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The ruminant stomach (compound stomach)

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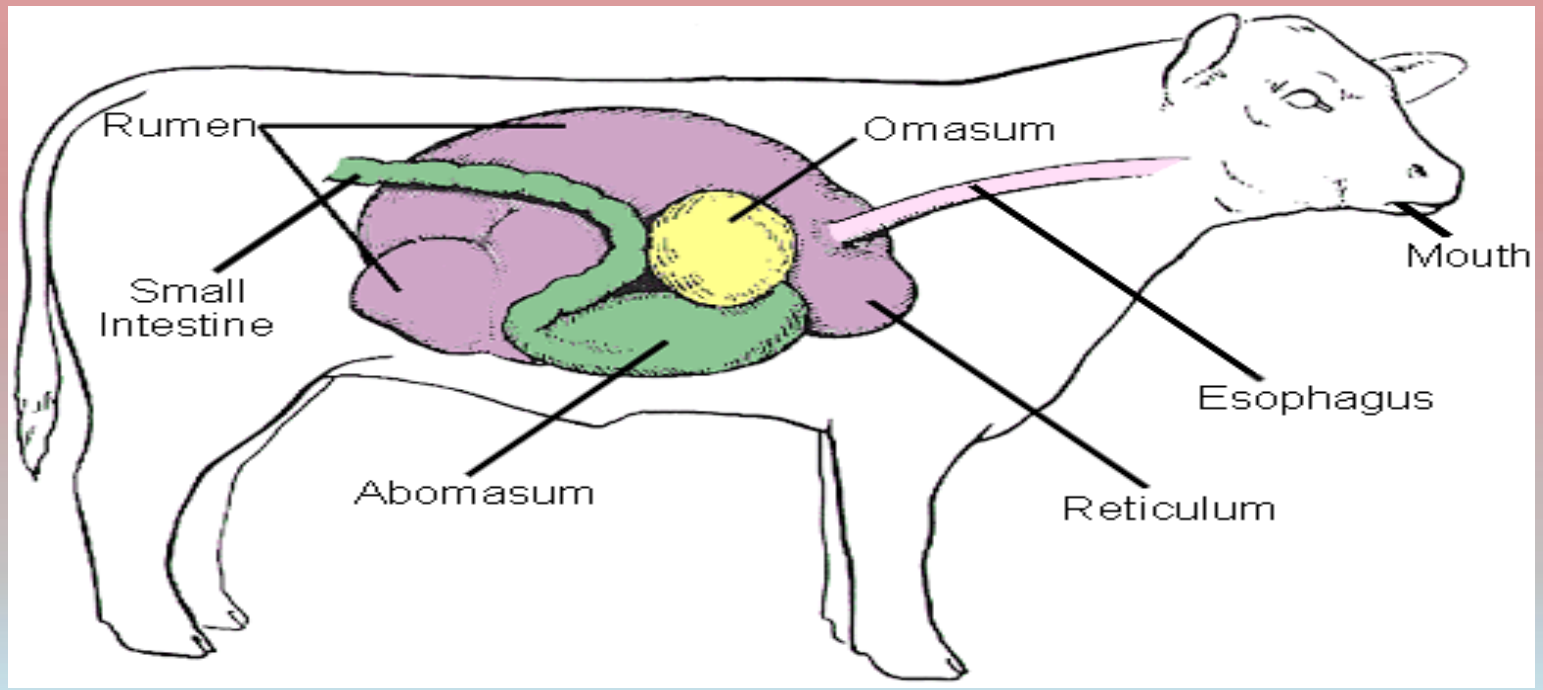
There are four divisions(compartments): Rumen, reticulum, omasum ,and abomasum.



The rumen:

1-it is a large muscular sac which extends from the diaphragm to the pelvis.

2- it fills the left side of the abdominal cavity.

3- it consists about 80% of the stomach.

4- it is divided into sacs by muscular pillars.

5-the floor of the rumen is separated from the floor of the reticulum by the rumino- reticular fold.

6- the mucous membrane lining the rumen is glandless and it contains numerous papillae up to 1cm. in length.

Rumen Development:

* Newborn rumen is nonfunctional Sterile, small, lack papillae.
* Reticular groove shunts milk from esophagus to omasum.

Rumen developed by:

-Exposure to environment & other ruminants.

-Consumption of solid feed.

-Consumption of water.

* Controlled by the producer if animal is separated from dam.

The reticulum:

*the inner surface of the reticulum is subdivided into honeycomb- like compartments.

*the mucous membrane is glandless.

***The reticulum functions in moving ingested feed into the rumen or into the omasum and in regurgitation of ingesta during rumination.

The omasum:

*it is a spherical organ, located to the right of the rumen and reticulum.

*the mucous membrane contains large folds(laminae) arranged in a form of leaves.

*the epithelium lining the first three parts of the stomach is stratified sequamous and keratinized.

The abomasum (true stomach):

*it is similar by one way or another to the simple stomach of the non- ruminant animals.

*it is the first glandular portion of the ruminant digestive system, it secretes digestive juices and mucous.

*there is a sphincter at the junction of the end of the abomasum and the small intestine(circular smooth muscle fibers).

Esophageal groove:

*extends from the esophagus to the omasum.

*it is formed by two heavy muscular folds or lips.

*close to direct materials from esophagus into the omasum directly.

*open and permit the material to enter the rumen and reticulum.

*it is of importance in young ruminants.

*nursing stimulates closure of the groove so the milk passes directly to the omasum and runs through the omasum to the abomasum.

Passage of food

*the efficiency of digestion and absorption is highly dependent on the rate at which digesta move through the gastrointestinal tract.

*the rumen, reticulum, and omasum causes considerable delay to the passage of food stuffs.

*but the rate of passage of ingesta from the abomasum caudally is similar to that of animals with a simple stomach.

100 hours from ingestion to defecation.

30 hours from abomasum to defecation.

*food enters the rumen and slowly mixed with the residues of previous meals.

*the rumen never empties, but with fasting the contents become more and more fluid.

*there is a continuous flow of saliva into the rumen and reticulum and a continuous flow of material from them to the omasum and then to the abomasum and intestine.

Physiology of the ruminant stomach:

1- rumen and reticulum:

*fermentative digestion due to bacteria and protozoa occurs on a massive scale in the first two parts of the stomach before hydrolytic digestion due to enzymes in the abomasum and intestine.

*the soluble products of fermentation are largely absorbed from the rumen and reticulum.

*material leaving the rumen represents a mixture of food residues, bacteria and protozoa, and some soluble fermentation products.

*the rumen undergoes complicated contractions which are repeated several times per minute.

2-omasum:

*the material enters the omasum from the reticulum through the reticulo-omasal orifice.

*the flow of water is much greater than the flow of solid material.

*The material entering the omasum passes into the interolaminal spaces and the excess fluid is squeezed from it and passes to the abomasum.

*So that the contents of the omasum contain less water than the contents of the other parts of the stomach.

*stimulation of vagous nerve causes strong contractions of the omasal wall.

*omasal contractions help in grinding the solid to some extent by help of laminae and move the material into the abomasum.

*material can not remain for along time in the omasum because of the limited capacity of it.

3-abomasum:

*strong waves of contraction pass over this part of the stomach.

*the food flow into the duodenum.

*activity of the abomasum depends on the contents of the duodenum as in the simple stomach.

*If the abomasal content is increased, the strength and frequency of the reticular and omasal contractions are reduced.

*Clotting of milk occurs rapidly in the abomasum.

Rumination:

*is the process of returning the food to the mouth (regurgitation), remastication, mixing it with saliva (reinsalivation) and filling reswallowing of the food.

*so the ruminants can ingest food rapidly, then complete the chewing at a later time.

*regurgitation occur by contraction of the reticulum and by help of the abdominal muscles, but mainly by an inspiratory movements.

*by this movement and by closing of the glottis, negative pressure in the thorax is produced and this will produce a negative pressure in the esophagus.

*therefore the cardiac sphincter and the thoracic esophagus dilate.

*in cattle rumination is about eight hours a day. one rumination cycle requires about one minutes, few seconds are utilized for both regurgitation and reswalling.

*rumination appears to be reflex in nature through the vagous nerve and it is also under voluntary control.

Eructation or belching :

*in ruminants eructation is a reflex event, occurring once or twice a minute.

*receptors in the rumen are stimulated so a reflex is irritated.

*relaxation of the cardiac sphincter occurs.

*the gas is expelled through the esophagus and the mouth due to contraction of the rumen and abdominal muscles.

*in man also the gas is expelled by relaxation of the lower esophageal sphincter and contraction of the abdominal muscles to increase the intra abdominal and intrathroracic pressure.

Emesis or vomiting :

In ruminants vomiting does not occur, but ejection of abdominal content into the omasum, reticulum and rumen occurs.

Microbiology of the rumen

*microorganisms enter the G.I.T. after birth and they become primarily restricted to the stomach and large intestine due to the slower rate of digest a passage through these parts of the tract.

*the population of bacteria in the rumen is 109(1000,000,000)cells per gram.

*the population of microorganisms is affected by several factors such as the:

1-ph changes.

2-starvation or over feeding.

3-administration of antibiotics.

4-antimicrobial drugs.

Functions of microorganisms:

*to convert a poor quality diet into more utilizable nutrients.

*to protect the gut from some diseases by direct competition with pathogenic organisms.

*to synthesize B vitamins.

In the rumen:

*about 75% 0f the dry matter of the usual diet suggested by microorganisms in the rumen.

*because moisture content is constant, the 0smotic pressure is maintained close to that of blood, the temperature is usually32-42c,and the ph usually between 6-7.

*the end products of microbial digestion are:

*organic acids: they are volatile fatty acids(VFA), used as the main source of energy for ruminants. They are acetic acid, propionic acid and butyric acid.

*amoniaNH3: as the main source of nitrogen for microorganisms to form microbial protein.

*carbon dioxide: CO2}

*methan:CH4}gases

*the undigested food residues and microbial cells(protein)passes to the lower tract.

PH of the rumen:

*the PH of the rumen does not deviate far from naturally, and is usually within the range of 6-7.

*it is buffered by the influx of quantities of saliva containing large amounts of bicarbonate and phosphate and by absorption of VFA and ammonia produced by fermentation.

*after feeding the PH decreases due to the formation of VFA. if the diet contains large quantity of rapidly fermented carbohydrates(starch and sugars) the formation of VFA will increase and the PH will decrease more. It may cause death duo to acidosis.

*excessive amounts of urea in the rumen cause alkalinity duo to excessive ammonia formation, which may also be fatal.

Microbial digestion of carbohydrates, lipids ,and protein in the rumen

- **Fermentation of carbohydrates in the rumen:**
- *microbes convert (ferment) soluble carbohydrates (glucose and starch) and insoluble carbohydrates(cellulose and hemicellulose).
- *the results of the carbohydrates fermentation are VFA,Co2, andCH4.
- *soluble sugars are rapidly fermented and starches are less rapidly fermented, while the cellulose and hemicellulose are slowly fermented.

Lipid hydrolysis in the rumen :

*triglycerides undergo hydrolysis in the rumen to glycerol and fatty acids duo to rumen microorganisms.

*glycerol is fermented into propionic acid.

Protein digestion in the rumen:

*diets for ruminants are very low in protein.

*dietary protein ingested by the ruminant is attacked by the enzymes of the ruminal microbes.

*bacteria have proteolytic activity, they can secret enzymes such as protienase and peptidase.

*Some of the peptides and amino acids are utilized directly by microorganisms for synthesis of microbial proteins in their own cell bodies.

*most of peptides and amino acids are catabolized (destroyed or fermented) by deaminative enzymes from bacteria and protozoa.

*the end products of catabolism or deamination areVFA,Co2 and ammonia.

*the ammonia is utilized as a source of nitrogen by microorganisms for synthesis of protein in their own cell bodies.

*30% of the microbial protein from the amino acids and 70%from the ammonia.

*the balance between the rate of production and utilization of ammonia by the rumen microorganisms is important because ammonia in the rumen is rapidly absorbed into the blood and excreted in the urine mainly as urea.

*microbial protein is high quality protein and it s digested by enzymes in the lower gastrointestinal tract. it has a high biological value.

Urea utilization:

*urea entering the rumen from both salivary secretions and from the blood(diffuses from the blood into the rumen)in addition to that in the diet.

*the normal levels of urea in the rumen are so low.

*the urea in the rumen is rapidly hydrolyzed to ammonia and Co2 by ruminal microbes (urease enzyme).

*the nitrogen of ammonia is utilized by the ruminal microbes for the formation of microbial proteins.

Protein regeneration cycle:

It is the recycling of urea through the body of the ruminant to the rumen .i.e.

Utilization of urea in the formation of microbial protein

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Breakdown of microbial protein to form amino acids

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Absorption of amino acids from the gastrointestinal tract

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Metabolism of amino acids in the body

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Production of urea

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Reentry of urea into the rumen

Gas production:

*the gas mixture in the rumen is largely composed of carbon dioxide and methane(CH4)

*Co2 is produced during the fermentation of carbohydrates and the deamination of amino acids, also from saliva bicarbonate as a result of neutralization of fatty acids formed during fermentation.

*CH4 is formed by the reduction of Co2by methanogenic bacteria.

*in cattle: methan forms 30-40% of the total gas.

Co2 forms 20- 65% of the total gas.

Synthesis of B vitamins:

*the b complex are synthesized in the rumen by microorganisms.

*some of the B vitamins can be absorbed from the rumen.

*some minerals are required in synthesis of B vitamins as cobalt so alack or insufficient cobalt leads to deficiency of vitamin B12.

Absorption:

* no food is absorbed before it reaches the stomach.

*the sites of absorption are the stomach , small intestine, and large intestine.

*VFA are absorbed from the rumen, reticulum, and omasum. but mainly from rumen because their concentration in the rumen is high and it is about 10 times greater than in the abomasum.

*ammonia, some of the B vitamins, electrolytes(k, Na, CL , Mg),and number of drugs are absorbed from the rumen too.

*water can move freely in either direction across the rumen epithelium and this movement depends on the osmolarity of the solutions.

*Co2 absorption from the rumen occurs rapidly. One-third to one-fourth of theCo2produced in the rumen is absorbed through the ruminal wall.

*methane is not absorbed but must be eructated or passed on through the gastrointestinal tract.