100kg body weight Approx. 8.4 – 9MJDE per kg of feed	9-11% CP (90-110gCP per kg of dry feed. Lysine 0.33% of feed

Mares Early Lactation 0-3 months	2.5-3.0% body weight. (Average 2.75%) **(2.75kg/100kg body weight)** Many mares will consume 3.0% body weight of dry feed – provide extra roughage.	**50%** May reduce to 40% if mare and foal sharing feed.	**50%** May increase up to 60% with crushed or extruded grains if mare and foal sharing feed.	28-30MJ DE/100kg body weight Approx. 10 MJDE per kg of feed	12-14% CP Lysine 0.41% of feed
Mares Late Lactation 3 months – weaning	2.0-2.5% body weight. (Average 2.25% body weight) **(2.25kg/100kg body weight)**	**65%**	**35%**	21-23MJ DE/100kg body weight Approx. 9.2MJDE per kg of feed	9-11% CP Lysine 0.34% of feed
Stallions (Stud Season) [Stallions (Off Season) as for resting horses]	1.75-2.25% body weight (Average 2.0%) **(2.0kg/100kg body weight)**	**70%**	**30%** Up to 35% if working on a regular basis.	17-18MJ DE/100kg body weight Approx. 9MJDE per kg of feed.	12-14% CP (no advantage in feeding a higher protein diet) Lysine 0.3% of feed
Growing Horses					
Foals 2 weeks to 3 months	1.5% body weight as a creep feed supplement. (Can consume up to 2.5-3% of body weight if pasture limited).	**20%** increasing to **30%** chaff and soft hay as fibre digestion limited as hindgut starts to develop after 6-8 weeks.	**80%** reducing to **70%** as hindgut starts to develop after 6-8 weeks. Pellets and/or crushed grains or extruded grains are better utilised in foals.	30-32MJ DE/100kg body weight Approx. 14MJDE per kg of feed	16-18% CP in concentrate if cereal chaff used. 12-14% if lucerne chaff used. Lysine 0.55% of feed.
Weanlings 4-6 months to 12 months	2.5-3.5% body weight (Average 3.0% body weight). **(3.0kg/100kg body weight).**	**30%**	**70%** Adjust to growth rate and condition of weanling, if heavy condition, reduce concentrates to 50%, increase roughage to 50%.	28-30MJ DE/100kg body weight Approx. 11MJDE per kg of feed.	12-14% CP (Up to 14-16% CP in concentrate if cereal hay/grass pastures) Lysine 0.55% of feed.

Yearlings 12-18 months	2.25-2.75% body weight (Average 2.5% body weight) **(2.5kg/100kg body weight).**	**40%**	**60%** If in heavy condition, reduce to 40% concentrate, increase roughage to 60%)	21-23MJ DE/100kg body weight Approx. 10MJDE per kg of feed	10-12%CP (Up to 12-14% in concentrate cereal/hay grass pastures). Lysine 0.48% of feed
Horses 18 months-24 months	2.0-2.5% body weight. (Average 2.25% body weight) **(2.25kg/100kg body weight)**	**55%**	**45%** If heavy in condition, reduce to 35% concentrates, increase roughage to 65%.	21-23MJ DE/100kg body weight Approx. 10MJDE per kg of feed	9-11% CP (Up to 12-14% CP in concentrate on grass pastures). Lysine 0.45% of feed

Source: NRC (1989)

TABLE 5.5

Guidelines for Estimating Dry Feed Intake, Balance between Roughages and Concentrates, Energy and Crude Protein Requirements Relative to Exercise, Reproductive or Growth Demands for all Classes of Horses

Total Daily Feed Intake Dry Feed (kg) Daily as fed (10% moisture)						
Body weight (kg)	**Resting Horses Mares Early Pregnancy 1.75% (kg)**	**Light Work Mares Late Pregnancy Stallions 2.0% (kg)**	**Moderate Work Mares late Lactation Stallions at Stud Horses 18 months 2.25%(kg) Endurance Horses**	**Yearlings 2.5% (kg)**	**Intense Work Mares Early Lactation 2.75% (kg)**	**Large Framed Working Horses** Heavy Lactating Mares **Weanlings 3.0% (kg)**
250	4.5	5.0	5.5	6.25	7.0	7.5
275	5.0	5.5	6.0	7.0	7.5	8.25
300	5.25	6.0	6.75	7.5	8.25	9.0
325	5.75	6.5	7.25	8.25	9.0	9.75
350	6.25	6.75	8.0	8.75	9.75	10.5
375	6.75	7.25	8.5	9.5	10.25	11.0
400	7.0	8.0	9.0	10.0	11.0	12.0
425	7.5	8.5	9.5	10.75	11.75	12.75
450	8.0	9.0	10.25	11.25	12.5	13.5
475	8.25	9.5	10.75	12.0	13.0	14.25
500	8.75	10.0	11.25	12.5	13.75	15.0
525	9.25	10.5	12.0	13.25	14.5	15.75
550	9.75	11.0	12.5	13.75	15.0	16.5
575	10.0	11.5	13.0	14.5	15.75	17.25
600	10.5	12.0	13.5	15.0	16.5	18.0
625	11.0	12.5	14.0	15.75	17.25	18.75

650	11.5	13.0	14.75	16.25	18.0	19.5
675	12.0	13.5	15.25	17.0	18.5	20.25
700	12.5	14.0	15.75	17.5	19.25	21.0

TABLE 5.6

Expected Total Daily Feed Intake of Dry Feed in Kilograms for Various Classes of Horses Related to Body Weight

(Calculated to nearest 0.25kg increments) (Refer also to Table 5.4 for specific details)

HOW TO USE THIS TABLE:

Oats is taken as the standard grain for energy, and the relative energy content and substitution weights of other grains and feeds are listed in comparison to this standard. For example, 1kg or 2 Litres of oats can be substituted by 830g or 1.3 litres of crushed lupins or **alternatively** 900g or 1.4 litres of rolled barley to give the same energy level. All other grains can be substituted in a similar way, eg. each 850g or 1.3 litres of crushed lupins in a ration can be replaced by 610g or 1.3 litres of black sunflower seeds for equal energy.

Feed	MJ/kg Digestible Energy	Protein % g/kg (% x 10)	Best Form to feed to Horses	Approx. Weight per litre measure	ENERGY Direct Substitution		Comments
					Weight to give same energy as 1kg oats	Volume in Litres Measures	
Oats (whole)	11.4	9.6 average (96g)	whole or crimped	500g	1 kg	2	Standard and safest grain- can be fed with hay as roughage for maintenance, breeding or working horses.
Barley (rolled)	12.8	10 (100g)	soaked whole, steam rolled	660g	900g	1.4	Palatable and well accepted- cool energy for performance and working horses.
Sorghum (whole) (milo)	13.0	11.0 (110g)	soaked whole, crushed	780g	870g	1.1	Best fed soaked whole or crushed- introduce in a step-wise manner over 5-7 days, maximum 40% grain accepted.
Triticale (whole)	14.2	14.0 140g	soaked whole, crushed	680g	800g	1.2	Sharp awns, soak or crush or mix into damp chaff mix. Good energy source for working horses- limit to one third total grain daily.
Wheat (whole)	14.1	11.4 (114g)	crushed	850g	800g	0.95	Often available on farm as animal feed in drought- care to introduce slowly and remove on rest days- limit to avoid founder.
Corn (cracked)	14.1	9.1 (91g)	whole soaked, cracked	760g	800g	1.0	Ideal energy dense boost for racing and high performance horses in place of oats. Cut out on rest days. Limit volume to avoid founder.
Lupins (crushed)	13.7	33.8 (338g)	whole soaked, cracked	660g	830g	1.3	Good energy and protein feed, no carbohydrates. Limit to one third total grain to avoid excess protein.
Sunflower Whole (black)	18.7	23 (230g)	whole only	480g	610g	1.3	The highest energy of all grains, well accepted, limit to 30% grain to avoid excess protein and bulk.
Polyunsaturated Oil (per kg)	37.7 (9.0 MJ DE per 250 mL cup)	-	Add in step wise manner over 10-14 days to replace grain.	230g per cup* 920g/L	300g	1.3 cups	Pure energy concentrate, often cheaper per energy unit than oats. Add in step-wise manner to ensure acceptance. Energy booster.
Wheat Pollard	13.1	15.6 (156g)	Dampened only	110g per cup 440g/L*	870g	2.0	Energy for conditioning. Limit to 3 litres daily on continuous basis- dampen and mix with chaff.
Stud mix 10% protein (low grain)	11.4	10 (100g)	Feed as presented	Weight varies with blend- see label.	1kg	Check bag label	Good source of balanced feed with roughage- see manufacturer's directions.
Stud mix 12% protein (high grain)	13.4	12 (120g)	Feed as presented	Weight varies with blend- see label	850g	Check bag label	Good source of balanced feed with roughage- see manufacturer's directions.
Molasses	11.4	4.3 (43g)	Mix 50:50 with warm water.	330g/cup*	1kg	not applicable	Common appetiser. 1% of hard feed. Used in Queensland as an energy source in mares. (See page xx).

*Cupful = 250mL standard metric cup.

Source: Table 10.1 and Kohnke (1998)

Table 5.7

Substitution Rates for Common Energy Feeds on a Weight and Volume Basis

HOW TO USE THIS TABLE:

Soyabean meal is taken as a standard protein source, and the relative substitution weights to provide the same amount of protein can be made up from single or multiple sources of protein meals. For example, one cup of soyabean meal can be replaced by 1.5 cups of canola or cottonseed meal for the same amount of protein. Because of the variation in weight and protein content, 2 cups of crushed tick beans are required to replace 1 cup of soyabean meal for equal protein.

Feed	Digestible Energy (MJ/kg)	Protein % % x 10 (g/kg) (L= Lysine g/kg)	Best Form to Feed to Horses	Approx. Weight per 250mL Cupful	Protein Direct Substitution		Comments
					Weight to give same Protein as 1 kg Soya Meal	Volume in cups compared to 1 cup of Soyabean Meal	
Soyabean meal (solvent extracted)	13.1	44.5% (445g) (L=28.0g)	Meal extracted	200g	1 kg	1 cup	The best source of balanced protein and amino acids available for growing and performance horses.
Full Fat Soyabean (Extruded 18% Fat)	17	38% (380g) (L=24.0g)	Granules/meal extruded	180g	1170g	1 3 cups	Higher energy than extracted meal, suitable to boost energy.- Very palatable. Turns rancid on storage unless extruded.
Linseed Meal (Mech. extracted)	14.1	34.6% (350g) (L=11.6g)	Low dust meal	190g	1270g	1.3 cups	Often expensive and not widely available, step-wise introduction to ensure acceptance.
Cottonseed Mea (Mech. Extracted)l	12.2	41% (410g)	Clean meal	150g	1085g	1.5 cups	Reduced availability in drought seasons. Step-wise introduction to ensure acceptance.
Sunflower seed whole (black)	18.7	23% (230g) (L=9.5g)	Plump whole seeds	120g	1930g	3.2 cups	Good 'cool' energy boost to performance and show horses, obviously lower in protein so more is required to replace high protein sources
Canola Meal (Mech. Extracted)	11.5	36% (360g) (L=21.2g)	Free flow meal	165g	1235g	1.5 cups	Good protein source if available, step-wise introduction to ensure acceptance
Tick Beans (cracked)	13.1	25.5% (250g) (L=17.0g)	Clean cracked beans	180g	1750g	2 cups	Common protein source in racehorses- may not be readily available- replace with lupins if available.
Lupins (crushed)	13.7	33.8% (338g) (L=16.0g)	Clean cracked seeds	165g	1320g	1. 6 cups	Good energy source, palatable and suitable replacement for other protein meals.
Peas (whole)	13.8	23% (230g) (L=16.0)	Whole clean seeds	180g	1930g	2.1 cups	Not widely available- best fed crushed- do not use treated seed peas.
Milk Powder	15.1	34% (340g) (L=25.4g)	Free flowing powder	150g	1310g	1.75 cups	Good protein source in young foals, expensive, other meals are cheaper.
Copra Meal	10.6	22% (220g) (L=5.4g)	Clean, Free of shells	150g	2020g	2.7 cups	Palatable, cool energy feed, low lysine content.

Source: Table 10.2 and Kohnke (1998)

Table 5.8
Substitution Rates for Common Protein Feeds on a Weight and Volume Basis

5.6 Summary

- ✓ Resting and lightly worked horses can usually be kept at pasture, with supplementary hay during critical times of the year when pasture is short.
- ✓ Horses in light to intense work can be trained from the paddock, with hay and hard feed provided overnight in a stable or yard.
- ✓ Heavily pregnant mares will require a hard feed and hay once daily during autumn and winter prior to spring foaling, relative to pasture growth and availability.
- ✓ Lactating mares will require a hard feed once daily, with additional hay relative to pasture availability, as pastures dry off over the summer months and early autumn.
- ✓ Rations for young foals should be formulated from crushed or extruded grain and pellets, providing 16 – 18% crude protein and a mineral mix containing a balanced calcium:phosphorus ratio, 30 – 50 mg copper, zinc, and manganese per kilogram of the feed mix as well as 0.1mg/kg of iodine and selenium in deficient areas.
- ✓ Weanling and yearling diets should contain 14 – 16% crude protein, and carefully balanced mineral and trace-mineral content, avoiding low or excess calcium or phosphorus, and providing 30 – 50mg of copper, zinc and manganese per kilogram in the feed in the mix as well as 0.1mg/kg of iodine and selenium in deficient areas.
- ✓ Weanlings and yearlings should be fed to maintain a moderate condition score with steady growth rate, complemented by opportunity for daily paddock exercise.
- ✓ Horses on total hard feed diets must be provided with a balanced ration, proportional to their body weight and relative to the type of exercise. Home-mixed or ready-mixed prepared feeds or a combination of both can be provided.
- ✓ All horses must be provided with free access to adequate volumes of clean, fresh water at all times.
- ✓ There are a number of rules that should be observed when formulating a (hard feed) ration.

• Make it simple	Select 1 or 2 energy sources, 1 protein source if necessary, and 1 or 2 roughages. Blend into a volume that can be consumed by the horse.
• Maximum quality ingredients	Select good quality ingredients to ensure optimum benefit and acceptance
• Measure it accurately	Measure out ingredients each time, to ensure the same ratios are blended into the feed.
• Make-up shortfalls	Add supplementary minerals, vitamins and electrolytes to make up known shortfalls in hard feeds relative to a horse's requirements.
• Mix it thoroughly	Mix the ingredients well, dampen or sweeten if necessary, to reduce dust and prevent selection.
• Monitor the results	Start in a step-wise manner for new feeds to ensure acceptance and monitor condition and its benefits or effects over 10-14 days.
• Make adjustments	Slight changes may be necessary to ensure acceptance, full consumption and optimum benefits.

CHAPTER 6

DOES MY HORSE NEED A SUPPLEMENT ?

One of the common queries raised by horse owners and trainers is related to the need for, and benefit of, dietary supplements to improve the health or performance of their horses. In the broad sense, a supplement includes any feed added in an amount less than 1000g daily to improve the nutritional quality of a horse's diet. The term "supplement", however, usually refers to the inclusion into the feed of a mineral, electrolyte, trace-mineral or vitamin, or a combination of these nutrients in a small amount of less than 100g daily for the average sized horse.

Over recent years, research in Australia and overseas has provided more accurate guidelines on the nutritional needs of horses and how they vary in relation to growth, exercise or reproductive demand. The widespread analysis of the nutrient composition of common feeds that are fed to horses has identified seasonal and locality variations that can result in low or inadequate levels of certain nutrients, which can affect the health and performance of a horse. In some cases, individual nutrients provided in feeds are imbalanced or in excess of needs and, if not corrected, can be detrimental to a horse's well-being.

KEYPOINT: Mature resting horses with access to good quality pasture are normally able to obtain an adequate intake of major nutrients, minerals and vitamins to meet their needs.

Note: In this text, **trace-elements** refer to soil content of microminerals, and **trace-minerals** refer to the nutrient in feed eaten by a horse.

KEYPOINT: Research has shown that long term and repeated removal of plant material from a paddock by hay or grain production can result in substantial mineral and trace-element removal from the soil.

Deficiencies of some nutrient elements such as copper, iodine or selenium may result from long term leaching of soluble soil elements in high rainfall areas. Unless these elements are replaced by fertiliser application, then horses grazing these areas may suffer a dietary deficiency of essential minerals and trace-minerals that could affect their growth, breeding efficiency and performance. Horses that graze these pastures may develop symptoms associated with a deficiency of these trace-minerals. (Refer to Chapter 9, Section 9.5.2, page XXX).

- Marginal deficiencies may severely limit plant growth and result in low pasture productivity.

  The acidity or alkalinity of the soil can also influence the availability of trace-elements to the growing pasture and hence the intake of these trace-minerals in the diet of the grazing horse, as illustrated in Figure 6.1. In many cases, cattle and sheep are affected by trace-mineral deficiencies of copper and cobalt when grazing deficient pastures earlier, and to a greater degree, than horses.

- Within the area of a horse pasture, there is also a net shift in the concentration of nitrogen and many other nutrients from the closely cropped 'lawns' to the 'roughs' or dung areas. This can reduce the rate of pasture regrowth and the nutrient and trace-mineral availability in the lawns or preferred grazing areas. Even when supplementary hay is provided, nutrients still continue to build up in the 'roughs' or dung areas around trees or feed bins.

- In localised areas, plants regarded as weeds can concentrate potentially toxic minerals, such as selenium, on soils containing a naturally high content of this potentially harmful trace-mineral. (Refer to Chapter 9, Section 9.5.2, page XXX).

- A high application rate of fertilisers containing molybdenum to soils that are marginal in copper or zinc may induce deficiencies of these trace-elements in plants grown on those soils. Likewise, application of high rates of nitrogen fertilisers could induce deficiencies of iodine and manganese in soils, which are marginal in these elements.

- Australian soils are almost universally deficient in phosphorus and nitrogen. In addition, there is a wide variation in soil levels of important major minerals (eg calcium, potassium, sulfur) and trace-minerals (eg selenium, copper, zinc, boron).

Research over many years has enabled major deficiencies of important nutrient minerals to be categorised for more intensively farmed agricultural regions of Australia.

KEYPOINT: Horse owners are well advised to contact the local or regional Agronomist, or their State Department of Agriculture or Primary Industry, to determine the type and extent of known soil nutrient deficiencies in their area.

✓ Soil testing, with a complete mineral analysis, is relatively cheap and a cost-effective way to determine which mineral problems, if any, need to be addressed through pasture management or dietary supplementation.

The main effects of soil acidity on the composition of plant materials are those resulting from induced deficiencies (or sometimes toxicities) of mineral nutrients in the soil. Trace-elements are particularly important in this respect, as they are required in only minute amounts and a slight change in availability may exert a major effect on the intake of these as trace-minerals from pasture or other feeds by horses.

The major management option for the reduction of soil acidity is the application of lime. While this may increase availability of some elements beneficial to plant growth (eg calcium, phosphorus, magnesium and copper), it may at the same time reduce the uptake of other trace-elements, such as zinc and manganese. (See Figure 6.1).

Source: Follet *et al*, 1981

FIGURE 6.1

The Influence of Soil Acidity and Alkalinity on the Availability of Major Minerals and Trace-Elements from Soils

KEYPOINT: Analysis of feeds in Australia has indicated that the content of many minerals and vitamins can vary between individual batches of feed. Feeds produced from plants or plant products grown in different areas may also vary widely in mineral content.

✖ Widest variations have been reported for the trace-minerals, copper, manganese and selenium in cereal grains, with narrower ranges of values for these trace-minerals in soyabean and cottonseed meals and least differences in lucerne hay and chaff.

✖ The vitamin A, E and pyridoxine (vitamin B6) composition of grains varied the most between samples. Vitamin content is further influenced by harvest, storage and processing conditions.

✖ Certain types of pastures contain high levels of chemical compounds, (such as oxalates in many tropical grasses) that can interfere with mineral uptake, in particular calcium, phosphorus and zinc leading to symptoms of deficiency. (Refer to Chapter 9, Section 9.5.2, page XXX).

KEYPOINT: A borderline deficiency of a trace-mineral or vitamin may be present in the diet without a horse showing any outward signs.

6.1 Common Reasons for Adding a Supplement

There are a number of reasons for the addition of supplementary nutrients to the rations of horses, some of which have been identified by research as being important to meet increased demands of growth, reproduction or performance, or to replace elevated losses in working horses.

KEYPOINT: Each year in Australia, about $10 million is spent on commercial (oral or injectable) mineral, trace-element and vitamin supplements for all types of horses. Up to 4 times this amount is outlaid on premixed and prepared feeds fortified with a variety of nutrients.

A supplement of a wide range of nutrients, or a single mineral, electrolyte, trace-mineral or vitamin added to a horse's ration may be beneficial under the following circumstances.

✓ **To correct known low or inadequate natural levels of minerals and vitamins in the feed relative to the daily requirements of a particular horse.**

Common Examples:

1. Grains and their byproducts contain from 4-15 times more phosphorus than calcium. Calcium supplementation is often necessary to balance the calcium to phosphorus ratio to 2 parts calcium to 1 part

phosphorus for adult working horses on high grain diets. This is particularly important when minimal amounts of lucerne or legume hays are being fed as roughage.

2. Lucerne contains high levels of elemental calcium (12.2g/kg) relative to phosphorus (2.2g/kg). When selected as the primary roughage, lucerne will correct inadequate levels of calcium in the ration. However, high intakes may cause a relative deficiency of phosphorus in a diet that is already lacking in this mineral, as is often the case with a young growing horse, lactating mare or a horse in heavy training.

☑ To correct high levels of certain compounds or nutrients that could bind up or interfere with the uptake of other minerals or trace-minerals in the diet.

Common Examples:

1. High supplementary intakes of calcium in the form of limestone, provided to correct a calcium deficiency in a high grain diet may, in fact, reduce the uptake of magnesium and trace-minerals including iron, zinc, copper and manganese from the small intestine of the horse. A supplement of these trace-minerals to counteract the reduced uptake may be necessary in growing, breeding and working horses.

2. High intakes of pastures in northern Australia which are dominant in tropical grasses containing oxalate chemicals can induce a calcium deficiency in a grazing horse by binding it in the small intestine and reducing its absorption. (Refer to Chapter 7, Section 7.4.7, page XXX). Owners of all horses that are grazing tropical grass based pastures must provide calcium and phosphorus supplements to offset this binding effect and help protect bone structure and limb soundness. (Refer to Nutritional Secondary Hyperparathyroidism - Glossary term)

3. Concentrate ('hard') feeds containing more than 10% by weight of bran, in which phosphorus is in the form of a phytate complex, can bind up and reduce the uptake of calcium, zinc and iron from the small intestine, leading to a relative deficiency of calcium and these minerals in the diet. A daily feed supplement of these minerals may need to be provided to offset the reduced uptake from the feed, or alternatively, the amount of bran limited to less than 10% of the hard feed mix.

☑ To provide additional specific nutrients to meet increased demands during growth, exercise and reproduction.

Common Examples:

1. Copper, zinc and manganese have been identified as three of the important trace-minerals, which, although they may not be deficient in the diet of a mature horse, are required in higher concentrations in the feeds and rations of heavily pregnant mares and growing horses to ensure optimum bone and joint cartilage formation. When combined with an otherwise adequate, but not excessive energy intake, a balanced diet and daily exercise, specific supplementary intakes of copper, zinc and manganese have been shown to help reduce the risk of limb abnormalities associated with Developmental Orthopaedic Disease (DOD) in foals and young horses. (Refer to Chapter 4, Section 4.4.2.1, page XXX and Glossary term).

2. Supplementation with calcium, phosphorus, iodine and selenium will meet the increased needs of heavily pregnant mares on grass based pastures in mid to late winter. Mares that are being prepared for breeding may also benefit from supplements of phosphorus, iodine and selenium to correct low dietary levels that can adversely affect fertility.

☑ To replace a loss of specific nutrient(s), usually during lactation or exercise, or in certain disease states.

Common Examples:

1. Supplementation with electrolyte salts, including sodium, potassium, chloride, magnesium and calcium, to replace high sweat losses (up to 11 litres per hour under hot conditions) is recommended for horses exercising under hot conditions or for prolonged periods. (Refer to Chapter 4, Section 4.2.3.3, page XXX).

2. During lactation in mares, the major minerals such as calcium and phosphorus are secreted into relatively large volumes of milk (up to 15-20 litres per day in a 500kg mare), increasing demands by 100% for calcium and 57% for phosphorus over the needs of late pregnancy. Supplementation with these major minerals as well as many trace-minerals and vitamins A, D and E in a hard feed each day is necessary to meet the elevated needs of mares grazing on grass based pastures.

3. Heavy burdens of Strongyle worms (Bloodworms and Redworms) can result in substantial blood loss and anaemia. Supplementation with protein, iron, copper and B-group vitamins involved in the synthesis of red blood cells may be necessary to assist recovery after worming.

4. A horse that is prone to 'tying-up" when exercised may benefit from a review of feeding and exercise management, as well as supplementation with calcium, magnesium, a range of electrolytes, and Vitamin E combined with selenium.

To boost dietary intake of nutrients that are perceived, or are known, to improve performance, health and well-being, excluding drug and other medicinal therapies.

Common Examples:

1. Iron supplementation in racing horses is a widespread and traditional practice considered by many trainers to be necessary to improve the red cell count and haemoglobin content of blood. However, its use is based largely on anecdotal evidence. The availability of iron from feeds, ranging from 15-18%, is low compared to other trace-minerals.

Iron supplementation may have a beneficial effect in the following situations;

- **severe blood loss due to heavy Strongyle worm burdens or haemorrhage from large severe wounds;**
- **where the diet may be relatively low in iron, as in high grain rations; or if iron uptake is reduced, such as when calcium is supplemented in the same feed; or in a heavily sweating horse where iron is lost in sweat. Many trainers consider that standardbred racing horses benefit from iron supplements to a greater degree than thoroughbred racehorses in training. This may be relative to the elevated losses of iron in sweat (23mg iron per litre of sweat) as a result of jogging and a longer time spent exercising, usually during the warmer part of the day. Daily supplements of elemental iron, ranging from 75-120mg/100kg bwt are commonly added to the diet of racing horses.**

Dr. Louise Southwood and colleagues in a survey of 50 Thoroughbred and Standardbred trainers in 1992, found that Thoroughbred trainers fed on average 218% (85-461%) and Standardbred trainers 253% (125-381%) of the NRC (1989) daily requirements for iron.

2. B-group vitamin supplements in the feed, or by injection, are widely regarded as being useful to improve the appetite and feed utilisation in hard working horses with little or no access to pasture. It is also used to avoid the development of 'track sourness' in racing horses in long term training preparations.

3. Vitamin E alone, at a supplementation rate of 200iu/100kg bwt, or in combination with 0.25mg selenium per 100kg bwt is often given as a daily supplement. It is aimed at improving exercise capacity and stamina and preventing "tying-up" in working horses. (See Anti-oxidants – Glossary term).

To assist in improving appetite, counteracting the affects of stress, calming nervy or unsettled behaviour, or avoiding possible long-term consequences of hard exercise.

Common Examples:

Dr. Louise Southwood and colleagues in 1992 in a survey of 50 racing trainers within NSW found that the major problem with feeding was getting horses to eat enough feed as they reach peak fitness and racing condition. Dr. Southwood considered that loss of appetite may be caused by a number of conditions including intensive training programs, climatic stress and feeding larger volumes of grain in 2 or 3 feeds with minimum roughage as hay. Diets fed to racehorses in Australia have a high proportion of grain (70% by weight) relative to hay (and chaff) as compared to a 50:50 ratio in diets fed to racehorses fed in North America and the United Kingdom.

1. High raw grain diets result in overflow of undigested starch into the hindgut, which encourage an increased rate of fermentation to propionic acid and D-lactic acid. Vitamin B12 is required for the conversion of

propionic acid to glucose in the liver. High propionic acid levels in the blood may depress appetite, which may be partly improved by daily supplementation with Vitamin B12 in the feed (50-75μg/100kgbwt). (Refer to Chapter 2, Section 2.xx, page XX).

2. Vitamin B1 (thiamine or aneurine) at a dose rate of up to 750mg/100kg body weight daily (or 100 times the normal recommended daily requirement) is widely used to assist in calming "fizzy", unsettled and hyperactive behaviour in many horses. Although it has been difficult to scientifically prove that oral high dose vitamin B1 therapy has a 'calming affect', many horse owners perceive that it has benefit especially when given for an extended time. Other nutrients, including magnesium, the amino acid tryptophan and electrolytes, are often included in high dose vitamin B1 supplements, as these are considered to enhance the calming effect.

3. Supplements of calcium should be provided on a daily basis to counteract the low calcium and high phosphorus content of high grain diets fed to horses in training and help reduce the risk of long-term bone and joint unsoundness.

4. Biotin, or Vitamin H, supplemented at 3mg/100kg bwt daily, is widely recommended to assist in improving the hoof quality of horses in hard training, especially those with flaky, easily broken-away hoof walls. A set dose of 15mg daily or approximately 7-10 times the estimated daily requirement is usually given to all horses regardless of size.

☑ To ensure an adequate intake of specific nutrients, the availability of which could be affected by seasonal conditions.

Common Examples:

1. Warm, moist conditions, which promote rapid growth in tropical grasses including kikuyu in sub tropical, more temperate localities, may increase the production of oxalates in plant tissue. When consumed, the oxalates can bind calcium in the small intestine, leading to a relative deficiency of calcium in horses grazing these pastures, as well as a risk of bone weakness related to Nutritional Secondary Hyperparathyroidism (NSH). (Refer to Chapter 7, Section 7.4.7, page XXX and Glossary term).

2. A number of studies have indicated that blood serum levels of active vitamin D compounds decline during the winter months in non-supplemented pastured horses not supplemented with vitamin D_3 or suncured hay. This is considered to be due to lower levels of the specific wave length of the ultra violet light that activates the natural vitamin D sterol compounds (pre-cursors) in the skin. It is postulated that the low angle of the sun to the earth's surface in the southern latitudes, such as exist in the southern states of Australia, reduces the amount of ultra violet light reaching the earth's surface and hence vitamin D synthesised during the winter months. Supplementation with 500-750iu/100kg bwt of vitamin D_3 in the diet of young grazing horses and broodmares during winter in the southern states of Australia has been suggested as a way to offset the less efficient skin synthesis of vitamin D, especially when suncured lucerne hay is not available on a free choice basis.

3. Leaching of soluble nutrients such as electrolytes from hay can occur when it is immersed in water and soaked, rather than dampened to reduce dust prior to feeding.

☑ To counteract excessive losses during harvesting, processing, storage and mixing of feeds.

Many vitamins deteriorate as a result of exposure to oxygen (air), sunlight, moisture, trace-minerals, heat and pressure in hay and grains and following mixing and storage in prepared feeds. The greatest losses occur in the content of vitamin A, vitamin D, vitamin B1, folic acid, and natural vitamin C in feeds. Wax coated forms of vitamins and protection with antioxidants can be used in prepared feeds and vitamin/mineral supplements to reduce the loss of vitamin potency. (See Figure 6.1)

Common Examples:

1. Sun curing of hay, especially lucerne, increases the active vitamin D content of the hay, but vitamin A activity (as β-carotene) deteriorates substantially during curing and storage of hays and grains. Up to 80% loss can occur over a 6 month period in stored lucerne hay. It has been demonstrated that the natural vitamin D content of feeds deteriorates at a more rapid rate after 6 months of storage.

A horse returning from resting at pasture may have up to a 2-3 months store of vitamin A in its liver. Once this store is depleted, a supplement of vitamin A in the daily ration of a horse in heavy training will help offset any

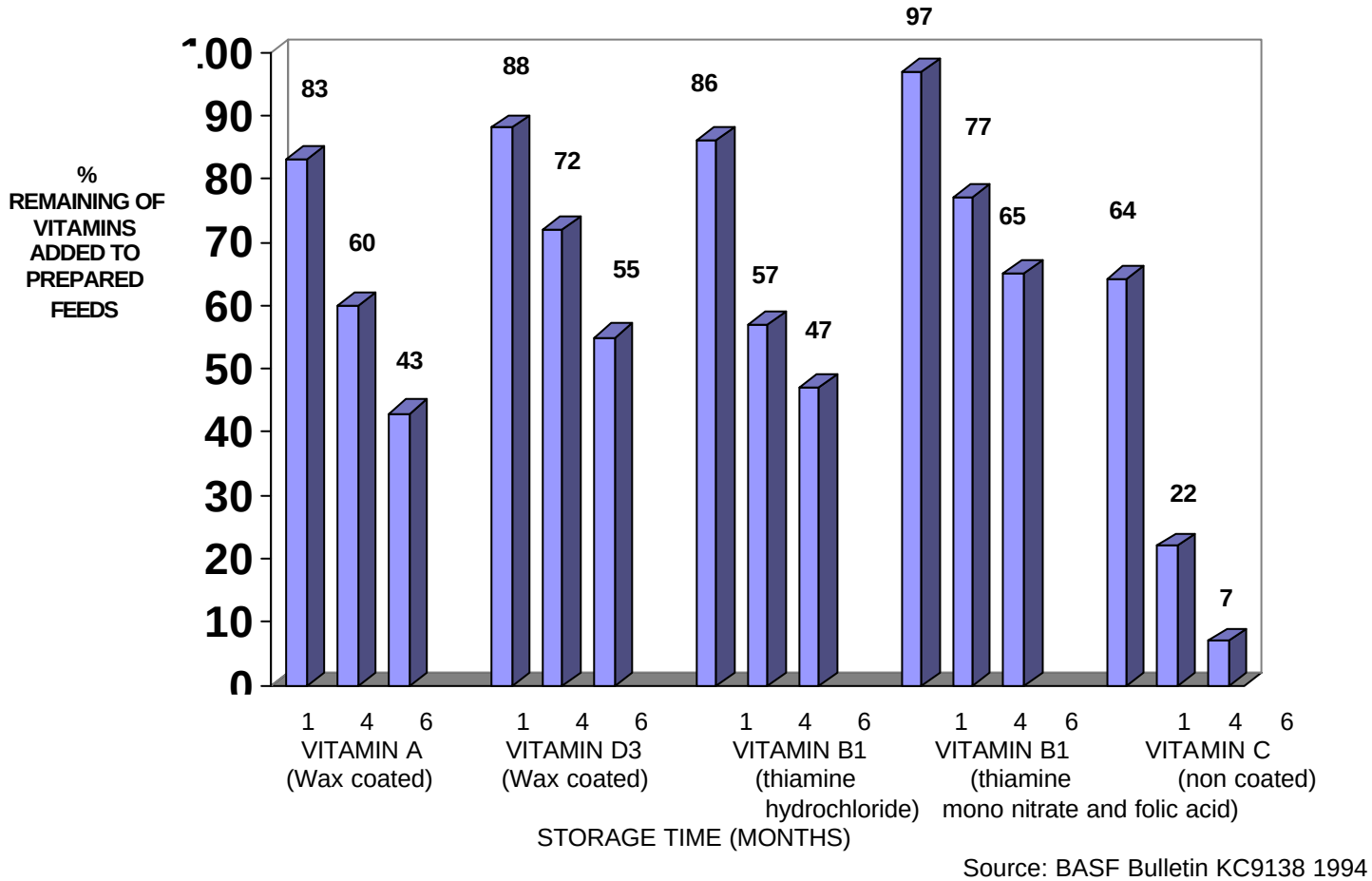
deficiency in sun-cured hay and grains stored from the previous season. Vitamin A is usually supplemented at a rate of 5000iu Retinol/100 kg bwt.

KEYPOINT: Access to pasture, green feed, or supplementation with vitamin A (Retinol) may be beneficial to maintain liver levels of vitamin A in horses fed for periods in excess of 2 months on sun-cured dry feeds.

Although a supplement containing vitamin A may be beneficial, synthetic vitamin A (Retinol) added to commercial feed additives can oxidise and deteriorate rapidly unless protected against moisture, mineral interaction, oxidation and heat by a wax coating and storage under dry, cool conditions.

2. Iron and copper have a damaging effect on vitamin E (and vitamin C) when mixed into the same damp feed. These particular anti-oxidant vitamins should be mixed into another feed separately from iron and copper to help retain their activity. It is wise to adopt the same procedure for all vitamins, if possible.

Feed Industry Averages



Source: BASF Bulletin KC9138 1994

FIGURE 6.1

% Retention of Vitamins included in Prepared Feeds following Storage under Moderate Conditions for 2, 4 and 6 Months Duration

*** Thiamine mononitrate as a source of vitamin B1 is more stable than thiamine hydrochloride in mixed feeds and supplements.**

✓ To give peace of mind that a horse's nutritional needs will be satisfied by adding a supplement to the ration.

Individual vitamins and minerals are perceived to provide benefits, which are often based on traditional use, folklore and anecdotal evidence, particularly in racing and performance horses.

Common Examples:

1. Supplements of B-group vitamins and trace-minerals often fall into this category for resting or lightly worked horses fed a well-formulated, adequate diet with access to good quality pasture that should meet their needs.

2. Adopting a "shot gun" approach by providing a wide range of minerals, trace- minerals, vitamins and other nutrients in both supplements and prepared feeds as an insurance against possible deficiencies in the diet.

3. Over recent years there has been an increase in the popularity of use of additives containing nutrients called neutriceuticals or ergogenic compounds, such as dimethylglycine (DMG), methylsulphonylmethane (MSM), creatine, carnitine, gamma oryzanol and other compounds involved in metabolic pathways. These compounds are given as dietary supplements in an attempt to improve athletic performance in racing and competitive horses.

   In some cases, there is research data and well documented evidence to support the use of dietary supplements containing these nutrients. However, recommendations and dose rates are often based on anecdotal observations and poorly conducted field trials with inadequate scientific design and statistical analysis.

6.2 Disadvantages of Using Supplements

There are a number of disadvantages of routinely adding supplements to a horse's diet.

KEYPOINT: **Supplements can add greatly to the cost of the ration without significantly improving a horse's health, performance and well-being, especially those at rest or performing occasional light work with minimum needs.**

✖ Many supplements, or fortified feeds, often fall short in correcting deficiencies or create further imbalances and relative excesses of specific nutrients in the diet.

In Australia, feed supplements for which a claim is made as an aid to improving health or assisting in correcting a nutrient deficiency must be approved by application and assessment of the product formulation, stability, and safety aspects by the National Registration Authority (NRA).

Formulations are checked so that the daily doses recommended do not fall short of minimum requirements or exceed maximum recommended levels of nutrients, based on published research. Approved products must contain 50% or more of the NRC (1989) recommendations in each daily dose to make a claim as a dietary supplement. An approval number is issued by the NRA and it is required to be displayed on the label of the product, along with full details of the formulation, daily supplement rate and optimum storage conditions.

Products that claim only to correct low or inadequate levels in the diet are not required to be licensed at this time, and may contain low or ineffective levels relative to the 50% minimum level required in an NRA approved supplement. Products that contain potentially toxic nutrients, such as selenium, are restricted to a certain level of supplementation and must be approved by the NRA and carry appropriate poison cautions. Feed supplements containing the B-group vitamin, biotin, with a claim to assist hoof growth, have to be approved by the NRA.

At this time, there is no NRA control on the trace-mineral, mineral and vitamin content of ready-mixed or prepared feeds. Many are formulated to provide daily intakes to NRC (1989) standards. In some cases, insufficient consideration is given to the natural content of minerals and vitamins in the feed ingredients or rate of deterioration of vitamins in damp sweet feed mixes during storage prior to use.

✖ Interaction between an added supplement and nutrients within the feed, or within or between additives, can reduce the nutritional benefit of supplementing the nutrient by reducing its activity or stability.

Common Examples:

It is well established that stored feeds and supplements stored feeds and supplements are prone to the loss of vitamins A, D, E and B1, folic acid and vitamin C in. (See Figure 6.1). Iron, copper and choline, incorporated into a supplement or a prepared feed, are particularly destructive to these vitamins, especially in damp mixes, or when stored under hot, humid environments.

Interaction is more likely in liquid supplements containing ionised forms of trace-minerals together with unprotected vitamins than in dry mixes of powdered or granulated supplements.

✖ **Supplementing with a number of sources containing one or more of the same nutrients can increase the risk of exceeding the Maximum Safe Limit.**

Common Examples:

The most common risk of overdosing can occur when high amounts of calcium or phosphorus are supplemented to young growing horses, as well as iodine, selenium, vitamin A, and vitamin D in all horses. (Refer to the Maximum Safe Limits for individual minerals and vitamins in Chapter 3, Sections 3.6 and 3.7, pages XX).

✖ Providing additional nutrients far in excess of requirements that are quickly eliminated, or could be toxic in the short or long term.

Common Examples:

1. **The water soluble B-group vitamins, including vitamin B12, are known to be rapidly excreted after oral or injectable administration in horses.**

   Studies in Australia in the late 1970's by Dr. Ivan Caple and co-workers indicated that intramuscular injections of vitamin B12 reached a maximum plasma (blood fluid) concentration after 4 hours, decreasing over the next 24 hours and returning to pre-injection levels within 96-144 hours.

   However, when successive weekly injections of vitamin B12 were administered at the commonly used doses, the retention time in the plasma decreased more rapidly, reaching pre-injection levels within 48-96 hours. In another study, vitamin B12 levels in urine increased by 1000 times, and in the droppings by 20 times above normal levels, after a single injection.

   These findings suggest that only small amounts of vitamin B12, not exceeding approximately 4000µg in a single injection, should be given at intervals exceeding 7-10 days.

2. Supplementation with excessive amounts of kelp (seaweed meal) with a naturally high iodine content, has been associated with iodine toxicity in horses. Seaweed meal (kelp) should not be offered as a free choice or ad-lib supplement to horses. (Refer to Chapter 7, Section 7.7.4 page XX).

3. Commercial supplements of trace-minerals, purposely sweetened with sugar or molasses to encourage consumption on a free-choice basis to stabled or pastured horses have been associated with trace-mineral toxicity in horses. It is unwise to provide sweetened supplements containing potentially toxic minerals, such as iodine and selenium to horses on a free-choice basis.

✖ Increasing the environmental concentration of certain potentially toxic trace minerals or other compounds, when excess amounts or poorly absorbed forms are passed out in the urine or droppings.

Common Example:

The mineral chemical, sodium selenite, has been used for many years as a source of selenium in supplements and ready-mixed feeds. In many overseas countries, the use of inorganic selenium compounds has been banned because of the risk of environmental build-up in the soil and waterways of this poorly absorbed form of selenium. Selenium protein complexes and selenium yeasts, containing organic forms of selenium proteinate or selenium-methionine combinations are considered to be better utilised with less selenium being passed out in the droppings.

✖ The selective and careful eating habits of horses can result in them sifting-out additives or leaving feed containing the nutrients.

Common Example:

There is a risk of loss of dry supplement powders that can blow out of paddock feeders under windy conditions or the sifting out of granules or powders from dry feeds. Dampening of feeds just prior to feeding can help to reduce wind-blown or sift-out losses. A new supplement should be introduced in a step-wise manner over 10-14 days to a suspicious or young horse to give it time to accept the change of taste and smell of the feed mix.

6.3 How to Determine if your Horse needs a Supplement

Research has established that specific minerals and vitamins are likely to be low in certain types of pasture diets or ration formulations. Supplementation may be necessary or beneficial to meet the normal or increased requirements of a wide range of horses.

The daily feed requirements of minerals, electrolytes trace-minerals and vitamins are summarised for all types of horses, relative to their intake and body weight in Tables 6.1, 6.2 and 6.3. Suggested supplementary rates are also provided in Tables 6.1, 6.2 and 6.3.

6.3.1 General Guidelines for Supplementation of Horse Diets

In most cases, the following general recommendations apply to the use of supplements to correct low, inadequate or imbalanced levels in the feed, or losses from stored feed.

Common Examples include:

✓ Calcium for horses grazing grass based pastures, particularly on acid soils.

✓ Calcium and phosphorus for horses grazing tropical grasses that are high in late chemicals.

✓ Calcium for horses on high grain diets to balance the high phosphorus content of grain.

✓ Phosphorus for horses, especially breeding and lactating mares, grazing on pastures with a high legume content that contain excess calcium relative to phosphorus. Phosphorus supplementation may be required for all horses that are fed a diet containing lucerne as the major roughage.

✓ Calcium, phosphorus, copper, zinc, manganese as well as iodine and selenium in known deficient areas during the mid-to-late pregnancy period in mares to ensure adequate intake for bone and cartilage growth and maturation of the unborn foal.

✓ Calcium, phosphorus, copper, zinc, manganese, iodine and selenium in the diet of young growing horses to help reduce the incidence of Developmental Orthopaedic Disease (DOD).

✓ Vitamin A, D and E in young horses, breeding and lactating mares grazing dry pastures.

- ✓ Phosphorus, iodine and selenium in breeding and lactating mares to help correct relative deficiencies that may affect fertility.

- ✓ Selenium and iodine for pastured horses grazing on areas where soil deficiencies of these elements are well known, and in horses fed grains and hays known to come from these areas.

- ✓ Sodium, potassium and chloride to replace electrolyte loss in sweating horses, with additional magnesium, iron and selenium in heavily sweating horses, especially for horses that are working or housed under hot conditions or that do not have regular access to pasture.

- ✓ Vitamin A in horses fed on stored or processed feeds, especially sun-cured hay, without recent or regular access to pasture. Daily supplements of vitamin A given to racehorses, at the rate of 10,000iu Retinol/100kg body weight daily, was observed in the UK to reduce the incidence of tendon strain for horses fed on a cereal grain and hay based diet.

- ✓ Vitamin D supplementation at the rate of 100-200 iu vitamin D_3/100kg body weight daily to stabled horses with limited outdoor grazing, or where the diet contains little or no suncured lucerne hay or chaff as a natural source of vitamin D.

- ✓ A daily intake of 1000iu vitamin E in the diet of racing and performance horses is recommended by the NRC (1989), following studies where supplementation ranging from 600-1800iu daily was found necessary to maintain adequate blood, muscle and liver levels. A study in Germany has suggested that race performance and number of wins by horses could be improved by routine supplementation of 2000iu vitamin E daily over a 6 month period.

  It has also been suggested following a review in USA that endurance horses may benefit from supplementation of 4000-5000iu of vitamin E to improve stamina and endurance capacity.

- ✓ A number of studies suggest that vitamin B-group supplements, including vitamin B12 and folic acid, be provided to stabled horses under the stress of training, particularly horses that develop a poor appetite, become 'track sour', or those fed on dry feeds without access to pasture.

  Studies in Queensland by Dr. Malcolm Roberts in the early 1980's found that grazing horses, including pregnant and lactating mares, had significantly higher blood serum levels of folic acid (as folate) than permanently stabled horses on hard feed rations. Levels in grazing horses were higher in spring and summer. It was concluded that stabled horses may benefit from daily supplementation with folic acid, at a rate of 3mg/100kg bwt, in the feed. In Dr. Roberts' study, it was found that supplementation with vitamin B12 did not appear to be justified in stabled horses in race training. However, it has been observed that vitamin B12 supplementation may help improve the appetite of horses on high starch grain based diets. (Refer to Chapter 2, Section 2.x.x, page XX).

- ✓ Supplementation with biotin at 15mg daily, in conjunction with calcium and a diet containing adequate good quality protein from oil seed meals, has been shown by a number of studies to improve the hardness and quality of the hoof wall over a period of 6 months, where horses have brittle or easily broken away hooves.

6.3.2 Analysis of Feed, Soil, Blood or other Tissue

A number of commercial feed companies provide this type of service to horse owners, as a means of identifying low or inadequate levels in the feed being used. Feed analysis of this type can then be used as a basis for formulating a specific "custom" supplement or feed mix.

There are a number of more specific methods by which the need for supplementary minerals, trace-minerals and vitamins for a particular group of horses, or an individual horse, can be determined.

- ✓ **Analysis of Nutrient Content of Feed Samples**
  The standard costs often apply to the quantitative analysis of a single nutrient, and obtaining meaningful values on a range of mineral and trace-minerals can be expensive.

KEYPOINT: Feed analysis only provides a nutrient profile for the one sample or batch of feed and values may vary between different sources, batches of feed, the moisture content and the method of processing and length of storage.

Soil Testing
Complete soil analyses will reveal the acidity/alkalinity status and the content of the key mineral and trace-mineral elements in the soil. The resulting data can be used to identify potential imbalances in these nutrients in feeds grown on deficient soils. Soil test interpretation should be done by a qualified Agronomist who can provide advice on the methods by which potential problems can corrected.

In most cases, a well planned fertiliser top dressing program will correct the majority of the trace-element deficiencies in soils, or overcome any binding effects, so that the pasture is better able to meet the needs of grazing horses.

KEYPOINT: Where particular trace-element deficiencies are present in the soil, dietary supplementation with the specific trace-minerals, especially copper, zinc, selenium, manganese or iodine, may be the most cost-efficient and accurate means of ensuring horses are provided with an adequate and balanced intake.

A Common Misconception

High calcium soils do not always result in a high plant content of calcium, contrary to popular claim by many studs that their locality is well known for its high calcium soils. It is often inferred that young horses grazing pasture on high calcium soils have better bone development but research evidence to support this association is lacking at the present time. Routine supplementation of calcium, phosphorus and other trace-minerals should be considered for all broodmares and growing horses grazing on grass based pastures, especially as they dry off or are grazed down.

Blood Testing
Samples of blood can be analysed for a wide range of minerals and trace-minerals, but correct interpretation is necessary to provide meaningful recommendations.

For example, blood levels of vitamin C in aged mares have been shown to be lower than levels in younger mares on the same pasture. However, there is no evidence at this time that supplementary vitamin C is beneficial in improving the health or fertility of aged mares at stud.

Common Examples:

1. The blood level and activity of the enzyme glutathione peroxidase, which contains selenium, can be monitored and related to selenium deficiency in the diet.

2. Testing for blood levels of important minerals such as calcium, by taking blood samples, usually has no meaningful interpretation. Calcium levels change from hour to hour relative to digestive uptake and losses during exercise. The continuous action of the parathyroid hormone (see NSH Glossary term) maintains blood calcium by resorbing calcium from bone stores to maintain blood levels, even in an acute dietary deficiency of calcium. If not corrected in the long term by calcium supplementation, this can lead to weakened bones and unsoundness.

3. Electrolyte deficiency can only be evaluated by a number of blood samples taken before feeding and exercise to obtain the most meaningful results (Refer to Chapter 4, Section 4.2.3.3, page XXX).

4. Blood levels of copper, zinc, iron and many vitamins can be analysed, but are usually only of help to confirm poor uptake and/or utilisation, rather than a deficiency in the feed.

Liver, Bone Marrow and Tissue Analysis
Samples of these tissues are useful in determining and confirming very severe deficiencies in the diet, which are often displayed by other clinical signs. Biopsy tests are expensive to analyse, and carry some risk of injury or infection during sampling.

Urine Testing
Increased outflow of certain minerals can be an indication of dietary excess and imbalance. The clearance of calcium and phosphorus through the kidneys, using a urine testing method developed in Australia by Drs. Lex Carroll and Ivan Caple in the early 1980's, can provide a guide to calcium and phosphorus imbalances and excesses. However, urine samples have to be collected following a 48 hour rest period with no exercise and after a 12 hour period with no food to provide meaningful results.

Hair Analysis
Hair analysis does not provide a useful or reliable indication of other trace-mineral or vitamin deficiencies in the diet of horses. Hair analysis is a technique that is promoted as a simple means of monitoring the content of protein, minerals and trace-minerals in hair, which is claimed to relate to a deficiency in the feed. Although a reduced diameter of hair fibres can be related to deficiency of protein in the diet of a horse, other more accurate tests to evaluate the adequacy of protein are available. The

level of toxic minerals, such as lead and selenium can be determined by hair analysis, but toxicity arising from high feed intakes of these minerals is uncommon in Australia.

FIGURE 6.3

Localities in Australia Where Trace-Element Deficiencies in Soils Are Known To Occur

Source: Trevor-Jones 1998

Mineral	Common Source	Mineral Content (Amount per level metric 20mL tablespoon)	Standard Rate for Supplementation in a 500kg working adult horse

Calcium (Ca)	◆Calcium carbonate (microfined limestone or agricultural lime) ◆Dolomite (Dolomite limes) 80% calcium carbonate (23% Ca) 20% magnesium carbonate (12% Mg)	◆**39% calcium** (390g/kg) 8g/level tablespoon calcium ◆**31% calcium** (310g/kg) 6.2g/level tablespoon calcium.	**Daily Rate**: Calcium carbonate High grain diets. 1 tablespoon/2kg grain Low lucerne diets 1½ tablespoons for each 1kg lucerne below 3kg daily. (Add an additional ½ tablespoon if Dolomite is used).
Calcium (Ca) and Phosphorus (P)	◆Dicalcium phosphate (DCP) Also called Calcium hydrogen phosphate.	◆**23% calcium** (230g/kg) 4.6g calcium/level tablespoon ◆**18% phosphorus** (180g/kg) 3.6g phosphorus/level tablespoon	Source of both calcium and phosphorus, with phosphorus content promoting calcium uptake. **Daily Rate:** High grain 1 tablespoon for each 2kg of grain. Low lucerne diet 2½ tablespoon for each 1kg lucerne below 3kg daily.
Sodium (Na) and Chloride (Cl)	◆Rock salt Coarse salt (Sodium chloride) (also in Lite salt – see below)	◆**39% sodium** (390g/kg) 8g sodium/level tablespoon ◆**61% chloride** (610g/kg) 12g chloride/level tablespoon	Rock and coarse sea salt are suitable sources if crushed into fine crystals prior to feeding. **Daily Rate:** Light sweaters 2 tablespoons daily. Heavy sweaters 3 tablespoons daily.
Potassium (K) and Chloride (Cl)	◆Potassium chloride (Chloride of potash) Note: ◆ Lite salt is a 50:50 mix of sodium chloride and potassium chloride. Lite salt provides 6.5g sodium 5.2g potassium 8.3g chloride per level tablespoon.	◆**52% potassium** (520g/kg) 10.4g potassium/level tablespoon ◆**48% chloride** (480g/kg) 9.6g chloride/level tablespoon	Available as potassium chloride, or contained in Lite Salt. **Daily Rate:** **Potassium chloride**: Heavy sweaters ¾-1 tablespoon, plus 3 tablespoons salt, daily. **Lite Salt** 1½-2 tablespoons, plus 2 tablespoons salt daily.
Magnesium (Mg)	◆Magnesium sulfate (Epsom salts) ◆Dolomite is also a popular source of calcium and magnesuim. Dolomite 80% calcium carbonate (23% Ca) 20% magnesium carbonate (12% Mg)	◆**20% magnesium** 200g/kg 4g magnesium/ level tablespoon ◆**5.7% magnesium** (57g/kg) 1g magnesium /level tablespoon (Bioavailability of magnesium in dolomite is low)	Epsom salts has a laxative effect if given at dose rates of greater than 1 tablespoon/100kg bwt daily. **Daily Rate:** Epsom Salts Intense work, heavy sweaters 1-1½ tablespoons daily Dolomite Heavy sweaters 3-4 tablespoons daily. Also provides calcium - do not add extra calcium.

Source: NRC (1989)

TABLE 6.1

COMMON MINERAL SOURCES SUITABLE FOR HORSE FEEDS

One level metric tablespoon (20mL volume) weighs approx. 20g for the above major minerals used as supplements

COLUMN	1	2	3	4	5	6	7	8	9	10
Type of Work Breeding Growth	**Ave Daily Feed Intake kg/100kg Body weight**	**Calc (Ca) g/kg of feed**	**Phos (P) g/kg of feed**	**Magn (Mg) g/kg of feed**	**Sod (Na) g/kg of feed**	**Pot (K) g/kg of feed**	**Mang (Mn) Zinc (Zn) mg/kg of feed**	**Iron (Fe) mg/kg of feed**	**Copper (Cu) mg/kg of feed**	**Cobalt (Co) Iodine (I) Selenium (Se) mg/kg of feed**
Maintenance /Resting	1.75 (1.5-2.0)	2.1	1.5	0.8	1.0	2.7	36	36	10	0.1 ✷✷✷
Light Work	2.0 (1.75-2.25)	3.2	1.9	1.0	3	3.4	36	36	10	0.1✷✷✷
Moderate Work	2.25 (2.0-2.5)	3.5	2.2	1.1	3	3.6	36	40✷	10	0.1✷✷✷
Intense Work	2.75 (2.5-3.0)	3.6	2.3	1.2	3	3.9	36	44✷	10	0.1 ✷✷✷
Pregnancy First 8 months	1.75 (1.5-2.0)	2.1	1.5	0.8	1.0	2.7	36	36	10	0.1 ✷✷✷
Pregnancy 9th and 10th month	2.0 (1.75-2.25)	3.9	3.0	1.0	1.0	3.3	36	45	44 ✷✷	0.1 ✷✷✷
Pregnancy 11 months	2.0 (1.75-2.25)	4.1	3.1	1.0	1.0	3.5	36	45	44 ✷✷	0.1 ✷✷✷
Early Lactation 0-3 months	2.75 (2.5-3.0)	4.7	3.0	1.0	1.0	3.8	36	45	44 ✷✷	0.1 ✷✷✷
Late Lactation 3 months on	2.25 (2.0-2.5)	3.3	2.0	0.8	1.0	3.0	36	45	44 ✷✷	0.1 ✷✷✷
Stallions Stud Season	2.25 (2.0-2.5)	2.6	1.9	1.0	1.0	3.3	36	36	11	0.1 ✷✷✷
Weanlings 4 months	3.0 (2.5-3.5)	6.2	3.9	0.7	1.0	2.7	36	45	44 ✷✷	0.1 ✷✷✷
Weanling 6-12 months	3.0 (2.5-3.5)	5.5	3.5	0.7	1.0	2.7	36	45	44 ✷✷	0.1 ✷✷✷
Yearling 12-18 months	2.5 (2.25-2.75)	4.0	2.5	0.7	1.0	2.7	36	45	44 ✷✷	0.1 ✷✷✷
Young Horse 18-24 months	2.25 (2.0-2.50)	3.2	2.1	0.8	1.0	2.7	36	45	44 ✷✷	0.1 ✷✷✷

Source: NRC (1989)

✷ **Requirements for Iron estimated higher than NRC (1989) in heavily sweating horses**

✷✷ **Requirements for Copper estimated higher than NRC (1989) in pregnant, lactating and growing horses.**

✷✷✷ **Requirements for Iodine range between 0.11-0.66mg/kg (NRC 1989)**

Abbreviations: Calc=Calcium, Phos=Phosphorus, Magn=Magnesium,Sod=Sodium, Pot=Potassium Mang=Manganese

To calculate your horse's approximate requirement of a mineral or trace-mineral, use the following steps:

1. Select the type of horse – work, breeding or growing.
2. Estimate its body weight in kilograms (See Chapter 1).
3. Estimate expected daily dry feed intake in kilograms using kg/100kg body weight in Column 1. Example: 425kg bwt = 4.25 x kg/100kg Column 1.
4. As an example, calculate calcium requirement = Feed intake (kg) by value in Column 2.
5. As an example, calculate manganese or zinc requirement = Feed intake (kg) by value in Column 7.

Rate of Supplementation

The rate of supplementation is usually 50% of the total daily requirement for a mineral from the above calculations.

Example: If horse requires 40gms calcium per day, supplement with 20gms if feeding less than 50% roughage as lucerne, which will be provided by 50g of calcium carbonate (2 ½ x 20mL metric tablespoons daily),as detailed in Table 6.1.

TABLE 6.2

Recommended Calcium, Phosphorus, Electrolyte And Trace-Mineral Requirements For Horses Related To Kilogram Daily Intake Of Feed (As Fed-10% Moisture)

COLUMN	1	2	3	4	5	6	7	8	9	10
Type of Work Breeding Growth	**Ave Daily Feed Intake kg/100kg Body weight**	**Vit A iu/kg of feed**	**Vit D iu/kg of feed**	**Vit E iu/kg of feed**	**Thiamine Vit B1 of feed**	**Riboflavin Vitamin B2 mg/kg of feed**	**Vit B6✷ mg/kg of feed**	**Panto-thenate ✷ mg/kg of feed**	**Vit B12✷ mg/kg of feed**	**Folic Acid ✷ mg/kg of feed**
Maintenance /Resting	1.75 (1.5-2.0)	1800	270	45	2.7	1.8	4	5✷	-	0.5✷
Light Work	2.0 (1.5-2.5)	1800	270	72	4.5	1.8	4	5✷	5✷	0.5✷
Moderate Work	2.25 (2.0-2.5)	1800	270	72	4.5	1.8	5	5✷	5✷	0.5✷
Intense Work	2.75 (2.5-3.0)	1800	270	72	4.5	1.8	6	10✷	5✷	1.5✷
Pregnancy First 9 months	1.75 (1.5-2.0)	1800	270	45	2.7	1.8	4	5✷	-	1.0✷
Pregnancy 9th and 10th month	2.0 (1.75-2.25)	2700	540	72	2.7	1.8	5	5✷	-	1.0✷
Pregnancy 11 months	2.0 (1.75-2.75)	2700	540	72	2.7	1.8	5	5✷	-	1.0✷
Early Lactation 0-3 months	2.75 (2.5-3.0)	2700	540	72	2.7	1.8	6	8✷	-	1.0✷
Late Lactation 3 months on	2.5 (2.5)	2700	540	72	2.7	1.8	6	8✷	-	1.0✷
Stallions Stud Season	2.0 (1.5-2.5)	2700	540	72	2.7	1.8	5	5✷	-	0.5✷
Weanling 4 months	3.0 (2.5-3.5)	1800	720	72	2.7	1.8	6	10✷	15✷	1.5✷
Weanling 6-12 months	3.0 (2.5-3.5)	1800	720	72	2.7	1.8	6	10✷	15✷	1.5✷
Yearling 12-18 months	2.5 (2.25-2.75)	1800	720	72	2.7	1.8	5	5✷	0	0.5✷
Young Horse 18-24 months	2.25 (2.0-2.75)	1800	720	72	2.7	1.8	5	5✷	0	0.5✷

Source: NRC (1989) ✷ Values included from Frape (1997) (88% moisture)

✷ The NRC (1989) contains no estimates of vitamin requirement. No evidence for supplementation with Niacin (vit B3) vit K or vit C in the diet of healthy horses.

To calculate your horse's approximate requirement of a vitamin, use the following steps:

6. Select the type of horse – work, breeding or growing.
7. Estimate its body weight in kilograms (See Chapter 1).
8. Estimate expected daily dry feed intake in kilograms using kg/100kg body weight in Column 1. Example: 425kg bwt = 4.25 x kg/100kg in Column 1.
9. As an example, calculate vitamin A requirement = Feed intake (kg) by value in Column 2.
10. As an example, calculate Folic Acid requirement = Feed intake (kg) by value in Column 10.

Rate of Supplementation

The rate of supplementation of a vitamin is 50% of total daily requirement for a vitamin from the above calculations, e.g. if horse requires 40000iu vitamin A per day, supplement with 20000iu from a proprietary supplement.

vitamin A, vitamin D and vitamin E are often expressed in micrograms/milligrams rather than International Units (iu).

vitamin E is often given at doses of 1000iu daily to racing, performance and breeding horses.

Conversion

- 10mg vitamin A (Retinol) is equivalent to 18200iu vitamin A.

- 10µg vitamin D3 (Cholecalciferol) is equivalent to 400iu vitamin D3.
- 100mg vitamin E (Dl-∝-tocopherol) is equivalent to 100iu vitamin E (synthetic).
- 83.6 mg vitamin E (D-∝-tocopherol) [natural vitamin E] is equivalent to 100iu vitamin E (synthetic).

TABLE 6.3

Recommended Vitamin Requirements For Horses Related To Kilogram Daily Intake Of Feed (As Fed-10% Moisture)

6.3.3 Guidelines When Using Feed Supplements

The following guidelines should be adopted when adding mineral and vitamin supplements to the daily ration of a horse.

✓ Choose supplements to make up specific shortfalls, likely deficiencies in the diet, or to cater for increased nutrient needs relative to exercise, breeding or growth requirements. (See Section 6.3.1, page XXX).

✓ Commence on a lower dose initially to aid acceptance of a mineral and vitamin supplement, or any other supplement. Either dampen feeds containing powders or granules to prevent sifting out, or sweeten with molasses and water to ensure palatability and prevent sifting out.

✓ Mix supplements thoroughly into the feed just before feeding to minimise any risk of interaction between minerals and vitamins, especially in a dampened feed.

✓ Modify the daily dose relative to the horse's change in requirements, or to changes in feed composition.

✓ Monitor the effects of the supplement by appraising general health, performance, appetite or other benefit sought, on a regular basis.

✓ Store supplements as recommended on label, adhere to dosage rates and use by the expiry date. Reseal containers after each daily use. Store supplements containing vitamins in a cool place – refer to label directions.

The following precautions should be adopted to avoid loss of potency, reduced availability, or toxicity when adding supplements.

✗ Do not over supplement – more is not necessarily better – this practice can result in unnecessary increase in cost and may risk overdose. Do not allow a horse ad-lib or free choice access to supplements as over consumption can lead to toxicity (eg iodine in kelp, trace-minerals in sweetened supplements).

✗ Do not overlap potentially cumulative nutrients such as Vitamin A, Vitamin D, iodine or selenium in supplements or natural feeds (e.g. iodine in kelp as well as incorporated in a supplement). Seek advice from the manufacturers.

✗ Do not routinely add supplements to ready-mixed or prepared feeds that already contain 100% of NRC (1989) levels of added minerals and vitamins. Be cautious when adding supplements containing the same range of nutrients – check labels. However, some loss of vitamins, such as vitamin A, D, C, B-group and E may occur during storage of dampened, sweet feeds prior to use. Water-soluble B-group vitamins and vitamin C do not have a cumulative effect, as excess is not retained.

✓ Do not mix calcium into pure bran feeds or mashes as it can be bound to phytic acid and rendered less available. It is best to add calcium to a separate feed rather than to a bran mash. Standard amounts of bran, not exceeding 10% of the meal, mixed thoroughly into the feed, should not significantly reduce calcium uptake from the small intestine.

✗ Do not add vitamin E (or vitamin C) to damp feeds containing iron or copper (and choline) as contact with these minerals in a moist feed will reduce the activity of both these vitamins. Some B-group vitamins may also be reduced in potency, especially in feeds containing added choline.

✗ Do not administer injections of fat-soluble vitamins A and D to horses unless under veterinary supervision, as these vitamins are potentially cumulative.

6.4 Summary

There are a number of reasons for providing supplementary nutrients to horses to correct low or inadequate levels in their diets.

- ☑ Resting and lightly worked horses at pasture will normally obtain an adequate intake of minerals and vitamins to meet their needs. However, in some areas, soil deficiencies of selenium and iodine may reduce pasture levels, or use of fertilisers may bind other trace-elements, leading to lower levels in pasture plants. A supplement of these nutrients may be necessary to avoid deficiencies. Other pastures, such as tropical grass pastures, contain oxalate compounds that bind calcium. Under these conditions, supplementary calcium and phosphorus will need to be provided to meet daily needs and prevent deficiency diseases.

- ☑ The most common minerals that require supplementation in the diet are calcium and phosphorus to meet requirements and ensure an optimum and balanced ration in the diet, especially for young horses.

- ☑ Copper, zinc, manganese, iodine and selenium are the trace-minerals that are most likely to vary in feeds and supplementation is recommended for growing horses, heavily pregnant and lactating mares on pasture based diets and for horses in hard work on grain and hay based feeds.

- ☑ There is a wide range of feed supplements available in Australia, as well as ready-mixed and prepared feeds fortified with a complete profile of minerals and vitamins.

- ☑ The use of some supplements, such as iron in racing horses, vitamin E and C in breeding horses and vitamin E/Selenium for horses that tie-up during exercise is largely based on anecdotal evidence, but in many cases, benefits are claimed from their use.

- ☑ Supplementation should be used judiciously to obtain benefit at a reasonable cost and care should be taken to avoid excesses of iodine, selenium, vitamins A and D by overlapping supplements or exceeding the daily recommended dose. Kelp should not be provided on a free-choice basis due to the risk of iodine toxicity. It is also unwise to provide sweetened trace-mineral powdered supplements on a free choice basis to stabled or pastured horses, as over consumption may be encouraged. Mineral and salt blocks and sweetened licks are also available, but the amount consumed varies considerably between horses and therefore not every horse in the group will be supplemented to the same degree.

- ☑ Vitamin supplements are prone to loss of potency if not stored under cool conditions. The container must be resealed between each use to avoid deterioration by oxidation, moisture and light.

- ☑ All vitamin supplements should be mixed into the meal just prior to feeding and not stored in damp feeds, especially where added iron and copper are also present.

CHAPTER 7

COMMON FEEDS FOR HORSES

Horses are able to adapt to a variety of feeds to meet their nutritional needs. In Australia, there is a greater range and often higher quality of feeds suitable for horses than in many other countries because of our temperate, although drier, climate.

The availability and cost of feeds is influenced by the seasonal conditions and often the demand and volume of individual feeds used for other livestock. The improvement in transport over the past 30 years has resulted in a more regular availability of grains and hay as feed for horses on a year round basis. Suitable feeds for horses are sourced over a wider area and horse owners have a more assured supply of quality feeds for their horses.

Over the last decade, a large range of commercial ready-mixed "sweet feeds" and dry multi-ingredient rations that are scientifically formulated to meet the needs of specific classes of horses have become widely available.

The common feeds for horses are broadly grouped relative to their energy, protein, fibre (or roughage) and mineral content. Although pasture or good quality hay should provide the base for any diet, grains and other feeds can be used to make up shortfalls of these major nutrients to satisfy a horse's needs.

KEYPOINT: Some feeds contribute a more concentrated source of one major nutrient, such as energy, protein or fibre, whilst others, particularly hays and pasture, provide a wider range of nutrients.

Feeds are traditionally divided into the following groups:

Feed Group	Major Sources
✓ Energy concentrates	Cereal grains, fats/oils and whole oil seeds Wheat pollard, rice pollard
✓ Protein supplements	Oil seed meals, lucerne hay, milk powder.
✓ Roughage sources	Cereal and legume chaff and hay
✓ Pasture or forage	Growing grass and legumes.
✓ Mineral supplements	Salt, limestone, dolomite, dicalcium phosphate, Epsom salts.
✓ Appetisers	Molasses, bran, yeast.
✓ Other common additives	Apple cider vinegar, cod liver oil, kelp.

The comparative contribution of the major nutrients contained in individual feeds and pastures is summarised in the feed composition tables in Chapter 10, Tables 10.1-10.5 on pages XX to XX.

KEYPOINT: The individual feeds should be selected and blended to provide a well-balanced, palatable and economical diet. Unless a horse is fed correctly, it will not develop to its full potential.

Other factors that must be taken into account when choosing feeds for horses include:

- ✖ Horses are selective feeders and develop distinct likes and dislikes for certain feeds. Horses often become accustomed to a particular feed or feed mix and will not readily accept even small changes in feed.
- ✖ There is less scope to select and blend feeds on a least cost basis, such as widely practised for other domestic and productive animals.
- ✖ The varying seasonal intakes of pasture and the risk of overfeeding and underfeeding relative to pasture supply must be considered when choosing and commencing to provide supplementary feeds for grazing horses.

7.1 Energy Concentrates

When the energy demands for exercise, growth or lactation are increased, cereal grains and fat can be used to boost the energy content of the diet.

KEYPOINT: There is no harm in feeding cereal grains as an energy source, provided the amounts are controlled relative to the type of grain, the daily exercise need, the horse's targeted condition score and its temperament.

These feeds not only vary in energy density relative to bulk, as summarised in Chapter 5, Tables 5.6 and 5.7, but also significantly in palatability, digestibility, cost per unit of energy, risk of deterioration during storage and balance of other nutrients. Most cereal grains are deficient in lysine and imbalanced in other essential amino acids for growth. They are low in calcium relative to phosphorus, containing from 3-10 times more phosphorus, with the majority in the form of poorly available phytate phosphorus (See Glossary term). Cereal grains are generally low and variable in their content of other minerals, trace-minerals and vitamins.

The three common cereal grains that are fed to horses in Australia are oats, barley and corn (maize). Wheat, although plentiful in supply, is usually too expensive relative to other grains and is traditionally considered to be less suitable for horses. Sorghum (milo), triticale, rye and brown rice grain are less widely available. These alternate grains are used only when the common three grains are not readily available or are higher in price. Supplies are more constant in areas where seasonal conditions are suited to their cultivation, or where they are used for other livestock feed.

7.1.1 Oats (*Avena sativa*)

Oats is the traditional and still the most popular grain fed to horses as a starch based energy source. It is grown in most cereal growing areas in Australia. (Refer to Figure 7.1)

Major Advantages

- ✓ Horses of all ages find oats palatable as it has a soft kernel. It is the easiest of all the cereal grains for horses to chew. Horses prefer oats, followed in order by corn, wheat, barley and rye.
- ✓ Oats is a "safe" grain to feed because of its high crude fibre content (10%) in the outer hull, which dilutes its starch content, helping to reduce the risk of digestive upset and laminitis if excess is fed relative to needs.
- ✓ Whole oats contains the lowest amount of starch but the highest proportion of starch digested in the small intestine, ranging from 61-83%, followed by sorghum, corn and barley. Processing oats by crimping, rolling or grinding does not significantly improve digestibility of its starch in the small intestine.
- ✓ Oats can be fed alone or with roughage, such as lucerne hay or chaff, to maintain a horse at pasture during winter, or when fed out in controlled amounts during drought conditions.
- ✓ The protective husk reduces the risk of deterioration of whole oats by moulds and insect attack during storage.

Major Disadvantages

- ✗ Oats has the lowest digestible energy concentration of any cereal grain, although it is well digested in the small intestine. This increases the bulk that has to be fed as an energy concentrate to hard working horses. The bulk required to meet energy needs may not be able to be consumed in small-framed horses or those that develop a poor appetite when worked hard.
- ✗ Oats has greater variability in protein, fibre content in its hulls, and weight than other cereal grains. It has lower yield per hectare than corn, barley and sorghum commonly used for livestock feed. Oats grown under dry conditions has almost twice the crude protein content (12%) as compared to 6-7% crude protein for very plump oats grown under wet conditions.
- ✗ In terms of cost per unit of energy, oats is often more expensive because it is lower in digestible energy on a weight and volume basis than all other grains, as its fibrous husk can contribute from 23-35% of its weight.
- ✗ The higher phosphorus content, in the form of phytate in oats, has a greater binding effect on calcium, magnesium, zinc and iron than the other cereal grains.

✖ The fermentation of its higher fibre content in the hindgut increases the "heat waste" during fermentation, which adds to the overall heat load of horses in hard work that are fed oats as the primary energy source under hot conditions.

✖ Feeding even a relatively small amount of oats has been associated with an increased risk of "tying-up" and nervy, hyperactive behaviour in some individual horses.

Selection and Quality

The quality of oats is evaluated by weight, the plumpness of the seed, contamination with plant material, weed seeds, dust, moulds and presence of weevils.

Processing

Oats is normally fed as whole grain. Oats can be processed to break open the kernel by rolling to produce crimped or "bruised" oats. Crimping and rolling oats does not significantly increase the digestion of starch in the small intestine. (Refer to Chapter 2, Figure 2.3, page XX). Any form of rolling or crimping however, increases the dust content and rate of deterioration during storage as compared to whole grain.

Clipped oats or "racehorse oats" is produced by removing the pointed ends of the fibrous hull, increasing the relative starch to fibre content and therefore the energy density of the grain. Clipped oats are not as "safe" to feed as whole oats in large amounts because they contain less fibre relative to their starch content. Normally 10% less in weight can be fed as compared to whole oats to provide an equal amount of energy.

7.1.2 Naked Oats

Naked oats is a new variety of oats in which the husk falls off during threshing to give a dehulled or "naked" oat. The seed has double the weight per volume and is higher in digestible energy, protein, lysine, phosphorus and oil content compared to the conventional oats used as horse feed.

Naked oats are being cultivated in Australia, but the cost at present is considerably higher than standard oats and will remain so unless much larger areas are brought into production.

In European countries, naked oats are blended into the rations of horses at a rate not exceeding 100-200g/kg of cereal grain mix. Feeding naked oats to fully replace normal oats is likely to result in digestive upset because of the higher starch content and much lower fibre level.

7.1.3 Corn (maize) (*Zea mays*)

Corn (maize) is mainly used in Australia as an energy booster in a standard oat or barley base ration for racing and other hard working horses. It has become more popular in Australia over the past 10-15 years, especially as an energy supplement in the rations of Standardbred racing horses, eventers and endurance horses. Corn is grown in summer rainfall or irrigation areas and most of it is used in pig and poultry rations.

Major Advantages

✓ Corn is an energy dense grain, containing 18% more energy on a weight basis, but twice as much energy as compared to oats on a volume basis. Therefore it can be substituted for part of the oats to reduce the volume of the ration that has to be consumed by a hard working horse, a small-framed horse or a "poor eater" with a limited or reduced appetite.

✓ Heat waste from hindgut fermentation of the lower fibre and protein content in corn is about 30% less than oats, making corn a suitable energy feed under hot conditions where horses often have a reduced appetite as well.

Major Disadvantages

✖ Whole raw corn, or cracked corn, is poorly digested in the small intestine, with only about 30% of the starch being digested, as compared to 65% or higher for whole oats. (Refer to Chapter 2, Figure 2.3, page XX). Overloading of excess starch into the hindgut increases the risk of D-lactic acid build-up, which can trigger the onset of laminitis and founder as well as excitable behaviour. Gorging on raw corn, at an intake of more than 1kg/100kg bwt in one feed, is a historic cause of grain-induced laminitis and founder in horses and ponies.

✖ Most horses readily accept corn added to their feeds in small amounts. However, its high palatability can increase the risk of more rapid consumption, up to a 50% faster rate for corn sweetened with molasses, as compared to 14% for oats. Feeding more than 250g of corn per 100kg body weight in a meal that is consumed quickly, can overload excess corn starch into the hindgut and lead to digestive upset.

✖ Corn is prone to "mouldy corn poisoning" due to moulds that produce mycotoxins (aflatoxins) under damp conditions, which can lead to brain damage and death if small amounts of mouldy corn greater than 1-1½kg is fed to horses. (Refer to Chapter 8, Section 8.2.2, page XX)

Selection and Quality

Good quality whole corn is plump, free flowing and bright yellow in colour with a sweet smell and taste, minimal insect damage (as evidenced by holes in its surface) and freedom from mould (as indicated by surface mould, black spots and a musty odour). Cracked corn should be free flowing, without a rancid smell, or oily sticky feel due to fat oxidation. Cracked corn should be stored tightly packed, ideally left in the bag it was purchased in, and used within 3 weeks of processing, especially when stored under hot humid conditions. This will help minimise the risk of rancidity and maintain its palatability.

Processing

Small amounts of whole corn up to 150g/100kg bwt can be fed whole in a dry or damp feed mix. There is little advantage in cracking corn to improve the digestibility of corn starch in the small intestine, as it is only marginally increased, but the risk of rancidity is accelerated during storage. Grinding corn to a powder, or cooking corn by extrusion greatly increases the digestibility in the small intestine (Refer to Chapter 2, Figure 2.3, page XX). Extrusion, or "popping" corn by infrared micronization, helps to reduce the risk of excess raw starch being rapidly fermented in the hindgut and its associated side effects.

7.1.4 Barley *(Hordeum vulgare)*

Barley is grown widely throughout the wheat belt (Refer to Figure 7.1) of Southern, Eastern and Western Australia and the majority is used for brewing and as livestock feed. Barley has less outer hull (10-14% by weight) than oats, with a correspondingly higher energy density.

Major Advantages

✓ Compared to oats, barley has an energy density 10% higher on a weight basis, and almost 30% higher on a volume basis. On a weight basis, it has an energy and protein content midway between oats and corn. Its lower oil content (2%) reduces the risk of rancidity when it is stored after rolling or steam flaking to open up the grain in an attempt to improve starch digestibility in the small intestine.

✓ Barley can be fed as the major cereal grain in a ration, with acceptance ensured by a step-wise introduction over 3-5 days.

✓ Boiling barley at a simmer for 10-15 mins significantly improves the digestion of its starch in the small intestine as compared to rolling or steam flaking. It is a traditional conditioning and "cool" feed when offered at 500g in wet form/100kg body weight to show or other horses, or as a soft, easily chewed energy feed for aged horses with poor teeth.

Major Disadvantages

✖ Whole barley grain is harder and less palatable than oats. It is accepted better when soaked in warm water for 2-3 hours, or when mixed into a damp feed so that it softens during the time a horse takes to consume the hard feed.

✖ Steam rolling barley does not significantly increase the digestibility of its starch in the small intestine, but its acceptance is improved.

✖ The starch content of raw barley (not ground, boiled or extruded) is not as well digested in the small intestine as compared to oats, and in large amounts, it is likely to overload into the hindgut with a risk of hindgut acidosis.

✖ Of the common grains, barley is more likely to attract weevil infestation than oats or corn.

Selection and Quality

Whole barley should be free flowing, plump, with well-filled kernels and a rough surface texture and pointed awns. Steam rolled barley should be evenly opened, without excessive dust and free of a musty odour resulting from mould growth after processing.

Processing

The hull of barley is closely attached to the hard seed, so steam rolling or crimping aids its palatability and opens up the grain to facilitate chewing. Boiling barley at a simmer for 10-15 minutes, or cooking it under controlled extrusion and infrared micronisation, opens up the starch particles to improve the overall digestibility in the small intestine, giving it a reputation for reduced nervous, or "hyper" behaviour ('cool' feed) (See Glossary Term) in working horses.

7.1.5 Wheat (*Triticum aestivum*)

Wheat is the most widely grown grain in Australia, but of all the readily available grains, the least used in horse rations. It is primarily used for flour milling, with cheaper grades used in pig and poultry feeds. Wheat has a reputation for causing colic and digestive upset in horses, but if carefully fed and slowly introduced to the ration, it is a useful energy grain for horses.

Major Advantages

✓ Wheat is a small grain that packs closely together, with an energy density slightly higher than corn on a weight basis, and almost 2½ times higher when compared to oats on a volume basis.

✓ Wheat is similar to corn in its major nutrient content and it can be used as an energy booster when limited to one third of the total concentrate weight in the diet.

✓ Wheat is normally more expensive than oats on a weight basis, but on a cost per energy unit basis, feed-grade wheat is comparable to oats.

Major Disadvantages

✖ Wheat is a small hard grain, which if not chewed efficiently in large volumes as whole grain, will result in considerable amounts passing into the hindgut. This overload of the starch can rapidly ferment causing hindgut acidosis with digestive disturbances, hyperactive behaviour and high risk of laminitis and founder.

✖ Feeding more than 20% of the grain as finely ground wheat is likely to result in the formation of a sticky mass of gluten (wheat protein) in the stomach, preventing gastric acid attack and increasing the risk of fermentation with gas build-up and colic. (Refer to Chapter 2, Section 2.3, page XX).

✖ Wheat is less palatable than oats or corn, but its acceptability can be increased by sweetening the meal with molasses, provided that only limited amounts are fed, as the sweetened feed is likely to be consumed more quickly.

Selection and Quality

Wheat should be hard in texture, with free flowing, evenly shaped and coloured grains. Pinched or deformed kernels can indicate moisture stress or disease during growth. It should weight about 750g/litre and contain little dust.

Processing

Wheat is best fed cracked or coarsely ground, as the small whole grain can miss being chewed, and fine grinding can lead to digestive upset. The cracked grain is often dusty and should be dampened and introduced in a step-wise manner over 7-10 days.

Source Kelleher 1994

FIGURE 7.1
CEREAL GROWING WHEAT BELT AREAS IN AUSTRALIA

7.1.6 Grain Sorghum or Milo (*Sorghum vulgare*)

Grain sorghum is also an energy dense, small naked grain without a protective hull, providing an energy density similar to corn. It is grown under warmer climates in Queensland and northern New South Wales, often under contract to large pig and poultry producers. Milo is a low tannin, yellow grain variety of sorghum.

Major Advantages

✓ Its high energy density makes it a useful grain, similar in this respect to corn, that can be used as an energy booster for hard working horses. However, its lower palatability often limits its inclusion rate to 30-50% of the total grain content of a ration.

✓ Sorghum has a high content of fermentable fibre which helps promote efficient hindgut digestion. If its palatability was better, sorghum could safely be used as the primary energy source in a ration. In Queensland, sorghum has been used as a maintenance feed at a feeding rate of 250-300g/100kg body weight, mixed with lucerne chaff, during drought conditions.

Major Disadvantages

✖ Sorghum, as compared to corn has a lower oil, lysine and variable protein content.

✖ The grain contains tannins, which can reduce its palatability initially to horses and may cause constipation and colic. Milo, a low tannin yellow sorghum, is better accepted by horses and other livestock.

✖ Sorghum protein is deficient and imbalanced in many amino acids, with a significant content of fat soluble vitamins but is variable in other vitamins.

Selection and Quality

Good quality Sorghum or Milo is a free flowing, plump, round, hard grain without split or damaged kernels. It should be uniform in colour and not mottled with dark spots, which could indicate mould if it has been stored under damp conditions.

Processing

Sorghum should be coarse rolled, cracked or steam flaked to open up the grain in order to soften it and improve its palatability.

Processing increases the digestibility in the small intestine by up to 15% for a hard grain such as sorghum.

Grain sorghum can also be soaked in hot water for 15-20 minutes prior to feeding to soften it and allow easier and more complete chewing. Extruding sorghum is likely to significantly improve its digestion in the small bowel and its palatability by reducing its tannin activity.

7.1.7 Triticale (*Triticale hexaploide*)

Triticale is a hybrid cross of wheat and rye. It is grown in limited amounts mainly for use in pig rations in each state, often in a crop rotation program. It is lower yielding than wheat but more winter hardy under cold growing conditions. It has been used for horses, but it is often more expensive than barley, although it is higher in energy content.

Major Advantages

✓ Triticale is higher in energy density than corn and has a higher, but more variable crude protein content, ranging between 13-18%. As compared to other cereal grains triticale has a higher content and better balance of amino acids including lysine, tryptophan and threonine.

✓ Horses find it reasonably palatable if it is soaked or crushed before feeding.

Major Disadvantages

✗ Raw triticale grain contains trypsin inhibitors that may reduce digestion of protein in the small intestine, as well as other compounds that are thought to cause an appetite limiting effect if it is fed in large amounts as the sole cereal grain. Heat treating the grain by steam flaking and extrusion destroys these compounds and improves digestibility and palatability.

✗ Triticale is normally higher in cost as compared to most other grains and its availability is variable and seasonal.

✗ The grain is subject to ergot spoilage, in which case it is toxic to horses and other livestock and should not be used.

Selection and Quality

Triticale is a rough coated grain, with better quality samples being heavier than barley. The grain should consist of easy flowing clean plump seeds, free from black mouldy spots that signify damp harvest and storage conditions.

Processing

Triticale is usually not well accepted by horses in whole grain form, but its palatability can be improved by soaking, coarse crushing, steam flaking and extrusion. Extrusion and micronisation improves starch and protein digestion in the small intestine and may destroy the compounds that depress appetite. Processed triticale, when introduced in a step-wise manner, can be fed as the sole cereal grain, although in practice, its higher cost and less than optimum acceptance limits it to a 50% blend with oats or rolled barley.

7.1.8 Rice (*Oryza sativa*)

In Australia, rice is limited in its cultivation area because of the need for a warm climate with a plentiful supply of water for flood irrigation. It is almost entirely produced in the Riverina region of NSW with a small area of cultivation in the northwest area of Western Australia. It is an expensive grain for animal feed and all of the Riverina production is processed for human consumption. Broken rice and rice milling byproducts are used in the manufacture of animal feeds by Coprice Feeds, Leeton, NSW. Rough or paddy rice is available for animal feed in very limited amounts in Northern Australia. (Refer also to Rice Pollard and Rice Hulls).

Major Advantages

✓ Rice starch is well digested, even in its raw, non-cooked state. Studies in Queensland indicated that the starch content in broken polished rice, a byproduct of human rice production, was 100% digested by horses.

✓ Brown rice or unpolished rice with hulls removed has a similar energy content to corn, but because the starch is digested primarily in the small intestine, it is more suitable than corn as a ‘cool’ low fizz feed for horses. (See Glossary term)

Major Disadvantages

- ✓ Rice is not available in Southern Australia as a livestock feed in grain form.

- ✓ The crude protein content of rice is often less than other cereal grains and it is lower in B-group vitamins.

Selection and Quality

Rough or paddy rice with hulls should be plump, clean, easy flowing, even in colour and free from mould odours or evidence of damaged kernels. The hulls of paddy rice have a high silica content and low digestibility and therefore rice is best fed as dehulled or brown rice.

Up to 30% of the roughage in a hard feed mix can be replaced by finely ground rice hulls, without any apparent digestive problems, provided the feed is dampened before feeding to reduce dust. (See page XX).

Processing

Overseas, where brown rice is available for horse feed, it is often par boiled for 3-4 minutes or soaked before feeding to improve digestibility.

In Australia, a pelleted blend of broken rice, rice pollard and lupins manufactured by Coprice Feeds, Leeton, NSW is widely available and regarded as a 'cool' feed for all types of horses as well as a suitable pelleted feed for growing foals.

7.1.9 Rye (*Secale cereale*)

Rye is not cultivated widely and is mainly limited to low rainfall areas with sandy, drift prone soils in north west Victoria, the region of the Murray Mallee, the South East and Eyre Peninsula of South Australia and south western New South Wales.

It has a similar energy content to corn, but is slightly higher in crude protein, although it is deficient in some essential amino acids. Whole rye is bitter to taste and not very palatable to horses and, being a small hard grain, it is best crushed or cracked prior to feeding. It may also become contaminated with a fungal ergot, which is toxic to horses. Rye should not make-up more than 30% of a ration, as it forms a sticky mass as it is chewed which slows down its intake when fed at higher levels. It may be useful as an alternative grain during drought if it is processed prior to feeding and fed with other grains, mixed with at least an equal volume of chaff.

7.1.10 Millet (*Setaria spp, Panicum milaceum*)

Millet is grown mainly for bird seed in northern New South Wales and southern Queensland. It is a very small hard grain that must be finely crushed to ensure best acceptance and digestibility in horses. Whole millet is likely to miss being chewed and can pass through the gut undigested. It has a feed value similar to oats, but is lower in fibre. Like rye, it is a useful alternative energy grain during drought, or when crushed and mixed with other grains.

7.1.11 Vegetable Oils and Tallow

Vegetable oils and tallow (rendered animal fat) contain triglycerides, or blends of fatty acids, which can be digested in limited amounts by horses to provide a high energy boost to the diet of hard working horses.

The major advantages and disadvantages of using oils or fat as an energy source are more fully discussed in Chapter 3, Section 3.4, pages XX to XX.

Oils are liquid at room temperature (10ºC or above) while fats remain solid as their melting point is above 50ºC.

The common seed oils used as an energy supplement for horses include corn oil, soyabean oil, sunflower oil, canola oil and blends of these oils produced as edible and cooking oils for human use. Tallow (rendered meat fat) can also be fed to horses in small amounts as an energy booster, provided it is of good quality.

The triglyceride content of oils is classified in relation to the number of carbon complexes, their saturation and the position of double bonds within the chains of linked fatty acids that form the specific oil. Each oil or fat has a blend of different fatty acids in its triglyceride content.

Over recent years, there have been a number of commercial blends of oils developed as a high energy horse feed based on blends of polyunsaturated oils containing specific ratios of Omega 3 and Omega 6 fatty acids.

Omega-3 (n-3) fatty acids have the first double bond in their structure at the third carbon position and Omega-6 (n-6) at the sixth carbon position. Monounsaturated fatty acids have the first double bond at the ninth carbon position in the chain. The omega position of the fatty acids cannot be converted from one to another in an animal's body.

- ☑ Oils that contain higher amounts of Omega-3(n-3) fatty acids are considered to provide natural anti-inflammatory compounds (called eicosanoids) and hormone action to improve the function and strength of blood vessels and body cells.

- ☑ It may take as long as 6-8 weeks before the Omega-3 fatty acids added to the diet are incorporated into cell membranes and have a beneficial effect. Horses cannot synthesise n-3 and n-6 fatty acids in their bodies, so the dietary intake reflects the fatty acid composition of cell wall membranes.

- ☑ High intakes of Omega-3 fatty acids can imbalance the controlling action of other fatty acids.

- ☑ Omega-6(n-6) fatty acids in high intakes impart hormone induced inflammatory activity, which can interfere with cell metabolism. They contain more linoleic acid (an n-6 fatty acid) which has a coat conditioning effect.

- ☑ The monosaturated (n-9) fatty acids help lessen the harmful effects of the other polyunsaturated fatty acids during metabolism.

In animals, an Omega-3 to Omega-6 fatty acid ratio of 1 part Omega-3 (n-3) to 5-10 parts of Omega-6 (n-6) is considered beneficial.

KEYPOINT: Oils that contain higher levels of Omega-3 relative to Omega 6 fatty acids are considered to be less likely to result in muscle, blood vessel and other cell wall damage when used as an energy source for horses. Commercial blends of high Omega-3 fats are available as energy supplements in Australia. The ratios of n-3 to n-6 for common oils are summarised in Table 7.1.

Oil	% of Fatty Acids in Oil *** MUFA = Monosaturated Fatty acids**				**Comments**
	Omega 3	**Omega 6**	**MUFA**	**Saturated Fats**	
Canola Oil	10	20	63	7	Palatable, well accepted, cold pressed is stable, less risk of oxidation.
Soyabean Oil	8	54	23	15	Reasonably well accepted, some Omega-3, but high levels of Omega-6. Higher levels of natural Vitamin E.
Corn Oil	2	52	32	14	Low Omega 3, not as palatable, more easily oxidised.
Sunflower Oil	Less than 1	66	23	11	Palatable. Contains high levels of Omega-6 linoleic acid for coat conditioning but very little Omega 3.
Safflower Oil	Less than 1	77	14	9	Palatable. Contains high levels of Omega-6 linoleic acid for coat conditioning but very little Omega 3.
Blended Polyunsaturated Cooking Oil	1-5	45-60	20-30	10-11	Ratios depend on blend of oils. Canola blends contain higher Omega-3 fatty acids.

Source: Florence TM and Setright RT (1994)

Note: Linseed oil (flaxseed oil) has an Omega-3 fatty acid content of 57% which provides excess Omega-3 when used in the volume required as an energy supplement. Small amounts are used to boost the Omega-3 fatty acid content in blended oils.

TABLE 7.1
Omega-3 and Omega-6
Fatty Acid Content in Common Seed Oils

Other less readily available or more expensive oils, such as peanut, cottonseed and olive oils, contain no Omega-3 acids. Cold water marine fish oils also have a 20-25% Omega-3 content but are unpalatable to horses in pure form.

Canola oil in pure form, or blended 50:50 with soyabean or corn oil, contains a suitable ratio of Omega-3 to Omega-6 essential fatty acids. Canola oil, containing 63% mono-saturated fatty acids, is less prone to oxidation, especially when produced by the cold press method of oil extraction. Canola oil has minimal content of anti-nutritional factors compared to oil from the original rapeseed varieties. (see page XX).

7.1.11.1 Quality of Oils and Fats

Fats and oils are subject to oxidation, which is inversely related to their degree of saturation, type of processing, storage conditions and contamination with impurities such as copper, or over heating as can occur when recycled

fats previously used for deep frying are fed to animals. Saturated fats, such as animal fats, can oxidise and become rancid only following hydrolysis. Polyunsaturated fats, such as in seed oils, are subject to oxidation if not stored carefully, or if lacking protection from added antioxidants such as Vitamin E. Damaged fats, usually resulting from oxidation or high temperature processing, are less palatable, are not digested well and can cause digestive upsets and interfere with metabolic and liver function.

7.1.11.2 Practical Guidelines for Feeding Supplementary Fat

Where fat is being substituted as an energy source for part of the grain in a ration, the following three measures should be adopted to ensure acceptance and gain maximum benefit from the added fat or oil.

1. Step-Wise Introduction

Pasture and the common grains and hays used as horse feeds contain low levels (less than 5%) of fat. Additional fats, used to boost the energy density of the ration, may not be digested efficiently if large amounts are added before pancreatic lipase enzyme activity can be adapted and increased to digest the elevated fat content in the diet.

In practical feeding terms, this means that:-

✓ A step-wise introduction of vegetable oil as a source of fat over 10-14 days, in 40mL (2 tablespoonsful) increments at 3-4 day intervals, will help encourage more efficient digestion of fat as amounts are increased. Fat, because of its high energy density, can be slowly introduced to replace a grain in the ration, such as oats, to reduce ration bulk. Approximately one cupful of oats, for example, should be removed for each 40mL increase in oil as an energy substitute. Ensure the oil is mixed evenly throughout the meal to prevent it separating to the bottom of the feed bin. (See page XX).

KEYPOINT: Horses will normally accept up to one cupful (250mL) of oil in each of the morning and evening feeds when added as an energy substitute for grain or as an energy boost to the diet of a hard working horse. This amount of oil (500mL) provides approximately 18MJ DE, or 12-15% of the total energy need of a racing or performance horse.

2. Avoid Rancid Fat

Vegetable oils, or even fresh tallow, can be added to the diet as an energy source. The oil must be low in rancid (oxidised) fat, which if present, can interfere with its uptake and metabolism in the liver and tissues.

In practical feeding terms, this means that:-

✓ Oils should be stored in a cool place, preferably in a refrigerator. Cold pressed oils normally contain less rancid fat. Cold pressed canola oil, a monosaturated fat, is less subject to oxidation and rancidity and horses often find it more palatable than other vegetable oils.

Many of the commercial fat supplements marketed for horses in Australia have added antioxidants to protect the oil against oxidation.

✓ Do not store feed with oil added to it – mix in the oil just prior to feeding.

✓ Do not aerate the oil by shaking the container prior to use. Recycled, filtered cooking oils heated to a maximum of 130°C are considered safe in small amounts, but fresh, properly stored oil should be used if more than one cupful (250mL) is provided daily.

3. Correct other Nutrient Imbalances

Fat as oil does not contain any other nutrient than energy and fatty acids for membrane stability. Adding small amounts up to 1 cupful as an energy booster to the normal grain mix requires no additional nutrient supplementation. Where a volume exceeding 2 cups (500mL) daily is substituted for grain to increase the energy density and reduce the bulk of a ration,

ideally extra protein, calcium, phosphorus and Vitamin E should be added to replace these nutrients removed as the grain content in the ration is decreased, especially in racing and performance horses.

In practical feeding terms, this means that:-

For each cup (250mL) of oil added above 2 cups into a ration:

- ☑ Mix in an extra cupful of a minimum 30% or higher crude protein meal (eg soyabean or canola meal).
- ☑ Add an additional source of calcium and phosphorus, eg 20g or one tablespoon of dicalcium phosphate daily.
- ☑ Daily provision of a supplement containing 250iu of Vitamin E, or preferably a Vitamin E/selenium combination in addition to any other routine supplement of Vitamin E, will help protect the polyunsaturated fats against oxidation within the cells during metabolism.

7.1.12 Molasses (Cane molasses)

Molasses contains sucrose sugar and provides a readily digested carbohydrate energy source. Usually molasses is added in small amounts to horse rations as an appetiser rather than an energy supplement. (See Appetisers page XX).

Molasses is a byproduct of the Queensland sugar cane industry that can be fed as an economical and palatable energy supplement during dry conditions in late winter and early spring. Grazing horses and particularly brood mares being prepared for the breeding season are often fed molasses.

Dr. Neil McMeniman of the University of Queensland has supplemented 500kg brood mares with up to 2kg (approx 1½ litres) of liquid molasses per head each day for extended periods as an energy feed. Molasses has the same energy content as barley on a weight basis, but is low in crude protein (4.3% crude protein). The protein content of the molasses feed can be boosted by mixing in 5-10% by weight of cottonseed meal (41% crude protein) to meet the protein needs of brood mares and other horses.

7.2 Protein Supplements

An additional source of good quality protein may be required to meet the needs of growing horses, lactating mares, horses in early race or upper level equestrian training, aged horses and those recovering from heavy parasite burdens where grass based pastures and grains provide less than 10% crude protein. In Australia, lucerne chaff and hay, which contain from 15-17% crude protein, is widely used as a roughage base in the rations for growing and working horses.

KEYPOINT: A protein concentrate is classified as a feed that contains more than 20% crude protein. The quality and amino acid balance of feed proteins is reviewed in Chapter 3 Section 3.3, page XX.

Historically, linseed meal, a byproduct of linseed oil production, was the most common protein source used in horse diets. However, because of the much reduced use of linseed oil in the paint industry and the increased production of soyabeans as a high quality protein and oil source for human and animal food, soyabean meal has become the most widely available protein concentrate for horses. Crushed lupins, canola meal, crushed tick and faba beans, cottonseed meal, copra (coconut) meal, peanut meal, sunflower seeds, field peas and milk powder are also used as protein sources in horse rations.

Although yeast contains from 47-52% good quality crude protein, it is a much more expensive source of protein as compared to oil seed meals and other protein sources. Yeast is usually added in small amounts as a source of natural digestive nutrients and B-group vitamins, rather than as a specific protein source. (See page XX).

7.2.1Oil Seed Meals

When the oil is extracted from the oil seeds, the byproduct meal or cake residue contains a higher percentage of crude protein than the original oil seeds. Generally, solvent extracted meals contain from 0.5-1.5% residual fat and mechanically pressed cakes up to 5% fat. Some seeds are covered by a fibrous hull, which when removed prior to processing, results in a meal with less fibre and a more concentrated source of crude protein. The majority of extracted oil seed meals also provide a range of B-group vitamins, but virtually no fat-soluble vitamins,

as these are removed in the oil. All contain reasonable amounts of phosphorus, often in the form of phytate phosphorus, but are consistently low in calcium.

Quality

All protein meals should be free flowing, evenly coloured, with a fresh, non-rancid smell. Poor storage conditions increase the risk of oxidation or rancidity in meals or cake residues containing a higher level of retained polyunsaturated oil.

7.2.1.1 Soyabean Meal (*Glycine max*)

Soyabean meal, a byproduct of soy oil production, is most commonly produced by the solvent extraction process. It contains the highest content of crude protein (CP) of any common oil seed meal and it is usually standardised at 44-45% CP by blending in hulls. Soyabeans are grown as a dry land crop on the north coast and northern Tablelands and under irrigation in the Riverina, central west and north west of New South Wales. In Queensland, they are grown both on dryland and under irrigation in the south eastern region, particularly on the Darling Downs. The processed meal is distributed through most produce stores. Extruded soyabean feeds (see whole soyabeans) are also available.

Major Advantages

✓ Soyabean meal contains 44-45% crude protein, providing a wide range of essential amino acids, and an adequate source of lysine, methionine, isoleucine, leucine, arginine, glycine and threonine, which makes it a high quality protein supplement suitable for growing horses and lactating mares.

✓ Careful control of the oil extraction and partial cooking or toasting of the meal during processing destroys the natural allergenic, digestive and growth inhibitors (anti-trypsin enzyme factors), goitrogenic and anti-coagulant compounds present in the raw seed, without damaging the amino acid content. (Refer to Chapter 8, Section 8.2.3, page XX).

Major Disadvantages

✖ Soyabean meal is not well accepted, especially by young horses when initially added to a ration. Its acceptance is aided by a step-wise introduction over 5-7 days, or sweetening feeds with molasses to mask the taste of soyabean meal.

7.2.1.2 Soyabeans – Full Fat (*Glycine max*)

Whole soyabeans with hulls can be freshly crushed and fed in small quantities of up to 250grams daily as an energy, protein and fibre source to horses. In the raw, high fat form they are not as palatable and contain digestive and growth inhibiting compounds that limit their value to growing horses. Because the whole beans contain 18% oil, crushing them exposes the oil to oxidation and it can rapidly turn rancid under warm conditions. The oil also seeps out of the crushed beans, making them sticky and greasy and even less palatable when stored.

Full fat extruded (cooked) soyabean flakes, granules or chips are commercially available as an energy and protein supplement for horses, either mixed in feeds or as a separate feed. The heat generated (135°C-145°C) during extrusion destroys the digestive and other inhibitors, improves the amino acid release and seals the oil within the soyabean particles, enhancing the overall digestibility and palatability and extending the storage time.

7.2.1.3 Canola Meal [Rapeseed Meal],(Brassica napus, Brassica campestris)

Over recent years, the widespread cultivation of canola for food oil production has increased the availability of canola meal for animal use. The original rapeseed varieties (from which canola was developed) contain two compounds, erucic and glucosinolic acids that generate toxic chemicals during digestion in the small intestine. (Refer to Chapter 8, Section 8.3.5, page XX).

The resulting compounds decrease iodine uptake and can lead to goitre or swelling of the thyroid gland. Rapeseeds also contain bitter tannins and other substances that limit palatability and digestibility. Canola contains ‘double-low’ levels of the toxic compounds, which are further reduced on heat treatment, making it more

suitable as a protein supplement for horses. Canola is now widely grown throughout the Australian wheat belt (See Figure 7.1).

Major Advantages

✓ Canola meal contains from 34-39% crude protein and 6.0-6.4% lysine and feed trials indicate that it can replace soyabean meal as a protein concentrate for young growing horses. It is comparable to soyabean meal in protein digestibility and availability of lysine to promote growth when fed as the sole protein concentrate in the diet of growing horses (on an equal crude protein basis).

✓ Horses often better accept good quality canola meal than soyabean meal and the higher mono-unsaturated residual oil content is less likely to turn rancid during storage.

Major Disadvantages

✖ Although canola meal is usually equal in price to soyabean meal, when compared on a crude protein basis, it is slightly more expensive and not as widely available. The rapid growth of the canola industry should alleviate both of these constraints in the near future.

✖ Some authorities suggest that canola meal should be limited to 200g per kg of concentrates for young horses, but generally the level fed as a protein supplement for growing horses is 100g/kg (10%) of concentrates, or even half this amount.

7.2.1.4 Linseed Meal (*Linum usitatissimum*)

Flax, known in Australia as linseed, was widely grown as an oil seed crop, but Australian production has decreased significantly over recent years and limited linseed meal is now available for animal feed.

Linseed meal is now largely produced by the mechanical (expeller) process, which retains more linseed oil in the meal cake. The heat produced during pressing is sufficient to inactivate the very toxic cyanide producing compounds (called glycosides) contained in the seed. (Refer to Chapter 8, Section 8.3.1, page XX). Cold pressed, non-heated linseed meal still contains these compounds that can release hydrogen cyanide when they come in contact with water during digestion. Small acreages of linseed are still grown under contract in northern and central western NSW, southern Queensland, Victoria and Tasmania.

Major Advantages

✓ Linseed meal contains about 35% crude protein, with a 66% protein digestibility, and higher than 50% uptake of calcium and phosphorus in young horses. However, it only has 40% of the lysine content as compared to soyabean meal.

✓ Linseed meal contains from 3-10% of an absorbent and laxative mucilage compound that holds water in the hindgut and may help maintain softer droppings. It is often recommended at a rate of 100g/kg of grain mix to relieve constipation in horses as it does not irritate the bowel. ??to cause looseness.

✓ Most horses find linseed meal palatable and accept it more readily than soyabean or canola meals.

✓ The 4% residual oil in the mechanically pressed linseed cake form contains 57% alpha-linolenic acid, an Omega-3(n-3) fatty acid, or 5-7 times higher than canola and soyabean oil (10% and 8% respectively) (see page XX). Solvent extracted linseed seed meal has 0.5-2% residual oil and a lower coat conditioning benefit.

Major Disadvantages

✖ Linseed meal has a lower lysine content (11.6g/kg) than soyabean meal (28.7g/kg) or canola meal (21.2g/kg), and around 50-60% of the amount of other essential amino acids. As it is more expensive

than soyabean or canola meal, it is less economical because larger amounts have to be fed to provide similar intakes of these amino acids.

7.2.1.5 Linseed Seed (*Linum usitatissimum)*

Whole linseed seeds are a traditional coat conditioning and laxative feed for horses. Most horses relish the taste of cooked linseed seed mixed into a wet bran mash. Like non-heat treated meal, linseed seeds contain cyanide producing compounds (glycosides) and an activating enzyme, linase, separately within the seeds. When raw seeds are soaked in water, the enzyme acts on the glycoside compound, releasing a toxic cyanide chemical into the water.

Large volumes of linseed seed should not be fed dry to horses. As it is a small hard seed, many seeds are not crushed thoroughly by the grinding action of the teeth. Moisture uptake may cause release of cyanide before the stomach and intestinal secretions destroy the activating enzyme.

Note: When amounts greater than ½ cupful (about 75g) of whole linseed seeds are fed, the seeds should be added to boiling water (rather than added to cold water and brought to the boil) to rupture the seed coat and boiled for at least 5 minutes. This allows the cyanide producing compounds to react and/or be destroyed by the heat and evaporate any cyanide produced as the cooked seeds form into a thick mucilaginous mass.

7.2.1.6 Copra Meal (Coconut meal) (*Cocus nucifera*)

Copra meal has become popular as a protein supplement since its supply from New Guinea and the Solomon Islands has become more reliable and the processing method has been improved to give a better quality, more consistent meal.

Major Advantages

✓ Copra meal is promoted as a 'cool' energy feed because of its oil content (5-7%) made up of saturated, medium chain length fatty acids. It contains about 22% crude protein and from 12.5-16% crude fibre.

✓ Amounts up to 300g/100kg body weight, divided between 2-3 meals, are palatable, well accepted and less likely to turn rancid during storage. Although amounts of up to 4kg daily are suggested as a dual energy and protein source for hard working horses, it provides excess protein and is often less palatable.

✓ The natural oil content is regarded as a coat conditioner, but amounts of greater than 1kg of copra meal would need to be provided to have any beneficial effect.

Major Disadvantages

✖ Copra meal has a low lysine content (6g/kg) compared even to lucerne chaff or hay (9g/kg) making it an unsuitable protein source for growing horses. If copra meal is used in rations for growing horses, lysine, methionine and threonine should be added by blending it with at least 50% or more of soyabean meal.

✖ Copra meal also absorbs moisture under humid conditions and fungal contamination at processing can result in growth of potentially toxic moulds (aflatoxins) during storage. It may also contain compounds that reduce protein digestibility. (Refer to Chapter 8, Section 8.3.6, page XX)

Only free flowing, dry copra meal should be used as a horse feed, and dampened feeds should be prepared just prior to feeding, rather than being stored in a wet mix.

7.2.1.7 Cottonseed Meal (*Gossypium hirsutum*)

Cottonseed meal has become more widely available due to the widespread cultivation of cotton in northern NSW and Queensland. Most of the cottonseed meal produced after the extraction of oil is blended into pig and poultry feeds and in Australia it has a less traditional use as a protein supplement for horses.

Major Advantages

✓ Meal made from seed with hulls provides 20-25% crude protein and meals with the hulls screened out (decorticated) may contain up to 41% crude protein.

✓ Cottonseed meal has become cheaper and more widely available with good quality meal being generally more palatable than soyabean meal to horses of all ages.

Major Disadvantages

✖ Although good quality cottonseed meal contains up to 41% crude protein (compared to soyabean meal with 45%CP), it provides 15-17g/kg lysine relative to soyabean meal which supplies 28-29g/kg and has a lower content of most other amino acids, except arginine. Lysine may be a limiting factor if cottonseed meal is used as a sole protein source or as a substitute for soyabean or canola meal in growing horses.

✖ Cottonseeds contain a toxic yellow pigment – gossypol, which, although it is less likely to be toxic in mature horses, may cause poisoning in young horses. Heat generated during the crushing and oil extraction process partly inactivates the toxin in the meal. However, the temperatures reached may bind lysine and make it less available for growth. Excess gossypol intake has been reported to reduce fertility in mares fed cottonseed meal as a protein supplement. (Refer to Chapter 8, Section 8.3.3, page XX).

Low gossypol varieties are available and ideally these should be used as a source of cottonseed protein in horses if meal from these varieties can be obtained.

✖ Cottonseed meal may vary in quality and palatability, relative to the amount of lint adhering to the seed surface. Excessive lint not only dilutes the protein content, but reduces the acceptance of the meal and makes it more difficult to mix into feeds.

7.2.1.8 Peanut Meal (Groundnut meal) (*Arachis hypogaea*)

Peanut meal is a byproduct of peanut (arachis) oil production. Peanuts are grown in central east Queensland and the variable availability of the meal byproduct makes it less widely used as a protein meal in horses.

Major Advantages

✓ Horses find good quality peanut meal one of the most palatable of all the protein meals, particularly when it is stored under dry conditions.

Major Disadvantages

✖ Peanut meal without hulls has a slightly higher protein content than soyabean meal, but its protein feeding value is less, due to its lower lysine (17g/kg), tryptophan, methionine and threonine content. Peanut meal is less suitable for young growing horses than soyabean or canola meal on a direct substitution basis.

✖ Mechanically extracted peanut meal may contain a higher content of residual peanut oil, which is likely to become rancid if stored under warm, moist conditions, making it less palatable to horses.

✖ Peanuts (groundnuts) develop under the ground and may become contaminated with moulds, such as Aspergillus flavus. Under moist conditions, the mould can develop a powerful aflatoxin to which horses are very sensitive, resulting in severe liver damage. Only free flowing, dry and non-rancid peanut meal should be used for horses. (Refer to Chapter 8, Section 8.3.2, page XX).

7.2.1.9 Sunflower Seed Meal (*Helianthus annus*)

Sunflowers are grown in Australia for the production of high quality edible oil for cooking and margarine production. Although in other countries sunflower seed meal is used as a protein source for horses, in Australia the whole sunflower seeds are traditionally used as an energy and protein feed. (See Sunflower Seeds). Sunflowers are mainly grown in northern New South Wales, south east and central east Queensland under dryland conditions.

Major Advantages

✓ Sunflower seed meal is palatable in amounts up to 10% of the concentrate mix, but can become less well accepted at higher inclusion rates. The residual oil content (up to 7% in mechanically extracted sunflower meal) contains 66% linoleic acid, a fatty acid which may have a useful coat conditioning effect if fed on a daily basis.

✓ Sunflower seed meal without hulls contains between 41-42% crude protein, with twice as much methionine (16g/kg) but a lower lysine content (17g/kg) as compared to soyabean meal.

Partially dehulled meal contains from 24%-28% crude protein relative to the amount of fibrous hulls remaining in the meal.

Major Disadvantages

✖ Sunflower meal with hulls has a much lower protein content than dehulled meal and, being less dense, up to double the weight has to be provided for an equivalent amount of protein. The presence of the fibrous hulls and lower protein content reduces its palatability with young horses. It should be boosted with a source of lysine if used as a part protein feed in the diets of young horses.

✖ The residual oil content makes it prone to rancidity, which, if it deteriorates under hot storage conditions, can significantly reduce its acceptance.

7.2.1.10 Sunflower Seeds (*Helianthus annus)*

Sunflower seeds are widely available and are a popular energy, protein and coat conditioning feed for hard working horses.

Sunflower seeds contain up to 26% oil (some overseas varieties contain 40% oil) and thus are higher in energy than cereal grains. They are light in weight compared to cereal grains and relatively large volumes are needed as a substitute for grains when used as an energy booster to grain based diets. Horses find whole sunflower seeds palatable, and because the oil is protected from oxidation in the seed, sunflowers remain palatable even after long term storage.

Sunflower seeds contain between 17-23% crude protein (due to their high oil content). As with sunflower seed meal, they are high in methionine, but lower in lysine than crushed whole soyabeans. Feeding more than 200g/100kg body weight of sunflower seed daily will provide extra energy, but will oversupply protein for horses working under hot conditions. Black sunflower seeds are usually slightly cheaper, higher in oil and lower in crude protein, as compared to the striped varieties grown for birdseed. Sunflower seeds are best fed whole to horses with good teeth, as crushing and storing the full fat seed results in oil leakage and build up of rancid caked residues of oil and fine particles in feed bins.

7.2.2 Other Common Protein Sources

Common protein sources used in horse rations include lupins, peas, tick beans milk powder and yeasts.

7.2.2.1 Lupin Seeds (*Lupinus albus, L.luteus, L.angustifolius*)

Lupin seeds are a popular energy and protein supplement for sheep and cattle in all states of Australia. The white seed varieties are the only ones recommended for horses, as the other strains contain toxic alkaloid compounds that can cause colic and digestive disturbances.

Major Advantages

✓ Lupin seeds contain from 4-12% fat (average 7% for common white varieties) and around 32% crude protein on average, with an energy content similar to corn on a weight basis.

✓ Lupins do not contain starch and their higher natural fat, protein and fermentable carbohydrate fibre content (up to 15%), as compared with cereal grains, is regarded as a “cool” form of energy for working horses. However, because of their relatively high protein content, lupins should not constitute more than one third of the total grain content of the ration, or a maximum of 300g/100kg body weight daily.

✓ Crushed white lupins are palatable to horses, but because of their fat content, the seeds are best crushed and used within 10-14 days to prevent the oil residues becoming rancid and rendering the meal less well accepted.

Major Disadvantages

✖ Lupins should be crushed or rolled prior to feeding to improve their utilisation, as the seeds are difficult for horses to chew whole. Alternatively, they can be soaked in water for 60-90 minutes to soften them prior to feeding.

✖ Lupins have a variable lysine content, ranging from 14-23g/kg, which makes them less suitable as a protein supplement for growing horses, as compared to soyabean or canola meal, or milk powder for foals.

✖ Black and coloured lupin seed should not be fed to horses.

7.2.2.2 Peas (Field Peas) (*Pisum sativum*)

Peas are grain legumes and are grown as field peas in the wetter, cooler parts of the Australian wheatbelt. Peas are a useful protein (called “pulse proteins”) source for horses.

Major Advantages

✓ Peas contain an average of 23% crude protein and a digestible energy content similar to barley. They are low in fat (1%) and contain 6% crude fibre. Horses find them palatable when soaked or crushed, and normally only 100-150g/100kg body weight is mixed into a concentrate feed for a working horse.

Major Disadvantages

✖ Peas provide less than half of the lysine and other amino acids required for growth as compared to soyabean meal, although their protein content is equally as digestible. Peas are not recommended as the only protein supplement for growing horses.

✖ Peas contain many anti-nutritional factors and soaking peas in boiling water for 5-10 minutes prior to feeding helps destroy some of these factors. Many of the newer varieties of field peas contain minimal amounts, but the older varieties still dominate the industry.

✖ Peas contain oxalates and phytic acid, both of which can bind calcium, zinc and iron, but this is usually not a problem where peas are limited to no more than 10% of the total grain concentrate in a ration.

7.2.2.3 Tick Beans/Faba or Horse Beans/Broad Beans (*Vicia fabia*)

Bean seeds, like peas, are legumes, which provide around 25% crude protein, 1-3% fat, 7-8% crude fibre, about 15g lysine/kg, with a digestible energy content similar to cereal grains. In common with peas and lupins, beans do not contain starch. However, bean protein is not as well digested in the small intestine and is likely to result in flatulence and higher ammonia release as excess protein is fermented in the hindgut.

Tick beans have been popular for many years as a protein source for racehorses, and are fed crushed in amounts ranging from 100-150g/100kg body weight per day. However, although reasonably well accepted, the cost per unit of crude protein and the lower levels of essential amino acids makes them less economic and a poorer source of protein than soyabean or canola meal.

Tick beans are not suitable as a single source of protein in young horses for these reasons.

Note: Mung Beans (*Phaseolus vulgaris*) (also called navy beans, kidney beans) and Lima beans (*Phaseolus limensis)* are sometimes used as a protein source for racehorses. However, although they have similar protein content to tick beans, in the raw form they contain cyanogenic antiproteases and other harmful compounds to digestion. They also contain a Vitamin E antagonist which binds Vitamin E during digestion. Mung beans in amounts greater than 20g/100kg body weight must be crushed, added to boiling water and soaked for up to 2 hours before feeding, to destroy the toxic compounds that can affect digestion.

7.2.2.4 Milk Powder

Skimmed milk powder is the only animal source protein commonly fed to horses. Meat and fish meals are not popular as a protein supplement because of their poor acceptance by horses in the amounts required. Depending on its cost and local availability, milk powder is either fed as full cream powder, or more commonly, skimmed milk powder as fed to calves. Milk powder is a good quality protein source for foals and younger horses. However, in Australia, milk powder is up to three times more expensive than soyabean meal, although it is competitive in price in New Zealand due to intensive dairy production.

Major Advantages

✓ Milk powder is very palatable to young foals and contains a balanced level of amino acids, including 25g lysine/kg in a crude protein content of 33%. It has a threonine content equal to soyabean meal and is suitable as a source of this amino acid in the creep feed of young foals on pasture diets. The energy content is directly proportional to the amount of fat. Full cream milk powder contains 26% fat, compared to 1-2% fat for skim milk powder. Skim milk powder has a digestible energy content similar to corn due to its lactose sugar content.

Major Disadvantages

✖ Milk powder contains about 50% lactose, (milk sugar), which is not digested by mature horses over 4 years of age, because lactase enzyme activity is lost from the small intestine. In mature horses, amounts in excess of 150g/100kg body weight in a single feed can lead to low grade diarrhoea due to the inability to break down lactose. (Refer to Chapter 2, Section 2.4.1, page XX).

✖ When used as a basis for a creep feed for young foals, milk powder should be progressively replaced by soyabean meal over a 10-14 day period, when foals are introduced to hard feeds. The changeover to soyabean meal will provide a more balanced, economical and complete source of amino acids for growth.

7.2.2.5 Yeast (Saccharomyces spp)

Supplements of dried and killed yeasts, such as Brewer's, Torula and yeast extracts are used as sources of digestive aids, B-group vitamins and amino acids for all types of horses. Yeasts have a variable crude protein content, ranging from 40-51%, relative to their fermentation state and substrate. Non-cultured yeasts do not contain Vitamin B12 as this vitamin is synthesised only by bacterial fermentation incorporating cobalt into the vitamin structure. Yeasts contain higher levels of nucleic acids, including purines, which may have an adverse effect on metabolism if the yeast is given in large amounts as a protein supplement.

Yeasts are an expensive source of protein as compared to oil seed meals, and generally their use is limited to daily addition of 30-60g as a micronutrient supplement. Dried killed yeasts can be used for foal diets at rates of 50-75g/kg of creep or weaner feed, but they are too expensive for addition at this rate for larger horses.

Live yeast cultures of *Saccharomyces cerevisiae* in commercial products have been shown to improve nitrogen retention and the quality of protein consumed when used as a supplement to a cereal based diet in young growing horses. Live yeast cultures may also improve general condition in athletic horses and brood mares, but have marginal if any benefit to healthy mature horses.

7.3 Roughages

The overall quality of hay as a roughage in Australia is much higher than in many other countries due to our drier harvesting conditions, resulting in lower risk of spoilage. However, there is a limited choice and availability of good quality grass hay that is suitable as a moderate energy and protein feed for resting and lightly worked horses. This is partly offset by the traditional feeding of cereal chaff as a roughage mixed into concentrate feeds.

KEYPOINT: Chaff is an expensive form of roughage, costing up to twice as much compared with a similar weight of hay. However, it has some distinct benefits as a roughage when mixed into a grain based concentrate.

Lucerne hay and chaff are the most popular forms of roughage for supplementary feeding of grazing horses as well as horses in training. The protein content of lucerne is often in excess of the needs of resting or lightly

worked horses. As excess protein is fermented to heat in the hindgut, feeding more than 1.0kg/100kg bwt of lucerne hay will add to the heat load that working horses have to lose under the warmer Australian climate.

KEYPOINT: On average, about 10% of hay is wasted by contamination, trampling and wind loss when fed out to pastured horses. Up to 50% of hay placed in hay nets or racks for stabled horses is pulled out and dropped onto the floor with some of it being trampled into the bedding as it is consumed.

7.3.1 Cereal Hays and Chaff (White Chaff) (*Graminae Species*)

Winter cereal crops of oats and wheat are grown in most states for chaffing, with limited amounts available as hay in sheaves, or as small and large bales. In some cases, cereal crops that have been stressed and stunted in growth by poor seasonal conditions before they come to head are cut, baled and then chaffed.

As cereal hay is often not well utilised and can be variable in quality, chaffing the hay helps to improve acceptance and reduce selectivity when it is mixed into a feed.

Quality and Selection of Cereal Hay and Chaff

Making hay or chaff from cereal grain crops before the heads are fully formed results in a higher fermentable cellulose content, more nutrients in the retained leaves and a "softer" chaff. Chaff made from mature cereals with a high stem to leaf ratio, with full seed heads, contains more indigestible lignin and a lower crude protein as well as other digestible nutrients. Leafy parts contain twice the protein and 40% more digestible energy on a weight basis than the stems.

Research has shown that the stage of cutting of cereal plants greatly influences the yield of the crop as a fodder. Cutting the crop early reduces the total yield to about 55-60% (mid stage growth) and 65-70% (prior to full flowering) compared to 100% of the potential yield of a fully mature cereal crop. However, although the total yield and return on the crop cut as hay is highest when the plants are mature with heavy seed heads, hay cut at the mid growth stage, with a 7-9% crude protein content and a lower indigestible lignin fibre content as fed, is more suitable for horses. Mature cereal crops contain from 4-6% crude protein and, although the crop may contain seed heads that boost the energy content of the hay, overall nutritional value and utilisation by horses is reduced as a crop reaches maturity.

Chaffing hay increases the rate of consumption and speed of passage of the fibrous mass through the digestive tract. Overseas studies suggest that finely cut cereal chaff, especially when moistened with molasses, may be consumed too quickly, without being mixed with sufficient saliva as it is being chewed, leading to a risk of impaction colic.

7.3.1.1 Cereal Hay (*Graminae Species*)

Major Advantages

Cereal hay is not widely fed, as it is not readily available in either sheaf or bale form, is often variable in quality and is not always well accepted by horses.

- ✓ Good quality oaten or wheaten hay, harvested at the early to mid growth stage, is palatable to horses and, when fed on a 50:50 basis with lucerne hay, helps to offset the high protein content of lucerne hay as a roughage base for resting and lightly worked horses.

- ✓ Cereal hay is a suitable low energy roughage to feed to overweight horses on a weight reduction program. Palatability can be improved by lightly spraying the hay with a 50:50 molasses-water mix to dampen and sweeten prior to feeding.

Major Disadvantages

✖ Cereal hay is not well accepted especially when fed to young horses and often has a high wastage factor.

✖ Mature cereal hay can contain full seed heads, which are often selectively consumed by horses, increasing the energy intake of the diet, with the mature stems and low leaf residues being wasted.

7.3.1.2 Cereal Chaff (*Graminae Species*)

Major Advantages

Cereal chaff is widely used as a bulking roughage feed when mixed into the grain based diets of racing and working horses.

✓ Mixing limited amounts of no more than 2:1 in volume of cereal chaff with grain helps dilute the concentrate portion of the ration, slowing intake and increasing the time taken to consume the meal, thus reducing the risk of grain overload into the large intestine.

✓ Good quality cereal chaff reduces the selectivity of horses, especially “picky” eaters, and minimises wastage of the roughage as compared to equal quality cereal hay.

Major Disadvantages

✖ Cereal chaff can vary considerably in plant maturity, stem to leaf ratio, amount of dust, grain content and digestibility depending on the time and conditions of harvest.

✖ Large intakes of dry, finely chopped cereal chaff in a hungry horse can lead to choke and may compact in the large intestine.

✖ Cereal chaff can be dusty and blow away easily from paddock feeders situated in windy or exposed areas, if the chaff is not dampened when mixed into the feed.

✖ Feeding a large bulk of chaff with grain can shield the action of enzymes that digest the grain starch in the small intestine and reduce the digestibility of the grain, with more being overloaded into the hindgut.

Selection and Quality of Cereal Hay and Chaff

Cereal hay and chaff can be evaluated by the following criteria:

✓ Leaf to stem ratio. A higher leaf to stem ratio indicates a greater content of fermentable cellulose to indigestible lignin, especially in mature stands.

✓ Colour of the leaf content. A green leaf does not always indicate a high Vitamin A or other nutrient content. However, bleached leaves and stems may suggest that soluble nutrients and vitamins may have been leached out by weathering prior to harvesting.

✓ Good quality cereal roughage has a low dust content and contains no mouldy or clumped areas in the chaff and is free of weeds or other plant contaminants in the hay.

- ✓ Presence of grain. Although some grain may increase the energy and protein content, a high proportion of mature stems and a low leaf content in hay or chaff indicates a less nutritious sample.
- ✓ Chaff containing larger bruised fragments of stem and leaf is less likely to compact in the large intestine as horses will normally chew and salivate more to prepare it for digestion.

7.3.2 Meadow Hay (*Trifolium/Graminae/Medicago Species*) / Clover Hay (*Trifolium Species*)

Meadow hay, pasture hay or mixed grass and legume hay, as well as clover hay, is available in many areas in the better rainfall, pasture improved areas throughout Australia, particularly where good spring rainfall results in a surplus of quality pasture growth.

Meadow hay contains a mixture of pasture grasses, with a variable content of medics and clovers. Its palatability is relative to the type, quality and maturity of the pasture stand when harvested. Horses will normally select palatable species out of the hay as they eat it, leaving more mature, coarse or prickly pasture plants. There is often a high wastage factor with meadow hay, but hungry horses will usually consume more than those being given a hay supplement at pasture.

Clover hay also varies in palatability relative to the quality of curing, maturity and type of clover, and its contamination with mature grasses and weeds. Good quality clover and medic hay has a high leaf, thin stems and low seed burr content. Well cured hay, without 'heated' and mouldy spots in the hay resulting from matting and poor drying out prior to baling, is often well accepted by horses, with less wastage than lucerne hay of a comparable grade. Good quality clover hay is often regarded as being "sweeter" than lucerne hay and many horses prefer it to lucerne hay.

The feeding value of clover hay is similar to lucerne, a higher crude protein content with mid growth, less mature clover hay providing a higher content of digestible energy and crude protein.

7.3.3 Lucerne Hay and Chaff (Green Chaff) (*Medicago sativa*)

Lucerne hay and chaff provide the most common roughage base in the diets of the majority of growing, breeding, exercising and resting horses in Australia. Alfalfa is the name used for lucerne in North America.

The potential for high yields for hay grown under both dryland and irrigated conditions makes lucerne one of the best suited of all the fodder plants for the Australian environment. This is due to the persistence and hardiness of this perennial legume, its ability to resist dry conditions, its high nutritive value and its strong competition with grass and weed contamination when growing in vigorous pure stands.

Quality of Lucerne Hay and Chaff

The palatability, wastage factor, digestibility and nutrient content of lucerne hay and the quality of the resultant lucerne chaff are greatly influenced by the time and conditions of harvest. These include the pureness of the plant stand, the stage of maturity at mowing, the efficiency of the method of conditioning to ensure even drying as well as the weather and conditions during curing prior to baling. All these directly affect the quality of lucerne as a horse feed.

Hay harvested in the mid to late vegetative (growth) stage has the highest digestibility and nutritive value. The utilisation and feeding value declines as the plant loses its lower leaves due to shading, forms flower heads and matures to full bloom (see quality appraisal below). The highest yield and quality combination is obtained from a pure stand of lucerne that is cut at early (10%) flowering.

First cut lucerne hay, or the first harvest of lucerne, usually in early spring after the dormant winter period, is often contaminated with grass and weeds. Contamination of the lucerne with other plants increases the degree of selectivity and wastage by horses, resulting in reduced utilisation and feed value, as compared to later cuts of pure stand, at the late vegetative to early flowering stage.

7.3.3.1 Lucerne Hay (*Medicago sativa*)

Major Advantages

Lucerne hay has become the most popular roughage fed to horses in Australia, and its wide availability helps maintain it at a reasonable price throughout most of the year.

- ✓ Good quality leafy, thin stemmed lucerne hay is palatable, well utilised and has minimal wastage as a roughage for horses of all ages.
- ✓ Lucerne hay provides additional protein, energy, calcium and other nutrients to supplement short winter grass or dried-off summer pastures in grazing horses, including pregnant mares and late lactation mares, yearlings and mature working horses.
- ✓ Sun-cured lucerne hay, fed as a roughage to horses in training, helps meet the requirement for energy, crude protein, calcium, trace-minerals and Vitamin D required by stabled horses provided with high cereal grain diets.

Major Disadvantages

- ✖ The higher than required protein provided by lucerne hay as the sole roughage for resting horses is often regarded as being 'too rich', increasing urinary outflow, ammonia and calcium content of the urine, hindgut heat production and sweat output as the excess protein is fermented and eliminated.
- ✖ In growing horses, lucerne hay provided as the sole roughage source to supplement dry, summer pastures, may increase the risk of Developmental Orthopaedic Disease (DOD – Refer to Chapter 4, Section 4.X.X, page XX). This is influenced by its relatively high energy contribution in the amounts fed, the high content of calcium relative to phosphorus (up to a 6:1 calcium to phosphorus ratio) and inadequate levels of trace-minerals such as copper, zinc and manganese.
- ✖ Dry, dusty or poorly cured hay containing minute mould particles can increase the risk of allergic airway reactions in horses in training, unless it is thoroughly dampened prior to feeding.

7.3.3.2 Lucerne Chaff (*Medicago sativa*)

Major Advantages

Lucerne chaff is commonly used as a supplementary feed to resting and lightly worked horses, or mixed with cereal chaff as a bulking feed in grain based rations.

- ✓ Lucerne chaff has the same nutritional value as lucerne hay on a weight basis, but because of the small fragment size, it is more bulky. It can therefore be used to increase the bulk and fibre of a grain based concentrate feed.
- ✓ Good quality lucerne chaff supplies a higher intake of reasonable quality protein as compared to cereal chaff, to help meet the requirements of all classes of horses fed on cereal grains as an energy source for growth, lactation and exercise.
- ✓ Dry lucerne chaff is usually more palatable and consumed more readily than dry cereal chaff when mixed into a "hard" feed, although all dusty chaff should be dampened prior to feeding.

Major Disadvantages

✖ Dusty and poorly cured samples that contain fine particulate moulds can increase the risk of airway disease, unless the chaff is dampened when mixed into the feed.

Selection and Quality of Lucerne Hay/Chaff

The highest quality lucerne hay is green in colour, has a high proportion of leaves with thin evenly flattened stems; contains minimal dust and bleached leaves; has well attached non-fragmented leaves and is free from mouldy or musty odours, weeds or grass contamination.

Lucerne chaff should be free flowing and green in colour; have a high leaf to stem content, with minimum dust or bleached leaves. It should be free from mould odour or clumping.

Mature, stemmy, low leaf hay with more than 30% of grass or weeds is much less palatable or suitable for horses.

A practical method for grading the quality of lucerne hay is presented in Table 7.2.

Grade	Description	% Crude Protein (as fed)	Digestible Energy MJ/kg (as fed)
Grade 1	Minimal external bleaching. Green colour inside mid to late growth – no flower heads. High leaf to stem ratio, well attached leaves, thin stemmed. No musty colour, mould or weather damage. Free of grass, weeds and foreign matter.	18-22% (180-220g/kg)	10-11
Grade 2 (Prime)	External bleaching to 15% of stem/leaves 10-15% flower heads. Coarser stem and minimal leaf loss. No musty colour or mould damage. Up to 5% grass.	15-18% (150-180g/kg)	9-10
Grade 3 (Medium)	External bleaching to 30% of stems/leaves. Less leaf, more mature plants. Stems thicker and flattened. Up to 10% grass.	12-16% (120-160g/kg)	8.5-9.0
Grade 4 (Stock)	External bleaching to 50% of stems/leaves by weather damage 50-75% flower heads. Higher stem to leaf ratio, thick stems. No moulds or musty odour. Up to 20% grass and a few weeds may be present.	9-12% (90-120g/kg)	8-8.5

TABLE 7.2
Practical Evaluation of the Quality of Lucerne Hay

A classification system for grading the quality of lucerne and cereal hay is presently being introduced by the Australian Fodder Industry Association (AFIA) with the support of RIRDC. It is planned that all hay produced in Australia will be classified and labelled with details of its grade of quality relative to its energy, crude protein and dry matter digestibility content. If adopted by feed merchants, the objective grading system, although not mandatory, will allow both the buyer and seller to recognise the quality grade of the hay.

7.3.4 Sunflower Hulls (*Helianthus annus*)

Sunflower hulls, produced by removing the fibrous hulls of sunflower seeds during oil seed meal processing, are a suitable roughage for resting horses. They are palatable and provide some digestible fibre, 4-6% crude protein, and 3-4% fat. The hulls are useful as a bulking agent when mixed 50:50 by volume with lucerne chaff in a maintenance diet, providing gut fill without contributing greatly to the energy intake of a resting horse. This is in contrast to sunflower seeds which provide a useful energy and protein boost to the diets of working horses. (See page XX).

Sunflower hulls are more digestible and softer for horses to chew than the hulls of most cereal grains. Because they are often dusty, the feed mix should be dampened prior to feeding. Sunflower hulls should not replace hay or chaff as the major roughage source and large amounts fed dry as bulk, if consumed quickly, may compact in the hindgut.

7.3.5 Soyabean Hulls (*Glycine max*)

Soyabean hulls, where locally available, can be used in the roughage mix for resting horses. They have a lower indigestible lignin content than cereal hulls. Soyabean hulls contain from 11-13% crude protein, 1-2% fat, and 36-45% crude fibre, although digestibility is less in horses than cattle. However, their low energy content makes them unsuitable as a major roughage in a hard feed for growing and working horses. When fed at a rate greater than a 50:50 mix with chaff, they may cause loose droppings and reduced feed intake.

7.3.6 Wheat Bran

Wheat bran, or common 'bran', is a byproduct of wheat flour milling. For centuries it has been popular as a laxative feed for stabled horses. In fact, it has no significant laxative effect to horses because of their high fibre intake in hay and chaff, even when given as a traditional 'hot' bran mash after soaking in hot water.

Various forms of bran, the fibrous coating on wheat grain, are available, graded as flaky, course or fine bran, or mixed as coarse "mill run" or "mill mix" bran. Bran is palatable to horses, it is bulky with a low weight per volume (density), containing 8-11% crude fibre, 4% fat and 14-16% crude protein. Although bran is slightly higher in the majority of essential amino acids than whole wheat, it is still low in those required for growth.

Bran contains useful levels of B-group vitamins, including niacin, pantothenic acid, and folic acid, but is low in most other vitamins. It also contains 1% phosphorus, of which 90% is in the form of phytate. Bran contains very low amounts of calcium and as phytate binds calcium (as well as zinc and iron) and decreases its uptake from the small intestine, large amounts of bran can lead to an induced calcium deficiency, known as Nutritional Secondary Hyperparathyroidism (NSH – See Glossary Term). Historically, it was referred to as "Millers Disease" in horses because flour milling companies often fed their horses rations containing high amounts of "flour offal" or bran.

Calcium, zinc and iron supplements should not be mixed into large amounts of bran, as they may become bound to the phytate in the small intestine and less will be absorbed. Calcium especially, should be fed in the main feed rather than in a bran mash. Calcium can be added to rations containing a small amount of bran as an appetiser without significantly affecting its uptake.

Bran is expensive for its nutrient content, but horses find it palatable and enjoy eating feeds containing up to 10% bran on a dry weight basis.

7.3.7 Wheat Pollard

The fine middlings of wheat milling and rice polishing are marketed as pollard in Australia, and are a popular conditioning feed for show and other horses.

Pollard contains more endosperm or grain germ than bran and is higher in energy and crude protein (17-18%) with 3.6% crude fat, but is lower in fibre than bran. Rice pollard contains a higher fat level than wheat pollard.

Wheat or rice pollard is often fed at rates between 200-400g (about ½ -1 litre volume) per 100kg bodyweight daily for short periods to help improve condition and body weight in show horses. However, when used routinely in a ration, pollard should be limited to 5% of the total ration (or approx 100g/100kg body weight) daily in all horses.

Pollard is dusty and dry pollard can cause respiratory allergy if inhaled by a horse when feeding. It should be fed dampened and well mixed into the feed.

A continued high intake of pollard will put on weight and body condition, although the common belief that it "puts fat around the heart" is not specific to pollard as a higher energy feed.

Like bran, wheat and rice pollard contains phosphorus in phytate form and supplements containing calcium, zinc and iron should not be mixed directly into a bulk of pollard because reduced uptake of these minerals may result.

7.3.8 Rice Bran

Rice bran is not available in Australia as a stock or horse feed. The byproducts of rice milling produced by Rice Growers Cooperative in Leeton, NSW, are blended by its subsidiary, Coprice Feeds, into a pollard that is a popular feed for horses. (See Rice Pollard).

Rice bran produced overseas is often contaminated with highly fibrous rice hulls (40% crude fibre) which results in a feed with variable nutrient content and digestibility from batch to batch.

7.3.9 Rice Hulls

Rice hulls are widely available as a bedding material. They are high in indigestible lignin, silica and fibre (40%), but low in protein (2%). If rice hulls are to be fed to horses they must be finely ground and dampened in the feed. Up to 30% of the standard chaff content can be replaced by ground rice hulls, which is sometimes used as a drought feed.

7.3.10 Rice Pollard

The form of rice pollard available as a horse feed is unique in Australia because it consists of a set blend of byproduct from the rice milling industry.

Rice pollard is manufactured by Coprice Feeds, Leeton, NSW, from the milling of brown rice ('rough' or 'paddy' rice with the hulls removed) blended with the outer layers of the rice grain, rice germ and polishings into a consistent 'pollard' mix.

Rice pollard has a high fat content (19%) due to the inclusion of the rice germ, resulting in a higher energy content than wheat pollard. The high polyunsaturated fat content can increase the risk of rancidity when rice pollard is stored for extended times under hot conditions.

Rice pollard, because of its oil content, is less dusty than wheat pollard and is often better accepted by 'picky' eaters.

7.3.11 Haylage

Haylage is made from fresh pasture that is fermented after it is harvested by sealing it in a strong plastic outer wrap. The moist, oxygen free, carbohydrate and protein rich environment promotes natural fermentation by fungi and acid producing bacteria to preserve the forage during its storage period. Horses generally find haylage palatable, as it is only partly fermented as compared to silage. Its feeding value is related to the type of pasture used for making the haylage.

Care has to be taken to limit intake to 300-400g/100kg body weight in each feed to avoid gas colic.

There is also a risk of abnormal fermentation with Clostridial bacteria, which may lead to the accumulation of preformed botulism toxin and risk of death in horses. Damaged or punctured plastic wraps can facilitate abnormal fermentation in a zone around the punctured area. A pH strip should be used to test the core pH of each haylage bag prior to feeding, and those with a pH of higher than 4.5, indicating lower acid preservation, must not be fed to horses.

Haylage that is dark brown or black in colour or very smelly must not be fed to horses.

7.3.12 Silage (Ensilage)

Silage is a more completely fermented form of haylage which is produced by compacting lush winter and spring grass and legumes in airtight mounds or as bales in thick plastic bags and stored above ground. Silage is a nutritious supplement feed for dairy and other cattle. Although silage has a distinct volatile fatty acid odour, horses readily consume it if it is introduced to them in a step-wise manner. Well cured silage is a useful drought feed or when hay is limited. Studies overseas suggest that horses which are sensitive to dust in hay suffer less respiratory allergy when fed on silage. Up to 1kg/100kg body weight of sweet silage (moist weight) can be fed daily as a part substitute for hay as a roughage.

Quality of Silage

Silage of the highest quality and palatability is made from early green growth corn, oats or other growing pasture grass (eg ryegrass) forage. Clover based silage is less sweet and palatable to horses. The moisture content of silage can vary from 85% (too wet – water squeezes out easily) to 60% (dry silage - very dry and less palatable silage). Silage with a moisture content of 70-75% (25-30% dry matter - it is difficult to squeeze water out of a sample) is considered the best quality and is usually well accepted by horses.

Sweet silage that has a clean, acid smell, with a yellowish to olive green colour is palatable to horses. Dry, brown (caramel) or wet dark green, putrid silage is not suitable for horses.

7.3.13 Hay Cubes

Hay cubes, usually made by compressing lucerne or meadow hay, into layered 50mm square blocks are not a common feed in Australia. They are often fed in the Northern Hemisphere during winter to horses confined to stables because storage is more space saving and there is less wastage. Hay in cubes reduces wastage of hay, whilst the nutrient value is increased by retention of more leaves, a low dust content and reduced weight of droppings due to lower water content.

Greedy or hungry horses may choke on hay cubes, but the risk can be reduced by dampening the cubes and mixing them with chaff prior to feeding.

7.4 Pastures

The case for greater emphasis on pasture feeding of horses in Australia is strong, as it offers the advantage of considerable reduction in overall feeding costs in combination with a return to the natural grazing conditions to which the horse is well adapted. The grazing horse benefits from exercise, as well as nutritionally, and is much less inclined to develop the behavioural idiosyncracies of a horse that is confined to a stable or yard for long periods.

Research on pastures for the horse industry in Australia is relatively recent, and much of it for temperate Australia (south of Dubbo in NSW) is summarised in the book by Angela Avery (Pastures for Horses – a Winning Resource) (Refer to suggested reading page XX). This section amplifies briefly on the work reported by Avery and extends the discussion to the tropical pastures used for horses in the northern regions of NSW and in Queensland.

Research in New Zealand has shown that well managed pastures can provide most or all of the nutritional requirements of horses and the stud industry there relies heavily on pastures as the basis of horse feeding systems. Supplementation is needed only where animals are involved in heavy work, where winter temperatures inhibit pasture growth, or where mineral deficiencies occur. Most of the experience with pasture feeding of horses in New Zealand should be directly applicable to temperate Australia, provided pastures are well managed and water limitations are overcome. As in New Zealand, Australian research on pastures for horses lags seriously behind that for cattle and sheep, and much of the Australian information on pasture species performance and management for horses has had to be extrapolated from that for cattle and sheep.

KEYPOINT: Well managed, productive pastures can supply all the nutritional requirements of the horse, with supplementation of actively growing pastures being required only where horses are in heavy work or where soil mineral deficiencies occur.

7.4.1 Advantages of Pasture Feeding

Well managed, productive grass-legume pastures can provide:

- ✓ All the nutritional requirements of a horse, except heavily worked or productive horses, such as a horse in moderate to full training or the breeding stallion.
- ✓ A natural grazing environment where the selective browsing behaviour of the horse can be expressed without constraint.
- ✓ Space for the horse to exercise at will.
- ✓ Opportunity for the horse to express its natural behaviour as a herd animal.
- ✓ Considerable cost savings over concentrate based feeding systems.
- ✓ A significant reduction in the occurrence of feeding problems compared with the hand fed horse.
- ✓ Markedly reduced demands on the management of individual animal nutrition.

✓ Freedom from, or a significant reduction in, the occurrence of typical behavioural problems of the confined horse.

7.4.2 Disadvantages of Pasture Feeding

The main disadvantages of pasture feeding of horses can be summarised as:

✖ The need for managers to acquire pasture as well as horse management skills.

✖ The risk of injury when horses are turned out on pasture singly or in groups, contact with other horses or with fences.

✖ The risk of plant poisoning (see Chapter 9) and the consequent need for managers to acquire the knowledge and skills necessary to identify, and either eliminate or avoid, harmful or potentially hazardous plant species.

✖ The risk of problems such as colic or laminitis during pasture growth flushes. (Refer to Chapter 2, Table 2.2 page XX).

✖ The need to supplement the diet during periods of low pasture productivity caused by drought or temperature stress (temperature stress can be induced by either high or low temperatures, depending on the adaptation of the pasture species).

✖ The need for regular rotation of horses between paddocks to minimise parasite build-up and the development of “horse-sick” pastures (this can be a major limitation on small land holdings).

✖ The need to restrict horse numbers to levels which can be sustained without severe pasture and soil degradation from overgrazing.

While the disadvantages listed above out***number*** the advantages in Section 7.4.1, on balance, the advantages far out***weigh*** the disadvantages of pasture feeding.

7.4.3 Management of Horse Pastures on the Small Holding

A large proportion of the Australian horse population is owned and managed on small land holdings ranging from 1 to 4 hectares, many of which become seriously degraded by continuous grazing of horses. This is likely to result in “horse sick” pastures, soil erosion and compaction, and

severe soil mineral imbalances by nutrient transfer between grazed ‘lawns’ and dunging ‘roughs’.

The owners of small land holdings face the greatest challenge to achieving a desirable level of pasture feeding, simply because they lack adequate land area and/or have too many horses to allow paddocks to be rotated effectively enough to prevent degradation. In these cases, it is invariably better to confine individual horses to small yards and to maximise the pasture area available on the remainder of the land.

✓ The pasture area should be subdivided with temporary fences and individual horses allowed a period at pasture each day, either singly or in company, depending on paddock size and the nature of the individual horses. As with larger holdings, paddocks should be rotated on a regular basis to avoid overgrazing and allow recovery to an active growth phase.

In this way, some of the benefits of pasture feeding may be achieved for each horse, while their combined impact on the pasture base is kept at an acceptable level. The length of the grazing period and the number of horses grazed can be adjusted according to seasonal conditions to maintain the pasture resource.

✓ During periods of drought or slow pasture growth, it may be necessary to exclude horses from the pasture areas completely. For more information on the subject, the reader is referred to the RIRDC publication by Arthur Stubbs and Jacqui Foyel on managing horses on small holdings. (Refer to suggested reading).

KEYPOINT: A sustainable and productive pasture resource base can be established and maintained on small land holdings by a combination of subdivision and managed access to pasture areas, relative to pasture growth and condition.

7.4.4 Pastures as Feedstuffs

Good quality pastures and forages can supply most or all of the dietary needs of a horse, particularly when it is not in full work or engaged in demanding activity such as breeding. Examples of typical plant nutrient content are illustrated in Table 7.3. Values for grains are included for comparison.

Plant Material	**Dry Matter % DM**	**Digestible Energy Megajoules (MJ/kgDM)**	Crude Protein **% CP**
Grains			
Oats	92	12.0	10.5
Barley	91	13.8	12.0
Sorghum	89	13.8	13.1
Maize	88	15.0	8.5
Wheat	92	14.3	12.6
Triticale	91	14.3	10.1
Lupins	92	14.9	33.8
Cowpeas (Poonapeas**)**	90	14.3	24.9
Pasture / Forage – Cereals and Grasses			
Wheat	19	10.1	14.1
Barley	18	10.5	13.5
Oats	20	10.2	14.6
Corn (maize)	15	12.0	18.3
Triticale	22	10.8	13.8
Millet (Feedmill)	10	13.7	13.9
Millet – Japanese or Shirohie	11	8.7	11.1
Ryegrass - Tetila (tetraploid)	18	11.9	24.9

- Perennial	25	9.5	18.2
Phalaris – dry, very mature	85	6.9	3.8
- fresh	25	8.4	11.2
Paspalum	35	6.9	9.6
Rhodes Grass	32	8.9	11.2
Pasture / Forage – Legumes			
Medic	23	12.2	20.5
Clover - subterranean	20	9.8	22.5
Lucerne - mature	68	11.1	18.8
immature early to mid vegetate	26	11.2	24.5
Mixed Pasture – Grass/Clover			
Close grazed, immature	20	12.0	14.7
Flowering	28	10.3	11.4

Table 7.3.
Average Values of Plant Composition for some Australian Grains, Pastures and Forage Crops.

The dry matter percentage (DM%) of the plant material is an important consideration, as dry matter content reflects degree of maturity of the plant material and hence its quality as a feedstuff. As dry matter % increases, quality in terms of DE and CP declines. (Refer to Table 7.3). Young, rapidly growing pastures and forage crops will contain only 5 – 10% dry matter and can be likened to a "thin soup" of nutrients when grazed as 90 – 95% of the material consumed is water.

Horses grazing high moisture, lush pasture would need to graze continuously for 20-24 hours to obtain their dry matter intake requirements (Refer also to Chapter 2, Table 2.2 page XX). Plant dry matter % increases with age, and a good example is shown for a barley crop in table 7.4. Similar changes would occur in pastures as they progress through their growing season each year. It is also worth noting that in Table 7.3, the legume material is consistently much higher in protein than that required by horses, regardless of growth stage. (Refer to Chapter 2, Section 2.4.1.2, page XX).

Age (weeks)	Growth Stage	DM%
4	Seedling – early vegetative growth	4
8	Vegetative growth	7
12	Mid vegetative growth	13
20	Late vegetative growth	16
24	Stem elongation – early reproductive	24
28	Booting – head almost emerged	32
32	Heading – head emerged	38
36	Grain filling	75
38	Grain maturity – plant death	92

Table 7.4.
Changes in Dry Matter Content of Barley Forage Over Time.

KEYPOINT: Pastures and forage crops should not be grazed until their dry matter content increases to 12% or more, which generally equates to 10 – 12 weeks after sowing.

7.4.5 Pasture Species

The pasture species grown in Australia and used in the horse industry are categorised on the basis of adaptation and seasonal growth patterns into temperate, sub-tropical and tropical grasses and legumes.

7.4.5.1 Temperate Species

Temperate species are those adapted to cooler season production and they grow actively through the autumn-winter-spring period. Peak quality, in terms of Dry Matter Digestibility, Digestible Energy content and Crude Protein percentage, occurs in late autumn, winter and early spring. Quality declines rapidly as they mature, flower and set seed in mid to late spring – early summer. Typical temperate species growth are shown in Figure 7.2, page XX. The majority of sown Australian pasture species fall into this group, with most of the improved pasture located in the temperate southern regions of Western and South Australia, Victoria, and the Slopes, Tablelands and Coastal Plains south of Dubbo in NSW.

Horses are browsers by nature, and exhibit highly selective grazing habits where a mixture of species is present. Research both overseas and in Australia has shown that there is a marked preference by grazing horses for temperate grasses over temperate legumes or other broadleaf species. The main temperate species reported in use for horse pastures both in Australia and overseas are outlined in Table 7.5.

7.4.5.2 Sub-Tropical Species

Sub-tropical species prefer warm to hot seasonal conditions and actively grow through the spring, summer and autumn periods. They are able to tolerate some frost damage and can continue growth at temperatures as low as 8^0 C. Quality peaks during late spring, early summer and declines into the autumn with flowering and maturity in annuals and the approach and onset of dormancy in perennials. Typical growth curves for these species are shown in Figure 7.2.

7.4.5.3 Tropical Species

True tropical species are not tolerant of frosting at any stage and require higher temperatures for all growth stages. They typically have very high growth rates through summer and their active growth period is restricted to the late spring and summer months. Quality peaks in early to mid summer and rapidly declines in late summer and particularly early autumn.

Overall, the true tropicals exhibit much higher growth rates and total dry matter production than temperates or sub-tropicals, but they are generally lower in quality, particularly in their later growth stages.
Sub-tropical and tropical species reported in use for grazing horses are outlined in Table 7.6.

Figure 7.2
Generalised Growth Curves for Temperate, Sub-Tropical and Tropical Pasture and Forage Species.

Common Name	Habit	Scientific Name	Country
Pasture Grasses			
Annual or Wimmera Ryegrass	A	*Lolium rigidum*	Aust.
Perennial Ryegrass	P	*Lolium perenne*	Aust., NZ, UK
Redtop or White Bent	P	*Agrostis gigantea*	USA
Meadow Fescue	P	*Festuca pratensis*	NZ, USA, UK
Kentucky Bluegrass	P	*Poa pratensis*	USA
Red Fescue	P	*Poa rubra*	USA
Timothy	P	*Phleum pratense*	USA
Cocksfoot or Orchard Grass	P	*Dactylis glomerata*	Aust., NZ, UK, USA
Phalaris	P	*Phalaris aquatica*	Aust.
Tetraploid Ryegrasses	A	*Lolium spp.*	Aust., NZ
Italian Ryegrass	B	*Lolium multiflorum*	Aust., NZ, USA, UK
Grasses Grown as Forage Crops			
Oats	A	*Avena sativa*	Aust., NZ, USA,UK
Barley	A	*Hordeum vulgare*	Aust., NZ, USA,UK
Triticale	A	*Triticosecale*	Aust.
Wheat	A	*Triticum aestivum*	Aust., UK
Tetraploid Ryegrasses	A	*Lolium spp.*	Aust., NZ
Pasture Legumes			
Subterranean Clover	A	*Trifolium subterraneum*	Aust.
Strawberry Clover	P	*Trifolium fragiferum*	Aust., NZ, USA
Red Clover	P	*Trifolium pratense*	Aust., USA, NZ
White Clover*	P	*Trifolium repens*	Aust., NZ, UK, USA
Barrel medic	A	*Medicago tribuloides*	Aust.
Legumes Grown as Forage Crops			
Berseem Clover	A	*Trifolium alexandricum*	Aust.
Other Broadleaf Species Sown for Horses			
Dandelion	A	*Taraxacum officinale*	UK
Ribgrass or Plantain	P	*Plantago lanceolata*	UK
Chicory	P	*Cichorium intybus*	UK

* Widely adapted sub-tropical species with a temperate growth pattern
Habit: A – Annual, P – Perennial, B – Biennial

Table 7.5.
Temperate pasture and forage species used for horses in Australia and overseas.

7.4.6 Quality and Plant Growth Stages

The length of the lifecycle of plants varies, and species are categorised as annuals, biennials (or short-lived perennials) and perennials.

- Annuals complete their entire lifecycle from germination to maturity in a single year. Stages in the lifecycle are germination, vegetative (leaf and stem) growth, flowering, seed formation, maturity and senescence (death) of the plant. Seed formed will produce the next generation of the species.

- ☑ Some annuals, such as subterranean clover, barrel medic and annual ryegrass are self regenerating and behave much like perennials, without having to be annually re-sown.

- ✷ Perennials follow the same stages in their lifecycle as annuals, but at the completion of a cycle the plant does not die after setting seed. It may continue growth at a slow to moderate rate, depending on temperature conditions and the adaptation of the plant, or become dormant (enter a resting stage where growth has ceased).

- ☑ Temperate perennials often exhibit summer dormancy to evade high temperatures, resuming growth when temperatures decline in the following autumn. Falling autumn temperatures may induce winter dormancy in summer growing sub-tropical and tropical perennials, with growth resuming when the temperature rises in the following spring.

- ☑ Perennials usually produce viable mature seed at each flowering, but maintenance of a healthy sward is often not dependent on this seed, other than for limited new plant recruitment. Maintenance of a poorly managed, run down pasture sward may, in contrast, be heavily dependent on new plant recruitment and provides ideal conditions with low competition for substantial weed invasion.

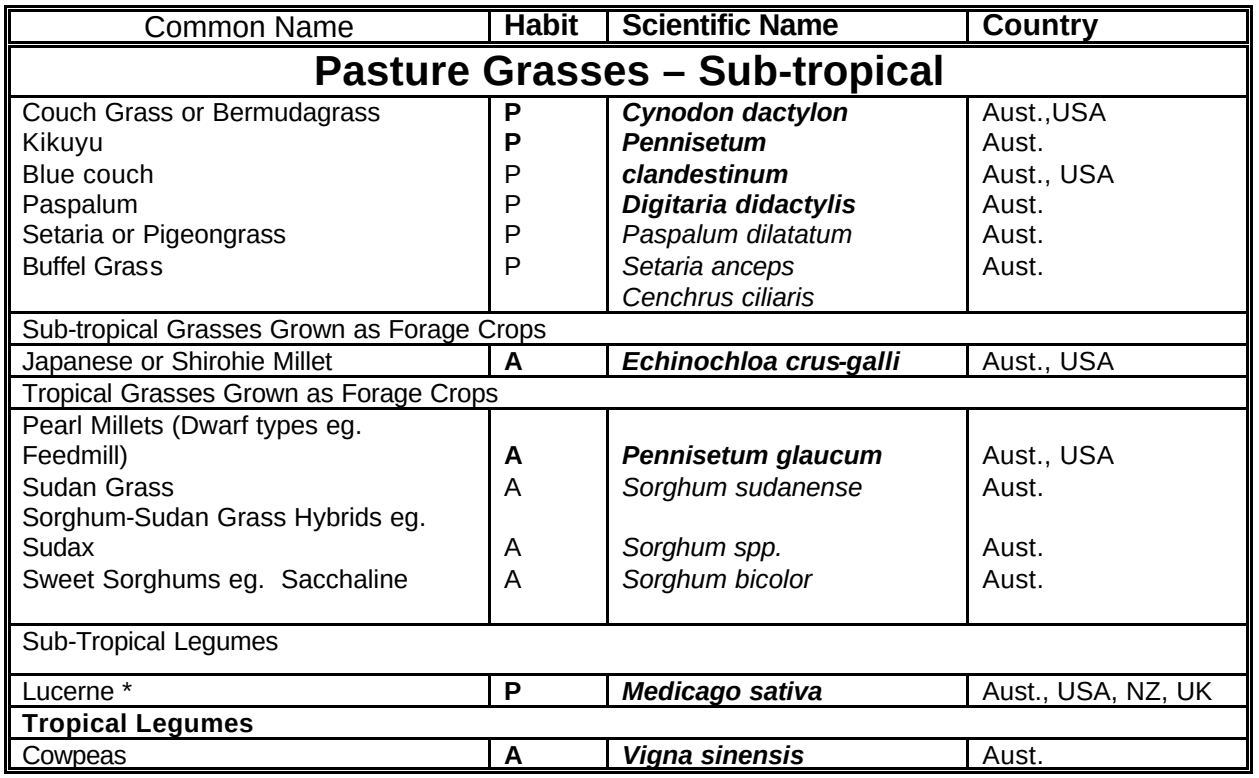
- ☑ Perennials are favoured because they offer continuous ground cover and protection against erosion and eliminate the high annual costs of re-establishing annual pastures.

- ☑ A well managed perennial pasture sustained by a proper fertiliser program (Refer to Avery, 1996 – Suggested reading list) with either irrigation or adequate rainfall, may be expected to last for 5 to 10 years, (depending on species) before being resown. Pastures established with species such as kikuyu, couch, paspalum and white clover can be regarded as permanent.

- ✷ Biennials are plants, which live for more than one, but usually less than two years. Some, such as Italian Ryegrass, are really short lived perennials which will complete two to three annual cycles, setting seed at the end of each cycle. Re-establishment costs are incurred every three years, rather than annually.

KEYPOINT: Properly managed perennial pastures offer the most cost-efficient source of quality dry matter for grazing horses. Self-regenerating annual species can also offer a cost-efficient supply of quality forage.

Figure 7.3
Variation in Pasture and Forage Crop Quality with Growth Stages



Common Name	Habit	Scientific Name	Country
Pasture Grasses – Sub-tropical			
Couch Grass or Bermudagrass	**P**	***Cynodon dactylon***	Aust.,USA
Kikuyu	**P**	***Pennisetum***	Aust.
Blue couch	P	***clandestinum***	Aust., USA
Paspalum	P	***Digitaria didactylis***	Aust.
Setaria or Pigeongrass	P	*Paspalum dilatatum*	Aust.
Buffel Grass	P	*Setaria anceps*	Aust.
		Cenchrus ciliaris	
Sub-tropical Grasses Grown as Forage Crops			
Japanese or Shirohie Millet	**A**	***Echinochloa crus-galli***	Aust., USA
Tropical Grasses Grown as Forage Crops			
Pearl Millets (Dwarf types eg. Feedmill)	**A**	***Pennisetum glaucum***	Aust., USA
Sudan Grass	A	*Sorghum sudanense*	Aust.
Sorghum-Sudan Grass Hybrids eg. Sudax	A	*Sorghum spp.*	Aust.
Sweet Sorghums eg. Sacchaline	A	*Sorghum bicolor*	Aust.
Sub-Tropical Legumes			
Lucerne *	**P**	***Medicago sativa***	Aust., USA, NZ, UK
Tropical Legumes			
Cowpeas	**A**	***Vigna sinensis***	Aust.

* Lucerne includes a range of ***cultivars*** (***culti***vated ***var***ieties) covering summer to active winter growth types which are grown in improved pastures and as pure stands for grazing or hay production throughout temperate and sub-tropical Australia where the rainfall permits its establishment.
Habit: A – Annual, P – Perennial.

Table 7.6.
Sub-tropical and tropical pasture and forage species reported in use for grazing horses in Australia and overseas

7.4.7 Grazing Sub-Tropical and Tropical Pasture and Forage Species

Much of the pasture base for horses in temperate regions of Australia contains kikuyu, often as a volunteer species, particularly under irrigated, high fertility conditions. This species is highly productive under good conditions, but is also very persistent under harsh conditions of drought, low fertility or soil acidity, recovering quickly when these stresses are alleviated. In northern regions, while kikuyu is an important species for horses, other sub-tropical and tropical species are widely sown for horse pastures. The most important of these are listed in Table 7.6.

Most of these species (Refer to Chapter 9, Section 9.5.2, page XX) can contain calcium as calcium oxalates, which is insoluble in the high alkaline environment in the small intestine and make calcium unavailable for absorption by the horse. Although the calcium oxalate is broken down in the hindgut by bacteria to release calcium, it is not absorbed well from the small intestine. This leads to calcium deficiency and the condition known as Nutritional Secondary Hyperparathyroidism (NSH) (see Glossary). NSH occurs where the level of oxalate in the forage exceeds 0.5% of dry matter by weight and the calcium to oxalate ratio in the dry matter is less than 0.5.

Despite this constraint, horses are successfully grazed on these species without problems and they form the main pasture base on Queensland studs. Oxalate problems are avoided by calcium and phosphorus supplementation of the diet with a combination of lime (calcium carbonate) and di-calcium phosphate (DCP). The cost of supplementation can be reduced by using a mixture of 2 parts lime to 1 part DCP, which provides 7g calcium and 1.2g phosphorus per 20g (1 level tablespoon measure) mixed into a blend of 100g oats or pellets and 200g chaff, but not including bran. The feed must be mixed well, and dampened to reduce sifting out.

The following daily supplementation rates are recommended:

(1 level 20mL metric tablespoon provides 20g of calcium powder containing 2 parts by weight of calcium carbonate (agricultural lime) to 1 part dicalcium phosphate (DCP or calcium hydrogen phosphate))

Adult horses	10g per 100kg bwt
Non Pregnant Mares	10g per 100kg bwt
Early Pregnancy	15g per 100kg bwt
Late Pregnancy	20g per 100kg bwt
Early Lactation	30g per 100kg bwt
Late Lactation	20g per 100kg bwt
Weanlings	40g per 100kg bwt
Yearlings	30g per 100kg bwt
18 month old horses	20g per 100kg bwt
Light and Moderately worked horses at pasture	20g per 100kg bwt

✓ Where pastures contain predominately buffel grass (*Cenchrus ciliaris)* on the inland areas and *Setaria* spp on the coast, high rates of calcium supplementation may be necessary to ensure adequate calcium is available for uptake. Growing horses, pregnant and lactating mares should receive a higher rate to meet their general calcium and phosphorus demands, particularly when lucerne hay is not provided. The supplement may need to be fed with a sweetener such as 50:50 molasses water to ensure that all horses accept it readily without leaving the mix so that adequate calcium and phosphorus is obtained to avoid oxalate induced problems.

✓ Young growing horses will normally need to be brought into a yard daily and fed the supplement to ensure they consume the full amount.

✓ A supplement of trace-minerals including copper, zinc, manganese, iodine (and selenium on coastal country) should be provided to breeding and growing horses. (Refer to Chapter 5, Section 5.X.X, page XX).

Under these conditions, sub-tropical and tropical pastures and forages are highly productive and a valuable component of horse feeding systems in the warm to hot northern regions.

KEYPOINT : Oxalate induced NSH in horses grazing productive sub-tropical and tropical grasses can be prevented by daily supplementation with a calcium source. A 2:1 mixture of lime : DCP at 40-60 g/day is adequate for adult horses.

7.5 Commercial "Sweet Feeds", Ready Mixed Feed

Over recent years, a large variety of ready-mixed and sweet feeds have become widely available in Australia. They are formulated to meet the requirements of many different classes of horses.
These include simple formulations of chaff and grain, multi-grain and oil seed mixes, often containing a full range of added minerals and vitamins at NRC (1989) recommended levels. Prepared and ready-mixed feeds are marketed in the form of dry stud mixes and muesli feeds, sweet feeds with molasses, as well as pelleted and extruded feeds. Many are scientifically formulated to meet the needs of specific classes of horses, while others are general feeds suitable for a range of horses.

Major Advantages

✓ Ready-mixed feeds are convenient and save time in preparation, requiring less storage space. Often only chaff is required to be blended into the feed to complete the meal.

✓ These feeds are often available in a large range from one manufacturer, which are formulated to suit the needs of a specific type of horse activity or purpose of use.

- ✓ **Many prepared feeds can be "mixed and matched" with other feeds for specific horses.**

- ✓ **Most ready-mixed feeds are scientifically formulated and free technical back-up is usually provided by the manufacturer or the distributing agent.**

- ✓ **Many are high quality feeds with a consistent formulation that ensures uniformity and acceptance by horses from batch to batch of feed.**

- ✓ The extruded (cooked) feeds, which are becoming more widely available, have an advantage in that the extrusion process improves starch and protein digestibility as compared to feeds formulated from raw and processed grains.

Major Disadvantages

- ✖ Some ready-mixed feeds are more expensive than home-mixed feeds, but provide convenience and ease of feeding.

- ✖ "Sweet" feeds containing molasses mixed into a raw (not cooked) grain base may be consumed too quickly by a hungry horse. This can lead to digestive disturbances, risk of starch overload into the hindgut and subsequent laminitis and founder. (Refer to Chapter 2, Section 2).

- ✖ Some of the basic prepared "stud" mixes are made to a budget price, with little consistency and quality control to ensure palatability and feeding value from batch to batch.

- ✖ Mixes containing crushed grains with added molasses as a "sweet" feed have an increased risk of losing the natural vitamin content during storage from manufacture to use. Added vitamins will deteriorate more rapidly during long term storage prior to sale or where damp mixes are used. (Refer to Chapter 6, Section 6.1, page XX).

✖ Sweet feeds containing molasses (sugars) and damp feed mixes may ferment during storage and spoil, developing toxic moulds which can result in colic and digestive upset. The palatability may also be reduced due to rancidity of added fat, particularly under hot, humid conditions.

✖ Many contain the full requirement levels of minerals and vitamins for horses. The addition of extra supplements is expensive and wasteful and may lead to an increased risk of toxicity from Vitamin A and Vitamin D if the total daily intake exceeds the maximum safe limit for a horse over a period of time. (Refer to Chapter 3, Section 3.7.1.1, page XX for maximum safe limits for these vitamins).

Selection and Quality

Prepared and ready-mixed feeds should be free from mould, fermenting odours, clumping and be consistent from batch to batch. Feeds containing a high content of molasses may clump under hot conditions if the molasses is not evenly distributed through the mix. Fat added to feed, or a high content of full fat oil seeds, may become rancid during storage, reducing palatability. Oxidised polyunsaturated fats may have an adverse affect on muscle membrane function and ultimate athletic performance.

7.6 Mineral Supplements

Feeds may contain a number of major minerals, electrolytes and trace elements in inadequate or imbalanced levels, creating a need for supplements to meet the elevated needs in growing horses, or to offset increased losses in exercising horses and lactating mares.

The most common mineral supplements that are required to make up shortfalls in the diets of horses include:

✓ Calcium and phosphorus in growing, exercising, heavily pregnant and lactating mares, and old horses.

✓ The electrolytes of sodium, potassium, chloride, as well as calcium and magnesium, in heavily sweating horses.

✓ Trace-minerals including iron in performance horses, as well as copper, zinc, manganese, iodine and selenium in growing horses and heavily pregnant and lactating mares.

KEYPOINT: These nutrients can be obtained from chemical sources as individual minerals or combinations, or from proprietary supplements that are formulated to provide a range of minerals and trace-minerals, often with added vitamins, or alternatively, as individual calcium, electrolyte or trace-mineral supplements.

The need for all types of supplements is fully reviewed in Chapter 6, including common sources of the major minerals required in the diet of horses.

7.7 Other Common Feed Supplements

Horse owners often add small amounts of other natural food supplements as sources of minerals and vitamins and to aid the appetite.

These include molasses, cod liver oil, apple cider, kelp and carrots.

7.7.1 Molasses (Cane Molasses)

Sugar cane molasses is widely added to rations as a sweetener to aid palatability, reduce dust and sifting out of fine particles. It usually is blended with an equal volume of warm water to make it thin enough to mix into feeds. Standard amounts are 1 cupful (250mL or 330g molasses) mixed into 1 cupful of hot water, which is then poured and mixed into approximately 20 litres (about a 5 gallon bucket full) of chaff and concentrate mix, usually as an evening feed.

Molasses contains energy in its sugar content, calcium and other trace-minerals, but not in sufficient amounts to be a useful source of these nutrients. Molasses should not be used to disguise or make poor quality feeds more palatable. It should not be mixed into grains, such as corn, as the rate of consumption of the sweetened grain mix will be increased, especially in a hungry horse. Unless the amount of sweetened grains is limited, rapid intake can result in overflow of raw starch into the large intestine and subsequent risk of laminitis and founder. (Refer to Chapter 2, Section X.X.X, page XX).

Moist, sweet feeds containing more than 2% added molasses should not be stored under hot humid conditions as the sugar content may ferment and encourage toxic mould growth, which if fed to a horse, may cause colic.

7.7.2 Cod Liver Oil

Cod liver oil is a traditional source of Vitamin A and D, which is less popular nowadays as many commercial supplements containing these essential vitamins are available. Horses will often not readily accept cod liver oil, so it may need to be introduced in a step-wise manner and mixed well into the bulk of feed. It must be sealed to prevent rancidity, and ideally refrigerated during storage. Each 20mL (1 metric tablespoon) of cod liver oil contains 5.6mg (18,666iu) Vitamin A and 48µg (1920iu) Vitamin D, which provides approx 124% of the Vitamin A and 90% of the Vitamin D needed each day in a resting 500kg horse. As both these vitamins can cause toxicity if over-supplemented, caution should be exercised when adding both cod liver oil and other supplements containing high levels of these vitamins to a horse's ration. (Refer to Chapter 3, Section 3.7.1.1, page XX).

7.7.3 Apple Cider Vinegar

Apple cider vinegar is a popular supplement to horse rations that is claimed to reduce the risk of "tying-up" in working horses, repel common flies and bot flies, reduce joint disease in growing horses, dapple the coat in show horses, and improve general health of all horses. These claims are entirely based on anecdotal evidence. Apple cider vinegar contains a range of electrolytes, including potassium, and very small amounts of trace-minerals including iron, copper, manganese and selenium. The most common supplementary rate is ¼-½ cup (60-125mL) daily to a 500kg horse.

7.7.4 Kelp (Seaweed)

Dried Kelp or seaweed in powdered form is a source of iodine and many other trace minerals. The iodine content is very variable and high iodine kelp can lead to excess iodine intake if given ad-lib or at supplementary rates exceeding 20g (1½ tablespoons) per day. The content of iodine is usually given on the container label as ppm of dried kelp. Iodine at 1ppm is equivalent to 1mg/kg of iodine. High iodine kelp can provide up to 24mg iodine per 15g (20mL tablespoon measure). Horses must not be fed any more than 5mg/100kg (25mg iodine daily for a 500kg horse) as a routine daily supplement.

Care should be taken to adhere to recommended supplementary rates. It is wise to check the iodine content with the manufacturer before adding kelp if other supplements such as iodised salt (contains 1.4mg/20g tablespoon), or ready-mixed feeds containing iodine are also provided on a daily basis. It is unwise to provide kelp or seaweed on a ad-lib basis, particularly if it is mixed into a sweetened feed that encourages free-choice consumption.

7.7.5 Carrots

Carrots, which should be chopped into maximum size sections of 5mm thick rings before feeding to reduce the risk of choke, are regarded as an appetiser for horses in hard work. Fresh carrots contain 90% moisture, approximately 20% of the energy of lucerne hay and are a source of β-carotene, the precursor of Vitamin A.

Each 500g of fresh carrots contain sufficient β-carotene to meet the daily Vitamin A needs of a 500kg resting horse. Larger amounts are required for working horses as Vitamin A needs are higher and conversion of β-carotene to Vitamin A may be reduced under stress.

7.8 Summary

Horses are able to adapt to a wide range of feeds that can be selected and blended to meet their specific growth, work and reproductive needs.

Feeds can be divided into energy concentrates, protein supplements, dry roughages and fibre sources, pastures and forages, common mineral supplements, appetisers and other common additives.

- ✓ Oats is still the most widely used grain for horses because of its good palatability, digestion of its starch, safety in feeding and ready availability.
- ✓ Fats, as vegetable oils, are becoming more widely used as energy boosters in hard working horses or under hot conditions.
- ✓ Soyabean meal has become the most widely used protein supplement because of its high quality protein with all essential amino acids for growth, with canola meal an economical and palatable alternative.

- ✓ Lucerne hay and chaff provides a suitable base for cereal grain rations in working horses and for pastured horses as a hay supplement when pasture value and availability declines.

- ✓ A large range of commercial ready-mixed and prepared feeds are now available, being convenient, time-saving and formulated to suit a wide range of horses and their activities.

Only good quality feeds should be selected for horses to ensure maximum nutritional benefit, palatability and freedom from digestive disturbances.

7.9 Suggested Reading

Frape,D Equine Nutrition and Feeding Edition 2, Blackwell Science Oxford UK 1997. p.96-156.

Kerrigan, RH Practical Horse Nutrition – Edition 3 Equine Educational Maitland NSW 1991 pp

Lewis, LD Equine Clinical Nutrition – Feeding and Care. Williams & Wilkins Baltimore USA 1995.p.90-136.

Nutrient Requirements of Horses Fifth Revised Edition, National Research Council (NRC) Washington DC, USA, 1989.pp

7.9.1 Suggested Reading - Pastures

Avery, Angela (1966). Pastures for Horses – a Winning Resource. A Manual for Horse Owners and Managers. Rural Industries Research and Development Corporation, P.O.Box 4776 Kingston, ACT, Publication R96/021.

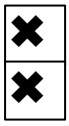
Foyel, J., (1992). Planning Considerations for Horse Keeping. Department of Primary Industries, South Australia. Occasional paper.

CHAPTER 8

COMMON ANTI-NUTRITIONAL FACTORS

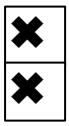
Most feeds provide a range of major nutrient classes to meet a horse's daily needs. However, some feeds contain natural compounds that, when consumed in sufficient quantities, can have an adverse effect on a horse's digestive and metabolic function. They are commonly referred to as "anti-nutritional" factors for this reason. These compounds are usually in low concentrations in the individual feed, but when given in amounts required to provide one or more major nutrients, they can reach potentially harmful concentrations in the diet. They can have a deleterious affect on **exercise capacity, appetite, soundness, health and well-being of a horse**.

The common anti-nutritional factors are distinct from chemical compounds in plants that result in direct poisoning, as discussed in Chapter 9.



Some feeds contain substances that increase the need for other nutrients in the diet.

A number of feeds contain nutrients that have inter-relationships with specific nutrients to assist their action, or to substitute for them in part, in metabolic processes.



Individual feeds may contain natural compounds that have well known anti-nutritional activity.

Contamination of feeds by moulds and development of rancidity during storage can cause toxic reactions and result in poor nutrient utilisation in horses consuming the feed.

KEYPOINT: The risk of toxicity or anti-nutritional effect is dependent on the **amount ingested, the duration of exposure** and **environmental factors related to the storage and processing of the feeds**, as well as the **conditions** under which the horse is kept. In certain cases, **seasonal influences** on the growth of the plant can increase the concentration of specific anti-nutritional factors.

Over recent years, some of the potentially toxic factors in common feeds have been eliminated by plant breeding to produce plants or seeds that are either free from or only contain low levels of an anti-nutritional factor. This helps to reduce the risk of toxicity when these plants or grains are fed at normal amounts to horses for extended periods.

8.1 Common Anti-Nutritional Factors

The major anti-nutritional factors that are contained in common grains, hays and other feeds are grouped in Sections 8.1.1 – 8.3.5, according to the types of chemicals or compounds that they can contain.

Recommendations on how to remove or lessen the risk of an adverse effect associated with a particular feed are included, as well as guidelines on how much of the feed can be consumed before it is likely to cause digestive or other potentially harmful problems.

KEYPOINT: The majority of commercially produced oil seed meals are heat treated or reach temperatures during processing and oil extraction which destroy or inactivate potentially harmful substances.

8.2 Grains/Whole Seeds

8.2.1. Phytates

Oats, Barley, Corn, Wheat, Triticale, Sorghum, Rice, Soyabeans, Brans, Pollards.

Anti-Nutritional Compound:

Phytates

Digestive Effect:

Grains commonly contain up to 1% phytates and 90% of their phosphorus content is in phytate form. Phytates are phosphorus – lecithin complexes that not only make phosphorus less available, but also bind up calcium, zinc and iron to prevent their absorption from the small intestine. Although phytates are destroyed by hindgut

fermentation, the released calcium and trace-minerals cannot be absorbed. High intakes of phytates can lead to weakened bones if calcium is not provided in adequate amounts to overcome the binding affect.

Management:
Add additional calcium, zinc or iron to a feed other than the one containing a high grain or bran content to offset the binding effect of the phytates.

8.2.2 Mycotoxins

Oats, Barley, Corn, Wheat, Triticale, Sorghum, Rice

Anti-Nutritional Compound
Mycotoxins (also cottonseed meal)

Digestive Effect
Moulds accumulate on grains before or after harvest or following processing to form aflatoxins. When the toxins are ingested in small amounts, they can cause neurological problems with brain damage, tremors, and eczema.

Management
Contamination with Mycotoxins is hard to identify in grain, and trace-back to the feed source is only possible after horses are affected and develop symptoms. Improving storage conditions of grains to discourage mould growth may reduce risk of toxicity.

8.2.3 Anti-proteases/Anti-trypsins

Rye grain, Triticale grain, Raw Horse beans, Raw Soyabeans, Raw Field beans, Rice germ, Peanuts

Anti-Nutritional Compound
Anti-proteases, Lecithins, trypsin and protease inhibitors. Anti-trypsin, protein or amino acid derivatives

Digestive Effect
Many of these seeds contain an anti-trypsin compound, which interferes with action of the important protein digestive enzyme, trypsin, leading to reduced digestive efficiency, diarrhoea and depressed growth in young animals. Lecithins are more damaging to the small intestine lining and reduce nutrient uptake. They also facilitate the absorption of toxic substances. High levels in the diet may deplete muscle glycogen, fat level and reduce performance.

Management
Controlled treating of grain by steam heating for 2 mins, or extrusion of rye and triticale at 135°C destroys the anti-trypsin chemicals as does pressing to extract oil from oilseeds to produce oilseed meal cake. Rice bran has only very low levels of rice germ and insignificant antiprotease content.

8.2.4 Condensed Tannins

Grain Sorghum, Lentils, Cotton Seed, Rape Seed, Field Peas and Beans

Anti-Nutritional Compounds
Condensed Tannins (polyphenol compounds)

Digestive Effect
Condensed tannins in these seeds and beans act to depress appetite, lower the digestibility of proteins and carbohydrates, and may retard trypsin activity in the small intestine. Soaking raw beans leaches out tannins into the feed mix, where they then react with proteins. The tannins in these raw grains can lower the protein and amino acid uptake in foals given rations containing raw meals or beans. Polyphenolic compounds may mimic oestrogen (female hormone) activity and affect fertility in mares.

Management
Extrusion at 135°C destroys the toxic tannin compound in feeds, but requires a prolonged time at lower cooking temperatures. Small amounts of up to 500g daily have no significant effect in adults, but may depress growth rates in foals and growing horses.

8.2.5 Oxalate Chemicals (Tropical Grasses)

Blue & Green Panic, Setaria, Buffalo Grass, fast growing Kikuyu (Also see Chapters 7 and 9). Common in central and northern Queensland.

Anti-Nutritional Compound
Oxalate Chemicals

Digestive Effect
Oxalate chemicals, which bind up calcium and zinc and limit phosphorus uptake, are released from the feed during digestion in the small intestine. Once in the large intestine, oxalates are destroyed by bacterial enzymes, releasing the calcium and zinc. These are not, however, subsequently absorbed from the hindgut, resulting in a relative deficiency of these important minerals.

Management
Avoid high oxalate pastures where possible to prevent the onset of Nutritional Secondary Hyperparathyroidism (NSH) that can result in bone weakness. (See Glossary term). The affect of reducing calcium uptake from the small intestine lowers blood calcium levels, the parathyroid hormone is activated to “mine” or resorb from bone stores to maintain blood levels. If there is no alternative pasture available, supplements of calcium and phosphorus must be provided. (Refer to Chapter 7, Section 7.4.7, page XX). Supplementation with zinc and a full range of trace-minerals should be considered in growing horses, heavily pregnant and lactating mares that are grazing on pastures containing tropical grasses.

Protein Meals

8.3.1 Linseed Meal

Anti-Nutritional Compound
Linatine, Linamarin

Digestive Effect
Linseed meal has a high natural soluble fibre mucilage content that has a beneficial natural laxative effect. The linatine and linamarin compounds in linseed meal that has not been heat-treated or friction heated when the oil is extracted can release cyanide compounds, but the small amounts are not usually harmful to horse health.

Management
The traditional amounts of 300-400grams (1½-2 cups) of heat treated linseed meal have a low risk of anti-nutritional effects. The relatively low lysine content of linseed meal as compared to soyabean or canola meals, however, lowers the protein quality when linseed is fed as a protein source to young horses.

8.3.2 Peanut Meal

Anti-Nutritional Compound
Aflatoxins

Digestive Effect
A potent aflatoxin compound produced by the soil fungus Aspergillus flavus can contaminate cereals, peanuts and peanut hay lying on the ground. Horses and ponies are very susceptible to the toxin, even when ingested in small amounts, at levels lower than 1mg/kg of contaminated feed. The toxin can cause severe bloody diarrhoea, liver and brain lesions. It has also caused death in ponies within 3-4 weeks when they were fed feed containing low levels of 0.15mg aflatoxin /kg bwt in their daily feed.

Management
Ensure peanut meal is fresh and avoid damp or mouldy samples. Do not store damp feeds containing peanut meal.

8.3.3 Cottonseed Meal

Anti-Nutritional Compound
Gossypol, Cyclopropenoid fatty acids

Digestive Effect
Gossypol is a pigment that is present in free and complexed forms, which combines in part with cottonseed protein and depresses the appetite, protein digestion and amino acid utilisation. Large intakes can result in death due to circulatory failure. Gossypol reacts with iron causing it to precipitate in the intestine, making it unavailable. Over a prolonged period, this binding effect can lead to iron deficiency anaemia.

Management
New strains of cottonseed meal have low gossypol pigments and less risk of toxicity. Iron supplementation can reduce their harmful effects by providing extra for uptake, but it does not protect against the other harmful digestive effects.

8.3.4 Lupin Seed Meal

Anti-Nutritional Compound
Unidentified growth retarding factor(s)

Digestive Effect
Black and coloured lupin seeds contain compounds that reduce palatability and cause digestive upset in horses, and may retard growth in young horses.

Management
The new varieties of white lupin seeds contain low levels of anti-nutritional factors and are a useful protein and energy source for working horses. Heat treating the meal, after processing of the seed to destroy the growth retarding factors, makes it suitable for growing horses as a protein source, but it is lower in lysine than soyabean or canola meal.

8.3.5 Rapeseed Meal

Anti-Nutritional Compound
Erucic acid and glucosinolates, sinapine (bitter compound)

Digestive Effect
The meal and seeds contain erucic acid and glucosinolates. Glucosinolates and the releasing enzyme, myrosinase, are separated in the seeds, but damaged seeds allow reaction and release of toxic goitrins (goitre causing compounds) that affect iodine uptake. Other anti-nutritional factors include bitter compounds that depress appetite and growth in young horses.

Management
Canola is a special genetically modified form of rapeseed (called 'double low' because it has low levels of both factors) which contains low levels of anti-nutritional factors and bitter compounds. It is suitable as a protein supplement for horses, including young growing horses.

8.3.6 Copra Meal (Coconut meal)

Anti-Nutritional Compound
Aflatoxins, Anti-protein digestion factors

Digestive Effect
Copra processed under humid conditions may develop moulds that release potent aflatoxins that can affect the nervous system. Copra meal may also contain compounds that reduce the digestibility of its own amino acid deficient protein.

Management
Careful selection of coconuts, quality control during processing and storage under dry conditions reduce the risk of contamination. Some sources of copra meal are tested and certified by the manufacturer to be free of aflatoxin contamination.

8.4 Grasses/Pasture Plants

8.4.1 Cabbages, Rape (Brassica forages)

Anti-Nutritional Compound
Goitrogens, Goitrin compounds

Digestive Effect
Goitrins (goitre causing compounds) are freed by enzymes present in the plant during digestion in the small intestine. These reduce iodine uptake and activity of the thyroid gland, which is not combated by iodine supplements, except in young horses. Brassica forages also contain a compound that can cause anaemia.

Management
Heat treatment by cooking or extruding cabbage destroys goitrins.
Adding extra iodine does not counteract the problem in adult horses and is only effective in young horses

8.4.2 Sorghum Leaves, Linseed Seed

Anti-Nutritional Compound
Cyanogenic Glycosides, Hydrocyanic acid (HCN)

Digestive Effect
Small amounts of dry feed have little adverse effect by depressing enzyme activity, but cold soaking linseed seed releases HCN, which results in respiratory failure. Thiosulphate compounds present in feeds can react with HCN, causing enlargement of the thyroid gland.

Management
Feed dry feed in small amounts – do not soak unless boiled to destroy toxic compound. Amounts over 300g linseed seed should be **added to boiling water** to rupture the seed coat and boiled for at least 10 mins to destroy the enzymes that releases HCN.

8.4.3 Lush Fodder, Grass Crops

Anti-Nutritional Compound
Nitrate toxicity, Nitrite poisoning

Digestive Effect

Rapid regrowth of pasture under good growing conditions of temperature after break of a drought, or after application of nitrogenous fertilisers, produces high nitrate levels in plants. The nitrogenous fertilisers may also be leached into water supplies. Nitrates can be converted to nitrite compounds after herbicide application or hay making, as the plant wilts. Nitrites convert haemoglobin to methaemoglobin, which acts to block oxygen uptake, reduce stamina and may cause diarrhoea and death in horses ingesting large amounts.

Management

It is best to limit grazing time on lush fodder crops, when an increase in toxicity is likely to occur after soaking rains. Grazing on wilted plants, when hay has been cut to cure, should also be avoided. Provide hay to hungry horses to fill them up, before turning them out to graze. Restrict grazing to 1-2 hours relative to the grazing habit and appetite of the individual horse. Restricted grazing will also limit the risk of hindgut overload of starch and onset of laminitis (founder). Much of the regrowth pasture will be trampled by horses as they feed, reducing its value, but if it becomes wilted, it may increase the risk of toxicity.

8.4.5 Lucerne, White Clover, Red Clover, Alsike Clover, Sweet Clover, Subclovers, Crown Vetch

Anti-Nutritional Compound

Legume Forage	Anti-Nutritional Compounds
Lucerne (Medicago sativa)	Saponins, Phytoestrogens, Anti-vitamin factor, Photosensitisation
White Clover (Trifolium repens)	Cyanogens, Phytoestrogens
Red Clover (Trifolium pratense)	Slaframine, Phytoestrogens
Alsike Clover (Trofolium hybridum)	Photosensitising agents
Sweet Clover (Melilotus spp.)	Coumarin
Sub Clover (Trifolium subterranean)	Phytoestrogens
Crown Vetch	B-Nitropropalol glycosides

TABLE 8.1
Anti-Nutritional Factors present in Green Legume Forages

Digestive Effects

- Saponins are glycosides that produce a frothy, soap-like compound when mixed with water. They do not affect horses, but are a problem in cattle, causing 'bloat'.
- Phytoestrogens are natural oestrogen (female) hormones in plants that can mimic oestrogen activity in horses and are thought to cause infertility in mares.
- Cyanogens release hydrogen cyanide that causes diarrhoea and affects oxygen uptake.
- Photosensitising agents increase risk of sensitivity to sunlight on non-pigmented skin areas on the nose and around the eyes, resulting in sunburn like lesions.
- Coumarins are anti-clotting compounds that can increase the risk of bleeding from gut and wounds.

Management

Phytoestrogens are associated with infertility in mares but it is not well documented. Photosensitising effects are a problem in grazing horses, so access to plants should be limited in horses with white skin areas to early morning or evening. The other compounds are potentially toxic, but on a mixed grass and legume pasture, risk of adverse nutritional effects is minimised. Fresh green lucerne contains both Vitamin E and a Vitamin E antagonist that reduces its availability and uptake on digestion.

8.4 Summary

A number of horse feeds contain anti-nutritional factors that can adversely affect digestive function, increase the requirement for nutrients and reduce uptake of other compounds. The most potent are aflatoxins from soil moulds, which can cause nervous signs and toxicity in very low concentrations.

- ✓ Many of the anti-nutritional factors are destroyed by heating during processing.
- ✓ Some of the new plant varieties of canola, lupins and cottonseed have been genetically modified to minimise potentially harmful factors.
- ✓ Care should be taken to avoid mouldy feeds.
- ✓ To minimise risk of poor digestion or other side-effects, ensure that oil seed meals have been heated, toasted or extruded prior to feeding.
- ✓ Individual horses have been reported to be allergic to certain feeds, developing localised skin swellings. Skin testing with extracts from the feeds used can help to determine specific allergic compounds in the feed.

CHAPTER 9

PLANTS THAT ARE POISONOUS OR HAZARDOUS TO HORSES

Plants and plant products form the dietary basis for every horse. They may be consumed directly as leaf, stem or seeds by a grazing horse, or as conserved plant products including hay, cubes, pellets, grains or grain mixes. Plants also yield derivatives such as oils, protein meals or vitamins, which are fed as dietary supplements to meet the nutritional requirements of a horse. (Refer to Chapter 7 for a review of common feeds).

Many plants, however, are hazardous to horses by either interfering with the normal metabolism or organ function of the horse when eaten, or by physical damage to the horses mouth or digestive system whilst being consumed.

KEYPOINT: Careful attention must be paid to identification of all plant species accessible to the horse and to the removal of all plants or plant material likely to cause poisoning or injury. If unable to remove the plants, then remove the horse or exclude it from access to the pasture.

9.1 Plant Poisoning

9.1.1 The Grazing Horse

Many factors contribute to the danger of plant poisoning in grazing horses, including:

- ✓ The species of plant – some are poisonous at all times, others only at certain times of the year.
- ✓ The part or parts of the poisonous plant eaten by the horse and, in particular, the quantity consumed.
- ✓ The general condition of the horse and, in particular, whether it is hungry when exposed to the poisonous plant or plant material.
- ✓ The availability of safe alternative feeds.
- ✓ **The general level of activity of the horse – idle horses in retirement or at rest will often eat frequently or continually, because of boredom.**

Individually, horses may vary considerably in their susceptibility to plant poisoning, depending on their general state of health, condition and previous exposure to the hazardous plant.

- ✓ Horses new to a region may become exposed to different plant species than they are accustomed to and have little tolerance of any poisonous factor in new plants they eat. Horses native to the region may in contrast have developed some tolerance as a result of eating a low intake of the plant over long periods. Avoidance of hazardous plants by mares may condition their foals to recognise and leave them alone.

- ✓ Hungry horses, exposed to poisonous plants with little alternative feed available, are especially at risk. Garden plants pose a particular danger to horses as many have been shown to be highly toxic. Some shade trees may also be particularly dangerous, with the common Oleander tree, for example, blamed for many livestock deaths. Some cultivated garden plants such as Green Cestrum that spread into pastures are very palatable and attractive to livestock while being extremely poisonous and are the proven cause of many losses.

KEYPOINT: Horse owners should familiarise themselves thoroughly with poisonous or hazardous plants in their region. Excellent, well illustrated books are available at relatively low cost and are invaluable for this purpose. Contact with the regional Agronomist or Weeds Officer can alert owners to local plant risks.

Regular paddock inspections are a must.

Horses are by nature very selective grazers and can cause severe rundown of pastures when grazed continually on the same areas. Desirable species are heavily suppressed while unwanted species remain untouched, resulting in a shift from a nutritious, well-balanced pasture to a weed infested, patchy state. These rundown horse pastures are dominated by irregular patterns of weed infested, rank growth areas (“roughs”), where dung

and urine are deposited and closely cropped, short grass "lawns". Poisonous weed invasion into the high fertility rough areas can result in considerable risk to the grazing horse.

In some species, all parts of the plant are poisonous to horses, while in others only part of the plant may be hazardous. The combination of selective grazing by the horse and a preference for particular plant parts, particularly seed heads, could place the horse at risk from some plants. Horses are well known for spreading weeds by this habit and research has demonstrated that many weed seeds can pass through the digestive system of the horse without affecting their subsequent germination ability.

The seed heads of some plants, which are otherwise valuable pasture species, can become poisonous to horses when infected by fungi. The sticky seed heads of ***ergot*** infected Paspalum in late summer are a well-known example of this problem. In other species, the seeds contain toxic substances, which are very poisonous if eaten.

Periods of active flowering and seed growth can thus be times demanding great caution by horse owners.

Plant composition changes with the seasons and growth stage through the year and the risk of poisoning may also vary relative to changes in plants as they grow and mature. Plants, which may normally be safely eaten by the horse, may be dangerous at particular stages. Members of the sorghum family, such as Sudan Grass, accumulate prussic acid (cyanide) in their leaves during the young growth stages and horses must be excluded from the high risk pasture at those times. Later growth, in contrast, is considered safe to graze. Sudden growth flushes after rain, especially after a dry period or drought, may result in considerable risk as levels of toxic factors, such as nitrate or prussic acid may accumulate in plant tissues. Similar problems may arise with young active regrowth after cutting for hay, slashing or heavy grazing.

9.1.2 The Hand Fed or Supplementary Fed Horse

With few exceptions in Australia, breeding and sporting horses, particularly those in full work, receive the great majority of their dietary needs through hand feeding rather than from grazing. Many horses at pasture receive supplementary feeds to balance their diet, but as outlined in Chapter 7, Section 7.4, page XX, good quality pasture can usually meet all of the nutritional needs of the grazing horse. In all cases of hand feeding, particular care is required to ensure that all ingredients are free from contaminants such as weed seeds and toxic moulds.

KEYPOINT: Hand feeding does not safeguard against plant poisoning unless all feed ingredients are free of toxic weed seeds and moulds. Feedstuffs, which have been wet or stored in hot, humid conditions, should be avoided. ***Always*** check hay for mould before feeding – if in doubt, don't use it.

Both grains and conserved plant products (hay, pellets, cubes, and meals) will deteriorate quickly if not harvested, processed and stored at the correct moisture levels. All will rapidly spoil if moisture is above critical levels and the resultant moulds which commonly develop, have been shown to be highly toxic to pigs and horses in particular. Poorly cured hay can develop considerable mould inside the bale, even though the external appearance of the bale is good. Any feedstuffs, which show evidence of mould, moisture or heating should be rejected. Research in Australia and overseas has identified many toxic fungal compounds in mouldy grains, hay, silage and lucerne cubes.

Grains and feedstuffs may also be contaminated by poisonous weed seeds. The contamination of oats and corn with the seeds of the common thornapple (*Datura stramonium*) has been identified as the cause of poisoning in a number of cases. Strict maximum limits on the number of *Datura* seeds in grain samples apply in feed and export industry standards. Some plants and seeds contain compounds that have stimulant, depressant or drug action. Contamination of grain and chaff samples by the seeds of the opium poppy (*Papaver somniferum*) have resulted in blood irregularities leading to inquiries in the racing industry.

9.2 Types of Plant Poisoning

Much of the material in the remainder of this chapter has been drawn from the excellent and comprehensive books published by E.J.McBarron in 1977 and 1983, and by S.L.Everist in 1981. Full details are outlined in the list of suggested reading and references. Subsequent, comprehensive reviews have been sadly lacking in the Australian literature. Poisonous plants were described by McBarron in 1977 as follows :
" ..a plant is poisonous when either by consumption or contact with an animal by the plant or a natural product of the plant, it evokes a physiological response which prevents, hinders, arrests or destroys the natural processes of the animal, giving rise to distress, pathological manifestations or death of the animal".

A large number of toxic substances have been isolated from plants, although the number of plant species which have been directly implicated as poisonous to horses is small relative to the total number in the plant kingdom. In addition, many species of plants, which have been recorded as poisonous to sheep, cattle, pigs and poultry, contain the same toxic factors as other plants, which have been shown to poison horses, but there is no record of

horses being poisoned by them. In these cases, it is reasonable to assume that if horses did eat them they would be affected. The fact that there is limited or no recorded evidence of direct poisoning by a particular plant species does not mean that it is not hazardous to horses.

Mist flower, for instance, is fairly common in eastern Australia and is closely related to Crofton weed, which causes severe and often fatal lung damage and respiratory disease in horses. Although there are few Australian records of Mist flower poisoning horses, it contains the same alkaloids as Crofton weed, has been demonstrated to cause lung lesions experimentally and it must therefore be considered as dangerous to horses.

A closely related species, white snakeweed, has been positively identified as the cause of a number of horse losses in the USA. Similarly, St Barnaby's thistle has been shown to be poisonous to horses, yet there is no Australian record of poisoning by other closely related species in the Centaurea genus. Most have been shown to contain the same neurotoxins and must be considered as potentially dangerous to horses.

In all cases of suspected poisoning by plants, every attempt should be made to identify all plants accessible to the affected horse. Where none of them have been reported as poisonous to horses, but related species may well have been, this may provide a valuable guide for veterinary treatment, particularly in emergencies.

9.3 Diagnosis of Plant Poisoning

Diagnosis often relies on circumstantial evidence, which includes:

- ✓ That the horse had access to the suspected plant.
- ✓ That the plant was present in sufficient quantity to cause the effects observed.
- ✓ That the suspect plant had been grazed.
- ✓ That the symptoms were consistent with the known toxic effects of that plant, or of a related species.

9.4 Symptoms of Plant Poisoning

The symptoms of plant poisoning may be grouped into several categories, which can aid in diagnosis of the possible cause. The major categories, together with the plant species reported to cause them in horses, are outlined in Table 9.1. Both general and specific symptom categories are those described by McBarron, (1983). Scientific names for each species are included to assist in identification, as local common names often vary between regions or states.

General Symptoms	Specific Symptoms	Plant Species	Common Name
Photosensitisation and sunburn	Sunburn and swelling of unpigmented areas of skin, usually on the nose, lips and around eyes.	*Heliotropium europeaum* *Panicum sp* *Echium plantagineum* *Hypericum perforatum* var *angustifolium* *Senecio lautus* *S.madagascarensis*	Common heliotrope Panic grass Patersons curse Salvation Jane St John's Wort Fire weed
Sudden Onset - Illness or Death	• Hungry horses feeding greedily • prussic acid plants	*Sorghum sudanense* *Sorghum spp* *Scleroblitum atriplicinum* *Eremophila maculata* *Lotus cruentus*	Sudan grass Sorghums Lambs tongue Native fuchsia Red-flower lotus
	• nitrate poison plants	*Polygonum aviculare* *Silybum marianum* *Arctotheca calendula*	Wireweed Variegated thistle Capeweed

	• After access to garden wastes and trimmings	*Cestrum parqui*	Green cestrum
		Cestrum auranticum	Orange flowered cestrum
		Nerium oleander	Oleander
		Solanum tuberosum	Potato
		Persea americana	Avocado
		Taxus baccata	Yew
		Caesalpinia pulcherrima	Ponciana
	• Staggering, collapse blindness, weakness in hind limbs	*Cucumis myriocarpus*	Paddy melon
		Phalaris aquatica	Phalaris
		Lolium perenne	Perennial ryegrass
		Craspedia chrysantha	Round billy button
		Stachys arvensis	Stagger weed
		Vinca major	Blue periwinkle
		Malva parviflora	Small flowered mallow
		Agrostis avenacea	Blown grass
	• Salivation, stumbling, trembling, paralysis heart and breathing failure	*Vinca major*	Blue periwinkle
		Cestrum parqui	Green cestrum
		Conium maculatum	Hemlock
		Nerium oleander	Oleander
		Cestrum auranticum	Orange flowered cestrum
		Allium spp	Wild onion
		Trachyandra divaricata	Branched onion weed
	• Diarrhoea, scouring	*Vinca major*	Blue periwinkle
		Ranunculus spp	Buttercups
		Ricinus communis	Castor oil plant (seeds)
		Adonis microcarpa	Pheasants eye
		Pimelea pauciflora	Poison pimelea
		Pimelea decora	Pimelea poppy
		Pimelea spp	Flaxweed
		Craspedia chrysantha	Round billy button
	• Dark or red urine	*Pteridium esculentum*	Bracken fern
		Ranunculus spp	Buttercups
	• Excitability, frenzy	*Cestrum parqui*	Green cestrum
Chronic Onset - illness, poor Thrift, intermittent Deaths, solitary habits, addiction	• Poor thrift due to liver poisons	*Senecio jacobea*	Ragwort
		Senecio cunninghamii	Groundsel
		Senecio linearifolius	Fireweed (Tas.)
		Senecio lautus	Fireweed
		Senecio madagascarensis	Fireweed
		Crotolaria aridicola	Chillagoe horse poison
		Crotolaria crispata	Crotolaria
		Heliotropium europaeum	*Common heliotrope*
		Heliotropium supinum	Creeping heliotrope
		Echium plantagineum	Paterson's curse
		Convulvulus arvensis	Salvation Jane
		Trifolium hybridum	Bindweed
		Cynoglossum officinale	Alsike clover
	• Addiction, staggers, paralysis, stringhalt 'star gazing', ataxia constant chewing, 'wobbling', muscle tremors, limb stiffness	*Pteridium aquilinum*	Hounds tongue
		Macrozamia spp.	
		Hypochaeris radicata	Bracken fern
		Swainsonia spp	Burrawangs
		Marsilea drummondii	Catsear, flatweed
		Centaurea solstitialis	Darling peas

	• Lameness	*Centaurea spp*	Nardoo
		Claviceps paspali	St Barnaby's thistle
			Knapweeds
		Stypandra imbricata	Paspalum ergot
	• Laminitis, hair loss	*Neptunia amplexicaulis*	Blind grass
	• Collapse, sudden death after stress, staggers	*Ricinus communis*	Selenium weed
	• Bent legs, skeletal deformities, bone fragility	*Sorghum spp*	Castor oil plant (leaves)
			Sorghums and
		Macrozamia spp	Sorghum hybrids
		Ricinus communis	
	• Diarrhoea, scouring	*Duboisia myoporoides*	Burrawangs
		Cucumis myriocarpus	Castor oil plant (seed)
			Corkwood
		Duboisia myoporoides	Paddy melon
	• Blindness, vision disturbance	*Marsilea drummondii*	
		Cucumis myriocarpus	Corkwood
		Craspedia chrysantha	Nardoo
		Datura stramonium	Paddy melon
			Round billy button
		Eupatorium adenophorum	Thornapple
	• Lung congestion, Fluid accumulation In chest, chronic Panting		Crofton Weed
			Sticky Agrimony,
		Eupatorium riparium	White Top, Cat Weed
			Mist Flower,
			Creeping Crofton Weed

Table 9.1
Symptoms of plant poisoning and the identified plant causes in Australia.

The species listed in Table 9.1 are those which have been directly implicated in the poisoning of horses by consumption of the plant or plant parts. In these cases, poisoning is caused by natural components of the plant, or of its parts such as the seeds. Problems may also occur only under particular seasonal circumstances. In some cases, as in the suspected cases of nitrate poisoning by Capeweed and variegated thistle, high nitrate levels accumulate in the plant, particularly during the burst of rapid growth which follows rainfall after a dry period of some months. Nitrate accumulation in these weed species can be very high when a prolonged dry period is relieved by rain, and heavy losses of sheep and to a lesser extent cattle, have been recorded when these plants have been grazed by hungry stock.

Losses from nitrate poisoning are not confined to these weed species, but have occurred on improved pasture grasses such as ryegrass and fescue, as well as on forage crops of oats when high rates of nitrogen fertiliser have been applied to promote productivity. Young growth in these cases often contains dangerously high levels of nitrate and grazing stock should be excluded for 4 to 8 weeks, until the concentration of nitrate in plant tissue has dropped to a safe level.

9.5 Related Problems

In contrast to the above, where the toxic factor was a natural component of the plant, (whether induced by specific seasonal conditions or not) other cases of poisoning occur on grazed pastures as a result of infection of the plant, usually by a fungus. The infecting fungus develops inside the plant and is called an endophyte.

9.5.1 Endophyte Poisoning

Endophyte poisoning is a major problem in New Zealand, where pastures provide the bulk of the diet of horses in the stud industry. The industry is thus vulnerable to seasonal variation in pasture supply and quality, pasture decline and weed invasion, and pasture related

toxicities induced by endophytes. Under conditions of limited pasture availability, horses may graze more stem tissue than usual, particularly near the stem bases where the highest concentrations of endophytes are found.
Bacterial endophytes have also been reported in Australia in infected seed heads of annual (Wimmera) ryegrass, a naturalised species, which was widely sown in southern Australia as a pasture grass in the period 1940 to 1960. Losses of sheep have been reported even with hay produced from annual ryegrass, where infected seed heads are present, and it must be considered a risk to horses. A prolific seeder, annual ryegrass is now regarded as a serious weed of cropland. Poisoning of horses grazing ergot infected paspalum has also been recorded in Australia.

Pasture related problems in horses caused by endophytes are listed in Table 7.2. hile problems with horses grazing tall fescue are reported only for the USA, the species is grown as a pasture in Australia and problems of severe lameness in cattle have been confirmed in Victoria. Similarly, perennial ryegrass is a very important pasture grass in temperate Australia and many Australian cases of ryegrass staggers have been reported in sheep, but not horses. New Zealand experience with horses indicates that the problem could well occur in Australia as well.

Problem	Plant Species and Part	Symptoms	Season
Fescue toxicosis (USA)	**Tall Fescue** ***Festuca arundinacea*** (Seed heads)	**Reproductive disruption, weak foals, prolonged pregnancy, difficult foaling and loss of milk in mares**	**Late spring/ summer/ autumn**
Paspalum staggers (Aust., NZ)	**Paspalum** ***Paspalum dilatatum*** (Seed heads)	**Staggers, convulsions, excitability, elevated heart rate, panic**	**Late summer/ early autumn**
Ryegrass staggers (NZ)	**Perennial ryegrass** Lolium perenne (Stems)	**Staggers, collapse**	**Late summer/** early autumn (NZ)
Ryegrass staggers (Aust)	**Annual or Wimmera ryegrass** Lolium rigidum (Seed heads – grazed and hay)	**Staggers, collapse, convulsions, death**	**Late spring/ early summer**

Table 9.2.
Major Reported Endophyte Problems in Horses.

9.5.2 Mineral Element Imbalances

Plant poisoning can occur as a result of accumulation of potentially toxic minerals or, alternatively ingestion of a plant may induce a deficiency of a mineral, trace-mineral or a vitamin in the diet of a grazing horse.

9.5.2.1 Toxicities

A number of nutritional disorders and even toxicities can occur in grazing horses as a result of abnormally high levels of specific mineral elements in some plant species.

This can occur where:

- Certain plant species may preferentially accumulate the mineral element from soil, even though soil levels of the element may be within the normal range
- High soil concentrations of the element resulting from excessive fertiliser application, or other soil factors (eg high soil acidity) increase the natural availability of the element beyond the normal range
- Dumping of waste materials high in particular mineral elements has occurred in the past.

Consumption of plant material high in one element could result directly in poisoning by the element, or in some cases, cause a reduction in the availability of other elements in the diet, or affect the normal metabolic processes of the animal.

- High levels of zinc in the diet, for instance, have been shown to cause skeletal abnormalities in foals consistent with copper deficiency. In these cases, high dietary zinc was shown to be antagonistic to normal copper metabolism in the animals.
- Toxicities of many elements, including selenium, potassium, lead, molybdenum and zinc have been reported in grazing horses in Australia.

  Toxicity may also result from preferential accumulation of particular elements by plants, particularly on soils containing higher than normal levels of the element.
- Selenium weed *(Neptunia amplexicaulis)* accumulates selenium on seleniferous (naturally high in selenium) soils and has caused severe lameness and hair shedding in horses. The plant is only eaten by horses when there is little alternative forage available. Ragwort (*Senecio jacobaea*) may similarly cause selenium toxicity when eaten by horses.

9.5.2.2 Deficiencies

Mineral element deficiencies may occur whenever the diet contains insufficient quantity of one or more essential minerals or trace-minerals required for normal metabolic activity of the horse. They may also arise when higher than normal levels of an antagonistic element or substance in the diet causes in an induced deficiency of another element, or in disruption of normal metabolism.

- Oxalate is a substance present in many plants, including sown tropical grass pasture species such as kikuyu (*Pennisetum clandestinum*), buffel grass (*Cenchrus ciliaris*), green panic (*Panicum maximum*), para grass (*Brachiaria mutica*), elephant grass (*Pennisetum purpureum*) and Setaria (*Setaria anceps*).

Kikuyu, while a tropical species, is widespread throughout the higher rainfall areas of temperate Australia, so the occasional oxalate problem from this species is not limited to tropical regions. When ingested, the oxalates released during digestion in the small intestine bind up calcium and zinc and interfere with phosphorus uptake. The action of the parathyroid hormone resorbs calcium from bone stores, which can lead to decalcification of the skeleton. For more information on mineral elements refer to Chapter 3.

- Bracken fern (*Pteridium esculenturn*) can lead to an induced deficiency of thiamine (Vitamin B1) during a dry season, when ingested by horses. Horses most at risk are those that are seeking a green pick or horses new to heavily infested pasture. Horses will also consume the developing succulent fronds after the break of the season or eat regrowth after heavy frosts or ploughing.

  Bracken fern leaves and especially new succulent fronds, contain a thiaminase enzyme that destroys thiamine synthesized in the hindgut. Although amounts of up to 15kg daily of green young fronds have to be consumed for up to a month or more, nervous signs due to Vitamin B1 deficiency can develop, leading to initial weight loss, incoordination, staggering and trembling and collapse.

  Removal of affected horses from the pasture and treatment with courses of Vitamin B1 will enable horses to recover with no lasting affects in most cases.

Note: Bracken fern poisoning is more common in cattle, which develop symptoms of jaundice, anaemia, liver disease, nasal discharge, scouring, red urine and wasting. In sheep, it can lead to blindness.

9.5.3 Founder (Laminitis)

Laminitis, leading to the crippling condition of "founder", particularly in ponies, often results from grazing lush pastures during a spring growth flush. It may also occur when horses experience a sudden change of diet, particularly when the new diet comprises pasture with a high legume content. In such cases, access to lush pasture should be limited to short periods (one hour per day) of grazing initially, followed by a gradual increase, but only if the horse requires it. The condition of the horse is the best guide to follow in this case. Most cases of

founder in horses on pasture could have been prevented by regular observation and sensible management. (Refer also to Chapter 5, Section 5.1.1.1, page XX and Glossary term).

9.5.4 Colic

Most of the comments made above for founder apply equally to colic in horses on pasture. Over eating and sudden changes of diet are often major contributors to the onset of colic and should be avoided by sensible management.

9.6 Physical Injury

Physical injury by plants is largely confined to the grazing horse. Injury often arises from dry seed head parts in mature grasses.

✖ The awns on grass seeds may be long, sharp and abrasive and can injure the eyes and particularly the mouth, where they may irritate or even pierce mouth, cheek and throat tissue, causing ulceration and abscesses. Hay produced from overly mature grasses may also cause this problem and should be avoided.

✖ Spiny burrs from thistles and burr species such as spiny burr grass (*Cenchrus pauciflorus*) have also been reported as causing mechanical injury to the eyes and mouths of grazing horses.

✖ Physical injury may also result from consumption of fibrous plant material, which may form balls (phytobezoars) that impact in and block the stomach or large intestine.

✖ Species, which have been reported as causing fatal obstructions in horses are shown in Table 9.3. Many other species have also been suspected of causing digestive and bowel obstructions and the species listed in Table 9.3 are not an exhaustive list but rather those which have been positively identified as the cause of fatal obstructions.

Plant Species	Plant Part	Obstruction Location
Wild Oats *Avena fatua*	Straw	Stomach
Oats *Avena sativa*	Straw	Stomach
Shepherd's Purse Capsella bursa-pastoris	Fibrous stems	Bowel
Mallow Malva spicatum	Fibrous stems	Caecum
Rattlepod Crotolaria dissitiflora	Fibrous stems	Caecum
Spiny burr grass Cenchrus pauciflorus	Spiny burr masses	Mouth, throat and digestive tract
Haresfoot clover Trifolium arvense	Flower heads	Stomach
Onion grass Romulea longifolia	Fibrous stems	Large intestine

Table 9.3.
Plant species reported as responsible for fatal phytobezoars in horses in Australia.

9.7 Summary

Sound management to prevent or minimise poisoning or other undesirable plant effects on horses can be achieved by a combination of the following:

✓ Becoming familiar with local plant species and their potential effects on horses, by
1. Purchasing a good, well illustrated book with which to identify weeds or poisonous plants (see suggested reading list)
2. Contacting the local Agronomist for advice and identification of all plants in horse paddocks
3. Noting seasonal growth patterns and in particular, danger periods such as seeding in some species

✓ Preventing access to garden plants and trees at all times and ***never*** feed horses with plant trimmings and wastes from the garden.

✓ Erection of protective fencing around paddock shade trees to prevent horses from eating the leaves or bark with the risk of poisoning, or damaging the tree.

- [x] Ensuring all hand fed plant or grain feedstuffs are clean, dry and free of contaminants such as moulds, weed seeds, fibrous dry stems and insect pests.

- [x] Ensuring that adequate safe supplementary feed is provided or is available to horses grazing weed infested pastures or when confined to holding areas.

- [x] Eliminating where possible all undesirable plant species from horse yards and paddocks.

- [x] Avoiding introduction of hungry horses to new areas, particularly where potentially harmful plant species are present.

- [x] Avoiding sudden diet changes, particularly a change to lush, legume dominated pastures, or allowing hungry horses to graze on dry stemmy indigestible plants.

CHAPTER 10

NUTRIENT COMPOSITION OF FEEDS USED FOR HORSES IN AUSTRALIA

Each feed has its own characteristic nutrient content. The type and variety of grain, hay or pasture, soil fertility and trace-element content, rainfall and seasonal growing conditions can influence the nutrient profile and availability. The stage of maturity at harvest, duration and conditions of storage and final processing prior to feeding also affect its nutrient balance as well as each feed's final moisture level at feeding.

Until recently, nutrient values obtained from analysis of common feeds in North America and the United Kingdom have been used as a guide for feeding values for horses in Australia. However, the plant varieties and growing conditions of the Northern Hemisphere are different to those in Australia. Soil deficiencies of phosphorus, nitrogen and trace-element, combined with variable rainfall, can markedly influence the nutrient content of Australian feeds.

KEYPOINT: The availability and utilisation of nutrients in a particular feed is directly related to the quality of the individual feed, which can vary due to the variety, locality and growing conditions, as well as harvest time and storage conditions.

A general overview of the range of grains, meals roughages and pastures that are commonly used for feeding horses in Australia is provided in Chapter 7.

10.1 Feed Analysis

Limited analysis of common feeds to determine the digestible energy content has been carried out specifically for horses. The affect of locality and seasonal variations on nutrient content throughout Australia has not yet been determined. The Australian Feed Composition tables, published by the Australian Feeds Information Centre in 1987 (AFIC-CSIRO Sydney), provides useful data for ruminant animals on metabolisable energy and digestible protein, which can be a basis for calculating comparative values for horses. However, the data is not always based on a large number of samples or from a wide sample area. The nutrient content of feeds can be influenced by varying season conditions and individual varieties of grains, hays or pasture.

Feed testing services, such as the Feedtest® analysis system carried out by the Pastoral and Veterinary Institute, Hamilton, Victoria can provide a useful guide to the Metabolisable Energy and crude protein content of feeds for ruminant animals.

There are a number of equations that can be used to calculate the digestible energy content of feeds that can be used for horses by adapting the ruminant values provided by feed analysis.

KEYPOINT: As a guideline, the digestible energy content (DE) of grains utilised by pigs can be used to estimate the DE values for horses. An estimation of the digestible energy content of roughages for horses can be made from the metabolisable energy value for ruminant animals divided by 0.85.

The content of crude protein can vary with the nitrogen level of the soil and moisture availability during the growth of all plants and is reflected in the variable values for crude protein in cereal grains in particular. For example, oats grown in a wet season has only about half the crude protein of oats grown under dry conditions. Mineral and trace-mineral content is influenced by soil type and in some cases, leaching by rain. Leaching by rain and bleaching by sunlight during the hay making process can influence protein, mineral and vitamin content of the hay. Prolonged storage time will result in further degradation of vitamins and nutrient value.

The transport of feed over large distances to meet shortfalls in local production or provide improved quality and variety in hay or grain not available locally, increases the likelihood of nutrient transfer into semi-urban areas and trace-mineral deficiencies in traditional production areas.

The feed values used in Tables 10-1, 10-2, 10-3 and 10-4 have been prepared using a number of literature sources and feed analysis data from Australia and overseas. The values can be used as a basis for nutrient comparisons when formulating rations to meet the requirements of all classes of horses. However, much more

widespread feed analysis from a variety of geographical areas needs to be carried out to provide a basis for nutrient composition tables for all feeds commonly fed to horses in Australia.

KEYPOINT: Measuring feed by weight (kg) rather than volume (number of litres or dippers etc) minimises the variation in energy and protein content between feeds.

Feed	Digestible Energy Megajoules MJ DE/kg	Crude Protein % (g/kg)	Lysine % (g/kg)	Crude Fat % (g/kg)	Crude Fibre % (g/kg)	MAD Fibre** % (g/kg)	Ca (g/kg)	P (g/kg)
OATS	11.4 (10.6-12,2*)	9.6% (7.2-12.0%*) (96)	0.36% (3.6)	4.5% (45)	10.0% (8.9-11.1%) (100)	17.1% (171)	1.0	3.2
BARLEY	12.8	10.0% (100)	0.32% (3.2)	1.9% (19)	5.0% (50)	7.1% (71)	0.63	3.8
CORN	14.1	9.1% 91	0.25% (2.5)	3.8% (38)	2.5% (25)	3.1% (31)	0.2	2.8
GRAIN SORGHUM	13.0	11.0% (110)	0.26% (2.6)	2.6% (26)	2.4% (24)	6.1% (61)	0.4	3.2
WHEAT	14.1	11.4% (114)	0.29% (2.9)	2.0% (20)	2.4% (24)	4.1% (41)	0.4	3.8
TRITICALE	14.2	14.0% (140)	0.32% (3.2)	2.1% (21)	3.5% (35)	-	0.4	3.0
RYE	13.1	12.0% (120)	0.4% (4.0)	1.5% (15)	2.2% (22)	-	0.6	3.1
MILLETT (Japanese)	10.3	10.0% (100)	0.21% (2.1)	4.6% (46)	9.4% (94)	-	0.27	4.0
RICE (Rough)	12.2* (10.0-12.4 *)	7.5% (75)	0.24% (2.4)	2.4% (24)	8.6% (86)	-	0.7	3.2
MOLASSES Sugar Cane Liquid kg (750mLs) (74%moisture)	11.4	43% (43)	-	0.2% (2)	0.4% (4)	-	7.4	0.8
250mL Cup (330g)	3.8	14.2g	-	0.7g	1.32g	-	2.4g	0.26g
MOLASSES Sugar Cane Powder (94% moisture)	13.4	9.0% (90)	-	0.8% (8)	6.3% (63)	-	10.3	1.4
per 30mL (32g) Heaped tablespoon	0.4	2.9g	-	0.26g	2.1g	-	0.34g	0.05g

VEGETABLE COOKING OIL kg (4.34 litres)	37.6	0	0	99.9 (999)	0	0	0	0
250mL cup (230g)	8.6	0	0	230g	0	0	0	0
TALLOW Rendered Fat Kg	33.2	1.5 (15)	0	96.8 (968)	0	0	0	0
WHEAT POLLARD	13.1	15.6% (156)	0.57% (5.7)	4.1 (41)	8.2% (82)	103	1.3	9.0
RICE POLLARD (Coprice Blend)	14.2	13% (130)	0.65% (6.5)	19% (190)	9% (90)	-	0.5	12.0

TABLE 10.1

NUTRIENT COMPOSITION OF GRAINS AND ENERGY FEEDS

(Average value as fed, 90% Dry Matter)

Note: These values are provided as a guideline only that have been sourced from Australian AFIC data and overseas literature. More accurate values can be obtained by analysis of samples of individual batches of feed.

Abbreviations: MAD fibre = Modified Acid Digestion fibre value. Ca = calcium, P = phosphorus, K = potassium, Cu = Copper, Zn = Zinc, Mn = Manganese, vit A = vitamin A, vit D = vitamin D, vit E = vitamin E. **---** values not available, 0 = Nil content.

* Energy and protein values of oats, and energy values of rough rice, are more variable due to fibrous hull content, seasonal conditions than other grains.

** MAD Fibre (See Glossary Term) is an estimate only, as values for the majority of Australian feeds are not available from published data on nutrient content. Values sourced from Frape (1997) are provided as a guideline for comparison between feeds.

*** Feeds, such as molasses and vegetable oil, are normally added in smaller amounts than 1kg as energy supplements. Calculations of the nutrient content per 250mL cup (liquid molasses and oil) and 30mL (32g) (1 heaped tablespoon) of molasses powder are provided as a practical guideline on the common amounts fed to horses.

**** Vitamin A, D and E values are widely variable as they are influenced by maturity, harvesting, processing methods and duration and conditions of storage. The values provided are a guideline for comparison between feeds.

Feed	Digestible Energy Megajoules MJ DE/kg	Crude Protein % (g/kg)	Lysine % (g/kg)	Crude Fat % (g/kg)	Crude Fibre % (g/kg)	MAD Fibre** % (g/kg)	Ca (g/kg)	P (g/kg)
SOYABEAN Whole Full Fat	15.4	38.0% (380)	2.4% (24)	18.0% (180)	5.4% (54)	-	2.5	5.9
SOYABEAN MEAL 44.5%CP (Solvent Ex) *	13.1	44.5% (445)	2.8% (28)	1.0% (10)	6.2% (62)	10.2% (102)	3.6	6.3
CANOLA MEAL (Mech Ext) *	11.5	36.0% (360)	1.7% (17)	2.6% (26)	13.2% (132)	13.3% (133)	6.0	10.4
LINSEED SEED WHOLE	18.1	21.1% (211)	0.86% (8.6)	36% (360)	6.3% 63	13.8% (138)	2.2	5.4
LINSEED MEAL (Mech Ext) *	14.1	34.6% (346)	1.16% (11.6)	6.1% (61)	9.1% (91)	17.4% (174)	4.0	8.0
COPRA MEAL (Mech Ext) *	10.6	22.0% (220)	0.54% (5.4)	8.0% (80)	15.0% (150)	-	2.0	6.5
COTTONSEED MEAL (Mech Ext) *	12.2	41.0% (410)	1.6% (16)	3.7% (37)	12.2% (122)	22.5% (225)	1.8	11.2
PEANUT MEAL (Mech Ext)	12.6	47.0% (470)	1.54% (15.4)	1.3% (13)	12.2% (122)	22.5% (225)	2.0	10.6
SUNFLOWER SEEDS (Whole)	18.7	23.0% (230)	0.95% (9.5)	26.0% (260)	29% (290)	-	2.0	6.0
SUNFLOWER MEAL with hulls	11.1	34.0% (340)	1.42% (14.2)	5.0% (50)	21.0% (210)	-	4.2	8.0
SUNFLOWER MEAL (without hulls)	10.8	41.0% (410)	1.68% (16.8)	2.7% (270)	12.7% (127)	-	4.0	9.4
LUPIN SEEDS Full Fat	13.7	33.8% (338)	1.6% (16)	9.5% (95)	12.5% (125)	-	2.3	4.0
PEAS (Field)	13.8	23.0% (230)	1.6% (16)	1.3% (13)	5.8% (58)	8.3% (83)	1.2	4.0
TICK BEANS (Horse Beans)	13.1	25.5% (255)	1.7% (17)	10.0% (100)	7.4% (74)	11.6% (116)	1.3	4.8
MILK POWDER (Skim)	15.1	34.0% (340)	25.4% (254)	0.6-1.0% (6-10)	0-0.2%	0	12.8	10.2
BREWERS YEAST ***	12.8	43.4%	3.23%	10.0%	3.2%	-	1.4	13.6

Per kg (dehydrated 93% DM)		(434)	(32.3)	(100)	(32)g			
1 heaped tablespoon 30mL	0.38	13.14g	0.97g	3g	0.96g	-	0.04g	0.4g
TORULA YEAST *** (dehydrated 93% DM)	12.8	48.8% (488)	3.7% (37)	1.6% (16)	2.2% (22)	-	5.0	15.9
1 heaped tablespoon 30mL	0.38	1.46g	1.1g	0.48g	0.66g	-	0.15g	0.48g

TABLE 10.2

NUTRIENT COMPOSITION OF COMMON FEEDS USED AS PROTEIN SOURCES
(Average value as fed, 90% Dry Matter, unless otherwise stated)

Note: These values are provided as a guideline only that have been sourced from Australian AFIC data and overseas literature. More accurate values can be obtained by analysis of samples of individual batches of feed.

Abbreviations: MAD fibre = Modified Acid Digestion fibre value. Ca = calcium, P = phosphorus, K = potassium, Cu = Copper, Zn = Zinc, Mn = Manganese, vit A = vitamin A, vit D = vitamin D, vit E = vitamin E. - values not available, 0 = Nil content.

* Solvent ext. = Oil extracted by solvent chemicals. Mech Ext = Oil extracted by mechanical press (Expeller).

** MAD Fibre (See Glossary Term) is an estimate only, as values for the majority of Australian feeds are not available from published data on nutrient content. Values sourced from Frape (1997) are provided as a guideline for comparison between feeds.

*** Feeds such as Brewers yeast are often added in small amounts as a digestive aid and source of B-group vitamins. The nutrient content per 30g (1 heaped tablespoon 30mL) is provided as a practical guideline.

**** Vitamin A, D and E values are widely variable as they are influenced by maturity, harvesting, processing methods and duration and conditions of storage. The values provided are a guideline for comparison between feeds.

Feed	Digestible Energy Megajoules MJ DE/kg	Crude Protein % (g/kg)	Lysine % (g/kg)	Crude Fat % (g/kg)	Crude Fibre % (g/kg)	MAD Fibre** % (g/kg)	Ca (g/kg)	P (g/kg)
LUCERNE HAY/CHAFF Pre Bloom	9.3	18.0% (180)	-	4.1% (41)	20.7% (207)	-	13.4	3.0
Early Bloom	8.5	17.0% (170)	0.81% (8.1)	2.8% (28)	22.5% (225)	-	12.2	2.2
Mid Bloom	7.9	16.0% (160)	0.80% (8.0)	2.4% (24)	25.5% (255)	35.0% (350) Estimate	11.8	2.0
Full Bloom	7.7	15.5% (155)	0.79% (7.9)	2.4% (24)	27.3% (273)	-	10.8	2.2
LUCERNE HAY First Cut Early Bloom (Estimate only)	7.5	14.5% (145)	-	2.1% (21)	30.3% (303)	-	13.3	2.3
CLOVER HAY (Alsike Variety)	7.2	11.5% (115)	-	2.0% (20)	29.0% (290)	-	11.4	2.2
OATEN HAY/CHAFF (Average)	7.4	8.6% (86)	0.15% (1.5)	2.2% (22)	29.1% (291)	-	2.9	2.3
WHEAT HAY CHAFF (Average)	7.0	7.7% (77)	0.15% (1.5)	2.0% (20)	25.7% (257)	-	1.3	1.8
MILLET HAY Japanese (Barnyard Grass)	6.2	8.0% (80)	-	1.7% (17)	26.3% (263)	-	2.0	-
MEADOW HAY Clover/Cereal (Estimate only)	7.3	9.8% (98)	-	2.1% (21)	29.0% (290)	-	6.8	2.2
SUNFLOWER HULLS (no seeds)	4.3	4.8% (3.6-6%*) (36-60)	-	2.4% (1.9-3.0%*) (19-30)	50% (43-56%*) (430-560)	-	1.5-4.4	0.3-1.6
SOYABEAN HULLS	6.9	11.0% (110)	0.47% (4.7)	1.9% (19)	38.0% (380)	-	4.8	1.7
WHEAT BRAN	11.0	15.4% (154)	0.57% (5.7)	3.8% (38)	10.0% (100)	12.5% (125)	1.4	11.4

TABLE 10.3

NUTRIENT COMPOSITION OF DRY ROUGHAGES
(Average value as fed, 90% Dry Matter, unless otherwise stated)

Note: These values are provided as a guideline only that have been sourced from Australian AFIC data and overseas literature. More accurate values can be obtained by analysis of samples of individual batches of feed.

Abbreviations: MAD fibre = Modified Acid Digestion fibre value. Ca = calcium, P = phosphorus, K = potassium, Cu = Copper, Zn = Zinc, Mn = Manganese, vit A = vitamin A, vit D = vitamin D, vit E = vitamin E. - values not available, 0 = Nil content

* Values for fibre content in sunflower seed are variable, and the high lignin relative to fermentable fibre can affect the energy content of the feed.

** MAD Fibre (See Glossary Term) is an estimate only, as values for the majority of Australian feeds are not available from published data on nutrient content. Values sourced from Frape (1997) are provided as a guideline for comparison between feeds.

*** Vitamin A, D and E values are widely variable as they are influenced by maturity, harvesting, processing methods and duration and conditions of storage. The values provided are a guideline for comparison between feeds.

Feed	Digestible Energy Megajoules MJ DE/kg	Crude Protein % (g/kg)	Lysine % (g/kg)	Crude Fat % g/kg	Crude Fibre % (g/kg)	MAD Fibre** % (g/kg)	Ca (g/kg)	P (g/kg)
LUCERNE FRESH Pre-Bloom 26%DM	2.1	4.3% (43)	0.26% (2.6)	0.6% (6)	4.9% (49)	-	4.4	0.7
Mid Bloom 26%DM	2.6	4.8% (48)	0.29% (2.9)	0.6% (6)	6.5% (65)	-	4.0	0.6
Full Bloom 26%DM	2.8	4.6% (46)	0.28% (2.8)	0.6% (6)	7.2% (72)	-	2.8	0.6
RED CLOVER Early Bloom 20%DM	2.9 (Estimate)	3.8% (38)	-	1.0% (10)	4.6% (46)	-	4.5	0.8
WHITE CLOVER Fresh 18%DM	3.0 (Estimate)	5.0% (50)	-	0.6% (6)	2.8% (28)	-	2.5	0.9
PERENNIAL RYEGRASS Fresh Regrowth 29-42 days 25%DM	2.3 (Estimate)	4.5% (45)	-	0.7% (7)	7.0% (70)	-	1.1	0.3
PHALARIS Fresh 25%DM	2.1 (Estimate)	2.8% (28)				-	0.7	0.7
KIKUYU Fresh, immature 21%DM	2.3 (Estimate)	2.9% (29)	-	0.6% (6)	6.1% (61)	-	0.7	0.7
PASPALUM Fresh Carpet Grass 35%DM	2.4 (Estimate)	2.8% (28)	-	0.5% (5)	8.5% (85)	-	1.2	0.5
COCKSFOOT Early Bloom 25%DM	2.3 (Estimate)	3.2% (32) Estimate	-	-	-	-	0.6	1.0
MILLET Japanese (Barnyard grass) 10%DM	1.0 (Estimate)	2.5% (25)	-	0.6% (6)	6.8% (68)	-	1.1	0.7
RHODES GRASS (Late vegetative) 26%DM	2.3 (Estimate)	2.6%	-	2.3%%	12.2%	-	1.3	1.0
BUFFEL GRASS Pre bloom Fresh 21%DM	2.1 (Estimate)	1.7% (17)	-	2.7% (27)	6.3% (63)	-	1.9	0.3
SILAGE (Grass) legume	9.2 (Estimate)	10.0% (110)	-	3.5% (35)	23.0% (230)	27.2% (272)	5.3	2.6

30%DM						(Estimate)		

TABLE 10.4

NUTRIENT COMPOSITION OF PASTURES
(Average value as grazed, based on dry matter ranging from 15-35% relative to plant type and stage of growth)

Note: These values are provided as a guideline only, and more accurate values can be obtained by analysis of samples of pasture.

Note: These values are provided as a guideline only that has been sourced from Australian AFIC data and overseas literature. More accurate values can be obtained by analysis of samples of individual types of pasture.

Abbreviations: MAD fibre = Modified Acid Digestion fibre value. Ca = calcium, P = phosphorus, K = potassium, Cu = Copper, Zn = Zinc, Mn = Manganese, vit A = vitamin A, vit D = vitamin D, vit E = vitamin E. - values not available, 0 = Nil content

* Estimated values. Values for Digestible Energy (DE) content of pastures at various stages of growth used by horses are not available. Values for Metabolisable Energy (ME) content are published for ruminants. A conversion of ME divided by 0.85 = DE for roughages has been made to provide an estimate of DE in horses. Values for Digestible Energy and Crude Protein of other pasture plants are given as guidelines in Chapter 7, Section 7.4.4, page XX.

** MAD Fibre (See Glossary Term) is an estimate only, as values for the majority of Australian feeds are not available from published data on nutrient content. Values sourced from Frape (1997) are provided as a guideline for comparison between feeds.

*** Vitamin A, D and E values are widely variable as they are influenced by maturity, harvesting, processing methods and duration and conditions of storage. The values provided are a guideline for comparison between feeds.

GLOSSARY OF TERMS

There are a number of technical terms used in this book that could not be explained fully in the text. A glossary of terms has been prepared to provide you with a better understanding of these commonly used nutritional terms.

Acidosis (muscles) — The build-up of acid concentration due to L-lactic acid production in rapidly contracting muscles during exercise, without sufficient oxygen (anaerobic conditions), (especially in a horse unfit for the intensity of exercise), causes a localised "acidosis" in the muscles that spills over into the surrounding tissue and blood. This can lead to fatigue.

Acidosis (large intestine) — The rapid bacterial fermentation of starch and sugars overloaded into the large intestine (or hindgut) produces higher levels of d-lactic acid (an isomer or relative to l-lactic acid produced in the muscles) that results in an "acidosis" in the large intestine. Refer to page XX for details on the symptoms of hindgut acidosis.

Ad-lib — Short for ad-libitum – a term to describe free and unlimited access to feed or water, often more than a horse requires, such as hay in a hayrack or water in a trough – which the horse can consume as it wishes.

Aerobic metabolism — The metabolic pathway in which energy sources of glucose, muscle glycogen, and fats are used to produce energy in the muscles and other tissue cells when oxygen is readily supplied from the blood.

> Up to 80% of the energy used during exercise, including at a fast gallop, is metabolised using oxygen in a fit horse. This pathway is very efficient, producing 12 times more energy than the no oxygen (anaerobic) pathway and gives endurance capacity.

Anaerobic Metabolism — The energy producing pathway used to metabolise glucose and muscle glycogen stores under conditions where oxygen supply is limited and unfit horses with reduced blood oxygen carrying capacity or delivery have a higher dependence on anaerobic metabolism, which uses energy stores 12 times faster than aerobic metabolism. A byproduct of anaerobic metabolism is D-Lactic acid, which accumulates in the muscles and blood, can cause fatigue and muscle soreness in horses worked faster than their fitness.

Anti-oxidants — Vitamin E, vitamin C, β-carotene and the trace-mineral selenium, contained in the enzyme glutathione peroxidase, have a primary anti-oxidant function as well as other functions in the blood, muscle cells and tissues. Vitamin E in the cell wall protects polyunsaturated fatty acids that form an integral part of cell walls against oxidation to harmful peroxides that affect cell function. Vitamin C in the blood helps regenerate vitamin E in its anti-oxidant affect. Selenium, in glutathione peroxidase, breaks down peroxides in the cell to prevent further oxidation to harmful inflammatory superoxide radicals. Vitamin E and Selenium supplements are recommended as anti-oxidants in the diet of hard working horses or horses on diets boosted with polyunsaturated fats as an energy source. β-carotene, a precursor of vitamin A, provides additional anti-oxidant protection of oxidised radicals in the blood and tissues.

Calorie — The amount of heat needed to warm one millilitre (mL or cc) of water by 1°C. A kilocalorie (Kcal) is 1000 calories, a megacalorie is 1 million calories (Mcal) and is used to describe energy content of feed as units of heat produced by combustion of the food.

Carbohydrates — Compounds composed of the elements of carbon, hydrogen and oxygen to form simple, short and long chain sugars, other types of sugars, and cellulose in plants. These can be digested

	to yield energy.
Cellulose	A structural carbohydrate that forms the fibre of plant cells acting like reinforcing strands to give the plant rigidity as it grows. Cellulose is able to be fermented into energy units by bacterial and other micro-organisms resident in the large bowel. (see Carbohydrates).
Compounded Feed	A feed consisting of processed feeds with chaff, added minerals and vitamins often purchased as a commercial prepared, ready to feed ration mix.
Concentrate Feed	A term used to describe a feed that is high in energy and often protein, consisting of either one or a mixture of grains, protein meals, oil, bran, pollard and molasses.
"Cool Feed"	This is a term often used to describe a feed mix that provides energy in a form that does not lead to "hyper", playful or over energetic behaviour by the horse. Slow release of energy from low starch fibrous pellets containing a blend of bran and pollard and feeds containing low starch and higher levels of fat are the basis of most "cool" feeds. Feeds, which contain a higher amount of cooked starch, for example boiled barley or extruded grain, are digested in the small intestine, with less overflow into the hindgut to rapidly ferment to acid (see Acidosis (hindgut) glossary term). These feeds are also promoted as "cool" feeds. However, feeding any "cool" feed in excess of the energy needs of a horse can result in over-energetic behaviour.
Crude Protein (CP) Crude Fat Crude Fibre	The base unit of protein, fat or fibre contained in feed before it is digested and utilised by the horse.
Developmental Orthopaedic Disease (DOD)	A term used to describe limb and joint developmental abnormalities in growing horses. These abnormalities are manifested as bent legs, poor cartilage formation, enlarged joints, weak bone and joint structure and incoordination due to spinal bone collapse ('wobbles') in young horses). These abnormalities can result in lameness and unsoundness. The most common incidence is between 3-9 months of age, often in rapidly growing, grossly developed young horses, or those with an imbalance of calcium to phosphorus ratio and a lack or imbalance of trace-minerals including copper, zinc, manganese and iodine in the diet.
Disaccharides	Disaccharides are two sugars joined by a bond, such as sucrose (galactose-fructose) and maltose (glucose) or lactose (glucose-galactose) (milk sugar) that need to be split by enzymes in the small intestinal lining before uptake as simple sugars into the blood.
Dry Matter (DM)	The organic and mineral components of the plant after removal of water by drying at 84ºC for 24 hours in a forced draught oven. The dry matter represents the net results of photosynthesis and mineral uptake by the plant. It is used as a standard for comparison of the nutrient content between plants and grains.
Dry Matter Percentage (DM%)	The percentage of plant material other than water contained in pasture hays or grains in their 'as fed' form eaten by horses. As plants and harvested feeds vary in moisture content, the dry matter percentage must be considered when comparing nutrient values. Growing green pasture has a dry matter percentage ranging from 28-35% and cured hay and grains from 85-90%.
Electrolytes	Minerals that are dissolved in the blood and cell fluids including sodium, potassium, chloride, calcium, magnesium, phosphate, bicarbonate and hydrogen (acid) as electrically charged salts or "ions". Electrolytes or 'body salts' are involved in nerve transmission, muscle contraction processes, metabolic processes, control of water excretion. Electrolytes are lost in sweat, tears, digestive secretions and in urine and droppings.
Energy Density	The concentration of energy in a feed by weight for a given volume, measure as megajoules of energy per kg of feed. Hays have an energy density ranging from 7-9.5 MJDE per kilogram. Energy dense feeds, such as starches in grams (11-15.5 MJDE/kg) and fats (37.7 MJDE/kg), can be fed in smaller quantities and hence in a smaller volume to achieve a desired energy value. Corn has twice the energy density per unit volume of oats, while fat as vegetable oil, has 6 times more energy compared to oats for an equal volume.
Enzymes	Enzymes are special proteins that are produced by cells in the intestinal lining of the small intestine or pancreas organ. They have specific action to split the bonds between chains of

glucose units, proteins and fats during digestion.

Enzymes are also secreted by bacteria, resident in the large intestine that attack the linking bonds of starch and long chain sugars that form cellulose, breaking the chains into smaller energy compounds called volatile fatty acids.

Epiphysitis

A term describing the enlargement of the growth plate areas of the long bones of the limbs, usually most evident in the growth plate at the lower end of the forearm (radius) bone that joins into the knee joint. In severe cases, the growth plates above the fetlock and the hock will also appear enlarged. Epiphysitis is a symptom associated with Developmental Orthopaedic Disease (DOD) and is most common in over developed, large framed young horses. (See also Developmental Orthopaedic Disease (DOD) – Glossary term).

Equine Degenerative Myeloencephalopathy

Overseas surveys have shown that up to 20% of young horses less than 3 years of age have evidence of spinal cord nerve and brain stem degeneration. It has not been reported in Australia. A deficiency of vitamin E, confinement to dirt yards with no access to pasture, diets of processed or pelleted feeds and ingestion of wood preservatives are thought to be the possible causes. Early cases respond to a diet of green pasture supplemented with vitamin E at 50-100iu/kg body weight.

Extruded Feeds

The process of extrusion of a finely ground, wet feed mix through a high pressure dry of steam heated screw chamber. The process cooks (gelatinises) the starch in grains and meals by heating to 135°C for less than one second. Expansion of the cooked starch allows more efficient digestion by enzymes in the small intestine improving digestibility of starch to 85-90%. Extrusion reduces the overload of excess starch into the large intestine and fermentation to D-lactic acid. Extruded feeds are often regarded as ‘cool’ feeds. (See Glossary term). However the extrusion process, if not carefully controlled, can damage proteins, fats and vitamins in the cooked feed. (Refer to Chapter 2, Fig. 2.3, page XX).

Fermentation Flora

The large intestine contains bacterial, protozoa and fungal “flora”, which total 10 times the number of cells in a horse’s body. The numbers of flora are influenced by the amount of fibre in a horse’s diet, with highest numbers in grass and roughage fed horses. The flora digest fibre, proteins and starches, release energy, warmth and minerals from the feed and provide B-group vitamins.

Forage

Generally described as fresh plant material (dry matter plus water) consumed by a grazing animal. Forage may be derived from pasture (usually a mixture of plant species, which may be native, naturalised or sown (improved)) or from a forage crop (a single species sown specifically to provide forage during periods of slow pasture growth). For example, oats and barley are commonly sown as winter forages while pearl millet, eg the Feedmill variety, is sown as a summer forage crop. Forage crops are annuals and have to be sown each year. Their high yields of quality dry matter for grazing or hay justify their costs of production.

Founder

This is a term synonymous with laminitis. Laminitis or damage to the laminae (See Glossary term) is the initial change that occurs within the hoof. Founder is the progression of laminitis resulting in tearing of the laminae, with structural changes as the suspension and support of the pedal bone is reduced within the hoof. The front hooves are normally more severely affected because they bear a greater weight load as a horse stands and moves around. The deep flexor tendon, which passes down the back of the pastern over the navicular bone in the heel to attach under the pedal bone, exerts a downward rotational force on the pedal bone as it supports standing weight. This rotational pull on the devitalised pedal laminae causes them to detach around the toe and the pedal bone rotates downwards. A rotation greater than 5% from its normal parallel position to the inside of the hoof wall is termed "founder", or the horse has "foundered". In severe “founder”, the pedal bone can rotate to push the toe rim through the sole, resulting in a long term, crippling disease.

Hard Feed

A term used to describe a dry or dampened feed mix of grains, protein meals, oil and other concentrates blended with chaff, used as a feed to supplement a pasture or hay based diet.

Hindgut

The large intestine formed by the caecum and large colon, small colon and rectum.

Hyperlipaemia	A severe metabolic disorder that affects ponies and has also been reported in thoroughbreds and donkeys. A survey indicated that 5% of ponies on studs in Victoria were likely to develop the condition. Hyperlipaemia is triggered by a sudden reduction in energy intake during pregnancy, lactation or as a result of periods of cold weather when energy losses exceed feed intake. Affected ponies are often fat, and sudden starvation such as denial of pasture by flooding, snow covering, bush fires or long distance travel for more than 12 hours or even refusal to eat poor quality unpalatable hay can be the triggers for the onset of this disease. Fat stores are mobilised and triglyceride levels increase in the blood and accumulate as lipoprotein complexes in the liver. Loss of appetite, depression and severe liver damage occur over 7-10 days, which can be fatal. Prompt treatment in the early stages combined with force feeding to reverse the energy deficit can alleviate the condition. If not promptly treated, the condition is invariably fatal. Note: It is unwise to purposely withdraw all food to make a pony lose weight. Small meals, made up of white chaff sweetened with molasses, must be provided at normal times to avoid onset of hyperlipaemia.
Ill-thrift	A term to describe a horse that does not do well or put on condition, loses condition or is thin and wasting, often despite a good quality diet. Heavy parasite burdens, poor teeth, organ diseases, sand accumulation in the large intestine and certain nutrient deficiencies can result in poor condition, a rough coat and an undernourished appearance.
Laminitis	Refers to inflammation and swelling of the laminae (or interlocking “leaves” or “zipper-like” formation) that supports the pedal bone within the hoof casing (capsule) and therefore the skeletal and body weight of the horse. Physical tearing of the laminae can occur in a horse that is galloped on a very hard surface, such as a roadway or compacted wet beach san. The most common cause is due to alteration to the blood flow within the hoof. This occurs as a result of toxins released when large numbers of hindgut digestive flora die in the presence of hindgut acidosis (see Acidosis (hindgut)). It is also related to toxic shock arising from infection, stress or gut surgery. It is estimated that up to 80% of laminitis cases are caused by starch and soluble sugar overload from high grain or lush pasture intake. Circulating toxins in the blood and the effect of reduced blood flow and lower oxygenation in shock are thought to cause damage to the soft laminae and bonding (basement) membranes of the laminae, resulting in fluid accumulation, internal pressure and weakened bonding. Laminitis is a very painful condition, usually located around the toe area as the swelling is enclosed within the hoof shell, making the horse extremely lame. Immediate therapy needs to be targeted at the underlying cause and minimisation of the progressive damage to the internal hoof structure. (See also Founder – glossary term).
“Lawns and Roughs”	A term used to describe the result of selective grazing of pasture by horses. The “lawns” refer to the short, close cropped areas of pasture that are selectively and heavily grazed by horses. In comparison, the less grazed areas or “roughs” contain longer, less palatable pasture, weeds and manure heaps. After a period of grazing, up to 48% of a pasture will be utilised as the preferred grazing area to form “lawns” leaving 52% to develop as “roughs”, spoilt areas and bare patches. Horses tend to pass their droppings in the “roughs” or less grazed areas, increasing the build up of internal parasite eggs and larvae. Over time, most palatable plants are eaten out of the lawn area, allowing weeds to infest the pasture.
Lignin	An insoluble, non-fermentable structural fibre compound of a plant (not a carbohydrate) that is not digested and passes out in the droppings. As a plant matures and the content of lignin increases, its fibre becomes less digestible.
Macromineral	A mineral, including calcium, phosphorus, magnesium, sodium, potassium and chloride that is required in amounts of more than one gram daily per 100kg bodyweight by a horse.
MAD fibre	A more accurate measure of total fermentable and non-fermentable fibre content is now universally accepted as the Modified Acid Detergent (MAD) process. The MAD fibre value includes the total fermentable cellulose and lignin content, which reflects a more accurate estimation of the energy digestibility of the feed. The MAD fibre value is higher than the crude fibre value for feeds containing a greater content of lignin and other structural carbohydrates. In this book, the values for fibre are expressed both as crude

fibre and MAD fibre % (where available), or on a grams/kg basis for fibre content.

Mastication	The act of moving the jaws when chewing to grind food into small particles between the large premolar and molar teeth, mixing in saliva in preparation for swallowing.
Megajoule	Megajoule is the standard unit of energy used in Australia to describe energy content of feeds released by the digestive process. One calorie is equivalent to 4.185 joules or 1 Mcal equals 4.185 Megajoules (MJ) of energy. One megajoule of energy is equivalent to one million watts of heat energy.
Micromineral	Another name for a trace-mineral, which includes the minerals required in amounts less than one gram daily per 100kg body weight by a horse.
Monogastric	Animals with a single stomach prior to the small intestine, such as dogs, cats, pigs, horses and humans, are monogastrics. The stomach is the initial storage and mixing compartment of the digestive tract and has variable digestive function relative to the animal species. Ruminants (e.g. cattle and sheep) have 3 fermentation compartments prior to the true stomach (omasum).
Monosaccharides	Monosaccharides are simple sugars such as glucose, fructose, galactose and xylose that are directly absorbed into the blood from the small intestine.
Nutritional Secondary Hyper Parathyroidism (NSH)	This is a condition that develops as a result of calcium contained in feeds, or given as supplements, being bound up by phytic acid from bran and pollard or high levels of oxalate chemicals present in tropical grasses. These two compounds bind calcium and prevent its uptake from the small intestine. The bound calcium complex then overflows into the large intestine. The fermentation process releases the calcium, but it is not absorbed efficiently from the large intestine of the horse. This results in a deficiency of calcium in the blood, although adequate levels are available in the diet. Low blood calcium triggers the release of the parathyroid hormone, which acts to resorb or demineralise ("mine") calcium from non-weight bearing bones of the face and pelvic structure. Chronic demineralisation of the facial bone results in the development of a 'big head', due to swelling of the nasal bones. Weakened limb bones fracture more easily. Supplementary calcium must be provided on a daily basis to ensure sufficient is absorbed. (See Chapter 7, Section 7.4.7, page XXX for dose recommendations).
Omega fatty acids	Polyunsaturated oils and fats contain chains of fatty acids linked by double bonds of repeating carbon sequences. The double bonds in Omega-3 fatty acids are situated at the third carbon position while the Omega-6 fatty acids are situated at the sixth carbon position. Omega-3 and Omega-6 fatty acids are structural components of muscle cell and other cell walls. Refer to Chapter 7, Section 7.1.11, page XXX for an overview of Omega fatty acids and their content in common horse feeds.
Oxalates	Oxalates are chemicals, which, like phytates, bind up calcium during digestion in the small intestine, leading to Nutritional Secondary Hyperparathyroidism (NSH) (See glossary term). Lush, rapidly growing tropical grass, such as Setaria, Buffalo, Pangola, Green panic, (see Chapter 7, Section 7.4.7, page XXX for a full list), all contain levels of oxalates that can bind up sufficient calcium to cause NSH. Rapidly growing fertilised kikuyu grass can also cause a similar oxalate induced calcium deficiency, but slow growing, dry land Kikuyu contains less than critical levels. Even lucerne contains oxalates, but at a level that has no significant effect on calcium uptake or onset of NSH.
Parasites	Horses can harbour a number of internal parasites within their digestive tracts. Heavy burdens of developing and adult internal parasites can irritate the stomach and intestinal walls, reducing food intake and causing blood loss, leading to ill-thrift and anaemia. Immature forms of common parasites such as the Strongyle worm (Bloodworm and Small Redworm) migrate within the gut cavity (Bloodworms) or penetrate the large intestine lining to remain dormant for up to 2 ½ years (Small Redworms). Heavy burdens of both of these worms can cause ill-thrift and symptoms of colic. Regular control of internal parasites in all horses, including young foals, is an important part of horse health and feeding management, as is providing feed bins and hay racks to avoid contamination of feed with eggs and worm larvae. Regular removal of manure will assist in reducing risk of recontamination in all horses.

Phytic acid (Also Phytate)	Cereal grains and their byproducts of bran and pollard contain about 1% of phytic acid, in which the phosphorus mineral is complexed to inositol (a B-group vitamin). Up to 90% of the phosphorus may be bound as phytate in grains. The horse lacks the necessary phytase enzyme in the small intestine to split this bond to release phosphorus. The complex passes into the large intestine, where bacteria secrete a phytase enzyme, which liberates the phosphorus, allowing some of the phosphorus to be absorbed from the large intestine. The availability of phosphorus from phytate sources is less than 20% in the horse. Phytic acid and phytates, however, can bond to free calcium salt in the small intestine as the food is being digested. This significantly reduces the uptake of calcium, which is primarily absorbed from the small intestine. A hormone, released from the parathyroid gland, which monitors blood calcium levels, is released to resorb (mine) calcium from bone stores, leading to bone and joint weakness (See Nutritional Secondary Hyperparathyroidism (NSH)). Horses on a diet containing phosphorus in phytate form may suffer a deficiency of calcium even though it is contained in the feed, or added as a supplement. Calcium should be fed in a meal separate to high grain mixes or a bran mash, to reduce the risk of poor uptake and skeletal weakness.
Polysaccharides	Polysaccharides are complex sugars, which include starch, amylose and amylopectin as repeating units of maltose sugar, which are broken down to glucose units by digestive enzymes secreted by the lining of the small intestine and pancreatic juice. Non-starch polysaccharides, such as cellulose gums, pectins and hemicellulose are not able to be digested by enzymes in the small intestine and are broken down to smaller units (volatile fatty acids) by bacterial and protozoal enzymes released during fermentation of fibre in the large intestine.
Quidding	The term used to describe the dropping of partly chewed masses of wet, saliva saturated food out of the corners of the mouth as a horse eats. Quidding is usually due to sharp-edged premolar and molar teeth that pinch the membranes and tongue during chewing, making the horse open its mouth to avoid pain and discomfort. This results in the heavy, saliva saturated food clumps falling out before they are swallowed. Grass seeds or other food particles trapped between the teeth can also cause quidding.
Raw Grain	A term that is used to describe grain that is not cooked by boiling (as in boiled barley), extrusion or infrared micronisation. The starch particles in raw grains, such as corn and barley, are not efficiently attacked by digestive enzymes in the small intestine, increasing the risk of overload into the hindgut. (Refer to Chapter 2, Fig. 2.3, page XXX and Acidosis (hindgut) glossary term)
Starch	The major form of enzyme digested and fermentable long chain carbohydrate mainly contained in grains, with less in other feeds that are used as an energy source by horses. Seeds such as lupins and horse beans do not contain starch.
Thermoregulation	The mechanism, controlled by the hypothalamus organ situated within the brain that controls body temperature, stimulating sweating to lose heat, or skin muscle activity (shivering) to generate heat under cold conditions.
Trace-element	The term used to describe a chemical element contained in the soil in small amounts that is required for plant growth. Once taken up by plants, they are referred to as trace-minerals in the feed.
Triglycerides	The base units of fat or oils that when digested produce free fatty acids as an energy source during aerobic (oxygen using) metabolism. Fatty acids are also important for maintaining muscle and cell membrane integrity and for health of the skin and coat. (See Omega fatty acids – Glossary term).
Tying-Up	“Tying-up” is a common term for a type of muscle cramping, which occurs during exercise or within 2 hours after exercise, and is scientifically referred to as exertional myopathy, meaning “muscle damage associated with exercise”. Clinical signs include a shortened stride, most commonly in the hind limbs, reduced weight bearing and gait discomfort, and in severe cases, knotting and development of a cramp-like consistency in the affected muscles. The underlying cause of “tying-up” is not fully understood, but is thought to be related to feeding management, electrolyte depletion and imbalance within the blood and muscles and in some cases, an abnormally high content of calcium in the muscle cells of horses with a history of the problem.
White Muscle Disease	A condition in newly born foals in which the major back and limb muscles have degenerative pale fibres that lack strength and stamina. It is due to a deficiency of selenium and/or vitamin E in the diet of the pregnant mare prior to foaling. It can be prevented by providing pregnant and lactating mares with dietary supplementation of selenium in conjunction with Vitamin E, or top dressing pastures with selenium in known deficient areas.

SUGGESTED READING

The information on the nutritional requirements, feeds and feeding practices presented in this book was researched and gathered from a large number of published text books, scientific papers and the combined nutritional knowledge of the authors.

The book was written as a handbook for horse owners and to improve the ease of reading, acknowledgement of the sources of information and data was not included as is customary within the text. These references are included in this suggested reading list.

The authors recommend the following textbooks and other scientific literature as a source of further information and clarification on the feeding and nutrition of horses in Australia. All relevant Australian references have been included as a guide to valuable nutritional research carried out in Australia relating to pastures and feeding of horses.

Only the latest editions of textbooks have been listed as suggested reading.

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