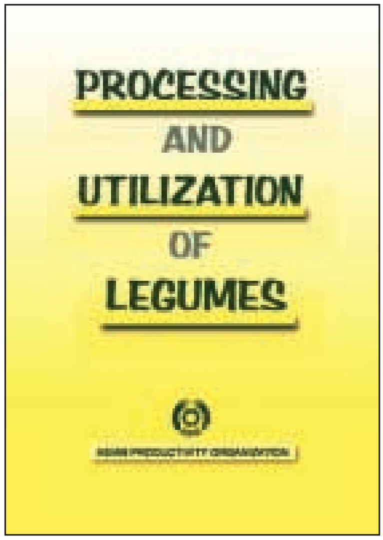
From:

Processing and Utilization of Legumes

©APO 2003, ISBN: 92-833-7012-0



Report of the APO Seminar on Processing and Utilization of Legumes

Japan, 9–14 October 2000

Published by the Asian Productivity Organization
1-2-10 Hirakawacho, Chiyoda-ku, Tokyo 102-0093, Japan
Tel: (81-3) 5226 3920 • **Fax:** (81-3) 5226 3950
E-mail: apo@apo-tokyo.org • **URL:** www.apo-tokyo.org

PROCESSING AND UTILIZATION OF LEGUMES

ASIAN PRODUCTIVITY ORGANIZATION

PROCESSING AND UTILIZATION OF LEGUMES

2003
Asian Productivity Organization
Tokyo

Report of the APO Seminar on Processing and Utilization of Legumes
held in Japan from 9 to 14 October 2000
(SEM-23-00)

This report has been edited by Dr. Sundar Shanmugasundaram, Plant Breeder and Director, Asian Vegetable Research and Development Center, Tainan, Republic of China.

ISBN: 92-833-7012-0

FOREWORD

The phenomenal economic growth in Asia and the Pacific in recent decades has resulted in significant improvements in living conditions in the region, as reflected in people expanded choices of the food they eat. Lifestyle changes have also occurred due to other factors, including increased interest in better health. All of these developments have contributed to major shifts in food consumption patterns, and more people are expressing a preference for healthier foods. In this context, legumes are playing an increasingly important role as people rediscover their high nutritive value and health-enhancing features.

Soybeans, for example, are the most common legume and are now being hailed as the miracle food of the future. Recent claims about their anticarcinogenic effects are stirring global interest in the commodity. Several processing and packing technologies are now being developed to maximize the potential of soybeans. Soy-based food initiatives are being pursued to address nutritional issues such as the development of low-cost, soy-fortified or -blended food, promotion of soy milk in school lunch programs, and fortification of soy sauce with iron.

The potential of legumes for meeting food requirements is great. However, in addition to developing the technologies for manufacturing legume-based products that are acceptable to consumers, there is also a need to undertake innovative marketing efforts and to educate the public about their benefits.

To discuss the present situation of legume processing and utilization in member countries and to identify measures to add more value-adding processes to legume products, the Asian Productivity Organization (APO) organized a Seminar on Processing and Utilization of Legumes from 9 to 14 October 2000 in Japan. This publication is a compilation of the papers and proceedings of the seminar. I hope that it will serve as a useful reference on the subject in APO member countries.

The APO is grateful to the Government of Japan for hosting the seminar, in particular to the Ministry of Agriculture, Forestry and Fisheries for providing financial and technical assistance, to the Association for International Cooperation of Agriculture and Forestry for implementing the program, and to the resource speakers for their valuable contributions. Special thanks are due to Dr. Sundar Shanmugasundaram for editing the present volume.

TAKASHI TAJIMA
Secretary-General

Tokyo
March 2003

TABLE OF CONTENTS

SUMMARY OF FINDINGS

INTRODUCTION

The Seminar on Processing and Utilization of Legumes which was organized by the Asian Productivity Organization (APO) and hosted by the Government of Japan was held in Tokyo from 9 to 14 October 2000. The program was implemented by the Association for International Cooperation of Agriculture and Forestry (AICAF) in cooperation with the Ministry of Agriculture, Forestry and Fisheries (MAFF). Fourteen participants from 13 member countries, and three resources speakers from the Asian Vegetable Research and Development Center (AVRDC), Thailand and Japan attended the seminar.

The objectives of the seminar were to: 1) discuss the present status of legume processing and utilization in member countries; and 2) identify measures for promoting more value-adding activities in legumes. The seminar consisted of the presentation and discussion of resource papers, as well as country papers and field studies in Ibaraki and Tochigi prefectures. The resource papers focused on the following topics: 1) Present Situation and Economic Importance of Legumes in Asia and Pacific Region; 2) Traditional Processing and Utilization of Legumes; and 3) Modern Processing and Utilization of Legumes – Recent Research and Industrial Achievements in Soybean Foods in Japan –. The country paper, on the other hand, presented the present situation of legume production and consumption, as well as future prospects of legume processing and utilization in respective countries.

The highlights of the seminar are presented below.

HIGHLIGHTS OF RESOURCE PAPERS

Present Situation and Economic Importance of Legumes (Sundar Shanmugasundaram)

The Asia and Pacific region is home to three billion people. Arable land, however, is limited, so countries are preoccupied with how to ensure self-sufficiency in cereals, the staple food crops. Legumes have been branded as secondary crops. They have always been relegated to marginal lands and given only meager inputs. The risks associated with producing these crops have also been high and research to improve legumes has been minimum. Resources have mostly gone instead to cereals.

After the Green Revolution, national and international research programs in Asia began turning their attention to legumes, due to the following reasons: 1) legumes play a major role in household food security; 2) they are the major source of protein, fat, supplemental energy and, more importantly, micronutrients (legumes complement the cereal diet of Asians); 3) they are the primary source of protein for vegetarians and resource poor rural and urban people; 4) they provide cash income to rural populations; 5) they help improve the soil for sustainable agriculture; 6) they diversify cropping systems (provide an alternative to cereal monocropping); 7) they have a wide range of uses as food, feed and raw material for industrial products; and 8) they are attractive to health-conscious consumers and medical practitioners. To ensure household "nutritional" security, governments and international agencies should provide a positive policy environment and financial support to increase legume production in the region, and quicken the pace of the "slow runners" as pulses before have been branded.

Plants provide almost 80 percent of the protein in the developing world. In almost all Asian countries, the major source of protein is legumes. Area, production and productivity of pulses have begun to show positive growth. Research is beginning to pay off. Farmers are recognizing legumes as important cash crops and countries are beginning to recognize legumes' export potential (which results in a spillover effect of increased domestic supply). Prices might decrease slightly, but this could be more than offset by significantly higher yields from improved cultivars. Area and production of pulses have increased in People's Republic of China, India, Myanmar, Pakistan, Cambodia, Laos and Vietnam. These increases have come primarily through productivity and area increases, especially in China, Myanmar and Vietnam.

The increase in total production was mostly due to the increase in area and productivity of dry beans. Mung bean, a short-duration legume, has contributed significantly to this increase. Improved mung bean cultivars from national programs and from AVRDC have been well accepted by farmers in China, Pakistan, Myanmar, Thailand, Indonesia, Philippines, Lao PDR, Cambodia and Vietnam.

The area and production of chickpea and pigeon pea increased between 1989 and 1999. Only a limited number of countries cultivate and consume these long-duration crops. Improved cultivars from national programs and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are used by farmers in the region, but production growth has been modest. Lentil production in Asia dropped between 1989 and 1999, but area and production of lentils have increased in Myanmar. The increase in production of groundnut was minimal between 1989 and 1998 in Asia. In recent years, groundnut has faced many competitors, such as rapeseed, sunflower, oil palm and soybean. Aflatoxin and other health concerns are inhibiting consumption. The production in China, India, Myanmar and Vietnam has been stable.

Soybean is the king of the legumes. China dominates in area and production. Growth stems mostly from productivity increase and to a limited extent through area increase. In the past 20 years, India recorded spectacular increases in area and production of soybean. From a meager 3,000 ha in 1969, cultivated area increased to more than six million ha by 1999. Increased soybean production helped alleviate an edible oil crisis in India. Soybean meal is also exported, earning for the country valuable foreign exchange. Myanmar, Pakistan and Vietnam are also emerging producers, with increased area and production. Indonesia will continue to import limited quantities of soybean to supplement domestic production to meet domestic demand. Japan, Korea and Taiwan will be major importers of soybean for food, oil and feed. Among the Pacific countries, Australia and New Zealand play a minor role in legume production. They make slight increases where they have comparative export advantage.

Half the world's population consumes half the world's pulses. Asia's share of this consumption increased in 1998. Of the amount of soybean consumed as food in the world, almost all is consumed in Asia. The amount of soybean consumed as food in Asia increased in 1998. Asia accounts for more than half of world groundnut (food) consumption. Asia's share of world groundnut (food) consumption increased to 58 percent in 1998.

There is an urgent need to increase per capita availability of pulses, which declined from 23.7 kg in 1960 to 11.4 kg in 1998. Both area and productivity of legumes must increase. Pulses area can be expected to increase in India, Bangladesh, Pakistan, China, Lao PDR, Cambodia, Myanmar and Vietnam. Chickpea and pigeon pea will show very modest increases. However, dramatic increases in area and productivity of mung bean can be expected. Because mung bean is a short-duration crop, it can easily take the place of fallow periods. Improved mung bean cultivars from national programs and AVRDC will help increase production in many Asian countries in the next 10-20 years. Consumers and producers in China, Pakistan and Myanmar are already enjoying the benefits of these improved cultivars. More benefits will follow in these and other countries, such as Bangladesh, Lao PDR, Cambodia and Vietnam. People from all income groups are consuming more legumes, but demand could be increased through development of attractive new processed products. And demand could be expected to rise if consumers are informed about the important micronutrients and nutraceutical properties in mung bean and other pulses. Increased demand would help stabilize prices.

Continued strong support for both basic and applied research on various legumes, especially mung beans and soybeans, are required at the national and international levels in Asia to maintain momentum generated by current improvements. In this regard, training for researchers and extension staff at both levels should be offered. International conferences should be organized periodically to facilitate the exchange of knowledge generated by research. In-country demonstrations of improved cultivars and improved production technologies should be organized for farmers. A decision-making tool for various legumes should be developed to assist farmers and traders. Socio-economic research should focus on the factors responsible for adoption and non-adoption of improved technologies, including cultivars. The impact of the improved cultivars and improved technology over traditional technology should also be assessed. Farmers should be educated to the fact that better land and timely application of appropriate agri-inputs are needed to exploit the high potential yield of improved cultivars. Research to improve the micronutrient and protein status of children and young women should be undertaken. The importance of alleviating nutrient deficiency through a food-based approach should be emphasized.

By eliminating the beany flavor of soybean, consumption of soybean as a food could be increased in many Asian countries. Vegetable soybeans have very little beany flavor. Probably vegetable soybeans could be used as a forerunner to the introduction of other soybean products to South Asia. Soybean flour can be used to enrich other legume or cereal flours and locally produced products. There is a wide range of indigenous underutilized legume crops. It is essential to investigate the potential usefulness of these indigenous species as food, feed, fiber, raw material for industrial and medicinal products.

Traditional Processing and Utilization of Legumes (Saipin Maneepun)

The food legumes can be divided into two groups: pulses and oilseeds. The pulses group includes dry seeds of cultivated legumes which are traditional food. The oilseeds group used primarily for their oil content consisting of soybean and peanut, that represent roughly 73 percent and 17 percent, respectively of the total world production of grain legume crops. Post-harvest losses of legumes in developing countries amount to about 20-25 percent.

In 1999/2000, the world soybean production will decrease slightly due to unpredictable effects of consumers' concern about genetically modified soybeans. To achieve nutritional balance, cereals and legumes need to be consumed in the approximate ratio of 65 (cereal) to 35 (legume). The problems in producing dry legumes are the poor grain quality, high production cost, low productivity and inefficient marketing. Most farmers in developing countries are small landholders, and they usually grow legumes after cereal crops such as rice, corn and sorghum. Post-harvest handling, transportation and storage are the most important factors to consider in producing quality dry legumes. Inefficient post-harvest handling of legumes in developing countries has affected grain quality. Most farmers in developing countries dry their mature beans under the sun. Several locally made threshing, shelling and grading machines have been introduced by local merchants.

The traditional processed soybean food products known in Southeast Asia can be classified into two categories: 1) non-fermented and 2) fermented. The former includes soybean milk, tofu or soybean curd and yuba. Soybean milk can be prepared at home by grinding whole soybean with water and straining to make rich, creamy milk-like liquid called "soy milk". The product has a unique, beany flavor, which is a well-accepted beverage in Southeast Asian countries. Tofu is closely associated with soy milk. Yuba is a sheet-like coagulant formed on the surface of warm soy milk as it cools. The lifted sheet of soybean contains emulsified oil from soy milk and has high protein with a delicate flavor. The production is still at the cottage scale and industry level technology is yet to be developed. Fermented soybean products include soy sauce and soy paste. Both soy sauce and soy paste products have to be processed through the fermentation step of "koji" production. Most fermented soy products are processed into both soy sauce and soy paste in the ratio 70:30, 60:40 and 50:50 depending on the market requirements. Other fermented soybean products are fermented soybean, fermented white soybean and imitation fried pork rind.

Peanut is prepared for direct consumption by boiling, drying, roasting and confectioning. Peanut bar and coated roasted peanut products are processed by using modern equipment. The products are packed in good quality packaging to control moisture and air to prolong shelf life.

About 73 percent of mung bean production is used for local consumption. The largest processing industry is transparent noodle production and starch extraction, which accounts for about 20 percent. Transparent noodles are processed from mung bean starch.

Bean sprouts are produced from mung beans and blackgrams. The product is produced for fresh market and for daily consumption. Bean sprouts are processed on a home or cottage scale, using traditional technology.

The soybean industry has introduced a number of new infrastructure and technologies which have, and will continue to have, significant impact on farming methods, bulk commodity storage, handling and distribution. Direct utilization of soybean in the food industry include full fat soyflour for baking, soy-based beverages, and snack foods. Texturized vegetable protein (TVP) made from soyflour using single and twin screw cooker extrusion is available in dry forms.

Peanut processing technology has been developed similar to soybean. Peanut flour is obtained from oil extraction process. Various snacks developed from peanut bases are packed in attractive packaging. Peanut butter processing is quite a large industry.

A mung bean cracking machine, a grinder which separates liquid and solid, a starch separator, a starch mixer and a noodle machine have been developed for making transparent noodles.

At present, modern biotechnology to produce soybeans with herbicide resistance has increased public awareness on biosafety and food safety. Consumers around the world have different views towards the technology. Labeling has become a major issue. However, specific method to determine genetically modified organisms (GMO) and genetically modified foods (GMF) requires more scientific information to make labeling possible. Grains would be the fastest track to increase production capacity to meet the world population needs.

Modern Processing and Utilization of Legumes (Akinori Noguchi)

In Japan, 5 million mt of soybeans are imported annually. However, 4 million mt are consumed for edible oil production resulting in more than 3 million mt of defatted soybean.

About 90 percent of defatted soybeans is used in livestock feed because of shortages of feed resources in the country. According to the Food Balance Sheet, the domestic soybean production was less than 120,000 mt whereas the amount of imported soybean was 4.8 million mt. Domestic consumption of soybeans according to use was as follows: feed, 110,000 mt; seed, 3,000 mt; industrial use, 3,901,000 mt; waste, 120,000 mt; gross food, 785,000 mt; and net food, 785,000 mt.

In general, soybean foods are considered as subsidiary items to the principal foods (e.g., cooked rice) in Japan. The continuous decline in rice consumption has been reducing the demand for soybean foods, especially among young Japanese, due to the change in their food habits. Since the early 1980s, Japanese food markets have been in the age of gluttony and the food companies continue their efforts to diversify their soybean products by making new ingredients such as substitutes for meat proteins and extenders and improving the quality of final products. Therefore, soybean food companies are very eager to open new markets, and thus putting a great deal of effort into food research on soybean foods.

The major traditional soybean foods in Japan are miso, soy sauce, tofu and its derivatives. In 1998, the consumption of each soybean product was, not so different from the previous years, as follows: miso, 165,000 mt; soy sauce, 26,000 mt; tofu and its derivatives, 494,000 mt; fermented soybean, 122,000 mt; shimi-tofu, 30,000 mt; and others, 101,000 mt. Domestic soybean has been used mainly for making foods due to its higher content of protein, large seed size and good taste. The consumption pattern was 44 percent for tofu, 30 percent for cooked beans and side dishes, 13 percent for fermented soybean and 9 percent for miso and other products. Data suggest that the market size of traditional foods of soybean is not likely to increase so much in the future in Japan.

The production of food derived from vegetable proteins such as meat extenders and meat analogues value has grown to about 61,000 mt in 1997 (41,000 mt from soybean and 20,000 mt from wheat), according to the Japan Association of Vegetable Protein Foods. However, the market of these foods in Japan is being met.

The following technologies are expected to create new products from soybean and create a new market for them: extrusion cooking, high pressure cooking, ohmic heating and others.

The twin screw extruder has attracted the attention of researchers and food manufacturers because of its high capability in material transportation as compared to a single screw type. The better mixing, kneading, heat exchange and self-cleaning functions of twin screw extruders also provide an incentive to develop such food technology in order to overcome the difficulties associated with the single screw type. Recent development of twin screw extruders provides us with new applications in various food processing, especially to wet processes. One company mixed the defatted soy flour with potato starch and extruded the mixture at relatively higher moisture content with twin screw extruder. The extrudates were found to have very fine well aligned fibrous structure upon rehydration in hot water. Another company extruded the mixture composed mainly of soy protein and obtained meat-like products successfully accepted in the market. The idea of a cooling die also promotes this development and enables us to process fish and animal meats which has been thought to be impossible to be texturized with the extruder.

High pressure cooking applies hydrostatic pressure of several hundreds MPa on foods for the purpose of sterilization, protein denaturation, control of enzyme and chemical reactions, homogeneous defrosting at low temperature and others. The soy milk remained liquid within the range of examined pressure and its viscosity increased when the time of pressurization was less than 10 minutes. However, 500 MPa for 30 minutes solidified the soy milk. Soy milk showed better emulsifying and stability properties but had poor capacity. Additionally the content of SH residue in soy milk increased a little under anaerobic pressurization. The hard-type tofu could be made from the pressurized soy milk with $CaCl_2$. Electrophoresis and isoelectro-focusing techniques revealed that soy proteins were dissociated while some of them were coagulated by high pressure. Fluorescence analysis also showed that soy proteins were modified by high pressure, having larger hydrophobic regions. After pressure treatment, soy milk showed higher affinity to beany flavor components and saponin which would lead to better use of soy milk in soy foods.

High pressure cooking is characterized by the following: 1) the transfer of high pressure is spontaneous and does not depend on the shape of materials; 2) high pressure cooking is free from the problem of mechanical deterioration of materials caused by the agitation necessary for the homogeneous and quick heat transfer; 3) high pressure could be maintained by the mechanical method and saves the energy needed for cooking; and 4) the release of high pressure could be achieved instantly which makes the cooking controllable.

When food products contain sufficient water and electrolytes to pass electric current, ohmic heating could be used to generate heat within the food products by the passage of an alternating current. The method enables the solid phase or viscous liquids to be heated as fast as thin liquids, thus making it possible to use HTST techniques on solid or viscous foods. The results clearly indicated that ohmic heating provides quick temperature rise in plants and protein solutions. The major benefits of ohmic heating are summarized as follows: 1) continuous production without heat-transfer surfaces; 2) rapid and uniform treatment of liquid and particulates, with minimal heat damage and residence-time differences; 3) ease of process control with instant shutdown; 4) reduced maintenance costs; 5) environmentally friendly system; and 6) ideal process for shear-sensitive products. Some Japanese tofu manufacturers are interested in these characteristics of ohmic heating and have started to examine its potential for tofu making.

Soy protein can form the translucent gel. The process involves defatted soybean extract being dialyzed against distilled water at 7.5 pH. The dialysate is a transparent solution having less beany flavor. After heating, the desalted soybean extract keeps transparency even in the presence of salt (NaCl). When the desalted soybean extract, preheated under salt-free condition is heated again in the presence of NaCl (0.2 M), it gives a translucent gel at a lower concentration than that of non-heated desalted soybean extract. The translucent gel is melted by the following heating and gellified again by cooling, that is, this gel is cold-setting and gel-sol transition is reversible, which is confirmed by the measurement of dynamic viscoelasticity. Desalted soybean extract preheated under salt-free condition could give a gel at room temperature or lower temperature only by addition of salt, and is not precipitated by the incubation at 4ºC, which is different from native soybean protein.

HIGHLIGHTS OF COUNTRY PAPERS

Legumes form one of the largest families of flowering plants but only a handful of them are grown extensively in Asia and the Pacific such as soybeans, peas, lentils, beans and peanuts. They constitute healthy and versatile food as they produce many of the nutrients the human body needs. Legumes are particularly high in protein, cholesterol-free, high in dietary fibers and low in saturated fat. In addition to their being a major source of food and nutrition for the population, legumes also contribute to agriculture and the environment. Their nitrogen-fixing property, for instance, can enhance soil fertility and as crop cover, they can help prevent soil erosion. Legumes also have potential medical applications as some are said to prevent or alleviate hypertension, diabetes and cancer.

Food legumes can be generally classified into pulses and oilseeds. In East Asia the most important legume grown and consumed is soybean. In other Asian countries it is economically less important although in recent years the commodity has grown in importance, particularly, due to its potential contribution to enhancing food nutrition security. In some countries it is a recently introduced crop.

Legumes comprise an important part of the Asian diet, being consumed usually in combination with cereals. Pulses, in particular, have been considered as the cheapest source of protein in South Asia and have traditionally been consumed by the rural poor. Accordingly, cereal-based diets have been improved in terms of overall nutritional value with the supplementation of pulses. Legumes have been used to address specifically the problem of protein-calorie malnutrition in a number of countries.

In general, however, legumes have been given lesser priority as they still account for a relatively small share of the diet in most Asian countries. Despite this, the production, particularly of pulses, has generally increased though not substantially, during the last decade. Productivity levels, however, have remained low compared to world averages. This indicates that a significant part of the production increases could be attributed more to area expansion. The crops are usually cultivated after rice. In some cases, it may be grown in poor or marginal lands. In a few countries (e.g., Iran and Mongolia), climatic conditions have served to increase the variability of production, as well as to limit the choice of crop varieties. In East Asia and a few other countries (e.g., Malaysia, Sri Lanka and Thailand), production of pulses has gone down due to a number of factors such as increased costs of production, shortage of labor and low returns to investments. Many of the countries in fact have been importing a significant amount of their legume requirements, particularly soybeans, for both human consumption and animal feeds.

Except for a few countries like the Philippines, consumption of legumes has had a long history. Consumption especially in South Asia is usually in processed form. Thus, mung bean and other pulses are traditionally consumed as dhal although recently people are consuming more bean sprouts in these countries. In East Asia, consuming legumes as vegetables is more common. Thus, legumes such as soybean and peanut are prepared for consumption by boiling, drying, roasting and confectioning.

In the case of soybean, a variety of processed food products are produced in the region. These products are generally classified into non-fermented and fermented. The major non-fermented products include soybean milk, soybean curd (tofu), soy cheese, yuba, soy flour and bean sprouts. Fermented products, on the other hand, include soy sauce, soy paste, fermented tofu and fermented whole bean. Each country has its own local names for these traditional products. Peanut processing has been developed in similar fashion as in soybean. The processed products come mainly in the form of snack foods. Mung bean, aside from its use as bean sprouts, is also processed to produce transparent noodles and starch.

The introduction of modern technologies has improved invariably the processing and utilization of legumes in the region. For instance, in Taiwan the beany flavor of soybean milk has been removed by enzyme inhibition and oxygen exclusion thereby enhancing the acceptance of the product by consumers. Improved packaging using tetra pak and addition of flavoring has also increased demand. The potential industrial and medical uses of legumes are also being increasingly exploited, particularly, in those countries where non-food benefits are receiving greater attention. To be sure, improved and low-cost technology packages have also been developed to enhance traditional processing of legumes. For example, mechanical dryers and power-operated cleaners and graders introduced in India and other countries, have served to improve the quality and safety of the products.

Despite these achievements, however, a number of problems and issues are affecting the processing and utilization of legumes in the region. Among these are: 1) significant amount of post-harvest losses, particularly, during storage and milling of grain legumes; 2) lack of support services, particularly, credit and marketing; 3) inadequate supply of high quality and reasonably priced raw materials; 4) mycotoxin contamination and pesticide residue in vegetables; 5) lack of appropriate storage facilities; 6) need to develop more suitable and efficient processing and packaging technologies; 7) social and cultural taboos and lack of consumer awareness of the nutritional value of legumes which has hindered their wider utilization; and 8) low profitability/returns of legume production compared to other types of farming. A potential issue that is yet to affect most of the developing countries in Asia is the current controversy on GMO. A few countries in the region like Japan, Korea and Taiwan are addressing the GMO issue already. In Korea, for instance, labeling of GMO products will be required by March 2001 in the case of soybean, corn and soybean sprouts and by March 2002 in the case of potato.

Legume production, processing and utilization are expected to expand in the future as further economic development takes hold in the region and as changing lifestyles compel more and more people to consume healthier foods. This will, however, require the undertaking of more programs to improve the quality of processed food products. In this regard, developing countries will need to strengthen the necessary systems for quality certification in order to improve the competitiveness of the legume industry. Such systems will increasingly become important with the increasing globalization trend and growing concern for food safety and sustainability issues. Another important factor to consider will be the profitability issue. To improve the returns in legume production, a more supportive policy environment will be vital. It will involve, among others, the provision of appropriate price incentives, adequate research and development (R&D) support, more effective technology transfer mechanism, better access to credit and improved post-harvest facilities. New product development will be market-driven and in this connection, market studies will be important. There will also be a need to obtain more knowledge about the nutritional/ functional properties of legumes.

FIELD STUDIES

For their field studies, the participants visited the following sites, namely: 1) National Food Research Institute in Tsukuba; 2) Fuji Oil Co., Ltd. in Tsukuba; and 3) Taishi Food Company in Nikko.

The highlights of these visits are presented below:

National Food Research Institute

The National Food Research Institute (NFRI) was established in 1934 as the Rice Utilization Laboratory mainly to develop new rice-based food products from the surplus rice that was mounting up during this period. As the Institute assumed wider functions it was renamed as the Food Research Institute in 1949 and as the National Food Research Institute, its present name, in 1972.

The Institute, which is one of the research institutes under the MAFF, is the only national research institution conducting post-harvest research in the country. It covers a wide range of research activities from basic to applied. The main research areas are: 1) analysis of food components and food quality; 2) evaluation and utilization of food materials; 3) technology development for food processing and distribution systems; and 4) elucidation and utilization of biological functions for new food materials. The Institute has about 130 scientists and research staff working in eight technical divisions and two administrative and planning divisions. However, it also provides research and training facilities to researchers from private companies, institutions and universities including doctoral and masteral students. All in all, therefore, at present there are some 400 people working in the Institute.

The eight technical divisions and their corresponding major research area are:

1) Food Science Division – physiological and biochemical properties of carbohydrates, proteins and lipids;
2) Food Analysis and Assessment Division – development of new methods for food analysis and quality evaluation;
3) Food Function Division – elucidation and evaluation of physiological functions of food components;
4) Post-harvest Technology Division – development of biological, chemical and physical processes to preserve quality and safety of food during distribution;
5) Food Materials Research Division – development of new technology for processing of agricultural products and waste;
6) Applied Microbiology Division – utilization of microorganisms and enzymes for food processing;
7) Biological Function Division – engineering and biotechnology of bio-molecules and cells; and
8) Food Engineering Division – development of new technology for food production and processing using physical and engineering methods.

Fuji Oil Co., Ltd.

The company is an intermediate food ingredients manufacturer which was established in Osaka in 1950. Since its founding, the company has focused its attention on oils and fats such as coconut and palm oils in creating its own unique products. The company was the first in the world to commercialize its fractionation and enzyme transesterification technologies which were used to complete hard butters that improved the properties of chocolate such as its melting characteristics and shelf life.

Fuji Oil is part of the Fuji Group of Companies which comprises 10 overseas companies located in seven different countries and 10 companies located in Japan. The Group is engaged in the following businesses: 1) oils and fats processing; 2) chocolate ingredients; 3) confectionery and baking ingredients; 4) processed food product ingredients; 5) soy protein; 6) processed soy protein food products; 7) soy milk; 8) new materials/ ingredients; and 9) household and home cooking products. Fuji Oil itself has three divisions: Oils and Fats, Confectionery Materials and Protein.

In developing its soybean-based products Fuji Oil initially focused on defatted soybean and it was the first domestic company to develop an isolated soy protein. The company expanded the nutritive potential of the latter and its applicability as a flavorful and functional food ingredient. In focusing also on carbohydrates of soybeans, Fuji Oil developed water-soluble soy polysaccharides which have a diverse range of functions and applications.

The Company uses high purity soy protein to create processed food products that can be stored for long periods in the refrigerator and that can be cooked easily without losing their shape such as tofu burgers and soy steaks. In developing new ingredients the company is working on the latest approach to soy peptide by using enzyme hydrolysis technologies. It is also now venturing into the development of non-food products.

The Fuji Group produces and sells their specialty intermediate food ingredients developed from its own R&D facility in Tsukuba which the participants had a chance to visit. The consolidated net sales of the Group amounted to ¥141.7 billion during the fiscal year ending March 2000.

Taishi Food Company

The company began its business as Kudo Shoten in Aomori Prefecture in 1940. It was reorganized in 1964 and became the present-day Taishi Food Company. The company has four plants. The newest one located in Nikko which the participants visited started operations only in 1998. Taishi produces soybean-based food products such as soy milk, tofu and natto. The company purchases its raw materials both locally (mainly from Hokkaido) and from abroad (mostly from Canada) due to research studies that show that "northern soybeans" are rich in natural nutrients, particularly, isoflavones. Taishi is a top producer of tofu in the country. Its Nikko plant produces soy products mainly for the Kanto market which includes metropolitan Tokyo.

The Taishi plants are all located near national parks to take advantage of the presence of natural spring water sources which are important for enhancing the quality and safety of the company's products. The new factory in Nikko has in fact adopted the HACCP (Hazard Analysis and Critical Control Point) management system to produce safe, worry-free, healthful and genuine products. Its factory administration policy puts emphasis on three areas: 1) maintenance of the safety and good health of employees; 2) keeping harmony with the environment; and 3) continuing improvement of the quality and safety of the products.

Taishi has set new standards for making tofu to offer consumers a healthy and enjoyable experience and a proper diet. These standards include: 1) use of only isoflavone-rich "northern soybeans" grown in Hokkaido and Canada; 2) use of only natural hybrid soybeans (strictly no GM beans are used); 3) production of the freshest tofu by using only water, beans and bittern (magnesium chloride); 4) use of healthful additive-free production methods; 5) use of an automated production line that is safe and clean to ensure that the tofu remains fresh for at least 10-15 days; and 6) development of "petit" tofu which is available in three flavors (plum, perilla and sesame) to appeal to feminine taste.

CONCLUSION

Given the continuing population growth and the still low per capita consumption of legumes in Asia and the Pacific, the prospects for further expanding legume processing and utilization in the region appears bright. To achieve this, however, some priority needs to be given to legumes in national development programs, particularly, as these crops attain greater importance in the food and nutrition security of developing countries and also as these countries are able gradually to exploit the non-food benefits and uses of legumes. There will further be a need to improve the knowledge about bioavailability, particularly, of micronutrients in legumes to be able to develop healthier and more nutritious processed food products. At the same time, consumer awareness about the food and health properties of legumes will need to be promoted. Consumer acceptance of legume-based processed foods will also require improvement in their palatability. In all this, it is essential that relevant national programs be developed more holistically involving closer collaboration among scientists of various disciplines.

The seminar provided the participants an opportunity to review the present situation of legume processing and utilization in their respective countries. It also gave them a chance to learn in greater detail current processing technologies being developed and applied by the government and private companies in Japan. The seminar discussions, in particular, raised a number of important issues which will need to be addressed by individual countries and by the region as a whole. In this regard, the participants felt that more attention and priority should be given to legumes in light of their increasingly important role in meeting the food and nutrition requirements of their respective countries.

1. PRESENT SITUATION AND ECONOMIC IMPORTANCE OF LEGUMES IN ASIA AND PACIFIC REGION

Sundar Shanmugasundaram
Plant Breeder and Director
Program I – Vegetables in Cereal-based System
Asian Vegetable Research and Development Center
Tainan, Taiwan
Republic of China

INTRODUCTION

The Asia and Pacific region has more than half of the world's population – about three billion people – but less than 3 percent of the world's arable land. The major focus of agricultural research in Asia since the 1960s has been cereals (wheat, rice and maize). Thanks to the Green Revolution, the region was sufficient in food energy (ESCAP, 1985). Protein-calorie malnutrition remains, however, a disturbing problem in developing countries (FAO, 1985), and almost two billion people in the world suffer micronutrient deficiency (Ali and Tsou, 1997).

By the year 2020, the population of Asia (excluding Japan) is expected to be at 4.42 billion, up from 3.31 billion in 1995, a 33.5-percent increase. Asia is expected to account for 60.5 percent of this population rise (Andersen, *et al*., 1999). New evidence has confirmed that anemia, the result of inadequate intake of iron, is widespread among women, especially pregnant women (76 percent), and children (63 percent). Legumes, including annual oilseeds, are high in protein, micronutrients, vitamins, minerals and plant fibers. In addition, legumes are able to fix nitrogen from the air (through their symbiotic association with the rhizobium bacteria), and they are adaptable to a variety of cropping systems. Legumes are the major source of protein and constitute an important supplement to the predominantly cereal-based diet of Asians (Singh, 1988). Cereals are deficient in amino acid lysine, which is compensated for by the surplus in legumes, while legumes are deficient in sulfur-containing amino acids, which is compensated for by a relative surplus in cereals (Thirumaran and Seralathan, 1988) (see Box 1 for a list of various legume crops. Many are commonly referred to as pulses in South Asia). Unfortunately, high-yielding varieties (HYVs) of Green Revolution cereals have taken over much of the area once devoted to legumes. Due to their low yield, risks involved in production, and poor return, legumes have been neglected. For example, per capita yield of wheat increased significantly from 1961 to 1972, but in the same period, per capita yield of legumes decreased. In the absence of sufficient domestic supply, importation met the demand for protein in most Asian countries. For example, Pakistan was forced to spend much-needed foreign exchange to import legumes to supplement domestic production (Ali, *et al*., 1997). Nearly 80 percent of dietary protein in the developing world is plant protein, compared to 43.4 percent in developed countries, which consume mostly animal protein (Paroda, 1995). In 2000, the per capita protein supply per day from vegetable sources in Asia was 49.8 gm, compared to 21.2 gm from animal sources. Asian countries consume mostly plant protein (Table 1). Invariably, cereals provide the major share of energy and protein. Legumes are supplementary sources of calories, protein and fat in several Asian countries (Table 2). Therefore, the importance of legumes in improving nutrition cannot be understated, especially when you consider that legumes help improve the income of farm households, diversify cropping systems and sustain the productivity of agricultural land.

Box 1. List of Various Legume Crops

Representatives of the legume family of crops can be found on all continents. Asia is a center of origin of some food legumes. The economically important legumes belong to the subfamily Papilionoideae. In South Asia, the economically valuable legumes include chickpea (*Cicer arietinum*), pigeon pea (*Cajanus cajan*), mung bean (*Vigna radiata* var. *radiata*), adzuki bean (*Vigna angularis*), cowpea (*V. unguiculata*), lentil (*Lens culinaris*), moth bean (*V. aconitifolius*), rice bean (*V. umbellata*), horse gram (*Kerstingiella uniflora*), khesari (*Lathyrus sativus*), broad bean (*Vicia faba*), lima bean (*Phaseolus lunatus*), common bean (*P. vulgaris*), garden pea (*Pisum sativum*), runner bean (*P. coccineus*), groundnut, peanut (*Arachis hypogaea*), soybean (*Glycine max*), winged bean (*Psophocarpus tetragonalobus*), and yard-long bean (*V. sesquipedalis*). Except for the major legumes, such as chickpea, pigeon pea, groundnut, peas, broad bean and soybean, the other beans including mung bean and black gram have been grouped under dry beans and statistical data for many of them are unavailable.

Source: Kyi, *et al*., 1997

While population growth has increased the demand for food, rising prosperity has increased demand for *quality* food. At the same time, migration to urban centers and changes in life style, due to education and job prospects, have changed food habits and dietary patterns. People want convenience foods, and they are becoming increasingly health-conscious. There is a need, therefore, to diversify food products made from legumes and oilseeds to meet the needs of modern, evolving consumers.

Kyi, *et al*., 1997 stated that although pulses are not known for their global or regional economic importance, they do constitute the third largest processing market in India. Because most legume species are local, and grown only in a few countries, they are often lumped together under the category ‘pulses’. Given their many names, sorting out which pulse is from one country to the next, even within a country like India, can be difficult. Internal trade in pulses and even international trade goes unregistered (Kyi, *et al*., 1997). Soybean, an internationally traded commodity, is somewhat of an exception. Very good data are available on this crop for the U.S.A., Brazil and Argentina, but are unavailable for other countries. Because the price of soybean is determined in international trade, it can be used to calculate the value of soybean in other countries, as can the value of soybean oil and meal.

This paper presents current trends in production and consumption of legumes in the Asia and Pacific region, and compares them to a decade ago. It also projects future prospects and issues related to legume processing and utilization in the region. Wherever data are available, economic aspects are briefly discussed.

Table 1. Source of Food Energy, Protein and Fat Supply for Different Countries in Asia, 2000

Country	Energy		Protein		Fat (gm/capita/day)	
	Vegetable	Animal	Vegetable	Animal	Vegetable	Animal
Australia	2,126.4	1,049.4	35.9	71.2	66.5	72.0
Bangladesh	2,035.4	67.3	38.8	6.1	18.1	3.9
Cambodia	1,887.8	182.0	37.1	12.7	18.3	13.5
China	2,445.9	583.3	55.7	29.8	34.7	49.3
India	2,233.7	194.2	46.8	10.4	34.9	13.1
Indonesia	2,785.4	116.9	52.8	11.4	48.0	7.1
Japan	2,193.2	569.1	40.4	51.3	48.5	34.6
DPR Korea	2,061.4	123.3	55.1	7.2	24.2	10.0
Rep. of Korea	2,629.0	463.7	51.6	38.4	44.8	30.9
Lao PDR	2,107.5	158.6	47.1	10.1	16.3	12.1
Malaysia	2,353.2	565.6	31.8	43.3	51.9	35.3
Myanmar	2,718.2	124.2	64.2	9.8	37.2	8.2
Nepal	2,275.7	160.1	53.2	9.1	24.8	11.2
New Zealand	2,165.7	1,086.5	36.9	66.8	38.4	81.9
Pakistan	2,022.8	429.4	40.2	22.2	34.8	29.3
Philippines	2,024.6	354.0	31.2	24.1	22.8	26.5
Sri Lanka	2,249.5	155.3	40.3	13.8	38.0	8.3
Thailand	2,222.4	284.0	32.6	22.7	31.5	19.3
Vietnam	2,310.8	271.9	46.4	15.4	18.0	22.4
Asia	2,345.1	367.9	49.8	21.2	35.6	28.3

Source: FAO, 2000, from Mariana Campeanu, Statistician/FAO (personal communication), November 2002.

Table 2. Source of Food Energy, Protein and Fat from Pulses, Soybean and Groundnut for Various Countries, 2000

Country	Energy (calorie/capita/day)			Protein (gm/capita/day)			Fat (gm/capita/day)		
	Pulses	Soybean	Groundnut	Pulses	Soybean	Groundnut	Pulses	Soybean	Groundnut
Australia	40.7	0.6	21.9	2.6	0.0	1.0	0.3	0.0	2.0
Bangladesh	35.1	-	0.3	2.2	-	0.0	0.2	-	0.0
Cambodia	14.0	0.6	4.4	0.9	0.0	0.2	0.0	0.0	0.4
China	13.3	65.6	45.0	0.9	6.1	1.9	0.1	2.2	3.7
India	106.2	4.4	4.9	6.3	0.5	0.2	0.9	0.2	0.4
Indonesia	35.6	78.2	52.7	2.3	7.2	2.2	0.2	2.7	4.4
Japan	17.2	95.1	14.8	1.1	8.5	0.7	0.1	3.7	1.2
DPR Korea	116.3	105.8	-	7.5	9.8	-	0.6	3.7	-
Rep. of Korea	15.9	68.0	11.3	1.0	6.2	0.5	0.1	2.9	1.0
Lao PDR	24.7	4.7	10.6	1.6	0.4	0.4	0.1	0.2	0.9
Malaysia	15.4	0.5	15.1	1.0	0.0	0.6	0.1	0.0	1.2
Myanmar	114.3	16.5	18.9	7.2	1.9	0.8	0.7	0.9	1.6
Nepal	74.6	-	-	5.0	-	-	0.4	-	-
New Zealand	34.1	2.1	27.5	2.2	0.2	1.3	0.2	0.1	2.4
Pakistan	61.3	0.4	1.6	3.7	0.0	0.1	0.4	0.0	0.1
Philippines	15.2	2.7	13.8	1.0	0.3	0.6	0.1	0.0	1.2
Sri Lanka	73.0	-	0.0	4.6	-	0.0	0.3	-	0.0
Thailand	31.9	24.6	18.9	2.0	2.2	0.8	0.1	1.1	1.6
Vietnam	25.8	12.8	22.5	1.6	1.1	1.0	0.1	0.5	1.9

Source: FAO, 2000, from Mariana Campeanu, Statistician/FAO (personal communication), November 2002.

CURRENT TRENDS IN PRODUCTION

Total Pulses

The area, production and productivity of pulses will be discussed separately from that of groundnut and soybean. Similarly the data for Asia will be presented separately from that of the Pacific or Oceania. For a recent review of production, consumption and marketing of pulses, readers are referred to three recent publications (Sinha and Paroda, 1995; Kumar, 1998; and Kyi, *et al*., 1997). The annual growth rates were calculated for each of the legumes. For pigeon pea, the trend reported by Nene, *et al*. (1990) is presented due to lack of annual data. And because cowpea is a very minor crop in Asia, annual data are unavailable to calculate trend.

In 1989, 35.61 million ha were planted to pulses in Asia (33 countries)*, representing 50.92 percent of world pulse production area. Farmers in Asia produced 24.04 million mt, or 43.61 percent of world pulse production. Average yield was 675 kg/ha. South Asia (comprising Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) accounted for 72.3 percent of production area and 61.7 percent of production; Japan, China and Korea, 13.78 percent of area and 22.18 percent of production; and Southeast Asia (comprising Cambodia, Indonesia, Lao PDR, Myanmar, Philippines, Thailand and Vietnam), 5.17 percent of area and 6.40 percent of production. India dominated with 65 percent of the production area and 56 percent of the production in Asia. Worldwide, India led with 34.4 percent of area and 24.84 percent of production (Table 3). Has the situation changed in 10 years?

In 1999, total area planted to pulses in Asia was 38.06 million ha, an increase of 6.88 percent over 1989. This amounts to 53.87 percent of world area, an increase of 2.95 percent over 1989 (FAO included Armenia, Azerbaijan, Georgia, Kazakhstan, Turkmenistan and West Bank in its data for 1999, but these are not reported in Table 3 because their totals are insignificant). Pulse area increased substantially (14.5 percent annually) in Myanmar, where pulses rank third in importance and are being promoted vigorously as an important source of foreign exchange earnings (Kyi, *et al*., 1997). India targeted production at 17.45 million mt in 1995 (Kyi, *et al*. 1997), but the 1999 production, at 16.1 million mt, fell well short of that mark. Twelve countries recorded a significant decrease in area planted to pulses (Table 3). Pulse production in Asia reached 28.84 million mt in 1999, a 19.96-percent increase from 1989. This represents 2.5 percent annual growth rate. Despite a 0.2-percent annual decrease in area since 1989, production in China increased annually by 1.5 percent, owing to a 1.7-percent annual increase in productivity. Rising land values and labor costs are responsible for declining trends in pulse area and production in Taiwan, Japan and Korea. In some Asian countries, such as Cambodia, HYVs have yet to make an impact and, therefore, production is in decline (Table 3). In 15 countries, pulses productivity grew 1-5.9 percent annually, while in all of Asia, pulses productivity increased from 675 kg in 1989 to 780 kg in 1999, which represents an annual growth rate of 1.8 percent (Table 3).

---

* The countries included in Asia are Afghanistan, Bahrain, Bangladesh, Bhutan, Cambodia, China, Cyprus, Gaza Strip, India, Indonesia, Islamic Rep. of Iran, Iraq, Israel, Japan, Jordan, DPR Korea, Rep. of Korea, Lao DPR, Lebanon, Macau, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Sri Lanka, Syria, Thailand, Turkey, Vietnam and Yemen.

Table 3. Area, Production, and Productivity of Pulses in Asia, 1989 and 1999

	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR (percent)*	1989	1999	GR* (percent)	1989	1999	GR* (percent)
Afghanistan	25.0	37.0	0.5	41.0	35.0	6.5	1,640	946	5.9
Bangladesh	695.0	667.6	-1.8	493.1	513.3	-0.8	709	769	1.0
Cambodia	44.0	25.0	-1.0	41.0	10.5	0.6	932	420	1.5
China	4,417.0	2,841.5	-0.2	4,814.0	5,347.0	1.5	1,090	1,882	1.7
India	23,244.8	25,394.0	-0.3	13,447.0	16,095.0	0.8	578	634	1.1
Indonesia	307.0	563.0	1.6	394.0	901.5	3.3	1,283	1,601	1.7
Iran	551.0	957.9	5.0	386.0	565.6	4.1	701	590	-0.9
Iraq	19.0	33.6	6.3	13.5	36.2	8.5	711	1,077	2.1
Japan	94.0	58.5	-4.0	147.0	103.3	-3.0	1,564	1,769	1.1
DPR Korea	350.0	320.0	-1.1	320.0	270.0	-2.1	914	844	-1.0
Rep. of Korea	45.9	29.1	-3.7	53.4	31.5	-4.0	1,163	1,082	-0.3
Lao PDR	15.9	15.2	-0.4	32.0	15.0	2.0	2,013	987	2.4
Lebanon	14.0	20.1	1.4	16.0	41.4	4.1	1,143	2,060	2.7
Myanmar	496.0	2,190.1	14.5	342.0	1,895.1	16.2	690	865	1.5
Nepal	292.2	298.3	0.3	171.1	213.1	2.7	586	714	2.4
Pakistan	1,407.0	1,715.3	-1.2	667.0	1,122.5	0.8	474	654	2.0
Philippines	39.0	76.0	1.7	31.0	59.0	-0.2	795	776	-1.8
Sri Lanka	93.0	47.0	-3.6	69.0	28.4	-6.6	742	604	-3.1
Syria	281.3	186.6	1.9	106.3	112.6	4.7	378	603	2.8
Taiwan	11.3	5.8		17.8	10.2		1,575	1,759	
Thailand	651.4	428.0	-4.6	511.1	367.0	-4.0	785	857	0.6
Turkey	2,169.0	1,651.6		1,680.0	1,661.1		775	1,006	
Vietnam	290.0	357.5	2.0	187.0	245.1	3.2	645	686	1.2
Yemen	30.0	61.1	2.5	47.0	74.1	0.3	1,567	1,213	-2.2
Asia	35,582.8	37,979.8	0.6	24,027.3	29,753.5	2.5	675	783	1.8

Source: *FAO Production Yearbook*, and FAOSTAT statistics database accessed September 2000, FARO, Rome, Italy.
Note: * GR = average annual growth rate.

Table 4. Area, Production, and Productivity of Dry Beans in Asia, 1989 and 1999

	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR (percent)*	1989	1999	GR* (percent)	1989	1999	GR* (percent)
Bangladesh	123.0	120.0	-2.3	80.0	85.0	-1.9	650	708	0.4
Cambodia	44.0	25.0	1.0	41.0	10.5	0.6	932	420	1.5
China	1,417.0	1,000.0	1.7	1,314.0	1,800.0	4.3	927	1,800	2.5
India	9,560.0	9,900.0	-2.4	3,658.0	4,550.0	-3.7	383	460	-1.3
Indonesia	300.0	560.0	1.7	390.0	900.0	3.3	1,300	1,607	1.6
Iran	230.0	116.1	-1.8	184.0	182.9	4.0	800	1,575	5.9
Japan	90.5	57.8	-3.8	142.2	102.0	-2.8	1,571	1,765	1.1
DPR Korea	350.0	320.0	-1.1	320.0	270.0	-2.1	914	844	-1.0
Rep. of Korea	33.9	22.4	-3.1	39.1	24.1	-3.4	1,154	1,076	-0.2
Lao PDR	4.9	1.7	-9.9	3.1	1.5	-7.0	633	882	3.3
Myanmar	300.0	1,674.7	16.6	209.0	1,207.5	18.8	697	721	1.9
Nepal	26.5	37.3	4.7	14.4	23.3	6.4	543	625	1.6
Pakistan	185.0	245.0	0.6	96.4	115.0	1.9	521	469	1.3
Philippines	37.0	36.0	0.2	27.0	26.0	1.6	730	722	1.4
Sri Lanka	70.0	30.0	-2.4	50.0	15.0	-7.7	714	500	-5.4
Taiwan	11.3	5.8		17.8	10.2		1,575	1,759	
Thailand	495.4	315.0	-4.8	356.1	245.4	-4.2	719	779	0.6
Turkey	177.0	171.0		193.0	242.0		1,090	1,415	
Vietnam	160.0	221.5	3.1	100.0	144.1	4.7	626	651	1.5
Asia	13,615.5	14,859.3	0.1	7,235.1	9,954.5	1.3	531	670	1.2

Source: *FAO Production Yearbook*, and FAOSTAT statistics database accessed September 2000, FAO, Rome, Italy.
Note: * GR = average annual growth rate.

Dry Beans

Among the pulses, dry beans (*Phaseolus* and *Vigna* spp.) account for one of the largest groups (FAO data). In 1989, India dominated with total area of 9.6 million ha, 72 percent of total dry bean area in Asia and 37.9 percent of world dry bean area. In 1999, although total dry bean area in India increased by about 340,000 ha, it represented only 66.4 percent of the dry bean area in Asia (Table 4). But on a worldwide basis, its position remained about the same as in 1989. The increase in area and production between 1989 and 1999 for Asia was primarily due to the remarkable jump in area in Myanmar, from 322,900 ha to 1,674,701 ha, 16.6 percent annual growth. China, Indonesia, Iran, Nepal, Pakistan, Philippines and Vietnam had modest annual production growth of 1.6-6.4 percent. Production in Sri Lanka declined 7.7 percent annually (Table 4). Taiwan, Japan, and Korea experienced decline, which is expected to continue, due to the reasons mentioned earlier.

Production of dry beans in Asia increased 1.3 percent annually from 1989 to 1999, due to increases in yield per unit area and a slight increase in area planted. The data indirectly show that legumes are catching up with cereals. Farmers are adopting improved cultivars and intensive cultivation practices because of better returns and lower risk. Myanmar's 18.8-percent annual growth in production is a shining example. That increase was the result of yield increases for mung bean (green gram) (720 kg/ha in 1996-97 compared to 307 kg/ha in 1980-81) and pigeon pea (576 kg/ha in 1996-97 compared to 389 kg/ha in 1980-81), which spurred increases in planted area. Mung bean and pigeon pea area increased from 41,000 ha and 68,000 ha in 1980-81 to 474,000 ha and 283,000 ha in 1996-97, respectively (Bahl 1999). Mung bean area is expected to reach 650,000 ha in 1997-98 and one million ha in 1999-2000 (Table 4 and Figure 1). A new mung bean cultivar from the Asian Vegetable Research and Development Center (AVRDC), VC1973A, with high yield, uniform maturity and resistance to diseases, occupies almost 90 percent of the mung bean area in Myanmar (Source: Bahl, 1999; Consultancy Report, FAO RAPA, Bangkok, Thailand; and Dr. R. T. Opeña, 1999).

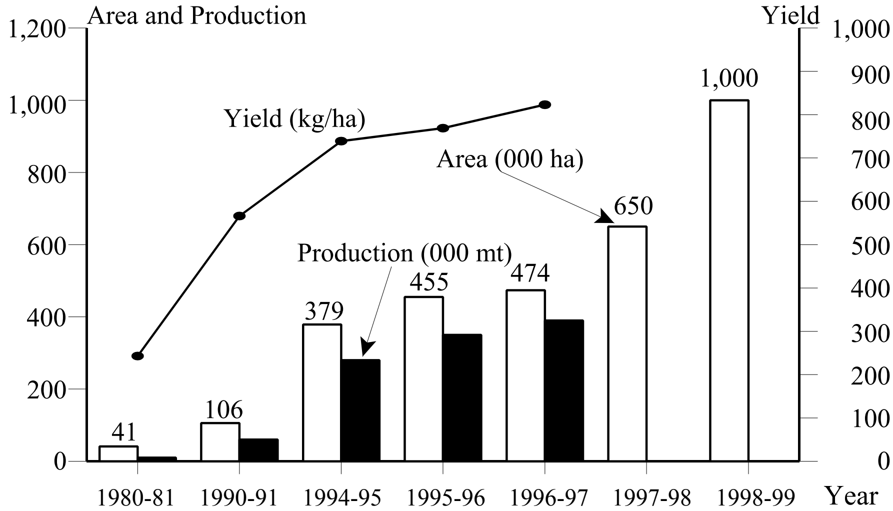


Figure 1. Area, Production and Yield of Mung Bean in Myanmar, 1980-81 to 1998-99

Source: Bahl, 1999 and R. T. Opeña, 1999.

Out of 19 countries producing dry beans in 1999, all but eight recorded positive growth in production compared to 1989 (Table 4). A 7.7-percent reduction in annual growth rate of dry bean production was observed in Sri Lanka. Of the 19 countries, India, DPR Korea, Rep. of Korea and Sri Lanka recorded a decrease in annual growth rate in yield per unit area from 1989 to 1999, while the other countries had growth in yield per unit area (Table 4).

The yield potential of mung bean in China has been reported as 4,500 kg/ha (Xuzhen and Lifen, 1993). Five high-yielding cultivars, namely; Zhong Lu #1 (VC1973A), Zhong Lu #2 (VC2917A), E Lu #2 (VC2778A), Su Lu #1 (VC2768A), and Yueh Yin #3 (VC1628A), were released and extended to farmers (Huanyu and Zhizong, 1993). In 1989, the area planted to Zhong Lu #1 reached nearly 267,000 ha, about 45 percent of the mung bean area. This was the first mung bean cultivar released for nationwide cultivation in China since 1949 (Xuzhen, 1993; and Xuzhen, *et al*., 1993). Average yield has risen 15-45 percent, and farmers commonly obtain a yield of 2,500 kg/ha. Such increases have resulted in increased mung bean area. In 1988, Babu and Hallam predicted that, given the rapid improvement in mung bean production, China would emerge as a mung bean exporter. Their prediction became a reality. The same authors projected that demand for mung bean in 1995 would far exceed supply. Some 1.8 million mt was predicted, but production reached 2.9 million mt in 1995, which exceeded predicted demand of 2.1 million mt (Tickoo and Satyanarayan, 1998; and Babu and Hallam 1988).

Working in collaboration with AVRDC, Pakistan has developed nine improved mung bean cultivars since 1983 (Shanmugasundaram, 1988; and Ali, *et al*., 1997). These cultivars have a yield potential of up to 1,800 kg/ha, compared to the local cultivars' 1,000 kg/ha. The new HYVs are early maturing (about 60 days compared to 90 days for the local cultivars), are uniformly maturing (so that they can be harvested in one picking), and, more importantly, they are resistant or tolerant to mung-bean yellow mosaic virus (MYMV), a serious yield-limiting disease in South Asia. A survey showed that more than 50 percent of Pakistani farmers are using the improved mung beans (Ali, *et al*., 1997). Yield of new cultivar NM92, for example, is 55 percent higher than the local cultivar, and the return to farmers is four-times higher due to a 25-percent reduction in cost of production. Because no insecticide is needed to control MYMV, it is also friendly to the environment. Moreover, rotation of mung bean with wheat helped to improve wheat yield (Ali, *et al*., 1997).

Peas

The total area planted to peas in 1999 was 1.69 million ha, with a 3-percent annual growth from 1989 (Table 5). Out of five countries, Myanmar and India had substantial annual growth rates of 9.7 percent and 5.3 percent, respectively. Area decreased significantly in Bangladesh and China (Table 5). Total production of peas has grown 3.8 percent per annum since 1989. All countries where there was a growth rate increase in area had a growth rate increase in production. Yield per ha in Asia grew at 0.8 percent per annum from 1989 to 1999 (Table 5).

Chickpea

The total chickpea area (11 million ha) in Asia in 1999 was 29 percent of the total pulses. Between 1989 and 1999 the area and production of chickpea increased at the rate of 3 percent and 4.7 percent per annum, respectively. The major chickpea producing countries are India, Pakistan, Turkey, Iran, Bangladesh and Myanmar. They accounted for nearly 98 percent and 95.4 percent of the total area and production, respectively, in Asia in 1999 (Table 6). Between 1989 and 1999, the yield per unit area increase per annum was 1.7 percent for Asia as a whole. India, Nepal, Pakistan and Syria had 1.6-3.4 percent annual increase in productivity (Table 6). The yield potential of chickpeas in China was 3,300 kg/ha and that of pigeon peas in India was 800 kg/ha. National programs and the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) have developed improved HYVs of both the crops and it is likely that they have been adopted by farmers. In some countries, such as Pakistan, Nepal and India, positive results with HYVs are forthcoming.

Table 5. Area, Production and Productivity of Dry Peas in Asia, 1989 and 1999

Countries	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR*	1989	1999	GR*	1989	1999	GR*
Bangladesh	43.7	18.4	-3.2	29.0	14.1	-4.8	664	766	-1.6
China	1,300.0	750.0	-1.5	1,200.0	1,300.0	-0.2	923	1,733	1.3
India	443.0	700.0	5.3	417.3	600.0	5.0	942	857	-0.3
Myanmar	15.0	57.2	9.7	8.6	38.0	12.4	573	664	2.4
Pakistan	145.3	141.5	-0.3	70.7	78.0	2.3	487	551	2.7
Asia	2,027.0	1,687.3	3.0	1,789.0	2,396.0	3.8	883	1,420	0.8

Source: *FAO Production Yearbook* and FAOSTAT statistics data base accessed September, 2000.
Note: *GR = percent average annual growth rate.

Table 6. Area, Production and Productivity of Chick Peas in Asia, 1989 and 1999

Countries	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR*	1989	1999	GR*	1989	1999	GR*
Bangladesh	102.8	84.0	-9.1	66.2	60.0	-8.5	644	714	0.7
India	6,809.5	8,400.0	1.9	5,129.1	6,700.0	3.5	753	798	1.6
Iran	110.0	592.1	7.5	79.0	248.6	5.6	718	420	-1.7
Myanmar	94.3	101.3	-0.9	71.0	67.9	-1.8	753	670	-0.9
Nepal	28.8	16.0	-5.6	17.1	12.8	-2.9	594	800	3.0
Pakistan	979.4	1,088.7	0.9	456.0	699.5	4.4	466	643	3.4
Syria	34.0	70.0	5.2	13.0	28.5	8.2	382	407	2.8
Turkey	796.0	630.0		683.0	600.0		858	952	
Asia	8,965.0	11,042.0	3.0	6,730.0	8,488.5	4.7	751	769	1.7

Source: *FAO Production Yearbook* and FAOSTAT statistics data base accessed September 2000.
Note: *GR = percent average annual growth rate.

Pigeon Pea

Bangladesh, India, Myanmar and Nepal are the only major producers of pigeon pea. Pigeon pea yields more energy, protein and beta-carotene per ha than other major pulses (Nene and Sheila, 1990; and Jambunathan, *et al*., 1991). India dominates the scene with 92 percent of the total area and 94 percent of total production (1999 figures). Since 1970, the area planted to pigeon pea has increased steadily in India, but productivity has remained static at 400-800 kg/ha (Nene and Sheila, 1990). The planted area in Myanmar was more than quadrupled from 1989 to 1999. The yield of pigeon pea increased from 776 kg/ha in 1989 to 787 kg/ha in 1999, and pigeon pea area increased from 3.6 million ha in 1989 to 3.8 million ha in 1999 (Table 7). Increase in production has come primarily from increase in area in Myanmar, Nepal and Bangladesh (Table 7).

Table 7. Area, Production and Productivity of Pigeon Peas in Asia, 1989 and 1999

Countries	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR*	1989	1999	GR*	1989	1999	GR*
Bangladesh	5.8	6.1	0.5	3.3	3.0	-0.5	569	492	-1.0
India	3,489.0	3,500.0	-0.5	2,717.7	2,800.0	-1.1	779	800	-0.6
Myanmar	62.0	255.0	18.0	41.5	159.5	19.0	669	625	0.8
Nepal	17.9	26.0	4.1	12.3	18.3	5.8	687	704	1.6
Pakistan	0.8				0.5				
Asia	3,575.5	3,787.1	-0.3	2,774.8	2,981.3	1.2	776	787	1.5

Source: *FAO Production Yearbook* and FAOSTAT statistics data base accessed September 2000.
Note: *GR = percent average annual growth rate.

Lentil

The total area and production of lentils in Asia dropped at the rate of 0.1 percent per annum between 1989 and 1999 (Table 8). India accounted for 40-44 percent of lentil area and 42-43 percent of the lentil production in Asia in 1989 and 1999, respectively. Between 1989 and 1999, while planted area increased 2.2 percent per annum, there was a 1.7-percent annual increase in production in India. During the same period, productivity increased 0.4 percent per annum. Therefore, the increase in production came from increase in area planted.

Table 8. Area, Production and Productivity of Lentils in Asia, 1989 and 1999

Countries	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR*	1989	1999	GR*	1989	1999	GR*
Bangladesh	215.3	209.0	-0.3	158.0	165.3	0.8	734	791	1.2
China	55.0	90.0	8.8	60.0	120.0	6.1	1,091	1,333	-2.5
India	1,081.1	1,100.0	2.2	733.6	900.0	1.7	679	818	-0.4
Iran	105.0	204.8	5.9	50.5	95.0	3.7	481	464	-2.1
Nepal	120.4	174.6	4.0	74.4	132.3	6.6	618	758	2.5
Pakistan	75.5	67.0	-1.0	32.8	37.0	2.7	434	552	3.7
Syria	188.3	70.0	1.3	64.0	43.4	2.8	340	620	1.5
Turkey	882.0	548.0		520.0	586.0		590	1,069	
Asia	2,722.6	2,463.4	-0.1	1,693.3	2,079.0	-0.8	622	844	-0.6

Source: *FAO Production Yearbook.*
Note: *GR = percent average annual growth rate.

Cowpea

Although cowpea is not a major crop in Asia, cowpea area was more than doubled and production was tripled between 1989 and 1999 (Table 9). The major force behind these increases was Myanmar. Cowpea area in that country quadrupled and production grew eight-fold between 1989 and 1999 (Table 9). Area, production and productivity for Myanmar showed an impressive positive annual growth (Table 9).

Table 9. Area, Production and Productivity of Cowpea in Asia, 1989 and 1999

Countries	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR*	1989	1999	GR*	1989	1999	GR*
Myanmar	23.6	100.0	16.8	11.3	80.0	23.2	479	800	5.4
Sri Lanka	28.8	17.0	-5.5	19.1	13.4	-5.3	663	788	0.1
Asia	52.4	117.0	12.1	30.4	93.4	14.3	580	798	2.0

Source: *FAO Production Yearbook.*
Note: *GR = percent average annual growth rate.

In summarizing pulses in Asia, India remains a major country in terms of area and production. However, India imports about 600,000 mt of pulses (worth US$240-300 million) annually to meet domestic demand. India has begun to export a small amount (40,000 mt, worth about US$16-20 million). Pakistan imports about 50,000-100,000 mt, while Sri Lanka imports about 35,000 mt annually (Kyi, *et al*., 1997). Although India has begun shipping modest exports, for the near term, India will continue to import pulses to meet domestic demand. Even though the area planted to pulses decreased in China, production of several pulses showed an increasing trend. Introduction of improved high-yielding mung bean cultivars from AVRDC has dramatically changed the position of China, from a net importer to a net exporter of dry beans. In technologically advanced countries, such as Japan, Korea, and Taiwan, both area and production of pulses have decelerated due to increased cost of production, non-availability of labor, low return on investment and high value of land. In the above countries, pulses are no longer economically viable crops. This trend is expected to continue in these countries. It is very clear from the data that Myanmar is emerging as a new strong market player with steady growth in area and production of various pulses. Myanmar exported about 578,000 mt of pulses, worth US$232-300 million in 1995-96 (Kyi, *et al*., 1997). Similarly, Vietnam is also expected to show positive growth in production. India, Pakistan, Sri Lanka, Nepal and Bangladesh will be net importers of pulses. China, Myanmar, Thailand and Vietnam will be net exporters. India has the potential to substantially improve production, particularly of dry beans (as we will discuss later) with new improved HYVs. Whether India will take advantage of this improved technology and adopt appropriate policy to accomplish such a breakthrough remains to be seen.

Groundnut

Groundnut area in Asia increased from 13.4 million ha in 1989 to 14.1 million ha in 1999. Asia accounted for 65.5 percent of the total world groundnut area in 1989, but that figure had dropped to 56.9 percent by 1999 (Table 10). Of the 16 countries listed in Table 10, seven had positive growth in area. Significant to mention on the positive side are Cambodia, China, Lao PDR, Pakistan and Vietnam, while Rep. of Korea, Japan and Philippines are worth noting on the negative side. In 1989, China, India, Indonesia, Myanmar, Thailand and Vietnam accounted for 93 percent of groundnut acreage in Asia. By 1999, that figure had risen to 97.8 percent. Together they accounted for 98.7 percent of the Asian production in 1989 and 97.8 percent in 1999 (Table 10). Asia accounts for 66 percent of world groundnut production. Most of the countries showed positive annual growth in productivity of 1-4.5 percent (Table 10). Again, it is likely that improved HYVs, developed by national programs in association with ICRISAT, contributed to the increase.

Table 10. Area, Production, and Productivity of Groundnuts (in shell) in Asia, 1989 and 1999

	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR (percent)*	1989	1999	GR* (percent)	1989	1999	GR* (percent)
Bangladesh	32.0	34.7	-1.4	45.5	39.5	-0.4	1,422	1,138	1.0
Cambodia	5.0	8.4	7.3	2.0	6.9	10.0	400	821	2.6
China	2,980.0	4,282.0	4.1	5,428.0	12,000.0	8.8	1,821	2,802	4.5
India	8,710.2	8,000.0	-2.3	8,088.0	7,300.0	-1.2	929	913	1.1
Indonesia	620.8	650.0	0.1	879.0	990.0	0.1	1,416	1,523	0.0
Japan	19.0	11.3	-5.2	37.3	26.4	-3.2	1,963	2,336	2.1
Rep.of Korea	16.7	7.5	-8.2	28.7	13.8	-6.9	1,719	1,840	1.5
Lao PDR	6.1	12.9	9.0	5.9	13.0	9.8	967	1,008	0.7
Myanmar	515.0	490.4	-0.9	438.2	561.7	3.2	851	1,145	4.1
Pakistan	80.1	97.5	2.1	81.7	104.0	2.3	1,020	1,067	0.2
Philippines	50.4	24.7	-6.4	37.6	25.0	-3.5	746	1,012	3.1
Sri Lanka	11.2	10.1	0.4	7.4	6.3	1.1	661	624	0.6
Taiwan	34.1	30.0		64.0	68.3		1,877	2,277	
Thailand	120.4	95.0	-3.4	161.5	153.1	-1.8	1,341	1,612	1.7
Turkey	20.0	35.0		50.0	90.0		2,500	2,571	
Vietnam	208.6	269.4	2.9	205.8	386.0	6.5	987	1,433	3.5
Asia	13,429.6	14,058.9	-0.4	15,560.6	21,784.0	3.0	1,159	1,400	3.4

Source: *FAO Production Yearbook.*

Note: * GR = average annual growth rate.

Soybean

The world area planted to soybean jumped from 58.6 million ha in 1989 to 71.9 million ha in 1999. Production increased from 107.3 million mt to 154.3 million mt, and average yield increased from 1,829 kg/ha to 2,148 kg/ha in the same period. In Asia, 15.3 million mt were produced from 12.8 million ha in 1989, and 23 million mt were produced from 16.9 million ha in 1999 (Table 11). The area planted to soybean in China remained static during the period, while area in Taiwan, where soybean production is no longer profitable, area decreased to an insignificant level. Taiwan imported US$512.6 million worth of soybean in 1990 and US$857.5 million worth (Council of Economic Planning and Development, 2000) in 1997. The increase was due to a rise in price, to US$7.42 per bushel (Soyatech, Inc., 1998). In Taiwan, grain soybean production has been replaced by production of high-value vegetable soybean for export to Japan (Benziger and Shanmugasundaram, 1995).

Japan imported 4.35 million mt of soybeans in 1989-90 and 5.06 million mt in 1997-98, valued at around US$1.88 billion and US$2.11 billion, respectively (Ministry of Agriculture, Forestry and Fisheries [MAFF], Japan, 1989-90 and 1997-98). Korea also imports substantial quantities of soybeans. Japan, Korea and Taiwan will continue to import soybean for food, oil and animal feed.

Only 3,000 ha was planted to soybean in India in 1969. In 1989, planted area was 2.13 million ha. Planted area increased at a rapid 10.8-percent per annum between 1989 and 1999, when it reached nearly 6.5 million ha. Production increased 14.1 percent per annum in the same period, from 1.72 million mt to 6.5 million mt. Growth of soybean in India since 1990-91 is shown in Figure 2. India now ranks fifth in total area and production worldwide (Paroda, 1999). Myanmar and Pakistan recorded 13 percent and 15.8 percent annual increases in area, respectively, while soybean production in these two countries grew 14.6 percent and 29.8 percent, respectively. Cambodia, Iran, Nepal and Vietnam also recorded increases in area and production. Most of the other South and Southeast Asian countries had negative growth (Table 11). There is still considerable scope to increase production in Asia with improved varieties and management practices.

Various Legumes in Pacific Countries

In the Pacific, only Australia cultivates virtually all of the major legumes, such as dry beans, chickpeas, cowpeas and soybeans. Australia and New Zealand produce both lentils and peas. Australia, Fiji Islands, Papua New Guinea, Tonga and Vanuatu cultivate groundnut (Table 12). Between 1989 and 1999, the area of dry beans and chickpeas in Australia increased at an annual rate of 7.7 percent and 6.0 percent, respectively, while production increased at 13.2 percent and 2.8 percent, respectively (Table 12). Cowpea area in Australia was static and production declined slightly during this period, due to decrease in productivity (Table 12). Soybean area in Australia declined 2.3 percent per annum, while production increased by 4 percent per annum, during the period. The production increase was primarily due to a 2-percent per annum increase in productivity (Table 12).

Australia recorded a remarkable increase in area and production of lentils, from 3,000 ha and 4,000 mt in 1989 to 70,000 ha and 76,000 mt in 1999. The increase in production was mainly due to area. Productivity declined slightly during the period (Table 12). In contrast, the area and production of lentils declined in New Zealand, but productivity was unchanged (Table 12). There was very little change in the area and production of peas in both Australia and New Zealand (Table 12). Area planted to groundnut increased 0.9 percent annually in Australia between 1989 and 1999, and production increased 3.8 percent per annum (Table 12).

Table 11. Area, Production, and Productivity of Soybeans in Asia, 1989 and 1999

	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
	1989	1999	GR (percent)*	1989	1999	GR* (percent)	1989	1999	GR* (percent)
Cambodia	7.0	30.6	10.0	12.0	27.7	3.4	1,714	905	-6.1
China	8,063.0	8,200.0	0.8	10,238.0	13,700.0	4.2	1,270	1,671	3.4
India	2,134.0	6,450.0	10.8	1,715.0	6,500.0	14.1	804	1,008	3.0
Indonesia	1,187.0	1,075.0	-1.9	1,315.1	1,275.1	-1.0	1,108	1,186	0.9
Iran	50.0	86.0	2.4	90.0	140.0	4.5	1,800	1,628	2.0
Japan	162.0	108.2	-4.7	271.7	187.2	-4.0	1,677	1,730	0.8
DPR Korea	340.0	300.0	-1.3	420.0	340.0	-2.5	1,235	1,133	-1.2
Rep. of Korea	157.4	98.0	-4.9	251.6	145.0	-5.8	1,598	1,480	-1.0
Lao PDR	6.0	6.8	-2.0	5.0	5.9	-2.5	833	868	-0.5
Myanmar	33.5	101.9	13.0	27.0	85.3	14.6	806	837	1.4
Nepal	20.7	23.0	0.7	12.7	17.8	3.1	613	774	2.4
Pakistan	2.3	8.1	15.8	1.2	10.0	29.8	522	1,235	12.1
Philippines	4.8	1.3	-15.8	4.0	1.5	-14.3	833	1,154	1.8
Sri Lanka	1.5	0.6	-12.3	1.5	0.6	-12.5	1,000	1,000	-0.3
Taiwan	5.7	0.7		11.0	1.5		1,930	2,143	
Thailand	502.4	240.0	-7.3	672.4	339.8	-6.4	1,338	1,416	1.0
Turkey	75.3	22.0	-12.1	161.0	49.0	-10.8	2,138	2,227	1.4
Vietnam	100.2	129.2	2.1	82.4	147.7	6.5	822	1,143	4.3
Asia	12,852.8	16,881.4	1.6	15,291.6	22,974.1	3.3	1,190	1,361	1.7

Source: *FAO Production Yearbook.*
Note: * GR = average annual growth rate.

Table 12. Area, Production and Productivity of Legumes in Pacific Countries, 1989 and 1999

Country	Crop	Area (000 ha)			Production (000 mt)			Productivity (kg/ha)		
		1989	1999	GR*	1989	1999	GR*	1989	1999	GR*
Australia	Dry beans	8.0	56.0	7.7	5.0	51.0	13.2	625	911	5.2
	Chickpeas	68.0	205.0	6.0	89.0	198.0	2.8	1,309	966	-3.0
	Cowpeas	7.0	7.0	2.9	3.8	3.0	1.9	543	429	-1.0
	Soybeans	74.0	48.0	-2.3	129.5	109.0	-0.4	1,750	2,271	2.0
	Lentils	3.0	70.0	43.4	4.0	76.0	47.0	1,333	1,086	2.5
	Dry peas	461.0	313.0	-0.3	523.0	336.0	-1.0	1,134	1,073	-0.7
	Groundnuts	22.4	25.0	0.9	25.0	39.0	3.8	1,116	1,560	2.9
New Zealand	Lentils	2.5	0.5	-18.2	5.0	1.0	-17.3	2,000	2,000	1.0
	Dry peas	18.5	19.0		47.3	57.0		2,557	3,000	
Papua New Guinea	Groundnuts	1.0	1.0	-0.3	0.8	0.7	-0.3	800	700	0.0
Tonga	Groundnuts	1.4	0.2	-25.9	1.7		-33.4	1,214		-10.2
Vanuatu	Groundnuts	1.8	1.8	0.0	1.8	1.8	0.0	1,000	1,000	0.0

Source: *FAO Production Yearbook.*
Note: * GR = percent average growth rate.

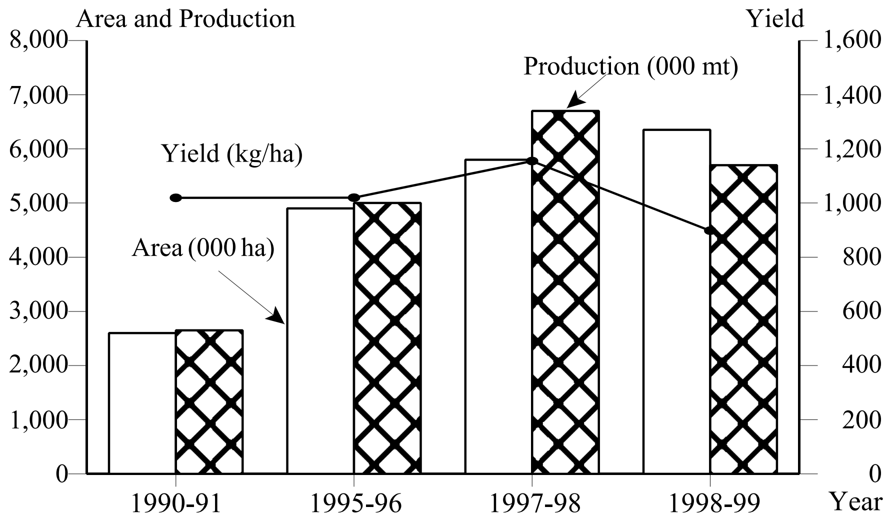


Figure 2. Growth in Area, Production and Yield of Soybean in India

Source: Paroda, 1999.

The major pulse importing countries are India, Pakistan and China. The major exporters are China, Australia, Thailand and, recently, Myanmar. Myanmar exported about 578,000 mt of pulses in 1995-96 (to Bangladesh, India, Japan, Malaysia, Pakistan and Singapore), up from 93,000 mt in 1985-86 (Kyi, *et al*., 1997). Myanmar's domestic consumption rose from 528,000 mt in 1985-86 to 775,000 mt in 1995-96. Pakistan imports mainly from Australia, China and Myanmar. Sri Lanka is also a net importer of pulses.

CURRENT TRENDS IN CONSUMPTION AND UTILIZATION OF LEGUMES

Pulses are an important part of the diet in South Asia, and to a certain extent in Southeast Asia. They are a major source of protein for the vast majority of vegetarians and the economically poor and the rural population. Half the world's population consumes half the world's pulses. Asia's share of this consumption increased in 1988.

Soybean is a major protein crop, while both groundnut and soybean are rich in fat (soybean fat is cholesterol-free). Except for these two crops, legumes are high in carbohydrates. Soybean, black gram, mung bean (green gram), moth bean, horse gram and chickpea are valuable sources of calcium. Soybean and several other legumes are rich in iron (Table 13).

Pulses

In 1989, consumption of pulses as food amounted to 32.2 million mt, 58.4 percent of world production. In the same year, 13.9 million mt was used as feed and 3.8 million mt was used as seed. It is alarming to note that nearly 4.5 percent of total production was lost to spoilage, and insect and rodent damage. In Asia, out of 24.8 million mt of pulses produced in 1989, 20.1 million mt was used as food, 1.7 million mt as seed and 2.7 million mt as feed. Some 3.6 percent was wasted (Table 14).

Table 13. Protein, Carbohydrate and Fat Content of Legumes and Pulses per 100 gm Dry Weight

Crop	Protein (gm)	Carbohydrate (gm)	Fat (gm)	Calcium (mg)	Fe (mg)
Soybean	43.2	20.9	19.5	240	10.4
Khesari	28.2	56.6	0.6	90	6.3
Groundnut	25.3	26.1	40.1	90	2.5
Lentil	25.1	59.0	0.7	69	7.6
Field bean	24.9	60.1	0.8	60	2.7
Cowpea	24.1	54.5	1.0	77	8.6
Black gram	24.0	59.6	1.4	154	3.8
Mung bean	24.0	56.7	1.3	124	4.4
Moth bean	23.6	56.5	1.1	202	9.5
Chickpea (roasted)	22.5	58.1	5.2	58	9.5
Pigeon pea	22.3	57.6	1.7	73	2.7
Horse gram	22.0	57.2	0.5	287	6.8
Peas	19.7	56.5	1.1	75	7.1
Chickpea	17.1	60.9	5.3	202	4.6

Source: Gopalan, *et al*., 1989.

In 1998, world production of pulses was nearly 56 million mt, out of which 34.6 million mt (61.8 percent) was consumed as food, 13.9 million mt was used as feed, 3.8 million mt were used as seed and 2.5 million mt were wasted. World pulse consumption rose 7.5 percent between 1989 and 1998.

Out of 26.2 million mt of pulses produced in Asia, 19.4 million mt was consumed as food in 1998. The amounts used as feed, seed and waste were 4.4 million mt, 1.8 million mt and 0.92 million mt, respectively (Table 14). The annual per capita supply of pulses exceeded 10 kg in India, DPR Korea, Lebanon and Turkey in 1989 and 1998 (Table 14). Per capita availability of pulses in India, however, has declined since 1961 (Figure 3). Per capita consumption of pulses in China amounted to 5.5 kg in 1990 (Gai and Jin, 1995), far short of the 18-kg recommended by FAO, but higher than the 2.8-kg in 1989 and the 1.7-kg in 1998 reported by FAO. The major producers and consumers of pulses are listed in Box 2. Annual per capita consumption of pulses in urban Pakistan rose to 9.0 kg in 1993, compared to 6.36 kg in 1986. During the same period in rural Pakistan, annual per capita consumption rose from 6.0 kg to 7.9 kg (Kyi, *et al*. 1997).

Among the Pacific countries, Fiji had the highest per capita supply (7.7 kg) of pulses in 1989, followed by Solomon Islands (6.8 kg). These islands nations' many citizens of Asian descent are the major consumers of pulses. Per capita supply in Australia was 4.9 kg in 1989. It rose to 6.4 kg in 1998, attributed to demand from Asian immigrants and export potential.

In 1982, von Hoppen reported income and price elasticities for pulses and other foods for different income groups in rural and urban areas in India. He reported that the income elasticity for pulses was around 1, suggesting that as income increases, the demand for pulses increases (except for the highest income group for which income elasticity was less than 1). The price elasticity for the poorer sector of the population was around -1, which suggests that when prices rise, people in this group reduce considerably their intake of pulses.

Table 14. Consumption of Pulses in Asia, 1989 and 1998

(Unit: 000 mt)

Country	Feed		Seed		Waste		Food		Per Capita Supply (kg/year)	
	1989	1998	1989	1998	1989	1998	1989	1998	1989	1998
Afghanistan	1	2	2		1		24		1.7	
Bangladesh	1	2	17	15	25	15	511	575	4.7	4.6
Cambodia			1	1		1	10		1.2	
China	1,192	2,232	354	261	162	154	3,134	2,117	2.8	1.7
India	1,038	1,240		843	465	428	11,891	11,240	14.3	11.4
Indonesia			25	28	67	92	589	787	3.3	3.8
Iran			43	86	8	17	213	463	3.9	7.0
Japan	16	10	6	3	12	11	301	279	2.4	2.2
DPR Korea			28	26	10	8	282	245	14.0	10.5
Rep. of Korea			2	1	2	2	51	66	1.2	1.4
Lao PDR				1			11	14	2.7	2.7
Lebanon	4	5	1	1	1	2	41	46	16.2	14.5
Myanmar		250	30	86	9	86	259	399	6.5	9.0
Nepal			10	10	6	8	156	143	8.5	6.2
Pakistan	120	197	79	73	23	25	789	964	6.8	6.5
Philippines			2	2	1	1	97	106	1.6	1.5
Sri Lanka			1	1	2	4	52	141	3.1	7.6
Syria	6	12	20	16	6	7	86	75	7.2	4.9
Thailand			35	26	15	11	313	303	5.7	5.0
Turkey	339	367	229	166	59	58	749	870	13.6	13.5
Vietnam		18	22	6	7	167	217		2.6	2.8
Asia	2,717	4,335	907	1,652	881	1,097	19,776	18,833	6.6	5.4

Source: *FAO Food Balance Sheets*, 1999 and FAOSTAT statistics data base (accessed September 2000).

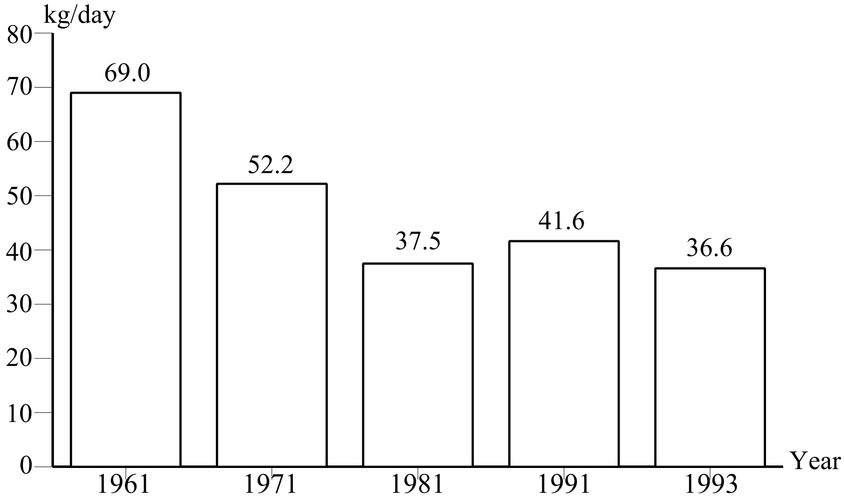


Figure 3. Per Capita Availability of Pulses in India

Source: Kumar, 1998.

Box 2. Major Countries Producing and Consuming Pulses in Asia-Pacific Region

Pigeon pea	*Cajanus cajan*	India, Bangladesh
Chickpea	*Cicer arietinum*	India, Pakistan, Bangladesh, Nepal, Afghanistan, Iran
Lentil	*Lens culinaris*	India, Pakistan, Bangladesh, Nepal, Iran
Mung bean	*Vigna radiata*	India, Thailand, Myanmar, Sri Lanka, Indonesia, Philippines, China, Bangladesh, Pakistan, Sri Lanka
Black gram	*Vigna mungo*	India, Pakistan, Sri Lanka
Pea	*Pisum sativum*	Ira, Pakistan, India, Bangladesh
Cowpea	*Vigna unquiculata*	India, Bangladesh, Philippines, China
Lathyrus	*Lathyrus sativus*	India, Bangladesh, Nepal
Groundnut	*Arachis hypogaea*	India, China, Indonesia
Soybean	*Glycine max*	China, Japan, Korea, Taiwan, Thailand, Philippines, Indonesia, India, Vietnam
Dry bean	*Vigna vulgaris*	Japan
Winged bean	*Psophocarpus tetragonoloba*	Papua New Guinea, Thailand

Source: Kyi, *et al*., 1997

A 1998 survey showed that between 1977 and 1987, consumption of pulses by the rural poor in India increased more than did the consumption by higher income groups and urban poor (Kumar, 1998). Using the national poverty line, Kumar (1998) classified the very poor and the poor as the 'poor group' and the non-poor and non-poor higher as the 'high-income groups'. The high-income groups consumed more pulses in absolute terms than did the poorer groups, regardless whether in rural or urban areas (Figure 4). The income elasticities calculated were similar to those calculated by von Hoppen in 1982. Increased income will prompt rural and urban poor to consume more pulses, but increased income will have very little effect on pulse consumption by high-income groups. The expenditure and price elasticities observed by Kumar (1998) in India were as expected. Own price elasticities for pulses were negative. Deaton (1997) reported the price elasticity of pulses on their own price was -0.57 in Maharashtra, close to the average reported for India by Kumar (1998). Expenditure elasticities declined with increase in total expenditure (Figure 5).

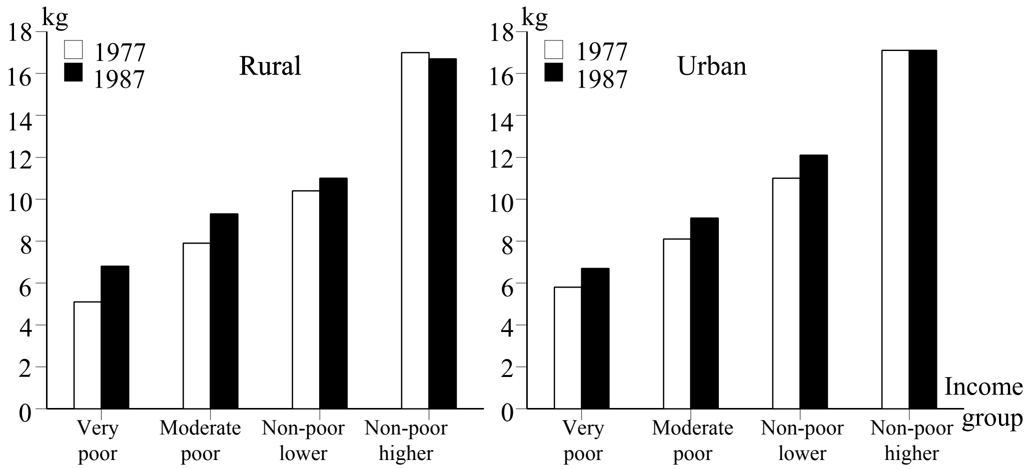


Figure 4. Annual Per Capita Pulse Consumption in India

Source: Kumar, 1998.

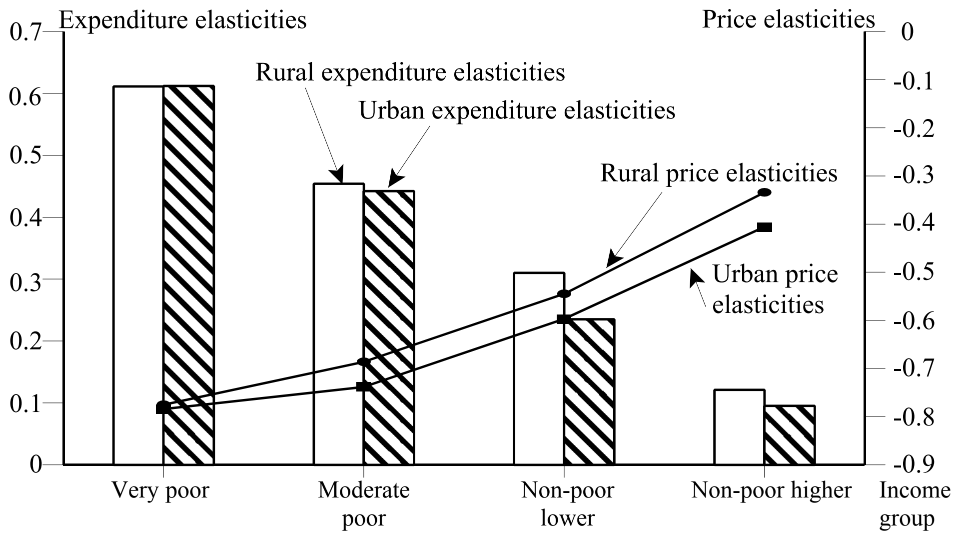


Figure 5. Expenditure and Price Elasticities for Pulse in Rural and Urban India for Different Income Groups Based on Food Characteristic Demand System

Source: Kumar, 1998.

Kumar's (1998) study assumed that demand for pulses is relatively high price elastic for poor income groups, yet as a whole in India, demand for pulses is price inelastic, at around -0.5 (Kyi, *et al*., 1997). Based on these seemingly contradictory signals, it is important to differentiate between various species and qualities (Kyi, *et al*., 1997).

Demand for pulses in the Asia and Pacific region, based on population and income growth, is predicted to increase 3-3.5 percent annually. This would require 3.5-4 percent annual growth in pulse production or importation (Nandi, 1995).

Trade in pulses is important in the region. Expanded domestic and international trade will benefit producers and consumers (Kyi, *et al*., 1997). It is estimated that around 60 million mt of pulses valued at US$15 billion enter the international market annually (Kyi, *et al*., 1997). The authors cited demand in South and Southeast Asia, the Middle East and, to a lesser extent, in Africa and Latin America (it is worth noting that pulses also serve as relief crops in times of disaster [Gai and Jin, 1995]).

Pulses are usually consumed in a processed form. The ways pulses are used in India and Pakistan are shown in Box 3. The method used to prepare pulse noodles in Myanmar is given in Box 4. Although mung bean and other pulses are traditionally consumed as *dhal* in India, people are learning about bean sprouting (especially mung beans), which is commonly used in China (Chen, *et al*., 1988).

Pulses are 11-14 percent seed coat (husk), 2-5 percent germ, and the remainder endosperm (Kyi, *et al*., 1997). In *dhal* production, the husk is removed and the bean is split. The maximum theoretical recovery from milling pulses is around 87-89 percent. In practice, traditional milling recovers only about 65-75 percent. Modern milling methods can recover 82-85 percent (Kyi, *et al*., 1997). The byproducts of pulse milling include broken grains (6-13 percent), germ and powder (7-12 percent), and husk (4-14 percent). The byproducts are fed to poultry, cattle, horses, swan and elephants. Broken mung bean and black gram grains are milled into flour, used for making *papad*, a fried snack food (side dish). Byproducts fetch less than the *dhal* price. For example, husks fetch about 30 percent of the *dhal* price (Kyi, *et al*., 1997). The seeds of improved mung bean cultivars are twice as large as the seeds of traditional cultivars. It would be interesting to study the husk-to-*dhal* ratio and recovery rates of the new cultivars compared to the old ones. In addition to *dhal*, a number of snack foods and extrusion products are made from pulses. Creativity is essential in developing food products that will attract consumer attention and please varied taste buds.

Box 3. How Pulses Are Used in India and Pakistan

Chickpea is the major pulse crop in India and Pakistan. Chickpea is called garbanzo bean in the West. It is used to make a variety of preparations, some of which are main dishes and others are snacks. Roasted and fried chickpeas are used as snack foods. Chickpea as *dhal* is a common dish in the rural and urban areas. Chickpea is soaked in water for a couple of hours and the water is drained. Then the chickpea is cooked with vegetables and eaten with rice or wheat breads. Chickpea flour is used either alone or in combination with rice flour to make a variety of sweet and salty and spicy snacks that are popular with evening tea. Such snacks are also popular during special festivals and festive occasions, such as weddings.

Pigeon pea is primarily used as *dhal* to go with rice or used to make soups.

Mung bean is a very popular pulse and has diverse uses. It is used as *dhal*; to make curries; sweet and salty soups; is broiled and toasted with onion, chili and salt; in sweet and salt *pongal* (rice preparation); and patties and sweets of different kinds (Thirumaran and Seralathan, 1988; and Singh, *et al*., 1988). In Thailand, mung bean is used to make mini sweet desserts (Prabhavat, 1988) of different shapes like vegetables and fruits. Mung bean noodles and breads are also common (Chiang and Chiu, 1988). Mung beans are prescribed for patients in the hospitals and served with bread.

Lentils are primarily used as *dhal*, and are also roasted and used as snacks.

Black gram is also a rich source of protein. Black gram is an important ingredient to make the popular breakfast food items called *idli, dosa* and *uttappam* in India. Rice and black gram are soaked independently in water for a few hours. The husk from black gram is removed. The rice and black gram are ground (wet grinding) separately and then mixed together. Salt is added to taste and the mix is fermented overnight. The next day it is ready to be used to make steamed bread called *idli* or pancake-like fried bread called *dosa* or *uttappam*. The above dishes are popular breakfast dishes in South India, but now they have become very popular all over India, served in the morning and in the evening.

From author's own observations

Box 4. Making Noodles from Pulses in Myanmar

Pulses, such as chickpea, pigeon pea, black gram, etc. can be used to make noodles. Soybean, *lablab* bean, and horse gram cannot be used for noodles. Well-cleaned pulses are first soaked in water for 24 hours and stirred occasionally. After draining, pulses are ground with a sour starter solution obtained from a previous batch. Then it is settled in a small tank and the liquid is removed. The residual meal is transferred into a wooden tub for eight hours; it is then transferred into a cloth bag which is hung up to drain for about 15 hours. Then, the material is put into tanks in an airtight room for sulfur fumigation, after which the product is allowed to dry for two days, and then fumigated again. After the second fumigation, the product is mixed with a sago solution (starch solution) and extruded into boiling water. The noodles are taken out of the hot water after five minutes, when they are soft, and put into cold water. After that, the noodles are put into an airtight room for sulfur-fumigation again. The noodles are then dried on poles or drying racks for 1-2 days. A typical pea noodle mill uses about 70-100 baskets of pulses daily as raw material, and operates 200-300 working days/year. All of the processes are manual. Grinding is the only mechanical process; it uses electric motors. Generally, one basket (31 kg) of pulses yields 7.4-8.2 kg of noodles. There are 32 mills in Monywa, two in Mandalay, two in Shwebo and two in Bago divisions in Myanmar.

Source: Kyi, *et al*., 1997

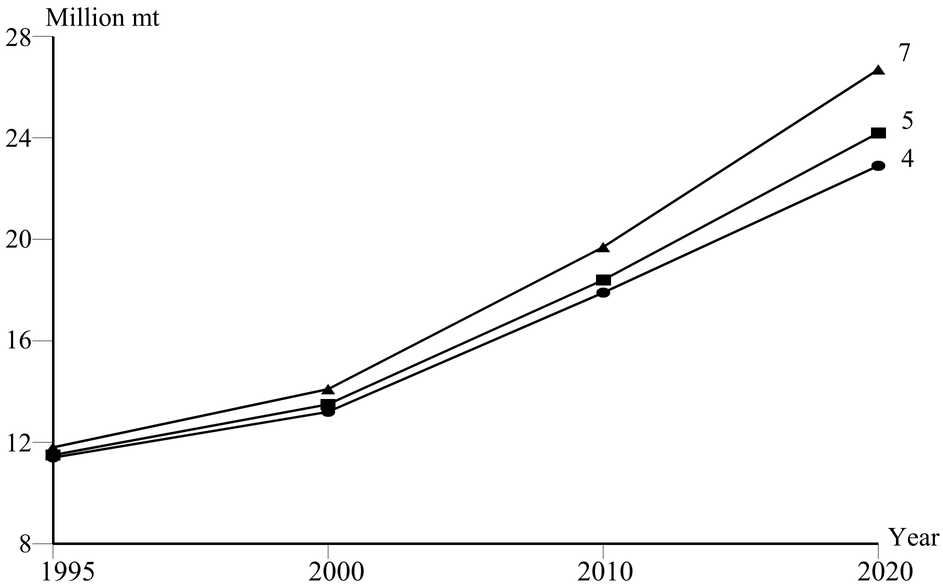


Figure 6. Household Demand for Pulses in India

Source: Kumar, 1998.

Soybeans

Domestic soybean supply in Asia amounted to 15.4 million mt in 1989; 8.3 million mt consumed as food and 13.4 million mt processed. Domestic supply jumped to 24.7 million mt in 1998; 13.1 million mt consumed as food and 23.1 million mt processed. Of the amount of soybean consumed as food in the world almost all is consumed in Asia as food (Figure 7). In India in 1989, about 85.6 percent of production (4.3 million mt) was processed for oil. The meal (2.41 million mt) was mostly exported, earning US$500 million. The amount used directly as food was only 4.8 percent. About 600,000 mt of edible oil comes from soybean annually (Ali, 1996). India has more than 150 soybean solvent extraction plants and 60 soy-food manufacturing units (Ali, 1996). It is heartening to note that between 1989 and 1999, consumption of soybean as a food in India increased from 85,000 mt to 857,000 mt (Table 15). India is self-sufficient in vegetable oil due to the introduction and expansion of soybean. But in Indonesia, in addition to domestic production of 13.2 million mt, another 65,000 mt were imported and used as food in 1989. In 1998 there was a 10-percent increase in the amount used as food in Indonesia. In contrast, in China in 1998 the amount used for food and for processing was 57 percent and 67 percent, respectively, in relation to domestic production (Table 15). Of course, in China soybean is a traditional source of protein. It is also a major source of calcium and other micronutrients. Chinese consider soybean a health food. But for Indians, pulses are the main protein source. The beany flavor of soybean is a major factor inhibiting the widespread use of soybean as a food in India and the rest of South Asia (Shanmugasundaram, *et al.*, 1998; and Shanmugasundaram and Tsou, 2000).

In Japan, Rep. of Korea and China (Taiwan), the amount used for food and processing changed little in the past decade. Various soy-foods and processed products consumed in different countries are shown in Box 5.

Table 15. Consumption of Soybean in Asia, 1989 and 1998

(Unit: 000 mt)

Country	Feed		Seed		Waste		Food		Per Capita Supply (kg/year)	
	1989	1998	1989	1998	1989	1998	1989	1998	1989	1998
Myanmar			2	6	1	1	24	63	0.6	1.4
Cambodia			1	1		1	1	6	0.1	0.6
China	300	1,000	794	861	253	265	4,962	8,639	4.4	6.9
India			154	387	84	314	86	857	0.1	0.9
Indonesia			51	53	85	91	1,370	1,505	7.6	7.3
Iran			5	7						
Japan	90	105	8	5	88	121	1,009	1,140	8.2	9.0
DPR Korea			27	25	22	15	208	216	10.3	9.3
Rep. of Korea	10	26	8	5	10	9	416	382	9.8	8.3
Lao PDR							2	1	0.6	0.2
Nepal					1	1				
Pakistan							1	1		
Philippines					1	6	4	14	0.1	0.2
Syria							1	2	0.1	0.1
Thailand			11	6	34	51	113	130	2.1	2.2
Turkey			7	2	7	13	3	12	0.1	0.2
Vietnam			4	5	2	5	28	69	0.4	0.9
Asia	400	1,131	1,072	1,357	588	893	8,228	12,974	2.7	3.7

Source: *FAO Food Balance Sheets*

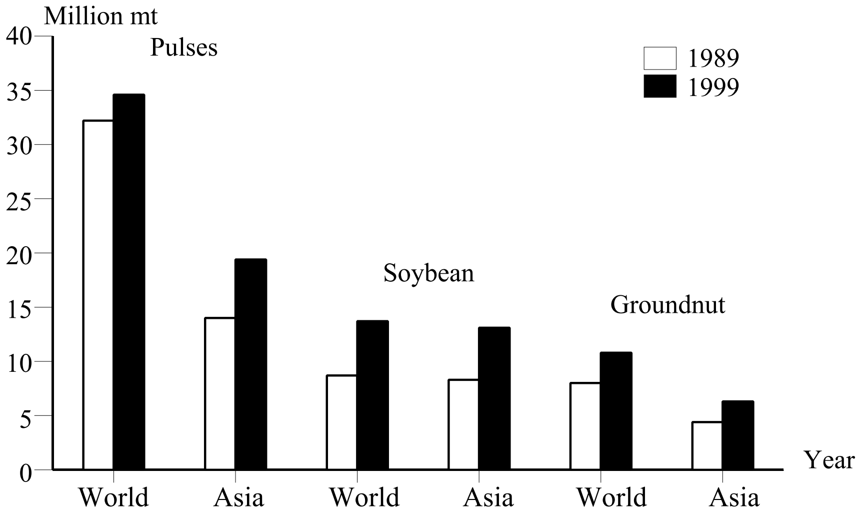


Figure 7. Amount of Various Legumes Consumed as Food

Box 5. The Common Uses of Soybean in Asia

The uses of soybean as food can be grouped into three categories: 1) fresh; 2) fermented; and 3) non-fermented. **Fresh** green soybean pods are harvested when the seed is full just before the pods turn yellow. *Edamame*, as it is called in Japan, is popular as a snack with beer or *sake*. Water is first boiled with a little bit of salt. The whole green pods are put in the water and cooked for 5-6 minutes and the water is immediately drained. The beans in the pod are ready to eat. The shell is discarded. The green beans can also be shelled and cooked with any other vegetable or meat of choice, just like peas. We can call this tropical pea. Small seeded soybeans are used to make sprouts, which can be used as a vegetable year-round. Large black seeded soybeans are cooked with rice in Korea to enhance appearance and flavor.

Fermented soy-foods include soy sauce, miso soup, *natto, tempeh* in Indonesia, and fermented tofu. Soy sauce is a flavor enhancer. Large seeded soybeans with high protein are preferred for making miso. Small seeded soybeans are required for making *natto*. Black seeded soybeans are fermented and used as a garnish. *Tempeh* is prepared using *Rhizopus oryzae* and *R. oligosporus*. It is the main protein source for the majority of Indonesians. It is rich in riboflavin, vitamins B_6 and B_{12}, biotin and folate. **Non-fermented** soy-foods include soy milk, an important source of calcium, especially in China. Various kinds of tofu are consumed in Asia. It is popular with soups and salads. Fried tofu is also a delicacy. Soybeans are roasted and served as a snack, like peanuts, in Nepal. Such roasted soy nuts are becoming popular in other countries as well. Soybean protein film called *yuba* is used in a variety of preparations. Soybean is an essential ingredient in the preparation of imitation meat. Other soybean products – soy flour, soy noodles, soy ice cream and soy protein isolates – are also popular in Asia.

Source: Shanmugasundaram and Tsou, 2000

The use of soybeans as food increased by 72 percent in Australia between 1989 and 1998. Although the amount of soybean used in the Pacific countries is small, there has been a significant increase in consumption (Table 16).

Table 16. Consumption of Soybean, Groundnuts and Pulses as Food in Pacific Countries in 1989 and 1998

(Unit: mt)

Country	Soybean		Groundnut		Pulses	
	1989	1998	1989	1998	1989	1998
Australia	1,118	1,919	38,071	28,731	81,327	118,218
Fiji Islands	67	168	574	681	5,586	6,037
French Polynesia	12	232		118	558	615
Kiribati		33		11		14
New Caledonia		86			254	394
New Zealand	901	730	6,808	8,877	7,814	9,073
Papua New Guinea		128		890	1,554	1,982
Solomon Islands					2,098	3,022
Vanuatu			1,452	1,452	2	

Source: *FAO Food Balance Sheets*, 1999 and FAOSTAT statistics data base (accessed September 2000).

Groundnut

Asia accounts for more than half of world groundnut (food) consumption. Asia's share of world groundnut (food) consumption increased to 58 percent in 1998 (Figure 7). China, Indonesia, India and Japan are the major groundnut-consuming countries in Asia (Table 17). In China, half is processed food and the other half is consumed directly as food. In Indonesia, 95 percent of the domestic supply is consumed as food. In India, only 7.5 percent of the domestic supply is consumed as food and 78 percent is processed (Table 17). The processed products are also consumed as human food. Groundnut meal is used as animal feed.

The quantity of groundnuts consumed as food in Australia dropped between 1989 and 1998. During the same period, consumption in New Zealand and Fiji increased (Table 16).

FUTURE PROSPECTS IN PRODUCTION, PROCESSING AND CONSUMPTION

Pulses

Reviewers of pulse production in Asia come up with the same findings: production has been stagnant for a long time (Singh, 1988; Paroda, 1995; and Sinha, 1995). As mentioned, annual per capita availability declined from about 23.7 kg in the 1960s to 11.4 kg in 1998. Sinha (1995) has argued that food habits have changed as a result of increased income and purchasing power. People are consuming more milk, vegetables, fruits and meat. Therefore, energy and protein requirements are being met by diverse foods rather than pulses. Food habits in Asia are changing, as a result of urbanization, job opportunities for women and other socio-economic factors. Fast foods and convenience foods are replacing laborious traditional foods. At the same time, surveys (Kumar, 1998; and Kyi, *et al.*, 1997) clearly showed that pulse consumption increases with increased income. Increased supply leads to lower prices and higher consumption by the poor, who get their protein primarily from pulses.

Table 17. Groundnut Consumption in Asia between 1989 and 1998

Country	Food (000 mt)		Per Capita Supply (kg/year)	
	1989	1998	1989	1998
Bangladesh	6	5	0.1	0
Myanmar	58	73	1.4	1.6
Cambodia	2	5	0.2	0.5
China	2,251	4,068	2.0	3.2
India	566	586	0.7	0.6
Indonesia	893	833	5.0	4.0
Japan	183	156	1.5	1.2
Rep. of Korea	20	32	0.5	0.7
Lao PDR	2	6	0.9	1.2
Pakistan	18	23	0.2	0.2
Philippines	83	86	1.4	1.2
Sri Lanka	0	0	0	0
Thailand	105	118	1.9	2.0
Turkey	44	93	0.8	1.4
Vietnam	55	103	0.8	1.3
Asia	4,286	6,187	1.4	1.8

Source: *FAO Food Balance Sheets*, 1989 and 1998.

Kumar (1998) projected that demand for pulses in India would amount to 13.2-14.1 million mt in 2000 and 22.9-26.7 million mt in 2020, due to growing population, but depending on GDP growth (Figure 6). India produced 13.4 million mt of pulses from 22.6 million ha in 1994-95. Self-sufficiency in pulses would require an increase in productivity and area. The average pulse yield in 1994-95 was 593 kg/ha. To achieve the production target of 16.1 million mt, 21.4 million mt and 27.8 million mt using 21.7 million ha, yield would have to increase to 742 kg/ha, 987 kg/ha and 1,282 kg/ha in 2000, 2010 and 2020, respectively (Kumar, 1998). That said, improved, short duration varieties, already available, should lead to some expansion of pulses into cereal-based production systems. India's National Commission on Agriculture (NCA) has revised the above estimates due to post-harvest losses and seed and feed requirements to 26.3 million mt, 27.8 million mt and 30.9 million mt for the GDP growth of 4 percent, 5 percent and 7 percent, respectively (Kumar, 1998).

Despite efforts to eradicate poverty, millions of people in Asia and Africa still live in poverty. For these people, pulses will continue to be the major source of protein and micronutrients. Governments in Asia should, therefore, work to improve pulses and increase pulse production.

So, what is the scope for increased pulse production in the Asia-Pacific region? Chickpea and pigeon pea are the major pulse crops and India is the major cultivator and consumer, followed by Pakistan and Myanmar. Considering that only a few countries use chickpea and pigeon pea (Box 2; and Sinha, 1995), and considering that they are long duration crops with limited use, their production is expected to increase only slightly. Within the region, Myanmar is emerging as a serious new player. A steady increase in production, specifically for export, is expected from that country (Kyi, *et al*., 1997).

Many countries in the region have an interest in mung bean production, utilization and trade (Sinha, 1995), and compared to other pulses, the production, yield and area of mung bean showed a significant positive trend in the post Green Revolution era (Singh, 1988), largely due to mung bean's short crop duration. Mung bean production in Asia grew 4.5 percent annually (nine times that of all pulses) between 1974-76 and 1984-86 (Singh, 1988). The yield and area of mung bean increased at a steady 2-percent per annum in the same period.

Multi-location trials (supported by the Department for International Development, U.K., and the United States Agency for International Development) conducted by AVRDC in six South Asian countries in 1997-99 identified promising cultivars with 55-65 days crop duration, with yield potential of up to 2,000 kg/ha in India, Bangladesh and Sri Lanka. They are also either resistant or tolerant to MYMV, the most serious disease affecting mung bean in the region. AVRDC developed these MYMV-resistant, high-yielding, early and synchronously maturing, bold seeded cultivars in collaboration with Pakistan. A new cultivar, Pusa Vishal, has been released for northeastern India, the main site of the Green Revolution in India. Farmers there grow wheat, then fallow their fields for about 65 days and then grow monsoon rice. As a result of extensive cultivation of rice, underground water is rapidly being depleted. It is a serious concern. Punjab Agricultural University has identified a new mung bean cultivar from the recent network trials: SML668 matures in 55-60 days, so it can easily fit between wheat and rice. Or it can be grown instead of rice, and earn the same income as rice. There are 10 million ha lying fallow where the new cultivar can be planted. There is, therefore, an excellent prospect for increased mung bean production in India. SML668 was also found to do well between wheat and rice in northeastern Bangladesh.

Sinha (1995) has discussed at length the factors to be considered in improving the yield of pulses. At AVRDC, plant breeders, pathologists and physiologists worked together to increase mung bean yield. Fundamental physiological studies showed that a plant type was needed that could give a high number of pods per plant, regardless of plant population density (AVRDC, 1975). A plant population density of 350,000-400,000 should be maintained (MacKenzie, *et al*., 1975). The plants should have plenty of vegetative growth prior to flowering and then stop vegetative growth so that they can focus on efficient translocation of photosynthates to the developing seeds. Research at AVRDC showed that the major source of dry matter for seed yield in mung bean is the photosynthate produced during the post-anthesis period, rather than dry matter translocated from storage in other plant parts during the vegetative period (Kuo, *et al*., 1978 and 1980). Harvest index was higher in early maturing cultivars. AVRDC was able to select such genotypes with early maturity and MYMV resistance.

Even on marginal land, improved cultivars outperform traditional cultivars, mainly due to disease resistance. But mung beans have become a high-value cash crop, and therefore they warrant good management. Mung bean HYVs truly deliver high yields when grown in the appropriate seasons with optimum inputs supplied at the right time. It is equally important not to plant mung bean after another legume in the cropping system, since it will seriously affect yield (Kuo, *et al*., 1981). Considering mung bean's potential, extension personnel and farmers should be trained how to grow it.

As mentioned earlier, product diversification is important to attract consumers in order to create more demand for the raw material. May be recipes could be exchanged: *idli, dosa* and *vada* from South India are gaining popularity in other parts of India and even abroad.

Soybean and Groundnut

Soybean is a 'global commodity' grown in more than one hundred countries. Numerous food, feed, fiber and medicinal and industrial products are produced using soybean. Today, soybean is a key source of protein and edible oil. Prior to 1940, soybean was produced and used mainly in China, Japan and Korea, and to a lesser extent in other countries in Asia. It is only in the past 60 years that the area and production of soybean has mushroomed in North and South America. It was only in the past decade that India emerged as a major player – from insignificance in the 1960s, India has grown to occupy fifth in area and production worldwide.

The yield potential of soybean in tropical and temperate countries varies from 3,500 kg/ha to 6,000 kg/ha (Paroda, 1999). It is predicted that major yield gains can be expected from conventional breeding, biotechnology research and improved management practices. India has 166 soybean processing plants crushing about 52,000 mt/day. It is projected that India will have around 8 million ha and 10 million ha producing around 10 million mt and 12 million mt of soybean in the year 2000 and 2010, respectively. Although the soybean processing industry in India has developed more than 19 soybean-based products and is trying to promote soybean as food, acceptance by the traditional consumer will be slow. Soybean will remain primarily an edible oil crop and meal exports will rise. The animal feed industry is expected to expand in pace with demand for meat, especially poultry, as incomes in India increase due to better employment opportunities.

Soybean area and production in China grew 1 percent annually between 1989 and 1999. China's population increases by 13 million annually, so demand for soybean is projected to rise: for food, for the government's Soybean Action Plan to supply soybean milk to school children and to meet the expected growth in meat consumption (now 40 kg/capita/year). Area is projected to increase to 9 million ha by 2020. In the past decade, soybean productivity increased 1 percent per annum. Productivity in the next 20 years is expected to appreciate substantially (Ming and Lianzheng, 1999). Production in 2020 is expected to reach 20 million mt from anticipated yield of 2,000-2,400 kg/ha.

The growth of soybean in China (Taiwan), Japan, Democratic People's Rep. of Korea, Rep. of Korea and Thailand will slow or decline. Most of these countries will remain net importers of soybean. Myanmar, Lao PDR, Cambodia and Vietnam are expected to register positive growth in area and production. Soybean will continue to be a major source of protein food in Indonesia, and imports will continue to supplement domestic production. Soybean will remain a dynamic crop in the region and even challenge the other regions in international trade.

Saio (1999) reviewed the current developments in soy-food processing. The use of soybean as functional food (for long-term nutrition and health needs) is increasing (Worrel, 1999). The major factor inhibiting soybean's utilization in South Asia is beany flavor (Shanmugasundaram and Tsou, 2000), but beany flavor can be minimized genetically and by processing.

Through the efforts of AVRDC, vegetable soybean is becoming a popular high-value crop in several countries (AVRDC, 1998; and Carter and Shanmugasundaram, 1999) Vegetable soybean is called *edamame* in Japan and *maodou* in China. Between 1979 and 1983, only 19 countries evaluated AVRDC vegetable soybeans. But in 1998, 50 countries were evaluating them. Twenty improved vegetable soybean cultivars have been officially released in 11 countries for domestic consumption and export. For many of these countries it is a brand new crop (Shanmugasundaram and Tsou, 2000).

World groundnut production increased from 23 million mt in 1989 to 33.7 million mt in 1998. Groundnut production in Asia grew 2 percent annually in this period. The major increases came from China, Myanmar, Pakistan and Vietnam. World consumption of groundnut as a food increased from 8 million mt to 10.8 million mt in the same period. Asia accounted for 59 percent of world groundnut (food) consumption in 1998. Health-related concerns about groundnut in many countries could affect its production and utilization (Fletcher, *et al*., 1992). Production in China, India, Cambodia and Vietnam might rise slightly, for domestic consumption and export. In other countries, the production and consumption will be static or decline.

Underutilized Legumes

There is a wide range of indigenous underutilized legume crops (Williams, 1993) (Box 6). It is essential to investigate the potential usefulness of these indigenous species as food, feed, fiber, raw material for industrial and medicinal products.

Box 6. Underutilized Legumes

There are many legumes that are used as food. Some native species used locally in some Asian countries are listed below. Some of these are also used in other parts of the world.

Bambara groundnut	*Vigna subterrance*	Used as a pulse
Yam bean	*Pachyrhizus* species	Tubers are used as a vegetable
Lupins	*Lupinus* species	High protein
Rice bean	*Vigna umbellata*	Food, fodder
Winged bean	*Psophocarpus tetragonalobus*	Multipurpose
Adzuki bean	*Vigna angularis*	Widely used in Japan as food
Faba bean	*Vicia faba*	Food
Moth bean	*Vigna aconitifolia*	Food
French bean	*Phaseolus vulgaris*	Vegetable
Horse gram	*Macrotyloma uniflorum*	Food
Hyacinth bean	*Lablab purpureus*	Popular in south Asia
Grass pea	*Lathyrus sativus*	Food
Lima bean	*Phaseolus lunatus*	Vegetable
Jack bean	*Canavalia ensiformis*	
Sword bean	*Canavalia gladiata*	
Zombi pea	*Vigna vexillata*	
Pillipesera	*Vigna trilobata*	Fodder

Source: Male, 1994

Acknowledgements

The author expresses his sincere gratitude to Mr. Teruo Miyake and APO for invitation to prepare this paper.

The author would like to express his sincere appreciation to Drs. R. B. Singh and Eric Kuenneman of FAO, Rome and FAO RAPA, Bangkok, respectively, for their assistance in accessing the FAO database. The author is also grateful to Dr. Katinka M. Weinberger for carefully reading the manuscript and offering useful suggestions. Thanks are due to Mr. David Abbass for editing the manuscript.

LITERATURE CITED

Ali, M., I. A. Malik, H. M. Sabir, and B. Ahmad, 1997. "The Mungbean Green Revolution in Pakistan", *Technical Bulletin* No. 24, AVRDC, Shanhua, Taiwan, Rep. of China, 66 p.

Ali, M. and S. C. S. Tsou, 1997. "Combating Micronutrient Deficiencies through Vegetables – A Neglected Food Frontier in Asia", *Asian Food Policy* 22 (1): 17-38.

Ali, Nawab, 1996. "Indian Soybean Industry", in Alex Buchanan (ed.) *Proceedings of the Second International Soybean Processing and Utilization Conference*, pp. 78-82, 8-13, Bangkok, Thailand, Institute of Food Research and Development, Kasetsart University, Bangkok, Thailand.

Andersen, Per Pinstrup, Rajul Pandya Lorch, and Mark W. Rosegrant, 1999. "World Food Prospects: Critical Issues for the Early Twenty-first Century", *2020 Vision Food Policy Report*, International Food Policy Research Institute, 32 p.

AVRDC, 1975. *AVRDC Progress Report '75*, AVRDC, Shanhua, Taiwan, Rep. of China, 60 p.

----------, 1998. *International Consultation Workshop on Mungbean: Proceedings of the Mungbean Workshop*, 7-11 September 1997, New Delhi, India, edited by S. Shanmugasundaram, AVRDC, Shanhua, Taiwan, Rep. of China, 198 p.

Babu, S. C. and A. Hallam, 1988. "Economics of Mungbean Production, Utilization and Trade – A Time Series Analysis", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 440-449, AVRDC, Shanhua, Taiwan, Rep. of China.

Bahl, P. N., 1999. *The Union of Myanmar – Report of the Consultancy Mission on Grain Legume Production*, FAO RAPA, Bangkok, Thailand, 22 p.

Benziger, Vincent and S. Shanmugasundaram, 1995. "Taiwan's Frozen Vegetable Soybean Industry", *AVRDC Technical Bulletin* No. 22, AVRDC, Shanhua, Tainan, Taiwan, Rep. of China, 15 p.

Campeanu, Mariana, 2002. Personal communication.

Carter, T. E. and S. Shanmugasundaram, 1993. "Vegetables Soybean (Glycine)", in J. T. Williams (ed.) *Underutilized Crops – Pulses and Vegetables*, pp. 219-239, Chapman Hall, London.

Chen, C. Y., S. C. S. Tsou, and H. H. Wang, 1988. "Utilization Patterns of Mungbean in the Chinese Diet", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 498-507, AVRDC, Shanhua, Taiwan, Rep. of China.

Chiang, W. C. and T. P. Chiu, 1988. "Utilizing Mungbean Starch Processing By-products: A Preliminary Study", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 520-527, AVRDC, Shanhua, Taiwan, Rep. of China.

Council of Economic Planning and Development, 2000. *Taiwan Statistical Data Book*, Republic of Cina, 354 p.

Deaton, Angus, 1997. *The Analysis of Household Surveys: A Microeconomic approach to Development Policy*, The John Hopkins University Press, 479 p.

ESCAP, 1985. *Economic and Social Survey of Asia and the Pacific*, Bangkok, Thailand. 320 p.

FAO, 1985. *The State of Food and Agriculture*, Rome, 103 p.

----------, 1990. *FAO Production Yearbook 1990*, Vol. 44, Rome, 283 p.

----------, 1990. *FAO Trade Yearbook for 1989*, Rome.

----------, 1993. *FAO Production Yearbook 1993*, Vol. 47, Rome, 254 p.

----------, 1996. *Food Balance Sheet for 1992-94 Average*, Rome.

----------, 1996. *FAO Production Yearbook 1996*, Vol. 50, Rome, 235 p.

----------, 1998. *FAO Production Yearbook 1998*, Vol. 52, Rome, 233 p.

----------, 1999. *FAO Trade Yearbook for 1997*, Rome.

Fletcher, S. M., P. Zhang, and D. H. Carlay, 1992. "Groundnuts: Production, Utilization and Trade in the 1980s", in S. N. Nigam (ed.) *Groundnut: A Global Perspective*, pp. 17-32, Proceedings of an International Workshop, 25-29 November 1991, ICRISAT Center, Andhra Pradesh, India.

Gai, J. and W. Jin, 1995. "A Report on Production, Research and Development of Pulse Crops in China", in S. K. Sinha and R. S. Paroda (eds.) *Production of Pulse Crops in Asia*, pp. 93-100, RAPA Publication No. 1995/8, FAO, Bangkok, Thailand.

Gopalan, C., B. V. R. Sastri, and S. C. Balasubramanian, 1989. *Nutritive Value of Indian Foods*, p. 156, National Institute of Nutrition, Indian Council of Medical Research, India.

Huanyu, Zhang and Wang Zhizong, 1993. "High-yielding Cultivation of Zhong Lu #1 in the Red Loam Region of Hunan", in Chen Xuzhen, Wang Youtian and Charles Y. Yang (eds.) *The Study and Application of AVRDC Mungbean in China*, pp. 114-117, AVRDC/ARC, Bangkok, Thailand.

Jambunathan, R., S. D. Hall, P. Sudhir, V. Rajan, and V. Sadhana, 1991. *Uses of Tropical Grain Legumes*, Proceedings of a Consultants Meeting, 27-30 March 1989, ICRISAT Center, India, 350 p.

Kumar, P., 1998. "Food Demand and Supply Projections for India", *Agricultural Economics Policy Paper 98-01*, Indian Agricultural Research Institute, New Delhi, 141 p.

Kuo, C. G., M. C. H. Jung, and S. C. S. Tsou, 1978. "Translocation of ^{14}C-Photosynthate in Mungbean During the Reproductive Period", *HortSci.* 13(5), pp. 580-581.

Kuo, C. G., F. H. Hsu, J. S. Tsay, and H. G. Park, 1980. "Variation in Specific Leaf Weight and RuDP Case Activity in Mungbean", *Can. J. Plant Sci.* 60, pp. 1059-1062.

Kuo, C. G., M. H. Chou, and H. G. Park, 1981. "Effect of Chinese Cabbage Residue on Mungbean", *Plant and Soil* 61, pp. 473-477.

Kyi, Hla., Mruthunjaya, Naseer Alam Khan, Rupasena Liyanapathirana and J. W. T. Bottema, 1997. *Market Prospects for Pulses in South Asia: International and Domestic Trade*, Working Paper 27, The CGPRT Centre, Bogor, Indonesia, 101 p.

MacKenzie, D. R., N. C. Chen, T. D. Liou, H. B. F. Wu, and E. B. Oyer, 1975. "Response of Mungbean [*Vigna radiata* (L.) Wilczek Var. radiata] and Soybean [*Glycine max* (L.) Merr.] to Increasing Plant Density", *J. Amer. Soc. HortSci.* 100(5), pp. 579-583.

Male, B., 1994. *Underutilized Grain Legumes and Pseudo-cereals – Their Potentials in Asia*, FAO RAPA, Bangkok, 162 p.

Ming, Lu, and Wang Lianzheng, 1999. "State of the Soybean Industry in People's Republic of China", in *Proceedings World Soybean Research Conference VI*, pp. 1-4, compiled by Harold E. Kauffman, University of Illinois, Urbana-Champaign.

Ministry of Agriculture, Forestry and Fisheries, 1989-90. *66th Statistical Yearbook of MAFF*, Statistics and Information Department, Association of Agriculture and Forestry Statistics, Japan, 947 p.

----------, 1997-98. *74th Statistical Yearbook of MAFF*, Statistics and Information Department, Association of Agriculture and Forestry Statistics, Japan, 621 p.

Naing, T., 1995. "Production of Pulse Crops in Myanmar", in S. K. Sinha and R. S. Paroda (eds.) *Production of Pulse Crops in Asia*, pp. 141-145, FAO RAPA Publication No. 1995/8, Bangkok, Thailand.

Nandi, B. K., 1995. "Nutritional Considerations Towards Production of Pulses in the Asia-Pacific Region", in S. K. Sinha and R. S. Paroda (eds.) *Production of Pulse Crops in the Asia*, pp. 15-24, FAO RAPA, Bangkok, Thailand.

Nene, Y. L. and V. K. Sheila, 1990. "Pigeonpea: Geography and Importance", in Y. L. Nene, Susan D. Hall and V. K. Sheila (eds.) *The Pigeonpea*, pp. 1-14, C.A.B International, U.K.

Opeña, R. T., 1999. Personal communication.

Paroda, R. S., 1995. "Production of Pulse Crops in Asia – Present Scenario and Future Options", in S. K. Sinha and R. S. Paroda (eds.) *Production of Pulse Crops in Asia*, pp. 1-13, FAO RAPA Publication No. 1995/8, Bangkok, Thailand.

----------, 1999. "Status of Soybean Research and Development in India", in *Proceedings of the World Soybean Research Conference VI* pp. 13-22, compiled by Harold E. Kauffman, University of Illinois, Urbana-Champaign.

Prabhavat, S., 1988. "Mungbean Utilization in Thailand", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 508-519, AVRDC, Shanhua, Taiwan, Rep. of China.

Saio, K., 1999. "Current Developments in Soybean Processing in East Asia", in *Proceedings of World Soybean Research Conference VI*, pp. 372-379, compiled by Harold E. Kauffman, University of Illinois, Urbana-Champaign.

Shanmugasundaram, S., 1988. *A Catalog of Mungbean Cultivars Released Around the World*, AVRDC, Shanhua, Taiwan, Rep. of China, 20 p.

Shanmugasundaram, S., Miao-Rong Yan, Ray-Yui Yang, and S. C. S. Tsou, 1998. "Three Near Isogenic Triple Null Lipoxygenase Soybean Lines for the Tropics and Subtropics", in Andrew James (ed.) *Proc. of 10th Australian Soybean Conference*, pp. 31-35, CSIRO, Australia.

Shanmugasundaram, S. and S. C. S. Tsou, 2000. "Quality Traits of Soybean for Food Use in Expanding Its Utilization in Asia", in Proceedings of the Third International Soybean Processing and Utilization Conference, p. 583-586, Korin Publishers, Ltd., Japan.

Singh, R. B., 1988. "Trends and Prospects for Mungbean Production in South and Southeast Asia", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 552-559, AVRDC, Shanhua, Taiwan, Rep. of China.

Singh, V. P., A. Chhabra, and R. P. S. Kharb, 1988. "Production and Utilization of Mungbean in India", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 486-497, AVRDC, Shanhua, Taiwan, Rep. of China.

Sinha, S. K., 1995. "Status of Pulses in the Asia-Pacific Region – Production, Research and Development", in S. K. Sinha and R. S. Paroda (eds.) *Production of Pulse Crops in Asia*, pp. 25-59, FAO RAPA Publication No. 1995/8, Bangkok, Thailand.

Sinha, R. S. and R. S. Paroda, 1995. *Production of Pulse Crops in Asia*, FAO RAPA Publication No. 1995/8, Bangkok, Thailand, 248 p.

Soyatech, Inc., 1998. *Soya Bluebook Plus*, ME, U.S.A., 400 p.

Thirumaran, A. S. and M. A. Seralathan, 1988. "Utilization of Mungbean", in S. Shanmugasundaram and B. T. McLean (eds.) *Mungbean: Proceedings of the Second International Symposium*, pp. 470-485, AVRDC, Shanhua, Taiwan, Rep. of China.

Tickoo, J. L. and A. Satyanarayan, 1998. "Progress in Mungbean Breeding Research with Special Emphasis on Disease and Insect Resistance, Constraints and Future Directions", in S. Shanmugasundaram (ed.) *International Consultation Workshop on Mungbean: Proceedings of the Mungbean Workshop*, pp. 58-77, 7-11 September 1997, New Delhi, India, AVRDC, Shanhua, Tainan, Taiwan.

von Hoppen, M., 1982. "Prospects for Grain Legumes in Asia", in *Grain Legumes Production in Asia*, pp. 191-212, Asian Productivity Organization, Japan.

Williams, J. T., 1993. *Underutilized Crops – Pules and Vegetables*, Chapman Hall, London, 247 p.

Worrel, C., 1999. "The Use of Soy-foods and Soy-based Ingredients in Functional Foods", in *Proceedings of World Soybean Research Conference VI*, pp. 372-379, compiled by Harold E. Kauffman, University of Illinois, Urbana-Champaign.

Xuzhen, Cheng, 1993. "Research and Utilization of AVRDC Mungbean Lines in China", in Cheng Xuzhen, Wang Youtian and Charles Y. Yang (eds.) *The Study and Application of AVRDC Mungbean in China*, pp. 7-13, ARC/AVRDC, Bangkok, Thailand.

Xuzhen, Cheng and Lin Lifen, 1993. "High-yielding Cultivation Technique for Mungbean", in Cheng Xuzhen, Wang Youtian and Charles Y. Yang (eds.) *The Study and Application of AVRDC Mungbean in China*, pp. 88-93, ARC/AVRDC, Bangkok, Thailand.

Zhang, H. Y. and Z. H. Wang, 1993. "High-yielding Cultivation of Zhong-Lu #1 in the Red Loam Region of Hunan", in *Compilation of Papers on Technology and Utilization of AVRDC-improved Mungbeans in China*, pp. 114-118, ARC/AVRDC, Bangkok, Thailand.

2. TRADITIONAL PROCESSING AND UTILIZATION OF LEGUMES

Saipin Maneepun
Director
Institute of Food Research and Product Development
Kasetsart University
Bangkok
Thailand

INTRODUCTION

Legumes have been widely grown and seeds of legumes are used for human food, to provide calories and protein. Leguminosae is one of the three largest families of flowering plants, comprising nearly 700 genera and 18,000 species. The legumes used by humans are commonly called food legumes or grain legumes. The food legumes can be divided into two groups, the pulses and the oilseeds. Pulses group consists of dried seeds of cultivated legumes, which have been eaten for a long time. The oilseeds group consists of those legumes used primarily for their oil content that may be extracted by pressing or by solvent extraction. The oil is known as vegetable oil and is used as cooking oil. The residue, called "oil cake", normally has high protein content and is used as food and animal feed. Generally, legumes can be classified into those that are relatively low and high in edible oil. Several crops from both the groups may be eaten raw as cooked or green vegetables, but invariably are harvested as dried grains.

The most widely cultivated legumes are the two principal oilseeds: soybean and peanut. In 1999, they represent about 75 percent and 16 percent, respectively of the total world production of grain legume crops. The other dried legume grains, mung bean, chickpea, pigeon pea, cowpea, etc. represent only 9 percent in the same year (Table 1). Legume cultivation in developed countries is mechanized, starting from planting, harvesting, handling, storage and processing. But legume cultivation in developing countries use traditional methods and they incur post-harvest losses of about 20-25 percent. The traditional processing and utilization of legumes also require more research attention.

PRESENT SITUATION AND ECONOMIC IMPORTANCE OF LEGUMES

The production of legumes in the world is increasing (Table 1). However, legume production could be increased more to meet the market demand. In 1998/99, United States Department of Agriculture (USDA) has estimated the world soybean production to be around 154.32 million mt, a decrease of about 5.5 million mt from 1993 to 1998. The United States is the largest producer and has increased production from 73.18 million mt to 75.03 million mt due to the expansion of soybean production in corn and wheat fields. But in Brazil, Argentina and China, soybean production decreased in 1999 compared to 1998 (Table 1).

In 1999/2000, the world production of soybean will be slightly lower due to the unpredictable effects of genetically modified soybeans being questioned by the consumers.

Table 1. World Production of Grain Legumes, 1993-99

(Unit: 000 mt)

Year	Soybean	Peanut	Dry Bean	Total
1993	115,039 (73.0)	26,078 (16.6)	16,419 (10.4)	157,536
1994	136,147 (74.5)	28,735 (15.7)	17,865 (9.8)	182,747
1995	125,868 (72.7)	29,277 (16.9)	18,060 (10.4)	173,205
1996	130,345 (72.0)	31,595 (17.5)	18,956 (10.5)	180,896
1997	147,028 (75.1)	29,898 (15.2)	18,936 (9.7)	195,862
1998	159,821 (76.0)	33,751 (16.0)	16,848 (8.0)	210,420
1999	154,323 (74.6)	33,073 (16.0)	19,393 (9.4)	206,789

Source: Agricultural Statistics of Thailand 1998/99.
Note: Figures in parentheses are the percentage of world production of legumes.

World production of peanut in 1999 was around 33.1 million mt (Table 1). The major world peanut producers are China, India, the United States, and Argentina, with a production of about 36.11 percent, 28.37 percent, 5.99 percent, and 2.43 percent, respectively. In 1998/99, USDA estimate of world production of peanut was about 27.76 million mt, an increase of about 3.87 percent from 1997/98 due to increase in production by China, India and the United States. The production of other legumes has been quite variable depending on their availability and price. The major legumes in Thailand are soybean, peanut and mung bean (Table 2) (Agricultural Statistics of Thailand, 1998/99). The soybean production decreased since 1995 due to high production cost, low yield and lower return. The farmers could earn higher income from other crops.

Table 2. Major Legumes (Grains) Production in Thailand, 1994-99

(Unit: mt)

Year	Soybean	Peanut	Mung Bean
1994/95	527,580	150,329	255,506
1995/96	385,550	146,755	234,351
1996/97	359,094	146,703	215,247
1997/98	337,790	126,497	199,935
1998/99	321,225	135,316	225,933

Source: Agricultural Statistics of Thailand 1998/99.

Since 1995, the demand for soybean in Thailand has increased by 18.34 percent while the local production declined and the import increased to 70.69 percent in 1998. In 1999, Thailand imported 870,000 mt of soybean grain for oil extraction and 1.3 million mt of soybean meal for animal feed. Due to the growth of animal industry, the demand for soybean meal will increase. The projection is the import of grain soybean and meal will reach 3 million mt in 2001.

India produced 7 percent and 2 percent of world production of chickpea and pigeon peas, respectively. To achieve nutritional complementarity, cereals and legumes need to be consumed in the approximate ratio of 2:1. The consumption of cereals and legume has been investigated on all continents. For example, rice with soybean in Southeast Asia, sorghum or millet plus chickpea or pigeon pea in South Asia, sorghum or millet with cowpea in Sahelien countries and maize with lima beans in Latin America have been studied (Hulse, 1991). The FAO statistics indicate in Latin America the total production of cereals and legumes is in the ratio of 70:30. Across Asia the ratio is closer to 90:10. In recent years legume production is declining, possibly due to the greater appeal of higher yield cereals to farmers. In most areas legumes are grown on poor land and given less attention than the more profitable cereal grains. Cereals are also processed to have more variety.

The other dried legumes production in Thailand is quite variable. From 1994 to 1999, peanut production increased about 2.04 percent since this legume is used locally as an ingredient in various food products. The export of peanut has also declined by about 28.76 percent due to its higher price, compared to that from neighboring countries. In 1998/99, about 1,660 mt of processed peanut products were exported (about 98 percent to Malaysia).

There are two types of mung bean being cultivated in Thailand; mung bean and black *matpe* bean. Mung bean production was declining from 1994 to 1998, primarily due to labor shortage. In 1998/99, the government launched a promotion campaign to grow mung bean instead of the second rice crops. As a result, the mung bean production increased. Mung bean is used for starch, vermicelli and bean sprout production. In 1998, local consumption of mung bean was about 180,187 mt or 95.54 percent of total production.

In 1994, black *matpe* bean was the major legume exported from Thailand. However, in 1999, mung bean was the major export legume followed by black *matpe* bean (Table 3). Japan, India and Pakistan are the key markets for Thailand black *matpe* bean.

Table 3. Legumes (Grains) and Their Products Export from Thailand, 1994-99

(Unit: mt)

Legume	1994	1995	1996	1997	1998	1999
Mung bean	12,099	8,697	11,825	6,565	8,403	21,306
Black *matpe* bean	45,439	16,225	6,973	9,085	10,505	12,073
Black bean	2,474	2,058	1,941	819	1,034	2,243
Red bamboo bean	4,480	10,026	6,563	8,991	5,429	3,230
Red bean	1,551	1,735	893	642	229	234
White bean	76	48	22	33	21	9
Other dried legumes	9,589	8,252	8,770	6,846	6,872	6,417
Vermicelli made from bean	564	737	664	625	635	1,802

Source: Agricultural Statistics of Thailand 1998/99.

The problems in producing dried legumes are: 1) maintaining the good grain quality; 2) high production cost; 3) low productivity; and 4) difficulty in marketing. Most farmers in developing countries are small landholders, and they usually grow legumes after the cereal crops like rice, corn and sorghum. Post-harvest handling, transportation and storage are the most important factors limiting the product quality of dried legumes.

TRADITIONAL PROCESSING AND UTILIZATION OF LEGUMES

Inefficient post-harvest handling of legumes in developing countries affects the grain quality. Traditional practices still employ manual labor. When post-harvest machinery replaced the manual operation, especially in the rural area several problems were encountered. Generally, 95 percent of bean production was sold directly to the local merchants, and the rest was sold through local middlemen or truckers.

Most farmers in developing countries dry their mature beans under the sun. Local merchants introduced several threshing, shelling and grading machines. Some farmer groups have their own local versions of the machines, if they can obtain a better price. Improved infrastructure, roads and markets could facilitate the farmers to improve their bean quality and price.

Soybean

The traditional processed soybean food products in Southeast Asia can be classified into two categories: non-fermented and fermented.

1. ***Non-fermented Soybean Products***

a) *Soybean milk* – Soybean milk can be prepared at home by grinding whole soybean with water and straining to make rich, creamy milk "soy milk". The product has a unique, beany flavor, which is a well-accepted beverage in Southeast Asian countries. The processing technology for soy milk is well-developed and therefore packaged soy milk is available through food stalls. At the local market, soy milk is usually dispensed from large stainless steel urns. At present, plain, sweetened and flavored soy milk in ultra heat treated (UHT) packaging is also available. Instant soy milk powder has also been developed for convenient use. Pasteurized soy milk can be stored in the refrigerator for a week.

Soy milk factories use sophisticated equipment and market them in tetra packs and plastic bottles and their shelf life is about six months. The indigenous soy milk taste, texture and flavor in those containers are still retained, as traditional products in the fresh market. At present, three large companies are producing and marketing soy-products. Bean quality is the major problem. The factories purchase the bean through contractors and store them in their own warehouses. Local soybean is the best raw material for soy milk processing, even though the factories have to store the beans, paying interest and rent. Normally, the factories have to stock their grain supplies for about four months. The arrangement to purchase soybeans has to start early in the season, since the premium grade is in high demand.

The market potential for soy milk is expected to expand and even compete with soft drinks, especially in the Thai market.

b) *Tofu or soybean curd* – Tofu is prepared from soy milk. After coagulating soy milk with coagulant, the curd is separated from the water and pressed into blocks or rolls. There are several soft/hard gels like products promoted in the market; white hard curd, yellow hard curd, white soft and soft curd in plastic bags.

Based on production capacity of tofu industries they are classified into two types.

i) More than 1 mt of grain used daily – about 200 factories; and
ii) Less than 1 mt of grain used daily – more than 5,000 factories.

The tofu production is considered as a cottage and small-scale enterprise. There are two to three medium-size factories investing in more sophisticated machines to produce packaged firmer curd or pressed tofu in airtight plastic containers and marketed in the supermarket. Their shelf life under refrigerated storage is about one week.

The factories buy premium grade grain from local farmers for tofu production. The market potential of tofu products is expected to expand in the future. With the development of more varieties tofu is made with different taste, texture and flavor.

c) *Yuba* – A sheet-like coagulant, *yuba* forms on the surface of warm soy milk as it cools. The soybean sheet contains emulsified oil from soy milk, high protein and a delicate flavor. *Yuba* production is a cottage industry. The film is formed at the surface of soybean milk, which is boiled until the sheet of film is thick enough, and then it is removed from the surface of soy milk by using a stick. The wet sheet is placed over a sheet of thick cloth, and air-dried by hanging them on a bamboo pole. The *yuba* is used for wrapping meat and vegetable fillings in Chinese cuisine.

2. ***Fermented Soybean Products***

There are several fermented soybean products available in the local markets. In Thailand, most fermented soy-products are similar to Chinese soy-fermented products such as soy sauce, soypaste, *tao-si* (fermented black-skin soybean), *thua-nao* (natural fermented soybean), and *sufu* (fermented curd). The processing still employs traditional methods. Each fermented product has a specific aroma, flavor and taste, that consumers could distinguish since they are quite familiar with those characteristics.

a) *Soy sauce (Si-iu)* – Several factors should be considered to produce quality fermented soy sauces. The soy sauce should have a bright reddish-brown to dark-brown color, with a salty taste, unique sharp flavor and aroma. It is made by hydrolyzing cooked soybean, with the addition of wheat or rice, by enzymes during mold and bacterial fermentation.

A two-stage fermentation is required to produce soy sauce. The first stage is *koji* production followed by second stage, called *aromi* fermentation and the last step is preparation of the extract. Production of *koji* is an aerobic solid-state mold fermentation by *Aspergillus oryzae* for 3-4 months. *Aromi* fermentation is an aerobic fermentation at 20-22 percent (w/v) brine solution by mixed cultures of halophilic yeast and lactic acid bacteria (Charoenthamawat, 1997). The perfect fermentation of *aromi* should produce a bright reddish-brown color, pleasant aroma and salty taste.

b) *Soy paste (Tao-cheow)* – The soy paste is semi-solid, light brown to dark brown color, salty taste with specific flavor and aroma. Using microorganisms; *Aspergillus oryzae, Lactobacillus delbrulckii, Pediococcus halophilus, Saccharomyces* sp. *Koji* production was developed. After the first stage of *koji* fermentation, about 3-4 months, the liquid was separated for production of soy sauce. The resulting paste-like solid part is packed in bottles and pasteurized. Soy paste can be kept for many years, but the flavor will improve if the product is kept for a year.

Most fermented soy products are processed into both soy sauce and soy paste with the ratio 70:30, 60:40 and 50:50 depending on the market requirement (Maneepun, *et al*., 1997). There are more than 100 soy sauce and soy paste factories in the country, of which only five factories have large production capacity. The market for both fermented soy products is growing at an annual rate of 15-20 percent.

c) *Fermented soy curd (Tao-hu-yi)* – Fermented soy curd is a soft cheese-type product which is made from cubes of soybean curd by the action of fungal culture, *Actinomucar elegans*. The product has a yellowish or red color, salty taste with characteristic aroma. Yellowish color type is eaten directly as a relish and the red color type is cooked with vegetables or meat. Making fermented soy curd involves three steps; preparing tofu, molding and brining.

The surface of soybean curd is applied with pure culture of appropriate fungus, then it is incubated at 20ºC for 3-7 days. The product needs to age for about 40-60 days to develop the specific flavor and aroma.

d) *Fermented whole soybean (Thua-nao)* – *Thua-nao* is a traditional non-salted soybean fermented like Japanese *natto* by mixing with microbial cultures and is widely consumed in the northern part of Thailand. The products available in the market are of two types:

i) Brownish-yellow paste with a slight salty taste and strong smell, and has a shelf life of about two days; and

ii) Brown dried chips with the same taste and smell and has a shelf life of two months.

The soybeans soaked in water are cooked in low heat for 3-4 hours until the beans are soft and the water is drained. The beans are placed on a layer of banana leaf on a bamboo tray and covered with banana leaves. The beans are allowed to ferment naturally for 3-4 days until the beans are covered with a sticky, viscous and colorless gum. Small quantity of paste is used to make small ball of one to one and half inches diameter and they are processed to form thin chips, sun dried and marketed.

Through research, it was found that use of mixed culture fermentation of oligosaccharides, utilizing *Bacillus subtilis* and vitamin B_{12} producing *Bacillus megaterium,* has improved the quality of *thua-nao*. Soybean oligosaccharide sugar utilizing *Bacillus* was isolated from various sources of *thua-nao*. *Bacillus subtilis* B_4 was found to produce the best proteolytic activity, as well as soybean sugar-utilizing property, among 120 *Bacillus* isolates. Mixed fermentation of *Bacillus* B_4 and *Bacillus megaterium* under optimum conditions, could improve the quality of *thua-nao* by enhancing more digestible soybean proteins, soybean sugar, as well as vitamin B_{12} content in the fermented masses (Yongsmith, 1999). Factors affecting the fermentation are currently examined to produce a more sanitary and uniform product.

Thua-nao is considered as an inexpensive high-protein food that could be easily produced, and if properly prepared has a long shelf life. *Thua-nao* paste and chips contain 16.9 percent and 36.8 percent of protein and 7.4 percent and 14.8 percent fat, respectively. Due to high vitamin B_{12} *thua-nao* products have become popular among vegetarian population.

e) *Imitation fried pork rind (kap-mu-tiem)* – Fried pork rind is a well-known snack that is widely consumed in the northern part of Thailand. Imitation fried pork rind has been developed by inoculating tofu with *Mucor zychae*, dried and fried.

The *kap-mu-tiem* is commonly processed by the home-scale industry. Soaked soybean is ground with water and strained through a coarse cloth to separate the extracted soy milk from the insoluble residue. The milk is heated to a boil and cooled to about 50ºC. Calcium or magnesium sulfate is added to coagulate the protein. Finally, firm cake-like curd (tofu) is formed by shaping the coagulated protein in a wooden box with a weight on the top to press out the whey. Tofu is cut into

11.0×2.5×1.5 cm and then inoculated with the mold, *Mucor zychae*. The inoculated tofu pieces are incubated at 22-23ºC or room temperature for 24 hours. The pieces are dried at 90ºC for four hours to stop mold growth. The mycelium is washed off with 10 percent saline water, and then slowly dried again at 40ºC for 12-18 hours. The product has to be fried before being consumed (Kuruwana, *et al*., 1980).

Kap-mu-tiem is considered an inexpensive high-protein food and a good source of B-vitamin. Fried *kap-mu-tiem* has 44 percent protein, 42 percent fat and 1-2 percent moisture. This fermented soy food is quite popular among the population, who enjoy consuming *kap-mu-tiem* for health reasons.

Peanut Processing

Peanut is predominantly utilized within Thailand. A few processed products such as roasted, dried, boiled peanut cake are exported. Research relevant to selection of peanut varieties with low aflatoxin has been undertaken. Research also focused on post-harvest practices to prevent microbial contamination (Maneepun, 1991). Boiled, dried, roasted and confectionery peanuts are used for direct consumption. Vendors use simple packaging. The peanut factories undertake shelling, boiling, drying and oil extraction. About 117 shelling factories handle a capacity of more than 55,000 mt per year. Ten boiling and drying factories use 15,600 mt per year. Thirty-four oil extraction factories use about 30,000 mt of shelled or 45,000 mt of unshelled peanuts, and produce about 10,000 mt of peanut oil.

Peanut oil extraction industry normally uses hydraulic or screw press and solvent with an extraction capacity of about 85-90 percent of total oil extraction. Peanut cake containing about 50 percent protein is used for animal feed, since it is a low-quality product. Both refined and unrefined peanut oil are available in the local market.

Peanut bar and coated roasted peanut products are processed and packaged using modern equipment to keep them fresh and to prolong their shelf life. Such new products with diverse flavors and texture could become major snack foods for export to neighboring countries.

Mung Bean and Black Gram processing

About 73 percent of domestically produced mung bean is used for local consumption. The largest processing industry is transparent noodle and starch extraction, which accounts for about 20 percent. Since transparent noodles are processed from mung bean starch, it is usually recovered from noodle processing. Traditional noodle processing is still popular. Recently modern machines for starch extraction has been developed. The recovery of starch is low with traditional technologies. To increase the recovery rate, wet and dry milling technologies have been developed. Wet milling is commonly employed in most industries and the residue from milling extraction is used for animal feed. The technology to recover byproduct (bean residue and waste liquor) has been developed. The residue is used for making high protein food. However, at present, protein residue is utilized only as animal feed. The utilization of protein from these noodle factories is commonly practiced in the Philippines, Taiwan and China.

Bean sprouts are processed from mung beans and black grams. Bean sprouts are produced daily to have them fresh. Traditional technology is used at home level or cottage industry level. In the canning factories, bean sprouts are packed with mixed vegetables for overseas market, but the market is still small.

Many colorful and attractive desserts are prepared from mung bean for local consumption. These preparations are done at household and cottage levels. Mung bean flour from wet-milling technology is processed as a secondary food product, for further processing, which is available in the local market. This flour is used as stuffing in various dessert products.

Ten mung bean-milling factories, export mung bean products. Most milling factories employ traditional technology, and after milling losses are about 30 percent. Since polished mung bean has potential market in Japan and Middle East countries, some technologies from India and Taiwan to polish mung bean has been imported and used. Polished mung bean has higher value than unpolished mung bean, use of machines will improve efficiency and quality.

MODERN PROCESSING AND UTILIZATION OF LEGUMES

Soybean

The soybean industry has introduced a number of new technologies that have, and will continue to have, significant impact starting with farming methods, bulk commodity storage, handling and distribution infrastructure. Soy meal and oil are the fundamental products of soybean, from which most other processed soy-related products are derived. In processing, the beans are first cleaned to remove foreign material. They are then dried and cracked into small pieces and dehulled. The resulting pieces are heat conditioned and rolled into “flakes” that are ready for oil extraction. Oil is extracted from soybean flakes by using hexane solvent. The protein-rich flakes are conveyed to toasters and are dried and ground while the crude soybean oil is degummed and refined for edible and non-edible uses.

Soybean meal serves as the basic protein source and is mixed with corn for use as animal feed. It is also processed into high-value food items such as soy flour, soy grits and soy protein isolates. Soy hulls are used in high fiber breads.

Refined soybean oil is used throughout the world in such edible products as cooking oil, salad dressings, margarine, shortening and mayonnaise. The degumming process also yields lecithin, which is widely used in the candy and baking industries.

Soybean is also used in several food industries as full fat soy flour for baking, soy-based beverages, snack foods and a myriad of traditional foods such as soy sauce, tofu, miso and *tempeh*. Led by soy milk and tofu, the United States soy food industry has been growing by an annual rate of 35 percent over the past few years and is expected to sustain a growth of 15-20 percent for at least the next 10 years.

Texturized vegetable protein (TVP) made from defatted soy flour using single- and twin-screw cooker extrusion, is available in dry forms. Various styles of TVP can be found in granules, flakes, chunks or slices. The product has low moisture and has a long shelf life. It can be kept in an airtight container at room temperature for several months. TVP must be reconstituted with equal quantity of water before use, and it can also be used as a meat substitute in main dishes and processed foods.

There are various technologies for developing soy flour, protein isolates, concentrates that can be incorporated in thousands of processed foods such as baked goods, meat products, protein drinks, soup bases and gravies.

Peanut Industry

Peanut processing technology has been developed similar to that of soybean. Peanut flour is obtained from oil extraction process. The flour (meal) protein concentrate and isolate for human consumption has to be prepared from edible-grade peanuts. The specific use of meal in various processed food products to improve nutritional quality has been developed, but the products are not as popular as soybean. Canned boiled peanut and frozen boiled peanut have been promoted in the global market. Various peanut-based snack foods are packed in attractive packaging. Peanut butter processing is quite a large industry. The quality of peanut butter has improved substantially since its discovery and initial manufacture. Good practices in storage, handling, processing and packaging have resulted in a product that is consistently high in quality. Good quality, nutritional value, economy, and preferred flavor continue to make peanut butter a popular food product.

Mung Bean Noodle Processing

Mung bean cracking machine, a grinder that separates liquid and solid, a starch separator, a starch mixer and a noodle machine have been developed for making transparent noodles which are widely consumed in South-East Asian countries. The development of these economical machines is for the small noodle industry. The noodle characteristics are evaluated for texture and color. The diameter of noodle is consistently about 0.5-1.5 mm.

FUTURE PROSPECTS AND ISSUES IN LEGUME PRODUCTION AND UTILIZATION

Improved soybean varieties in the future should help the farmer to reduce the cost of production and increase the productivity. Improved management technology should address the no-tillage production of legumes. Farmers should be able to choose varieties based on the soil type, moisture conditions, and biotic stresses.

Biotechnology developed herbicide resistant soybeans have brought considerable controversy among the public. Bio-safety, food safety, and environmental concerns are the major issues. There is a need to have cost effective technologies to detect genetically modified organism (GMO) and genetically modified food (GMF) so that labeling of such items can be effective.

Although biotechnology is a tool to increase world food production, there is an urgent need to educate the public. It may take time. Cereal and grain legume combination is an excellent one to combat growing hunger and malnutrition due to population growth.

REFERENCES

Charoenthamawat, P., 1997. *Fermented Soy Food Products in Training Course on Agricultural Products Processing and Quality Control*, Ministry of Education and Culture, Indonesia, 1 July-10 October, 8 p.

Hulse, J. H., 1991. “Nature, Composition, Utilization of Gram Legumes”, in S. D. P. Hall, Vithal R. Sidher, and V. Sadhana (eds.), *Use of Tropical Grain Legumes – Proceeding of a Consultant Meeting*, pp. 11-27, 27-30 March 1987, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India.

Kuruwana, P., S. Phapavat, W. Varanyanond, and S. Reungmaneepaitoon, 1980. “Kap-Mu-Tiem”, *Food*, 12 (1):43-51.

Maneepun, S., 1991. *Prospect for Post-harvest Handling, Utilization and Processing of Food Legumes and Coarse Grains (FLCG) in Thailand*, RAS/89/040 Working Group in Post-harvest Handling, and Coarse Grain (FLCG), 18-23 August, Chiang-mai, Thailand, 29 p.

Maneepun, S., S. Vatanutchariya, S. Taksinavisuth, W. Varanyanond, B. Sutsukon and S. V. Langley, 1997. *Project on the Study and Database Development of Soybean and Oil Crop: Research on Soybean Industry*, Office of Agricultural Economic, Ministry of Agriculture and Cooperatives, pp. 24-27 and 46-50, 30 December, Bangkok, Thailand.

Ministry of Agriculture and Cooperatives. *Agricultural Statistics of Thailand 1998/99*, Center for Agricultural Information, Office of Agricultural Economics, Agricultural Statistics No. 31/2543.

Yongsmith, B., 1999. "High Vitamin B_{12} Fermented Soybean (*Thua-nao*) by Mixed Cultures of *Bacillus* sp.", *Proceeding of World Soybean Research Conference VI*, 694-695.

3. MODERN PROCESSING AND UTILIZATION OF LEGUMES – Recent Research and Industrial Achievements in Soybean Foods in Japan –*

Akinori Noguchi
Director
Crop Production and Postharvest Technology Division
Japan International Research Center for Agricultural Sciences (JIRCAS)
Ministry of Agriculture, Forestry and Fisheries (MAFF)
Tsukuba, Ibaraki
Japan

INTRODUCTION

In Japan, five million mt of soybeans are imported annually. However, four million mt are used for edible oil production resulting in more than three million mt of defatted soybean. About 90 percent of defatted soybeans is used as livestock feed due to shortage of feed resources in Japan. According to the Food Balance Sheet (MAFF, 1996), the domestic soybean production was less than 120,000 mt whereas the amount of imported soybean was 4.813 million mt. Domestic consumption of soybeans for feed, seed, industrial use, waste, gross food and net food in 1996 was 110,000 mt, 3,000 mt, 3,901,000 mt, 120,000 mt, 785,000 mt, and 785,000 mt, respectively.

In general, soybean foods are considered as subsidiary items for the principle foods (e.g. cooked rice) in Japan. The continuous decline in rice consumption results also in reduced demand for soybean foods, especially among young Japanese, due to the change in their dietary habits. Since the early 1980s, Japanese food markets have been stagnant and the food companies continue to diversify their soybean products by making new products such as substitutes for meat proteins and extenders and improving the quality of final products. Therefore, soybean food companies are putting a great deal of effort into food research on soybean foods so that they can gain new markets. The recent research on the functionality of soybean foods and their hydrolyzed intermediates, encourages soybean food companies to continue their research efforts.

This paper will review the recent research and industrial achievement in soybean foods, including the major traditional foods in Japan.

TRADITIONAL USE OF SOYBEAN

Major traditional soybean-based foods are miso, soy sauce and tofu.

* This paper was presented to the APO Seminar by drawing largely from the draft that the author was preparing for the JIRCAS Integrated Research Project in India.

Miso

"It's Mom's Taste" is the way people describe the taste of miso. Both the taste and color of miso change according to the place of origin. Figure 1 shows the processes of miso making from different materials.

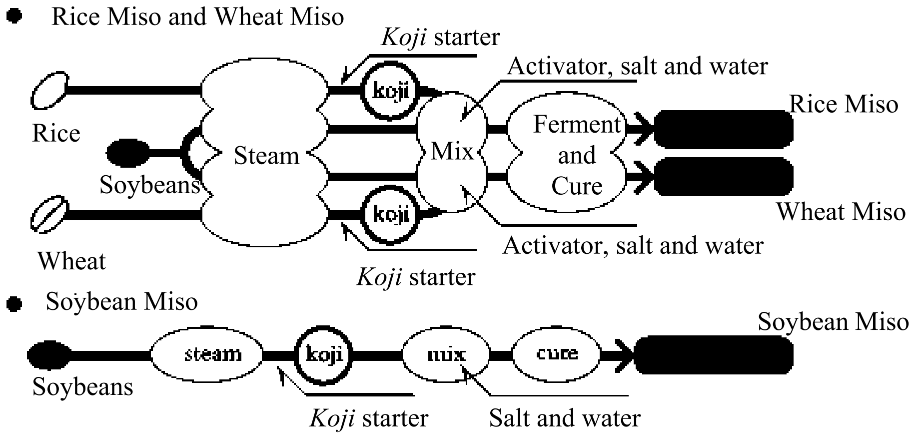


Figure 1. The process of Miso making

Soy Sauce

It takes time to brew the natural ingredients for "Soy Sauce", much like the aging of fine wines and cheeses. Wheat grains are roasted and crushed while soybeans are softened by steaming (Figure 2). A special seed starter is added to the wheat and soybean mixture and left to sit for three days. This forms a dry mash called *koji*. The *koji* is combined with salt and water to form *moromi*, which is fermented in large tanks until it reaches its full flavor. *Moromi* is then poured onto cloths, folded and pressed in order to obtain the raw soy sauce. The extracted soy sauce is refined and pasteurized, and the finished product is packaged in bottles.

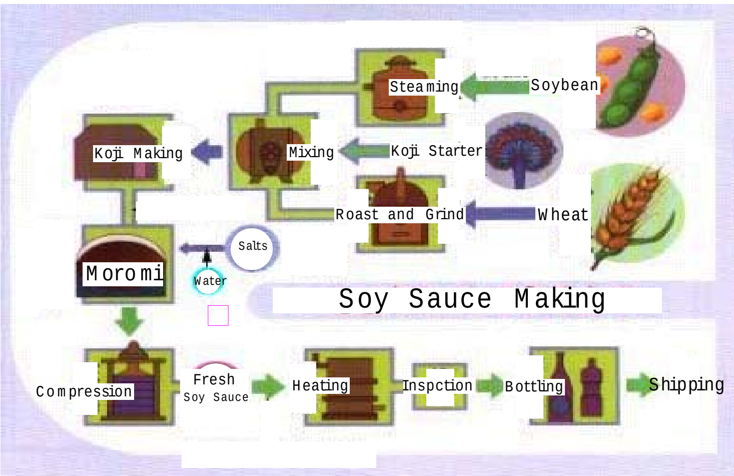


Figure 2. Outline of Soy Sauce Making

Tofu

Tofu is made using the following method: tofu grade soybeans are soaked overnight in water. After draining the water, a small quantity of boiling water is poured, the beans are pulverized. The mash is ladled into boiling water, like dumplings, and allowed to boil gently for about 10 minutes. This stage of the process is crucial since enzymes of the bean are inactivated during boiling. The resulting slurry is filtered to obtain soy milk and the residual material is called *okara*. A small amount of either calcium sulfate ($CaSO_4$) or magnesium chloride ($MgCl_2$) is added to coagulate soy milk. In this regard, the Chinese have been using calcium salts mined from mountain quarries for over 2,000 years. That salt is the pure form of gypsum. On the other hand, the Japanese traditionally use sea salt that contains small quantity of magnesium chloride ($MgCl_2$). After the coagulant is introduced, the milk separates into curds and whey. The curds are gently scooped off the top of the whey and ladled into a mould lined with cheesecloth. The forming container has many small holes to allow drainage of the whey.

Typical derivatives from soy milk or tofu making are "*yuba*" and "*shimi-tofu*". The relatively thick soy milk is poured into a shallow pan and heated to evaporate the water. A thin film formed on the surface of soy milk is gently removed and then dried. It is called "*yuba*". This process of dry-denaturation of soy milk results in cross-linking of proteins. As the film is pulled up (Figure 3), the remaining soy milk is concentrated with its carbohydrates and therefore, the films at early stage have fine texture and high quality.

Figure 3. *Yuba* Making

Figure 4. *Shimi-tofu*

Shimi-tofu (Figure 4) is prepared from soy protein curd. The curd is cooled to below 0ºC to form small ice crystals. As ice crystals grow, protein is concentrated and close proximity of reactive proteins allows additional linkages. The frozen curds are thawed to expel excess water, forming dried compound having sponge-like texture called *shimi-tofu*.

The consumption of each soybean product in 1998 was not so different from the previous years, and is as follows (in mt): miso, 165,000; soy sauce, 26,000; tofu and its derivatives, 494,000; fermented soybean, 122,000; *shimi-tofu*, 30,000; and others, 101,000. The domestic soybean has been used mainly for making foods due to its higher protein content, matched size and good taste. The consumption pattern was 44 percent for tofu, 30 percent for cooked beans and side dishes, 13 percent for fermented soybean and 9 percent for miso and other products. Data suggest that the market size of traditional foods of soybean is not likely to increase very much in the future in Japan.

Food Ingredients from Soybean

As shown in Figure 5, soybeans are used to make various products such as meat extenders and meat analogues with well-controlled nutritional value.

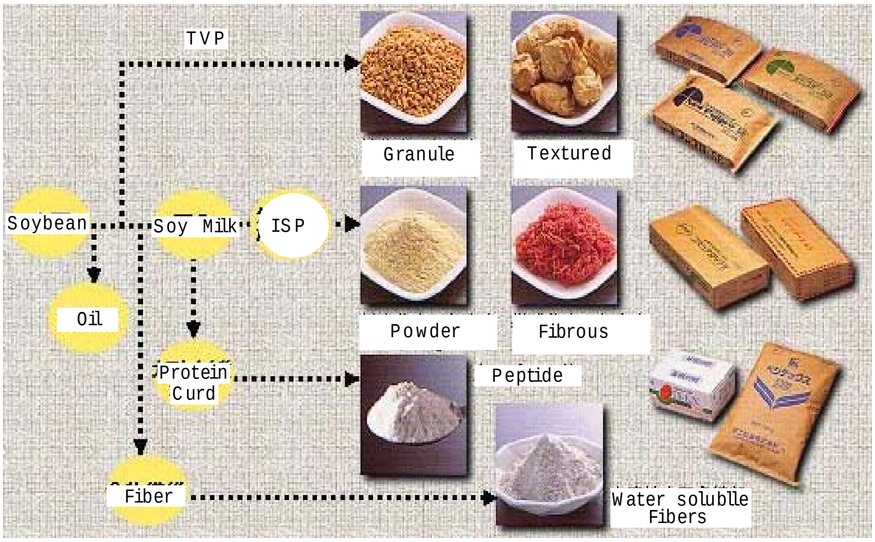


Figure 5. Soybean-derived Ingredients

According to the Japan Association of Vegetable Protein Foods, the production of food derived from vegetable proteins in Japan was about 61,000 mt in 1997, consisting of 41,000 mt from soybean and 20,000 mt from wheat by materials and 45,000 mt of texturized vegetable protein (TVP) and 29,000 mt of powder by product form.

Extrusion cooking is widely used to make TVP in Japan. Some novel technology and research related to soybeans processing in Japan are described below.

EXTRUSION COOKING

The twin-screw extruder has attracted the attention of researchers and food manufacturers because of its high capability in material transportation as compared to the single screw type. The better mixing, kneading, heat exchange and self-cleaning functions of twin-screw extruders also provide an incentive to develop such food technology in order to overcome the difficulties associated with the single screw type. Recent development of twin-screw extruders provides us with new applications in various food processing, especially to wet processes. The idea of a cooling die also promotes this development and enables us to process fish and animal meats that could not be texturized with the extruder in the past.

Fate of protein in extruders can be summarized as follows: the material is transported to the first heating zone where the proteins are reacted, denatured and separated from other components (e.g., oil and carbohydrates). Then they are fragmented into small coagulated particles. These particles are melted at higher temperatures and deformed by the shear stress imposed by the screw movement and the die. While the melted materials pass through the die, the super-heated water and the energy accumulated cause the expansion of the materials, resulting in a laminar or sponge structure. This is why extrusion cooking is sometime called thermoplastic extrusion. The thermoplastic properties of proteins are supported by the fact that heat-denatured soy proteins of defatted soybean is completely changed to different shapes from their original globular particles after extrusion cooking. Component separation during extrusion cooking is also supported by chemical analysis which reveals that the matrix is mainly composed of proteins free from other components.

Based on the hypothesis described above, two companies have succeeded in making a very fibrous protein product and TVP with chicken meat-like texture. One company mixed the defatted soy flour with potato starch and extruded the mixture at relatively higher moisture content with twin-screw extruder. The extrudates were found to have very fine well-aligned fibrous structure upon rehydration in hot water. The other company extruded the mixture composed mainly of soy protein and obtained meat-like products successfully accepted in the market.

High contents of liquids such as water and oil in the materials are localized between the protein matrices and thus making the products soft and juicy. The problem is how to remove the excess heat and mechanical energy accumulated in the materials in order to have continuous and dense products. The idea of a cooling die suggested by Crocco (1976), provides the answer to that problem by providing a suitable environment to impart sufficient viscoelasticity to the emerging melted material, and also increasing the shear stress needed to deform the melted proteins within the aligned structure.

The cooling die shown in Figure 6 has a built-in breaker plate to enhance the homogeneous flow of materials and deformation of the material by the shear. Defatted soybean flour (DSF) can be continuously extruded even at 60 percent moisture without any intermittent extrusion. The products are very tough and elastic. It is very interesting that the products can be easily torn, spreading the fibers parallel to the extrusion direction but hardly at all in the crosswise direction.

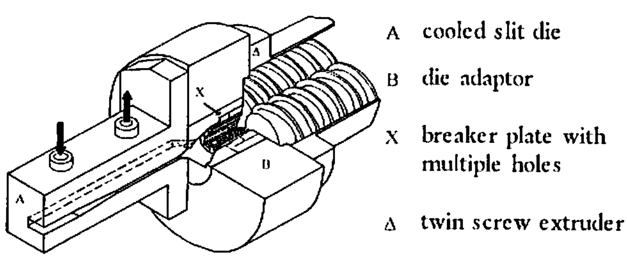


Figure 6. Sectional View of Cooled Slit Die

Figure 7. Crab Meat Analog

The distribution of components in the extrudate indicated that the protein was reformed into an aligned string structure and fused in places while other components (e.g. carbohydrates) were dispersed into the void spaces among the protein matrices. The effects of barrel temperature on the tensile strength of extrudates suggest that the cross-linking reaction occurs among the protein particles while they are melted. Effects imposed by pH suggest that the -S-S- exchange reaction at higher water contents occurs at neutral pH because the extrudates show the highest strength at pH 7 and higher protein solubility in a buffer containing SDS + 2-mercaptoethanol. When DSF is extruded at various water contents (20-60 percent) and different residence times at constant barrel temperature, the extrudates have lower solubility at lower water content and/or longer residence time. Near Infrared Analysis (NIR) shows the higher absorbance of -NHCO- for DSF processed at low water content in the high pressure cell.

These results suggest that two protein reactions, probably -S-S- and isopeptide bonding, compete with each other under the given conditions and that the latter likely takes place at lower water content and/or longer heating time. Isopeptide bonding is a kind of condensation reaction, just like amino acid polymerization which prefers dry conditions. Artificial peptide bonding should be avoided in order to maintain digestibility of products (Hurrel and Carpenter, 1977).

The thermoplastic property of protein at higher temperatures enables us to apply an injection moulding method to make a large meat lump. Isobe and Noguchi (1988) designed a special moulding and confirmed its high potential for DSF, deboned chicken and fish meat.

Wet extrusion is opening the way for fish and meat products. For example, one of the members of the R&D Association texturized the minced meat of Alaska pollack to a new crab meat analogue, "*Kanikama*", using the twin-screw extruder equipped with a cooling die. This product and its derivatives are gaining great success in the Japanese markets. Figure 7 shows the attractive product and its finely aligned string structure. *Kanikama* has been made by cutting sheets of fish protein curd into thin strings and bundling them to have a similar size to natural crab muscle. However, this company transformed fish proteins into more finely aligned strings (<60 :m) with wet extrusion and the resulting *Kanikama* is improved in the breaking strength by 1.5 times over the current *Kanikama*. It also possessed very similar texture to the natural one.

Ido, *et al*. (1993) examined the formation of fibrous structure in processed cheese using twin-screw extruder. They used two types of cheese, both contained whey protein concentrate (WPI [whey protein isolate]: protein content 75 percent). Gouda cheese ripened for two weeks and Emmental cheese ripened for eight months. The mixtures were fed into twin-screw extruder and cooked at 70-90ºC then cooled to approximately 45ºC in a low-shear kneader and subsequently stretched to obtain fibrous structure. The mixture cooked at 70ºC and 80ºC showed better fibrous structure than that processed at 90ºC. A decrease in fibrousness occurring when cheese was cooked at 90ºC was due to mutual adhesion of protein strings by heat. WPI probably protects the individual protein strings formed in cheese from their fusion by being absorbed to them and hence reducing their hydrophobicity, as shown in Figure 8.

There still remain some uncertainties in twin-screw extrusion cooking for food manufacturers. The large capital investment needed makes the industry hesitant to get twin-screw extruders in spite of the high potential of this technology. In short, the future of twin-screw extrusion cooking in Japan depends upon its being more economical with regard to flexible, optimum and automated operation, which can be accomplished by further research to produce new foods.

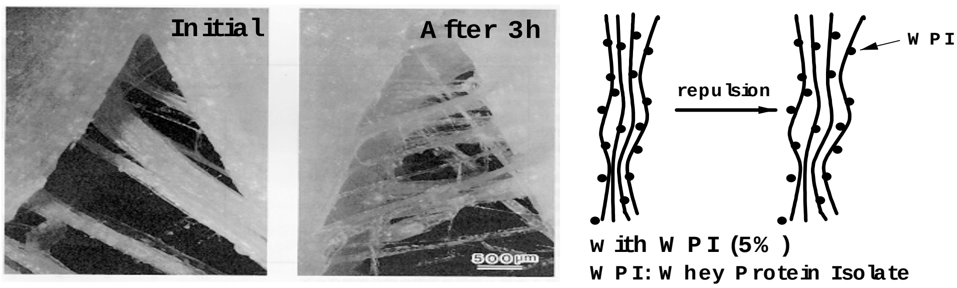


Figure 8. String Formation and Its Protection with WPI

HIGH PRESSURE COOKING

Use of pressure in food processing gets less attention than thermal processing. It is because the test apparatuses for food research have been developed only recently. In addition, the high pressure range has hardly any relevance to food processing. However, recent advances in equipment are expected to make this technology more feasible for food companies with the understanding that pressure can be momentary and equally applied to any form and composition of food without leaving any physical damages or any pressure energy after its release. The technique applies hydrostatic pressure of several hundreds MPa on foods for the purpose of sterilization, protein denaturation, control of enzyme and chemical reactions, homogeneous defrosting at low temperature and others. High pressure cooking is based on cold isostatic pressing (CIP) originally developed for ceramics process and achieved by applying high pressure to the foods through the surrounding water or other liquids.

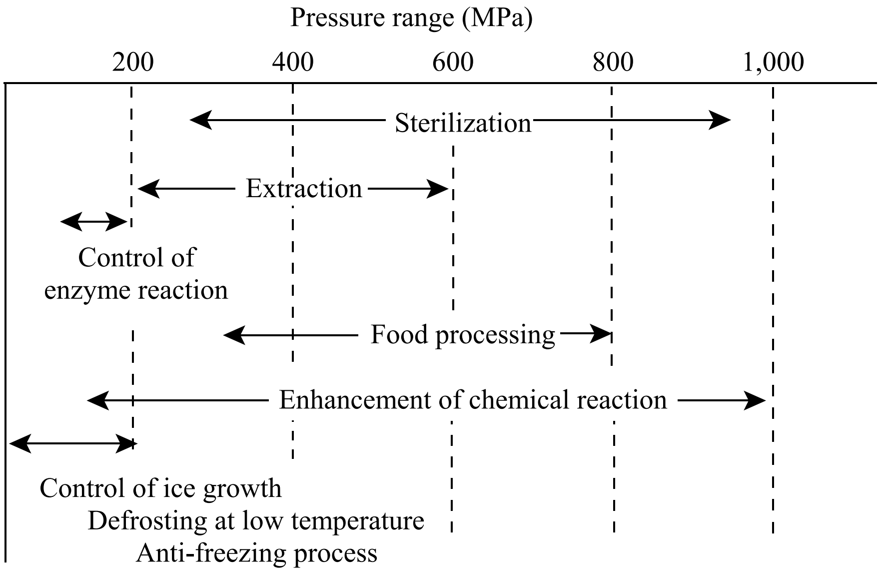


Figure 9. Pressure Range for the Applications

Sterilization is mainly accomplished through heat treatments as one of the most important processes involved in food manufacturing. Depending on the components of the materials handled, however, one may try all possible means in order to avoid undesirable changes and losses of components during thermal processing. For example, there are high-grade types jams that contain a fairly high proportion of strawberry which keep their original form. Because of their high viscosity, the homogeneous and quick heat transfer in the jam could not be achieved and thus such jams must be stirred well for long period during thermal sterilization. Longer stirring and heat treatment cause damages to strawberry, namely changes in color and flavor.

High pressure sterilization does not cause thermal degradation and losses of heat sensitive components (vitamins, color pigments and aromas). High pressure equally sterilizes the inside and the surface of foods, regardless of their shapes, and also reduces the necessary energy to one-tenth of that used in usual heat treatments. Until now, many researches believed that high pressure affects proteins and cell membranes of microorganisms. It is likely that proteins are changed at ≥300 MPa and cell membranes are forced to change its physical state from liquid to solid at ≥100 MPa due to the increase of the melting point of phospholipids under higher pressure. Generally, it is felt that the primary site damaged by high pressure is the cell membrane of microorganisms (Morita, 1975).

It should be noted that the necessary level of high pressure is variable depending on the composition and pH of food. Higher concentrations of sugars, salts and amino acids reduce the effects of high pressure on foods. Furthermore, the amounts and distribution of free water are the key for proper sterilization by high pressure. Recent research revealed that microorganisms become more sensitive to high pressure at relatively higher (60-80ºC) or lower (>-20ºC) temperatures. Some spores could germinate under high pressure of about 100 MPa and are inactivated at intermittent pressure of about 600 MPa. Hayakawa, *et al*. (1994) found that the oscillatory pressurization was more effective against *B. stearothermophilus* spores than the continuous process. However, the germination process is still unclear and not all spores germinate by applying pressure.

Bridgman (1914) reportedly carried out the first research on protein denaturation by high pressure. In Japan, Suzuki and Suzuki (1962, 1963, 1965) have done a number of studies on protein, demonstrating that protein denaturation occurred at 300 MPa, and that at above 700 MPa, the changes became irreversible. Recent studies on high pressure cooking have been expanded to cover fish protein (Yoshioka, *et al*. 1992 (1982?), seafood (Kimura, 1994) and egg protein (Honma, 1994). Honma (1994) examined the binding of fresh meats with egg white at 500 MPa at 20ºC for 10 minutes and found out that the prepared meats were not separated from each other even after cooking at 200ºC. Pork meat could be processed by high pressure in order to make a new product like raw ham, that was well-accepted upon sensory evaluation (Honma, 1994).

Kajiyama, *et al*. (1995) applied high pressure (<500 MPa) to soy milk and examined its protein changes. The soy milk remained as liquid within the range of examined pressure and its viscosity increased when the time of pressurization was less than 10 minutes. However, 500 MPa for 30 minutes solidified the soy milk. Soy milk showed better emulsifying and stability properties but had poor capacity. Additionally the content of sulfhydryl (SH) group residue in soy milk increased a little under anaerobic pressurization. The hard-type tofu could be made from the pressurized soy milk with $CaCl_2$. Electrophoresis and isoelectrofocusing techniques revealed that soy proteins were dissociated while some of them were coagulated by high pressure. Fluorescence analysis also showed that soy proteins were modified by high pressure, having larger hydrophobic regions. After pressure treatment, soy milk showed higher affinity to beany flavor components and saponin which would lead to better use of soy milk in soy foods.

High pressure cooking is characterized by: (1) the transfer of high pressure is spontaneous and does not depend on the shape of materials; (2) high pressure cooking is free from the problem of mechanical deterioration of materials caused by the agitation necessary for the homogeneous and quick heat transfer; (3) high pressure could be maintained by the mechanical method and saves the energy needed for cooking, and; (4) the release of high pressure could be achieved instantly which makes the cooking controllable.

OHMIC HEATING

Generally, the thermal processing of food products involves heat transfer into the food from hot surroundings, the driving force being the temperature gradient between the food products and its surroundings. Heat transfer in liquid foods mainly takes place by convection provided the liquid is not too viscous. However, in processing particulate foods, the solid phase is only heated by conduction which is a much slower process than convection due to the lower thermal conductivity of most foods (Sweat, 1986). The quality deterioration of food products during thermal processing could be minimized by a high temperature short time (HTST) process. However, there may be an upper temperature limit for avoiding overcooking of food’s surface.

When food products contain sufficient water and electrolytes to pass electric current, ohmic heating could be used to generate heat within the food products by the passage of an alternating current. The method enables the solid phase or viscous liquids to be heated as fast as thin liquids, thus making it possible to use HTST techniques on solid or viscous foods. One of the industrial achievements of this technology in Japan is the production of 60 percent of the annual production of bread crumb using ohmic heating (Figure 10). The companies claim that such method saves production cost by reducing the necessary energy for heat and simplifies the system.

Figure 10. Bread Bodies Prepared with Ohmic Heating for Bread Crumbs Making

The solid food such as plant tissue is composed of individual cell units separated by cell walls and membranes. The major component of cell membrane is phospholipid and regarded as an electrical condenser. Therefore, it is likely that the frequency of the alternating current becomes one of the key parameters for quick heating by reducing the impedance of plant tissue. On the other hand, the fish protein gel '*kamaboko*' prepared from Alaska pollack is reported to have a heating rate dependent on the frequency of alternating current, in spite of the fact that the gel does not have any membrane structure showing 7.5 times the heating rate at 10 kHz compared with that in hot water (90ºC). These results suggest that the state of liquid components in the matrix will also be one of the key points for quick ohmic heating.

The following section focuses on effects of alternating current frequency on heat generation in the plant tissue and also the heating rate of egg albumin solution and its change during ohmic heating.

Imai, *et al*. (1995) extracted a cylindrical sample (30×30 mm) from the middle of the radish, which was perpendicular to its vascular bundle, and applied a sine wave of variable frequency (50 Hz-10 kHz) of 20-40 V/cm through a titanium electrode (Figure 11). Of the frequencies examined, 50 Hz gave the sharpest initial rise of temperature and the shortest time to raise the temperature at the mid-part of radish to 80ºC. The heating rate above 60ºC was linear for all frequencies. The pressurization (400 MPa, 25ºC, for 10 minutes) of radish eliminated the sharp initial increase of temperature observed at 50 Hz, and gave an almost linear rise of temperature similar to those above 60ºC.

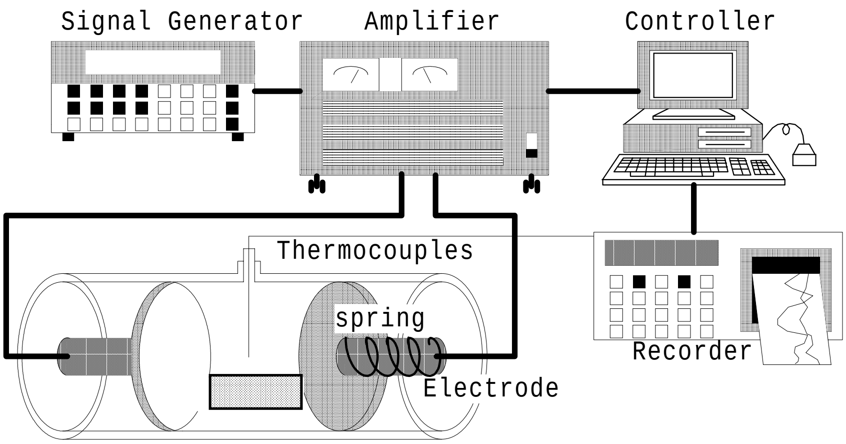


Figure 11. Schematic Diagram of the Ohmic Heating Setup

When radish was treated with a square wave (10 ms with 10 ms interval) of 45 V/cm for 30 seconds, its impedance decreased and never recovered even after storage at room temperature for 20 hours. Upon treating at 50 Hz and 40 V/cm until its mid-part reached 30ºC, or heated to 80ºC in hot water and then cooled to 30ºC, ^{1}H-NMR imaging analysis showed more free movement of liquid components than in the untreated radish. These results suggested that the initial rapid heating at low frequency was caused by the electroporation of tissue membrane of radish, resulting in reduction of its impedance. The breaking strength of the ohmic heated radish revealed that the original rigidity was maintained at its outer part even after heating. However the radish cooked in hot water was wholly softened, especially in the outer part.

Ohmic heating of egg albumin solution (10 percent w/vol) was also examined by Imai, *et al*. (1995) at 50 Hz-10 kHz under constant 10 V/cm. The heating rate of solution was almost constant and slightly increased as the frequency increased. The gel formation was observed at about 75ºC and the heating rate was rather increased above this temperature irrespective of frequency used. The solution and gel showed almost the same impedance at the examined temperature (20-90ºC) and frequency (10 Hz-100 kHz). When the concentration of egg albumin was reduced to 2 percent w/vol, this solution gave no gel formation and showed constant heating rate at over 75ºC. The breaking strength of gels showed little difference among the gels prepared by boiling water or ohmic heating. These results suggested that the liquid components are not compartmentalized in the gel and that the sudden increase of heating rate above 75ºC was caused by the reduction of heat transfer in gel at its phase change into gel. Imai, *et al*. (1995) also examined effects of ohmic heating on fresh egg white at the same conditions as that of the egg albumin solution. The fresh egg white did not show any sudden increase of heating rate until it reached 90ºC. However, the homogenized fresh egg white and its soluble part separated beforehand, showing the slightly reduced heating rate and its sudden increase at about 60ºC. They concluded that the gelatinous component of fresh egg white such as ovomucin repressed the transfer of generated heat during ohmic heating.

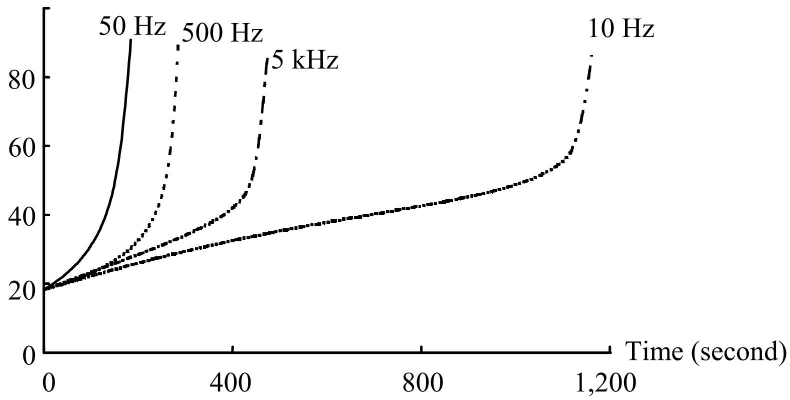


Figure 12. Center Temperature Profile during Ohmic Heating at 40 V/cm

These results clearly indicated that ohmic heating provides quick temperature rise in plants and protein solutions. The major benefits of ohmic heating are summarized as follows: (1) continuous production without heat-transfer surfaces; (2) rapid and uniform treatment of liquid and particulates, with minimal heat damage and residence-time differences; (3) ease of process control with instant shut down; (4) reduced maintenance costs; (5) environmentally friendly system; and (6) ideal process for shear-sensitive products. Some Japanese tofu manufacturers are interested in these characteristics of ohmic heating and have started to examine its potential for tofu making.

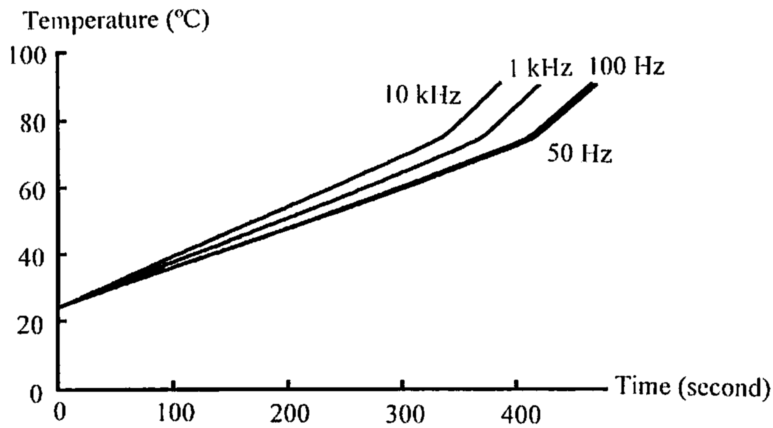


Figure 13. Heating Rates of Egg Albumin Solution during Ohmic Heating at Various Frequencies

Notes: Voltage applied = 10 V/cm; and egg albumin = 10 w/v percent.

OTHERS

Kitabatake, *et al.* (1997) succeeded in making a translucent gel from soy protein. The process is as follows; defatted soybean extract was dialyzed against distilled water at pH 7.5. The dialyzate was a transparent solution having less beany flavor. After heating, the desalted soybean extract kept its transparency even in the presence of salt (NaCl). When the desalted-soybean extract, preheated under salt-free condition, was heated again in the presence of NaCl (0.2 M), it gave a translucent gel at a lower concentration than that of non-heated desalted-soybean extract. The translucent gel was melted by further heating and gelified again by cooling, that is, this gel is cold-setting and gel-sol transition is reversible, which was confirmed with the measurement of dynamic viscoelasticity. Desalted-soybean extract preheated under salt-free condition could give a gel at room temperature or lower temperature only by the addition of salt, and was not precipitated by the incubation at 4°C, which is different from native soybean protein.

REFERENCES

Bridgman, P. W., 1914. *J. Biol. Chem.*, 19, 511.

Crocco, S. C., 1976. *Food Eng. Int.*, 1, 16.

Hayakawa, I., T. Kanno, K. Yoshiyama, and Y. Fujio, 1994. *J. Food Sci.*, 59, 164.

Hite, B. H., 1899. *Bull.* 58, p. 15, Agr. Expt. Sta., West Virginia Univ., Morgantown.

Honma, K., 1994. *Ibid.*, 35, 315.

Hurrel, R. F. and K. J. Carpenter, 1977. "Advances in Experimental Medicine and Biology", *Protein Cross-linking, Nutritional and Medical Consequences*, Vol. 86B, p. 225, Friedman. M. ed. Plenum Press, New York.

Ido, K., T. Nishiya, K. Tatsumi, and H. Yamamoto, 1993. *J. Japanese Soc. Food and Tech.*, 40, 170.

Imai, T., K. Uemura, N. Ishida, S. Yoshizaki, and A. Noguchi, 1995. *Int. J. Food Sci. Technol.*, 30, 461.

Isobe, S. and A. Noguchi, 1988. *Nippon Shokuhin Kogyo Gakkai Shi*, 35, 471.

Kajiyama, N., S. Isobe, K. Uemura, N. Ishida, and A. Noguchi, 1995. *International Journal of Food Science and Technology*, V. 30, 147-158.

Kimura, I., 1994. *Foods and Packaging*, 35, 428.

Kitabatake, N., Y. Fujita, and S. Tokumaru, 1997. *Soy Protein Res. Com., Jpn.*, V. 18, p. 31-36.

Kitagawa, M. and K. Nishi, 1988. Scientific reports of the Hokkaido Fisheries Experimental Station, 31, 63.

Morita, R. Y., 1975. *Bacteriol. Rev.*, 39, 144.

Suzuki, C. and K. Suzuki, 1962. *J. Biochem.*, 54, 214.

----------, 1963. *Arch. Biochem. Biphys.*, 102, 367.

----------, 1965. *Proteins, Nucleic Acids, Enzymes*, 11, 1246 (in Japanese).

Sweat, V. E., 1986. *Engineering Properties of Foods*, p. 49, Marcel Dekker, New York.

Yoshioka, K., Y. Kage, and H. Omura, 1992 (1982?). C. Balny, *et al*. (eds.) *High Pressure and Biotechnology*, p. 325, INSERM and JL.

1. BANGLADESH

Md. Amiruzzaman
Principal Scientific Officer and
Md. Shahjahan
Senior Scientific Officer
Both Postharvest Technology Division
Bangladesh Agricultural Research Institute
Gazipur

INTRODUCTION

Food legumes are species belonging to family Leguminosae, that may be consumed by people or domestic animals, commonly as mature dry seeds. The grain legumes, or pulses, can also be consumed in certain instances as immature green seeds, or as green pods as a vegetable. The two oleaginous legume crops, groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) are grown primarily for processing into edible oils. The protein residues are largely used as animal feed.

The grain legumes are important foodstuffs in most of the tropical and subtropical countries, where they are second only to cereals as a source of protein. The grain legumes are rich in protein (average 12-40 percent) and can be considered as a natural supplement to cereals. Although they are usually deficient in the essential amino acids methionine and cystine, they contain adequate amounts of lysine, whereas cereals are deficient in lysine, but contain adequate amounts of methionine and cystine. The food legumes are also important in cropping system because of their ability to fix nitrogen that increase the overall fertility of the soil, thus partially replacing the use of expensive nitrogenous fertilizers. For example, a vigorous growing food legume such as the cowpea (*Vigna unguiculata*) can add as much as 45 kg/ha of nitrogen to the soil, which is equivalent to 112 kg/ha of urea, or 255 kg/ha of ammonium sulphate.

PULSES IN BANGLADESH

A large number of pulses are grown and consumed in Bangladesh. The main ones are: lathyrus, lentil, chickpea, black gram and mung bean. The combined output of all other pulses, which include pigeon pea, cowpea, pea, soybean and other minor crops, however, does not exceed 510,000 mt annually.

Pulses in Bangladesh are traditionally grown during the dry winter months except for some beans which are raised around homestead. The land used for cultivating pulses, classified on the basis of water regime, falls into three categories:

- Level, marginal, unirrigated land where pulses are cultivated as a sole crop or as a mixed crop with various cereals and oilseeds such as wheat, barley, millet, mustard, and linseed;
- Low-lying areas where lentil and lathyrus may follow deep-water paddy; and

C Relatively terraced land, subject to periodic drought, unsuitable for any cereal or oilseed crop in the rabi (winter) season.

Pulses have been considered poor man's meat since they are the cheapest source of protein for the underprivileged people who cannot afford animal proteins. Pulses contain twice the protein content of cereals, they contain more protein, on weight-to-weight basis, than egg, fish and red meat. Cereal-based diets supplemented with pulses have improved overall nutritional value.

Pulses contain moderate amounts of minerals, particularly calcium and iron. It is possible to meet the total mineral requirement of the body merely by consuming required amounts of pulses. Pulses can provide all the B vitamins lost in polished rice. It is well known that the availability of vitamins B and C is enhanced when pulses are sprouted. It is unfortunate that sprouted pulses are not commonly consumed in Bangladesh.

Lathyrus

Local name: Khesari

Lathyrus sativus L.

Lathyrus is an annual, well-branched, semi-spreading to spreading herb.

Pods are flat, oblong, slightly bulging over the seeds, 2.5-4.5 cm in length, 0.6-1.0 cm in width. Dorsal part of pod is 2-winged, shortly beaked having 3-5 seeds.

Lathyrus plant is tough enough to tolerate flooding and drought. Tolerance to flood and drought has made it a very popular crop in drought-prone areas where heavy rains may occur for brief periods.

1. ***Harvest and Post-harvest Practices***

The leaves turn yellow and pods turn grey when mature. Pod shattering is common when the crop is not harvested in time. The mature plants are normally pulled out or cut with a sickle near the base. The plants are then stacked and allowed to dry in the field in the threshing floor for 7-8 days. The plants are spread out in the threshing floor and beaten with sticks. It is common practice to use cattle for trampling to help thresh the pods. The seed is then winnowed and cleaned. Seeds are dried for 1-2 days before they are stored. Most of the farmers' lathyrus crop is stored for domestic use, only a small part is sold. The seeds can be stored without difficulty in ways similar to other pulse crops. Hay making is not practiced in Bangladesh.

2. ***Use***

The grain is used as complementary or sole source of calories and proteins, mostly by the poor and landless laborers. The grains can be boiled whole but most often they are processed through a 'dal' mill to obtain solid dal. Dal is the most common item sold in the retail markets. The flour, made by grinding either whole or split seed, is also sold in the market as '*basan*'. In many parts of Bangladesh, *roti* (unleavened bread) made out of khesari is a staple for landless laborers during the lean periods. The lathyrus dal and '*basan*' are often used to adulterate chickpea '*basan*'. There are reports that lathyrus seeds are also reported to be used in homeopathic medicine and its leaves are used as green vegetable.

Lentil

Lens culinaris Medik

Pods are oblong, laterally compressed, bulging over the seeds, measuring 1.2-1.4 cm, rounded at base with a short beak at tip.

Seeds are lens shaped, about 4-8 mm in diameter. Color varies from light grey, brown, greyish-brown to greyish-black with speckles (marbled). Cotyledons are yellow to orange in color. The hundred seed weight may vary from 2-4 gm.

1. ***Harvest and Post-harvest Aspects***

Pod shattering is common in lentil, therefore harvesting is done before all pods are fully mature. Harvesting is done 15-20 days after the end of flowering and the plant and pods begin to turn yellow and brown, respectively. The plants are either pulled out along with the roots or cut at the ground level. The crop is left to dry in the field or in the threshing floor for about 6-7 days. When pods are brittle, the plants are beaten with sticks to remove the pods and break the pod wall. Later, the secondary threshing is performed by trampling with bullocks. The winnowed seeds are dried in sun for a day or two before they are taken home for storage or to the village for marketing.

2. ***Uses of Lentil***

Lentil seeds (whole, decorticated, or as 'dal') are cooked and consumed. The large seeded types are normally used as whole seeds. The small seeded types are used for making 'dal'. Several dishes are prepared from lentil in different countries. The ground flour of lentil is also used in some parts as a substitute for chickpea flour (*besan*).

The straw, broken stems and pod walls make excellent food for cattle. The young plants may also be used for grazing as green fodder.

Black Gram

Vigna mungo (L) Hepper

Seeds are oblong, measuring about 3 mm. Seed color varies from olive green to grey to black. Seed weight varies from 4 gm to 6 gm/100 seeds. Germination is epigeal.

1. ***Harvest and Post-harvest Practices***

There are two ways to harvest black gram. In the synchronous types where all the pods mature synchronously, harvesting is done when most pods have turned black. The plants are pulled out or cut at the ground level with a sickle, then stacked for 6-8 days in small bundles for drying in the field or on the threshing floor. When the plants are dry and the pod walls are brittle, the plants are spread on the threshing floor and beaten with sticks. Then cattle are allowed to trample on the plants to thresh.

Many local cultivars are non-synchronous, pod maturity extends over long periods. Pods have a tendency to shatter when left on the plants for a long time. The seeds may sprout on the plant itself, during the rainy season. Under these circustances, though time-consuming and labor-intensive, mature pods are picked manually. Two to three hand pickings may be required (sometimes up to six pickings) to realize full yields.

In some areas pod picking is done once or twice and the remaining green plants are either allowed for grazing by cattle, or cut for fodder or hay making. Green plants may be ploughed into the soil as green manure to improve soil fertility. Storage of the grain is similar to the other pulses.

2. ***Uses***

Black gram is one of the important pulses, providing grain for human consumption and fodder for cattle. The seeds are cooked commonly as de-husked, split or whole dal. The black gram dal is used to prepare several snacks.

Black gram is grown for fodder in many parts of the country. It is also the most commonly used green manure crop to enrich depleted soils.

The broken stems and pod walls remaining after threshing are used as cattle feed.

Mung Bean

Vigna radiata (L.) Wilczek.

Pods are linear, cylindrical, slightly bulged over the seeds, 5.0-9.0 cm long.

1. ***Harvest and Post-harvest Practices***

The harvest and post-harvest practices for mung bean and black gram are similar.

2. ***Uses***

Mung bean seeds are used either whole or split into dal for several dishes. Mung bean sprouts are also used to a limited extent. Mung bean dal is used to prepare sweets, and is also fried in oil for use as a snack. Young seedlings serve as nice vegetable.

The green plant is used as animal fodder in many areas. It is also a good green manure crop. The dried stems and shells remaining after threshing are also used as cattle feed.

Chickpea

Cicer arientinum L.

Pods are ellipsoid, inflated, with dense glandular hairs, 14-25 mm long, and 8-15 mm wide.

Seeds are angular and beaked, 6-10 mm long, 77 mm wide. Seed coat color may be brown, yellow, black or white with orange or pinkish tinge, sometimes with black spots. Surface of seed coat may be wrinkled or smooth. Cotyledons are yellow or pinkish yellow.

1. ***Harvest and Post-harvest Practices***

In Bangladesh, when rains occur during later stages, the subsequent water-logging may lead to forced maturity. Leaves start yellowing, followed by yellowing of pods, and later they fall off. Chickpea is usually harvested when most of the pods are yellow and leaves turn yellow. Harvesting is generally done by pulling out whole plants or by cutting with sickles at ground level (around big towns and cities, the whole chickpea plant with pods are sold in the market for eating in green form).

The harvested mature plants are bundled and transported to threshing floor, or near-to-home drying yard. Plants are allowed to dry for 5-6 days until the pod wall becomes brittle. The bundles are spread out on the threshing floor and beaten with sticks to break the pods. After initial threshing, the partly threshed stems are trampled by cattle. Seeds mixed with smaller stem parts and pod walls are winnowed to get clean seeds. They are dried on the threshing floor before storage.

2. ***Use***

The young leaves are used as a vegetable. The green seeds from young pods are eaten either raw or cooked. The mature seeds are cooked as whole seed or after making 'dal'. The seeds can also be eaten after soaking in water overnight. Parched seeds are used as snacks, and in food preparation. The '*besan*' is used for preparation of several salt and sweet dishes.

The dried and broken stems and pod walls after threshing serve as good cattle feed. Whole grains are soaked and fed to horses. The seed coat after milling for 'dal' is also good as cattle feed.

Pigeon Pea

Cajanus cajan (L.)

The pods are flattened, slightly curved or straight, and bulging over the seeds measuring 6-12 × 0.8-1.5 cm, with a conspicuous beak. They are hairy, and their color varies from light green, green to purple with blotches. Pods contain 2-8 seeds.

Seeds are round or oval, slightly laterally compressed and flattened at the hilum. Seeds may be white, with speckles, to yellow, brown chocolate or grey. The cotyledons are light yellow to yellow brown.

1. ***Harvest and Post-harvest Practices***

Green pods are hand-picked when used as a vegetable. For grain at maturity whole plants are cut at the base.

The pods may be hand picked at maturity when a second ratoon crop is needed. The cut plants are left in the field for drying. Sometimes the plants are tied and stacked in an upright position to facilitate drying of the pods. When the pods are completely dry, the plants are spread on the threshing floor and beaten with sticks to separate the seeds from pods. The seeds are dried after winnowing.

2. ***Uses***

Pigeon pea is a multipurpose plant. All plant parts are used in some form or other.

The young leaves and shoots are used as fodder. Green pods are used as a vegetable in many countries. The mature seeds may be cooked for consumption. Majority of people use the pigeon pea after de-husking and splitting of cotyledons to make dal.

The husk and pod walls are used as cattle feed. The stems are used as fuel by rural families. In fact, many farmers cultivate pigeon pea mostly for use as fuel.

Pigeon pea is also used to rear silkworm and lac insects.

Cowpea

Vigna unguiculata (L.) Walp.

Pods vary in size, shape, color and texture. They may be pendant, erect or spreading, linear, crescent shaped or coiled; slightly laterally compressed or near cylindrical, slightly bulging over the seeds. Length may vary from 9.0 cm to 25.0 cm (even up to 100 cm), 5-12 mm in width, with or without a curved beak. Color varies from yellow, light brown, to purplish-brown. Each pod contains 6-20 seeds.

Seeds vary in size, shape and color. They are mostly square-shaped, oblong, frequently laterally compressed, 5.0-9.0 × 4.0-8.0 mm. Color varies from white, cream, light-brown, grey with mosaic, with a brown ring around hilum. Cotyledons are white to yellowish-white in color.

1. ***Harvest and Post-harvest Practices***

The green pods can be harvested for vegetable purposes within 12-15 days after flowering. The pods mature in about 20-25 days after flowering. Mature pods are yellowish-brown. Maturity of pods is not synchronous in many cultivated types. One to two hand pickings may be needed. However, in synchronous and determinate types, most pods mature simultaneously. The plants are either pulled out by hand or cut at the base. The pods and plants are then allowed to dry in the sun for 7-8 days. When pods start breaking with little pressure, threshing is done by beating with a stick or occasionally by trampling with cattle.

Green pods and seeds are used as vegetables. The dry seeds are used as a pulse. It may be cooked as whole or after removing the seed coat. It is not normally split to make 'dal'. Cowpea is also used as fodder and green manure.

Pea

Pisum sativum L.

Pods are 3.5-15.0 cm in length and 1.5-2.0 cm wide, flat or cylindrical, shortly stalked, straight or curved, beaked, reticulately veined when mature. Color varies from yellowish-green, grey, to purplish-grey. Young pods are fleshy and waxy; pod wall is lined with parchment like membrane. Pods contain 2-10 seeds.

Seeds are globose or globose angular, smooth or slightly wrinkled, 4-8 mm in diameter; color varies from white, green, orange-brown, to brown, with brown, or violet spots. Hilum is small, elliptic, light colored. Hundred seed weight varies from 15 gm to 25 gm. Cotyledons are light yellow.

1. ***Harvest and Post-harvest Practices***

Peas for vegetable purpose are harvested at green pod stage for home consumption and marketing. At maturity, the leaves and pods turn yellow. The plants are normally pulled out by hand and stacked for drying in sun. Pods are threshed by beating with sticks after they are fully dried. The seeds are then winnowed and cleaned, then dried before storage.

2. ***Uses***

Young pods are harvested for getting tender green seeds as vegetables.

Groundnut

Arachis hypogaea

The size of pods range upto about 8 × 2 cm. Each pod contains on average two seeds and occasionally more.

1. ***Harvest and Post-harvest Practices***

Early and late harvesting equally reduce yield. So care should be taken to determine the optimum time for harvest. Pods are mature when kernels are fully developed. Maturation is indicated when test shows varietal color and seed coat wall inside the pod shows dark streaks. Thus regular inspection is necessary to determine maturity.

The harvesting operation consists of digging, lifting, clearing, sun-drying and threshing. The farmers in Bangladesh harvest manually.

2. ***Uses***

The whole nuts are roasted and are eaten directly with relish. Since the oil is good for human skin, it is used in the preparation of high quality soaps, hair lotions, cosmetics and toiletries. There is, however, no oil extraction in Bangladesh.

Soybean

Glycine max (L.) Merr.

Pods vary in length from 3 cm to 9 cm, color normally yellow-grey or black. Seed number varies between 2-5 with an average seed weight of 15-40 gm/100 seeds.

1. ***Harvest and Post-harvest Practices***

At maturity, leaves turn yellow and fall off. The pods turn brown and dry. A few varieties have a tendency to shatter, so harvesting must be done at the right time. Commonly farmers pull the plants by hand and stack them for drying. However, it is advisable to cut the stems at the base and leave the roots in the soil as this helps to improve the soil nitrogen level. The dried plants are spread on threshing floor and beaten with sticks. Winnowing should be done carefully so that minimum damage occurs to the seed coat. The seed should be dried thoroughly before storage.

2. ***Use of Soybean***

Soybean is rich in both protein and oil than any other legume crop. In Bangladesh, soybean could not become popular as a direct food either as whole seed or split dal. The major limitations of soybean for human consumption are indigestion, flatulence and stomach disorders. Soybean contains some anti-nutritional factors such as trypsin inhibitors, haemagglutinins, saponins, and flatulents such as stachyose and raffinose. Bangladesh Council for Scientific and Industrial Research (BCSIR) has developed recipes for use in Bangladesh for several traditional food items using soybean seeds. Some of them are soy milk, soy bread, soy biscuits and soy chapati. A few industries have started manufacturing some of these items for marketing.

PROCESSING OF PULSES

Milling of pulses involve removal of the outer husk and splitting the grain into two equal halves. Generally, the husk is much more tightly held by the kernel of some pulses than most cereals. Therefore, de-husking of some pulses poses a problem. In Bangladesh the de-husked split pulses are produced by traditional milling methods. In traditional pulse milling, the loosening of husk by conditioning is insufficient. Therefore, a large amount of abrasive force is applied for the complete de-husking of the grains which results in high losses in the form of brokens and powder.

It is, therefore, necessary to improve the traditional milling to increase the total yield of de-husked and split pulses and reduce the losses.

Traditional Dhal Milling

There is common processing method for all pulses. General operations of dry milling include cleaning and grading, rolling or pitting, oiling, moistening, drying and milling.

Cleaning and Grading

Pulses are cleaned free of dust, chaff, grits, etc. and graded according to size by rotating sieve type cleaner.

Pitting

The clean pulses are passed through an emery roller machine. In this unit, husk is cracked and scratched. This is to facilitate the subsequent oil penetration process for loosening of husk. The clearance between the emery roller and cage (housing) gradually narrows from inlet to outlet. As the material is passed through the narrowing clearance, mainly cracking and scratching of husk takes place by friction between pulses and emery. Some of the pulses are de-husked and split during this operation which are then separated by sieving.

Pretreatment with Oil

The scratched or pitted pulses are passed through a screw conveyor and mixed with edible oils such as soybean oil (1.5-2.5 kg/mt of pulses). Then they are kept on the floor for about 12 hours for diffusion of the oil.

Conditioning

Conditioning of pulses is done by alternate wetting and drying. After sun-drying for a certain period, 3.5 percent moisture is added to the pulses and tempered for about eight hours and again dried in the sun. Pulses are finally dried to about 10-12 percent moisture content.

De-husking and Splitting

Emery rollers, are used for the de-husking of conditioned pulses. About 50 percent pulses are de-husked in a single operation (in one pass). De-husked pulses are split into two halves. The husk is aspirated off and de-husked. Split pulses are separated by sieving. The tail pulses and unsplit de-husked pulses are again conditioned and milled as above. The whole process is repeated two to three times until the remaining pulses are de-husked and split. The machines used for de-husking are either power-driven disc type sheller '*chakki*' or emery-coated roller machine.

Blowers are used for aspiration of husk and powder from the products of the disc sheller or roller machine. Split dhals are separated from the unhusked and whole pulses with the help of sieve type separators.

All pulse crops, except small quantities of chickpeas and peas, are de-husked before consumption. Generally, pulse crops contain around 75 percent clean grain which is consumed as food and 20 percent bran (coating around the grain) which is used as animal feed; the remaining 5 percent is lost during processing on account of foreign matters (dust and dirt, chaff, particles of dried plants, stalks, non-seed etc.) which are separated/blown off before processing, and lost via evaporation of moisture and abrasion.

Pulses may be processed manually as well as mechanically. The growers generally process the pulses manually for home consumption (including farm-labor). A study showed that 17 percent of total pulses produced is consumed by the growers, and approximately 75 percent of that is processed manually by the family members. Hence, approximately 13 percent of total pulses produced is processed manually, and the remaining 87 percent is processed mechanically. However, cowpea, is primarily processed manually by the consumers. A sizeable quantity of black gram is also processed manually by professional huskers in some areas.

Manual processing may be done with the help of "*Jata*" "*dhenki*", mortar and pestle and simply two pieces of stones or wood. "*Jata*" is made of two pieces of disc-shaped stones one placed over the other. At the time of processing the lower stone remains stationary while the upper stone is rotated clockwise. The pulses are passed through a hole in the upper stone; the equipment is then operated manually with the help of a vertical handle fixed with the upper stone. The husk/bran is separated from the grains by rubbing and constant pressure of the two stones.

The quantity of pulses processed manually by the respondents of the study varied from less than one maund to over four maunds (Table 1).

Recovery of Dal, Bran and Milling Loss under Manual Processing

As mentioned earlier, the recovery of dal and bran and the extent of milling loss vary with the type of pulse crops, extent of moisture and foreign matter contents and the nature of processing. Table 3 shows the proportion of dal, bran and the milling loss under manual processing in survey areas.

Table 1. Quantity of Pulses De-husked in a Survey

Quantity De-husked	Number of Respondents	Percentage
Less than one maund*	5	9
1-2 maunds	11	19
2-4 maunds	19	33
Above 4 maunds	21	37
Not reported	1	2
Total	57	100

Note: Maund = 37.32 kg.

Table 2. Time Required for Manual Processing of Pulses
(Unit: Minute)

Name of Crop	Time for Milling One kg Pulse
Lentil	24.21
Black gram	18.19
Pea	18.12
Lathyrus	18.41
Mung bean	19.30
Chickpea	17.88
Cowpea	15.00

Table 3. Recovery of Dal and Bran, and Milling Loss of Different Pulse Crops under Manual Processing
(Unit: Percent of quantity of pulses processed)

Pulse Crop	Dal	Husk/Bran	Milling Loss
Lathyrus	71.80	22.92	5.28
Lentil	74.46	20.23	5.32
Chickpea	71.01	23.51	5.48
Mung bean	73.95	18.45	7.60
Black gram	73.86	20.46	5.68
Pea	71.06	23.00	5.94
Cowpea	80.00	15.00	5.00

Mechanical Processing

Almost the entire quantity of pulses marketed off-farm in Bangladesh is processed mechanically in dal mills established in the producing as well as important trading and consuming centers.

Dal Milling Equipment

Equipment used in local dal mills is quite simple, and all pieces are locally fabricated/ manufactured. The equipments include:

1) huller/stone mill disc-shaped ‘*chakki*’;
2) roller;

3) fan; and
4) sieve or '*chalni*'-cum-grader.

The huller and roller are used for de-husking, the roller is used for the lentil crop. After de-husking, the fan is used for blowing off dust and separation of bran/husk from grains. The sieve is used for cleaning dust, dirt, chaff etc. from the crop as well as grading of pulses into different sizes – small, medium and large. It is a very important equipment since milling of different sizes results in higher percentage of broken, which in turn reduces the market price of dal.

The capacity of dal mills covered under the study varied from 180 mt to 1,147 mt per annum, based on one shift of eight hours per day and 300 working days in a year. The capacity of different size mills are shown in Table 4.

Table 4. Distribution of Dal Mills in the Study Area According to Capacity

Category	Capacity	Number	Percent of Total Mills
Small	Below 375 mt	12	34
Medium	375-750 mt	13	37
Large	750-1,125 mt	9	26
Extra large	More than 1,125 mt	1	3
Total		35	100

Capacity varies with the pulse crops processed, the number of motors and the space available within the mill. Some pulse crops may be de-husked quickly but others require hulling several times. According to the millers the lentil crop requires hulling 5-6 times while lathyrus and chickpea may be de-husked in one hulling. As a result the same mill which may handle 3.75 mt of lathyrus per day can handle only 0.75 mt of lentil.

Storage Facilities

All mills have storage facilities. Some mills have storage space inside the mills; while most mills have separate storage facilities, depending on the volume handled, either owned or rented. Three types of storage are used by the millers.

Type I: Cemented floor, wall and roof
Type II: Semi-cemented floor, brick wall and cast-iron (CI) sheet roof
Type III: Brick floor, CI sheet wall and CI sheet roof.

The mills which operate on their own account store pulses from one day to six months; three mills stored up to seven days, four mills up to 15 days, six mills up to one month, three mills up to two months, seven mills up to three months and five mills for more than three months.

The storage loss is mainly due to rodents (56 percent), followed by insects (18 percent) and mold (16 percent); some loss was ascribed to weight loss due to evaporation of moisture from the crop.

In order to prevent/minimize storage loss, the millers use trap and rat killers to control rats, and use pesticides to control insects and pests. A few mills also use "neem leaves" to control insects and pests. Some mills also mentioned drying and re-drying of their stock and proper ventilation in storage godowns to minimize storage loss.

Milling Cost of Pulses

The main items of cost consist of (in order of importance):

1) electricity/power;
2) labor on account of handling, grading/cleaning, bagging etc;
3) interest on borrowing;
4) salaries to mill employees and other expenses incurred in connection with the operation of the mill;
5) repair/replacement of machineries/parts; and
6) depreciation on plant, machineries & structures.

The cost for the above for different pulses are shown in Table 5.

Table 5. Item-wise Breakdown of the Average Milling Cost of Pulses, 1992

(Unit: Taka per maund of whole pulses)

Item of Cost	Lathyrus	Lentil	Chickpea	Black Gram	Mung Bean	Pea	Cowpea
Electricity/power	3.62	5.01	3.82	4.49	4.01	3.26	2.42
Labor	2.89	4.24	2.68	2.94	2.48	2.42	1.05
Repairs etc.	0.89	1.02	0.92	0.86	0.81	0.83	0.43
Depreciation	0.79	0.87	0.73	0.78	0.88	0.91	0.45
Interest paid	2.84	2.97	2.53	2.63	2.81	2.59	nil.
Salaries and other expenses	2.60	2.83	2.57	2.62	2.60	2.29	2.16
Total	13.63	16.94	13.25	14.32	13.59	12.30	6.51

Note: US$1 = Tk.49.38; and 1 maund = 37.32 kg.

Milling Outturn

Table 6 shows the average recovery of "dal" and bran and the extent of milling loss from different pulse crops in respect of the sample mills as reported by the respondents.

Table 6. Outturn of Different Products from Different Pulse Crops

(Unit: Percent)

Crop	Dal	Husk	Milling Loss
Lentil	74.90	19.40	5.70
Mung bean	74.05	20.88	5.07
Pea	72.42	21.46	6.12
Cowpea	72.26	23.16	4.58
Black gram	71.97	22.01	6.02
Chickpea	71.17	23.40	5.43
Lathyrus	70.49	23.67	5.84

The proportion of husk is primarily determined by its thickness/weight in relation to the grain; to some extent bran may be allowed if it also includes small broken and foreign matters.

Recovery of dal (grain) is highest in the case of lentil followed by mung bean, and lowest in lathyrus. It is natural that in case the grain size is bigger and the bran is thin outturn of dal/grain will be higher. It was reported that recovery of dal/grain from the imported Australian chickpea was 75-77 percent due to large size, as against 71.17 percent in case of smaller size local chickpea.

Constraints of Millers

Inadequate supply of pulses, lack of fund, power failures, unstable price of pulses/dal and admixture of foreign matters have been mentioned as constraints by most of the millers. They also mentioned the transportation problem, improper operation of the mills, lack of market information, storage problems, law and order situation and labor problems but they were low in importance. Government control and regulations, restrictions imposed by different authorities which affect business, licensing and control by multiple agencies have also been mentioned by a few mills with very low importance.

Suggestion by Millers

Increasing local production of pulses to ensure adequate supply to the mills, provision of bank loan to the mills for procurement of pulses, improvement of the supply of electricity and improvement of transportation facilities have been suggested by most of the mills to improve the situation.

REFERENCES

Chakraverty, A., 1998. *Postharvest Technology of Cereals, Pulses and Oilseeds*, Oxford and IBH Pub. Co., New Delhi, India.

Department of Agricultural Marketing, 1998. *Production, Storage, Processing and Marketing of Pulses in Bangladesh*, Dhaka, Bangladesh.

Gowda, C. L. L. and A. A. Kaul, 1982. *Pulses in Bangladesh*, BARI-FAO, Dhaka, Bangladesh.

Kaul, A. K. and M. L. Das, 1986. *Oilseeds in Bangladesh*, Ministry of Agriculture, Government of Bangladesh, Dhaka, Bangladesh.

Kay, D. E., 1979. *Food Legumes*, Tropical Products Institute, London, U.K.

Ministry of Planning, 1998. *Statistical Yearbook of Bangladesh*, Government of Bangladesh, Dhaka, Bangladesh.

2. REPUBLIC OF CHINA

Wen-Lian Chen
Senior Food Scientist
Food Industry Research and Development Institute (FIRDI)
Hsin-chu, Taiwan

INTRODUCTION

Soy milk, tofu and soy sauce are well-known typical traditional Chinese legume foods. Processing and utilization of legume foods in China has a long history. Because of war, people from different regions of mainland China came to Taiwan. They brought their food preparation skills with them. In addition to famous soybean foods, many other kinds of legume foods are also processed in Taiwan. In recent years, modern processing technologies are used in preparing legume foods. The nutritional value and health benefits of legume foods are better understood than before. Phytochemicals in legumes have various functional effects to women and elderly. People can either consume legume foods daily or they can take purified phytocemicals from legumes as pills. People are concerned about animal protection. Due to this reason, some people like to become vegetarians. Other people are vegetarians due to religious reasons. People may consume more legume foods in the future. One day, these traditional Chinese legume foods may become a worldwide food. Although the processing technologies have been very much improved in Taiwan, still many problems remain to be solved. Taiwan would like to learn new technologies developed in other countries. They might help us to solve these problems.

THE ROLE OF LEGUMES IN THE FOOD CONSUMPTION IN TAIWAN

Legumes are consumed daily in Taiwan. In 1956, the legumes consumption per person per year was 11 kg. In 1996, the consumption rose to 32 kg, an increase of almost three times. During the same period, the consumption of rice and sweet potato decreased sharply from 133 kg and 64 kg down to 59 kg and 3 kg, respectively, while the consumption of other food items all increased many times as shown in Table1. In the same period, the consumption of calorie per person per day increased from 2,262 cal to 3,076 cal, animal protein consumption increased sharply from 13.5 gm to 49.6 gm, vegetable protein consumption increased slightly from 40.4 gm to 46.8 gm, and oil consumption increased sharply from 37.3 gm to 135.5 gm (Table 2). The major sources of vegetable protein and oil are legumes, especially soybean and peanut.

THE PRODUCTION AREA OF LEGUMES IN TAIWAN

The area planted to legumes is decreasing in Taiwan (Table 3). The area planted to soybean, adzuki bean, peanut, pea and kidney bean have all decreased. Only the area planted to vegetable soybean increased slightly. The farm prices of peanut, adzuki bean and mung bean were much higher than that of rice and sweet potato (Table 4). Although the prices of legumes were higher than that of rice, since the production cost of legumes are high, they are no longer competitive. The prices of locally produced legumes are higher than that of the import ones. When Taiwan joins the World Trade Organization (WTO) in the near future, the trade of agricultural products will be open to all foreign countries. Then, cheap legumes from foreign countries will get into local markets, and the local production of legumes may shrink even further. The land use concept is changing in Taiwan. Farm is not for agricultural use. This concept may result in the decrease in area planted to legume.

Table 1. Changes in Itemized Food Consumption During the Past 40 Years in Taiwan
(Unit: kg/person/year)

	1956	1966	1976	1986	1996
Rice	133	137	128	77	59
Wheat flour	17	17	21	28	30
Sweet potato	64	45	8	4	3
Legume and nut	11	14	19	26	32
Vegetable	58	53	118	93	109
Fruit	15	26	62	105	139
Meat	17	23	32	57	75
Milk	6	5	17	36	57
Egg	2	3	6	11	18
Fish	19	29	35	36	39
Sugar	9	12	20	27	25
Oil	4	5	10	18	26

Source: http://www.coa.gov.tw/statistic/agri/b8.htm

Table 2. Changes in Calorie and Major Nutrient Consumption per Person per Day During the Past 40 Years in Taiwan

Year	Calorie	Protein (gm)		Oil (gm)
		Animal	Vegetable	
1956	2,262	13.5	40.4	37.3
1966	2,433	19.3	43.0	47.0
1976	2,771	26.7	49.2	73.4
1986	2,760	38.2	44.1	102.1
1996	3,076	49.9	46.8	135.5

Source: http://www.coa.gov.tw/statistic/agri/b9.htm

Table 3. Changes in Production Area of Main Legumes During the Past 20 Years in Taiwan
(Unit: ha)

Crop	1976	1986	1996
Soybean	35,548	9,449	5,061
Adzuki bean	5,855	9,182	6,489
Peanut	58,831	56,592	34,016
Pea	5,447	5,862	2,050
Kidney bean	4,073	5,191	1,738
Vegetable soybean	-	7,864	8,637

Source: http://www.coa.gov.tw/statistic/agri/b12.htm

Table 4. Changes in Farm Prices of Main Crops During the Last Nine Years in Taiwan
(Unit: NT$/kg)

Year	Rice	Peanut	Adzuki Bean	Mung Bean	Sweet Potato
1991	16.44	49.71	35.14	37.65	8.44
1992	16.56	39.15	37.85	40.69	9.46
1993	17.68	42.84	56.38	40.42	9.00
1994	16.68	56.47	53.55	42.22	11.37
1995	18.74	46.96	44.32	53.06	8.00
1996	19.91	35.26	47.35	60.00	7.92
1997	17.95	44.05	46.17	60.00	8.13
1998	18.72	39.23	47.73	60.00	10.87
1999	19.61	44.10	56.26	63.58	8.25

Source: http:www.coa.gov.tw/statistic/mon/t16.htm

THE IMPORT AND EXPORT OF LEGUMES

Most legumes consumed in Taiwan were imported from foreign countries. The import and export of soybean, peanut, pea, vegetable soybean, kidney bean and broad bean in the last five years are shown in Tables 5-10, respectively. Soybean, pea, kidney bean and broad bean were all dependent on import. Peanut was the only protected crop with no import in the last three years. Vegetable soybean was the only export crop with an average export amount of 30,000 mt a year. The import of soybean decreased suddenly in 1998, due to the incidence of foot-and-mouth disease of swine. In that year, the total import of soybean was two million mt, among which 61.3 percent was from the United States, 23.8 percent from Brazil, 13.3 percent from Argentina and 1.6 percent from Paraguay. The import of pea, kidney bean and broad bean, as well as the export of vegetable soybean were quite stable over the years. More than 80 percent of the imported soybeans were used for soybean oil extraction, and less than 20 percent were directly used for foods. For the quality improvement of soybean foods, the food-grade soybeans were compared with the soybeans for oil extraction. Both the quality and the yield of soybean foods prepared with food-grade soybeans were better than those prepared with the soybeans for oil extraction. For substantial supply of food-grade soybeans require new arrangements.

Table 5. Changes in Import and Export Quantities of Soybean During the Last Five Years in Taiwan
(Unit: 000 mt)

Year	Import	Export
1995	2,585	1.7
1996	2,690	2.7
1997	2,758	1.7
1998	2,002*	20.3
1999	2,357	2.9

Source: http://www.coa.gov.tw/cgi-bin/db2www/ts1900g.d2w/report
Note: * A sudden decrease due to the incidence of mouth foot disease of swine.

Table 6. Changes in Import and Export Quantities of Peanut During the Last Five Years in Taiwan

(Unit: mt)

Year	Import	Export
1995	1,108	0.00
1996	128	2.37
1997	0	1.72
1998	0	1.36
1999	0	5.91

Source: http://www.coa.gov.tw/cgi-bi…/report

Table 7. Changes in Import and Export Quantities of Pea During the Last Five Years in Taiwan

(Unit: mt)

Year	Import	Export
1995	26,751	361
1996	27,845	443
1997	27,792	253
1998	27,661	179
1999	25,628	91

Source: http://www.coa.gov.tw/cgi-bi…/report

Table 8. Changes in Import and Export Quantities of Vegetable Soybean During the Last Five Years in Taiwan

(Unit: mt)

Year	Import	Export
1995	48	32,543
1996	241	29,097
1997	2	31,856
1998	44	29,794
1999	293	31,187

Source: http://www.coa.gov.tw/cgi-bi…/report

Table 9. Changes in Import and Export Quantities of Kidney Bean During the Last Five Years in Taiwan

(Unit: mt)

Year	Import	Export
1995	9,777	1,484
1996	9,643	284
1997	7,600	44
1998	8,115	42
1999	8,024	80

Source: http://www.coa.gov.tw/cgi-bi…/report

Table 10. Changes in Import and Export Quantities of Broad Bean During the Last Five Years in Taiwan

(Unit: mt)

Year	Import	Export
1995	1,829	37
1996	2,477	28
1997	3,119	17
1998	3,040	6
1999	3,344	6

Source: http://www.coa.gov.tw/cgi-bi…/report

THE KINDS OF LEGUME FOODS

Legume foods have a long history in China. Taiwan has a variety of legume foods. Soybean foods are a typical example. We can summarize soybean foods as follows:

Whole Soybean

Vegetable soybean – spiced and frozen
Seasoned and dried soybean
Roasted and spiced soybean
Sweetened soybean
Fermented soybean
Fermented black soybean
Soybean sprout

Soy Milk

Traditional soy milk with typical beany flavor
Modern non-beany flavor soy milk
Reconstituted soy milk from soy protein isolate
Aseptic pack soy milk – tetra pack, combiblock pack, polythylene terephalate (PET) bottle pack
Sterilized soy milk – polyproplylene (PP) bottle pack, glass bottle pack, metal can pack
Refrigerated soy milk – pure pack, plastic bottle pack
Instant soy milk powder

Soft Soybean Curd or Toflower

Traditional soft soybean curd coagulated with gypsum and sweet potato starch
Modern soft soybean curd coagulated with edible gums
Pudding-type soft soybean curd

Tofu

Traditional tofu coagulated with gypsum
Packaged tofu coagulated with glucono-delta-lactone
Frozen tofu
Frozen tofu prepared from soy protein isolate
Deep-fried tofu
Deep-fried tofu for sushi
Seasoned and dried deep-fried tofu for snack
Stinky tofu: deep-fried or steamed

Fermented tofu: prepared with soybean *koji*
with rice *koji*
with anka
by direct growth of mold on tofu

Firm Tofu
Plain-color firm tofu
Caramel-colored firm tofu
Seasoned and dried firm tofu for snack

Yuba or Soy Milk Film
Chicken roll
Vegetarian chicken meat
Deep-fried *yuba*

Textured Soy Protein
Vegetarian ham
Meat analogue

Soy Sauce
Soy sauce from soybean and wheat
Soy sauce from black soybean and wheat flour

Miso
There is no product like Japanese *natto* or Indonesian *tempeh* in Taiwan.

Peanut, adzuki bean and mung bean are processed into many kinds of legume foods in Taiwan. They are listed as the following:

1. ***Peanut***
Processed peanut include roasted peanut with husk, salted peanut with husk, steamed and dried peanut with husk, frozen cooked peanut with husk, roasted peanut kernel, peanut grits, peanut flour, peanut candy, peanut oil, peanut butter, peanut dumpling, peanut ice bar, peanut ice cream, rice-and-peanut milk, canned peanut with gluten, canned peanut with milk, peanut cake, and deep-fried peanut.
2. ***Adzuki***
Processed adzuki bean products are: bean paste dumpling, bean paste bread, adzuki bean ice bar, adzuki bean ice cream, adzuki bean and agar agar cake, adzuki bean soup, adzuki bean ice, red turtle cake, sweetened and dried adzuki bean.
3. ***Mung Bean***
Processed mung bean products are: mung bean soup, mung bean and rice soup, mung bean paste cake, mung bean starch vermicelli, mung bean starch gel, mung bean powder and mung bean sprout.

THE IMPORT AND EXPORT OF LEGUME FOODS

Most legume foods prepared in Taiwan are consumed locally. The importance of processed foods in international trade has disappeared in Taiwan. Instead, high-tech electronic products have taken their place. The import and export quantities of soy sauce, *miso*, peanut butter, adzuki bean paste, protein concentrate and textured protein in the last five years in Taiwan are shown in Tables 11-15, respectively. Every year, Taiwan imports high-price soy sauce and exports low-price soy sauce in large quantities. The import of *miso* and peanut butter are larger than the export. The imports were fairly stable, and the market seems to be saturated already. Adzuki bean paste is produced entirely for export, but the quantity exported is decreasing every year. This was due to the difficulty of wastewater treatment. Many producers have moved their production line to foreign countries. Taiwan imports protein concentrate and exports textured protein. The import of protein concentrate is quite stable in quantity, mainly from the United States, but now also from mainland China. The export of textured protein has increased about four times in the last five years.

Table 11. Changes in Import and Export Quantities of Soy Sauce During the Last Five Years in Taiwan

Year	Import		Export	
	Amount (mt)	Value (NT$ 000)	Amount (mt)	Value (NT$ 000)
1995	2,014	142,767	11,441	117,774
1996	2,268	140,267	12,223	175,268
1997	1,999	110,199	12,362	184,047
1998	1,689	101,698	12,238	213,977
1999	1,618	93,353	12,678	224,279

Source: http://www.firdi.org.tw

Table 12. Changes in Import and Export Quantities of Miso During the Last Five Years in Taiwan

Year	Import		Export	
	Amount (kg)	Value (NT$ 000)	Amount (kg)	Value (NT$ 000)
1995	439,316	25,230	7,648	381
1996	470,457	23,952	10,801	468
1997	464,353	18,857	15,604	795
1998	446,676	21,510	252,415	8,331
1999	532,314	33,020	16,376	944

Source: http://www.firdi.org.tw

Table 13. Changes in Import and Export Quantities of Peanut Butter During the Last Five Years in Taiwan

Year	Import		Export	
	Amount (kg)	Value (NT$ 000)	Amount (kg)	Value (NT$ 000)
1995	2,841,484	80,822	5,587	231
1996	2,569,434	81,451	5,442	337
1997	2,681,565	94,304	6,787	343
1998	2,403,424	93,466	9,169	487
1999	2,678,260	95,910	42,567	1,773

Source: http://www.firdi.org.tw

Table 14. Changes in Import and Export Quantities of Adzuki Bean Paste During the Last Five Years in Taiwan

Year	Import		Export	
	Amount (kg)	Value (NT$ 000)	Amount (kg)	Value (NT$ 000)
1995	320	32	3,373,381	115,637
1996	0	0	2,081,062	68,626
1997	0	0	1,537,667	54,231
1998	0	0	1,566,823	57,845
1999	0	0	1,251,168	48,947

Source: http://www.firdi.org.tw

Table 15. Changes in Quantities of Imported Protein Concentrate and Exported Textured Protein During the Last Five Years in Taiwan

Year	Imported Protein Concentrate		Exported Textured Protein	
	Amount (kg)	Value (NT$ 000)	Amount (kg)	Value (NT$ 000)
1995	1,536,764	62,068	23,841	2,446
1996	2,052,672	88,871	6,149	1,200
1997	1,720,034	75,244	27,487	2,075
1998	1,741,309	91,795	125,892	6,494
1999	1,869,922	84,233	148,345	9,987

Source: http://www.firdi.org.tw

THE PROCESSING TECHNOLOGY OF LEGUME FOODS

Vegetable Soybean

Frozen vegetable soybean is the number one frozen vegetable for export from Taiwan. The quality is good and the price is high in Japanese market. Every year the farmers use high-quality soybean seeds selected by local agricultural experimental stations for the raw material production. The management of farming, such as how to use the fertilizer and the density of planting, is also under the guidance by the experts from the stations. Imported mechanical harvesters are used to harvest the soybeans. They save labor and improve the quality of soybeans harvested. In the factory, a sorter separate sticks and leaves, a washer cleans the soybeans, a continuous cooker-cooler blanches and cools the soybeans, and an individual instant quick freezer freezes the blanched soybeans. After automatic packaging, the products are stored in a cold room.

Every year, the industry has a meeting with Japanese buyers to exhibit new products, and to discuss the extension of the business. They maintain excellent mutual communication. In recent years, the export of frozen vegetable soybean from mainland China increased rapidly, and the quantity is already larger than that from Taiwan. The producers have also developed the local market in Taiwan, and seasoned vegetable soybeans have become popular and are now a *hors d'oeuvre* in most restaurants in Taiwan.

Seasoned and Dried Soybean

Seasoned and dried soybean is consumed as a snack. The processing includes soaking, cooking with seasonings, hot air drying, and packaging after cooling. The texture of the product is tender and chewy.

Roasted and Spiced Soybean

Roasted and spiced soybean is also consumed as a snack. The processing includes roasting, mixing the hot soybeans with liquid spice, and packaging after cooling. The texture of the product is crispy. Black soybeans and the kernels of vegetable soybeans are also used as raw material for roasted and spiced soybean.

Sweetened soybean

Sweetened soybean is a dish for breakfast. The processing includes soaking, cooking to make it soft, adding sugar, and cooking again. The product is sweet with good soybean flavor.

Fermented Soybeans (*Taosi*)

Fermented soybean is generally used as a starter, but fermented soybean in brine is also consumed as a condiment. The processing includes soaking overnight, cooking for 4-5 hours without pressure, draining and cooling, mixing with a half weight of parched wheat flour, inoculating with short- or medium-stalk *Aspergillus oryzae,* incubating for three days, and finally drying in air, or aging in 18 percent brine. Fermented black soybean is more popular in Taiwan, because of its specific flavor after aging.

Soybean Sprout and Mung Bean Sprout

Soybean sprout is a fresh vegetable consumed like mung bean sprout. The processing includes soaking, draining, spreading and keeping in a dark humid room for a few days, and spraying water periodically for germination and sprouting. Plant hormones are used to control the growth of root. Mung bean sprout and soybean sprout are main fresh vegetables supplied during typhoon season, when other vegetables are destroyed by typhoon and need a period of time to grow.

Soy Milk

Soy milk is very popular in Taiwan. In traditional method of processing, soybeans are washed and soaked in water for a suitable period of time, ground in a stone mill with cold water, cook the slurry to boiling, filter through cloth, and add sugar before consumption. Some food processing factories belonging to farmers associations package the soy milk in glass bottles and sterilize them using the above method. About 30 years ago, this was the commercial soy milk in Taiwan.

In 1971, the Pulse Company introduced the Illinois process and aseptic processing equipment to make non-beany flavor soy milk. The product “Pulse Milk” was the first tetra pack soy milk in Taiwan. Due to technological and quality problems the processing line was closed after running for a few months. The Pulse Company was taken over by the President Company, and the new product was called “Honey Soy Milk” with strawberry, milk, egg, coffee, or malt flavor. There is no beany flavor in the flavored soy milk. The President Company enjoyed a big success on these products. In recent years, the Company also produces traditional refrigerated soy milk packaged in plastic bottles or pure pack. Wei Chuan Company produces traditional soy milk packaged in tetra pack. Two other companies produce different types of soy milk packaged in combiblock. One of them uses reconstituted soy milk from soy protein isolate. Another company produces aseptic soy milk packaged in PET bottles. There are many other producers packaging sterilized soy milk or black soybean milk in plastic bottles.

There are many small soy milk shops at every corner of the streets. They produce soy milk every morning and sell it by themselves.

The Illinois process uses blanching and homogenization to make non-beany flavor soy milk. Mr. Kuo's process uses two-stage blanching to make non-beany flavor soy milk. Mr. Liao's process uses de-aerated water to soak and grind soybeans, and injects steam to the grinder during the grinding process.

Many years ago, there was one company in Taiwan producing instant soy milk powder and exported it to other countries as a functional food or for cosmetic use. But now it has been replaced by instant adlay powder for export market.

There is a potential market for aseptic soy milk packaged in "bag in box" for food service use. But no one produces such a product. There is a fantastic soy milk-making machine sold in Taiwan. By using it, consumers can make soy milk very easily at home, and the soy milk is then cooked in a rice cooker to prevent charring.

Soft Soybean Curd or Toflower

Traditional soft soybean curd is prepared by pouring hot soy milk straight into a suspension of gypsum and sweet potato starch. The curd is formed on standing without stirring. After cooling in water, the curd is stored in a refrigerator. The curd is consumed with syrup containing cooked peanuts or ginger extract. A new type of soft soybean curd is prepared by adding edible gums to hot soy milk, mixing, and packaging in plastic containers when the mixture is still hot. After cooling, the coagulated product is stored in a refrigerator and consumed cool. A mixed powder of gypsum, sweet potato starch and other ingredients is available. Consumers can prepare soft soybean curd with this mix at home.

Tofu

Tofu is also very popular in Taiwan. The processing includes soaking, grinding with cold water, cooking the slurry to boiling, filtering the slurry to separate *okara*, adding a suspension of gypsum into the hot soy milk with gentle stirring, and allowing it to stand for the curd to set. The curd is then poured into a cloth spread in a mold, and pressed at a suitable pressure for shaping. After taking the cloth off, the tofu is cut into cubes for consumption or selling on local market. Traditionally, tofu is produced at night and sold in the morning. It is because tofu is a food very easy to get spoiled, and its shelf life is very short. In 1992, a small automatic tofu-making equipment was introduced into Taiwan from Japan. It saved labor and the quality of tofu was improved. Some tofu are chilled before marketing. Now tofu can be produced in the daytime, and sold all day long. Japanese packaged tofu was introduced to Taiwan in 1982. Although its characters were different from traditional tofu, local consumers preferred them. But currently there are only three producers produce this product in Taiwan. The coagulant of packaged tofu is glucono-delta-lactone. A new type of frozen tofu is prepared with emulsified soy protein isolate. Its price is higher than traditional frozen tofu. No one is producing aseptic packaged tofu in Taiwan.

Deep-fried tofu is very much preferred by many people for its flavor and texture. It is also used in the manufacture of sushi. For sushi preparation, its elasticity should be strong enough. It needs better technology to control the heat treatment of soy milk. So, only a few manufacturers can produce it.

Seasoned and dried deep-fried tofu is a snack. The deep-fried tofu is cooked with seasonings, such as sugar, salt, monosodium glutamate, pepper or other spices, and then dried with hot air. The product is sweet, salty and spicy. If the product is over-dried, it becomes too hard to eat. But if the product is soft and too wet, it is not easy to keep it away from molding. So, how to control the drying is the key technology. Hurdle technology is applied in processing this product.

Stinky tofu is prepared by putting tofu in a stinky liquid for a few hours and then deep-fried or steam-cooked. Although the smell of the product is not good, once people try the taste of it, most people like it. The preparation of the stinky liquid is by natural fermentation and hydrolysis of organic materials. So, the sanitation is out of control, and pathogenic microorganisms might be present in the liquid. Our Institute developed a pure culture method to prepare the stinky liquid. But the smell of the pure culture is not the same as that of natural fermentation. It appears that it is necessary to add some other pure microorganisms into the culture for fermentation to make it stinky.

Fermented tofu is also called *sufu* or Chinese cheese. Like cheese, there are many kinds of fermented tofu. It is prepared by growing mold (*Actinomucor*) directly on tofu, or by putting one layer of tofu upon one layer of rice *koji* (*Aspergillus*), or soybean *koji*, or red rice *koji* (*Monascus*), to form multi-layers, and a liquid is added. The liquid may be salty or sweet, or with rice wine added. Today, consumers are concerned about the salt content of the product.

Firm Tofu

Firm tofu is a meat analogue, and is also a cheap protein source. The processing of firm tofu is the same as soft tofu, except that the curd is first cut into small pieces to remove part of the whey, before putting it into the mold. The pressure applied upon the mold is higher, and the pressing time is longer. Traditionally, the product is sold under ambient temperature. So, its shelf life is less than one day. But the retailers want to sell the product at least for three days. The producers cook the firm tofu in a solution of H_2O_2 to meet the requirement, which results in H_2O_2 residue in the product. But Taiwan's food sanitation law does not allow such H_2O_2 residue. The solution to this problem is to sell the refrigerated product, but this is still practically difficult for the retailers.

Seasoned and dried firm tofu is another kind of snack tofu. It is an intermediate moisture food, very easy to get infected with mold. Preservatives are added to avoid the growth of mold. But the amount of preservatives added is often higher than the limit permitted by regulation. The hurdle technology is also used to solve this problem. Humectant is added to lower the water activity of the product. Acidulant is added to lower the pH. Preservative is added within regulatory limit. Oxygen scavenger is packed in the plastic bag. Mild heat treatment is applied after packaging. The shelf life of the product is thus extended to about four months.

Yuba

Yuba is a film formed on the surface of soy milk when it is cooked without boiling. *Yuba* can be processed into many delicious vegetarian foods. Usually the production of *yuba* by traditional method is not enough to meet the requirement of market. Therefore, the producers need an automatic method of *yuba* preparation. A continuous drum-drying method was developed at FIRDI. This method has been commercialized, and now there are four producers using this method. But the characters of drum-dried *yuba* are different from traditional *yuba*. FIRDI also developed a continuous method, which continuously picks up the film from the surface of hot soy milk. Only one factory is using this method. Now FIRDI is trying to use twin-screw extrusion to make *yuba* continuously. A T-die is used to form the film. As the film is still too thick, efforts are made to make it thinner. The new technology is not extended to the industry yet.

Textured Vegetable Protein

Textured vegetable protein (TVP) with very fine fiber structure was developed in Japan. From this TVP, a very high-quality vegetarian ham was produced in Japan and exported to Taiwan. The market size of this product is growing year by year. Under the cooperation of government, university, industry and research institute, we developed the twin-screw extrusion technology and it is commercialized by the industry. The price of TVP in Taiwan came down rapidly, and the market grew quickly. Now there are four TVP producers, and more than 20 vegetarian ham and meat analogues producers in Taiwan. They are competing seriously for the local market, and are also trying to find foreign markets.

The process by twin-screw extrusion includes mixing of the ingredients, such as soy protein isolate, wheat flour and gluten, and using a twin-screw extruder to texturize the mixture, while water is pumped into the extruder. The screw profile should be found out by many tests. The temperatures of barrel and die, the screw speed, the feed rates of powder and water are the control parameters of the extrusion. Products of different shapes can be obtained by using different dies. The extruded TVP is then dried in a hot-air drier. The quality of the extruded product can be tested very quickly by putting the TVP in boiling water, and observing its texture.

Tofu Whey and *Okara*

Tofu whey and *okara* are the liquid and solid wastes of soybean processing, respectively. Tofu whey is usually treated as wastewater, while *okara* is used as feed for animals. FIRDI has developed a soft drink from tofu whey by adding citric acid, flavorings, sugar and carbon dioxide. It is yet to be commercialized, since none of the tofu factories have the facilities to produce the drink. Furthermore, tofu producers also have difficulty to sell the soft drink with tofu. FIRDI imported an *okara* drier to dry wet *okara* to a powder, and use the dried powder in processing cakes and cookies, to find the suitable amount of *okara* powder in the formula. But it is not useful for the industry, since the local bakeries have other cheaper raw materials.

Soy Sauce

Soy sauce is produced in large, medium and small scale in Taiwan. In large-scale production, the industry is using the technology and equipment developed by Japanese companies. Soybean and wheat are the raw materials. In small- and medium-scale production, traditional technology and equipment are used. Black soybean is the raw material. Soybeans are soaked, cooked and mixed with roasted wheat and seed mold, incubated for *koji* fermentation, mixed with brine, aged, pressed, and pasteurized to obtain refined soy sauce.

Soy sauce may also be prepared by acid hydrolysis of defatted soybean. The compound called 3-monochloro-1,2-propanediol is a carcinogen, which can be detected in acid-hydrolyzed soy sauce. In the European market, the allowed residue of 3-monochloro-1,2-propanediol in soy sauce is very low. If the content is higher than this level, the product is prohibited to enter the market. In Taiwan and foreign countries, people prefer naturally fermented soy sauce due to health reasons. Low sodium soy sauce has become more popular than before among aged people.

Miso

Miso is a condiment and a soup base. The processing has been kept almost the same as before. Soybeans are soaked in water, cooked and cooled, mixed with rice *koji* and salt, and aged for a certain period. Some peptides in miso have been found to have some functional benefits for controlling hypertension. But the salt content of *miso* is fairly high.

Peanut Flavor in Peanut Products

People like processed peanut flavor, but the flavor disappears quickly. How to retain the flavor during storage is the main research objective. Addition of natural antioxidant is a choice. The use of superheated steam to roasted peanuts is another choice. Excluding oxygen during processing and storage may be helpful. Packaging with oxygen barrier film may also have some effect.

Adzuki Bean Paste

Adzuki bean paste is a product for export. It is used as stuffing in the baking industry. The processing includes soaking the beans, cooking to make it soft, grinding, filtering through a pulp finisher to separate pulp from starch, washing the starch with water at least twice, pressing in a bag to separate water, and then cooking with sugar and oil. The amount of wastewater produced during the processing of adzuki bean paste is very large. Its biological oxygen demand (BOD) is high and difficult to treat. Due to the wastewater problem, many producers moved their facilities to foreign countries. Therefore, the production and export of adzuki bean paste decreased in recent years. High potential induced static electric field developed in Japan may improve the treatment of wastewater, but it is not yet used in Taiwan.

Mung Bean Paste, Pea Paste and Kidney Bean Paste

The processing of mung bean paste, mung bean starch vermicelli, pea paste and kidney bean paste has the same problem as in making adzuki bean paste. Dried paste is used as an extender in the processing of meat products.

Food industry now is a low profit traditional industry in Taiwan. New investments go to high-tech industry or potential bio-tech industry. The progress of technology in food industry has slowed down in recent years.

POTENTIAL MEDICAL USE OF LEGUME FOODS

Consuming soybeans fermented with more than 30 strains of lactic acid bacteria and yeasts has the effect of prevention or therapy of some cancers. There are many kinds of phytochemicals in soybeans, that are activated by fermentation. Consuming tablets made from seeds of *Canavalia ensiformis* DC. (Jack bean, sword bean) can cure some cancers. These are hot topics of health news in the media. The price of sword bean has jumped from NT$20/kg to NT$2,000/kg. Legume foods have potential medical use in the future.

THE PROBLEMS OF LEGUME PROCESSING

Although modern food science and technology are used in the processing of legume foods, the following problems still remain unsolved:

1. Separation of oil and protein on the surface of packaged and sterilized soy milk in bottles.
2. Stability of tofu, firm tofu and snack tofu in storage is always a problem. Microorganisms grow easily on tofu, firm tofu and snack tofu. In traditional market, these products are not packaged and refrigerated.
3. Stability of processed peanut in storage is a problem. Good peanut flavor disappears easily and off-flavor appears in these products.
4. Waste water treatment is a serious problem in the processing of tofu, firm tofu and bean paste.
5. Handling *okara* in soymilk, tofu and firm tofu industry is a problem.
6. Difficulty in the development of new legume food products.
7. To confirm the functionality of health foods is difficult.
8. After Taiwan joins WTO, the sources of raw materials will be globalized. Then, to buy high-quality and low-price raw materials may become a new problem.

THE MUSEUM OF LEGUME FOODS

Da C, in Tao Yuan County of Taiwan, is famous for its seasoned firm tofu. The Vice President of Republic of China, Annette Lu, is the former governor of Tao Yuan County. She has an idea to build a museum of legume foods in Da C. This museum will be built in a park. She has the budget from the Council of Cultural Affairs. So the museum is currently being designed and planned. A garden of legumes will be established. The history of legume foods will be introduced. Ancient tools and modern equipments for tofu and soy sauce processing will be exhibited. Nutritional value of legume foods will be publicized.

THE FUTURE ROLE OF LEGUME FOODS IN TAIWAN

In Taiwan, the consumption of animal protein is already higher than that of vegetable protein. For health point of view, however, consumption of vegetable protein should be increased. But the consumption of traditional legume foods is almost saturated, and it is very hard to further increase the consumption of traditional legume foods. Therefore it is necessary to develop new legume food products in order to increase the consumption. Development of western type foods, such as soy yogurt, soy cheese, soy ham and soy sausage, may be a good choice.

Taiwan will join WTO, more legumes may be imported from foreign countries at lower costs. The quality of imported legumes must be as high as possible. The farmers may have a chance to produce perishable vegetable legumes for local fresh food market. The imported vegetable legumes will not be able to compete with fresh locally produced legumes.

In addition to the current understanding of the nutrition of traditional legume foods, additional health benefits have been discovered, and as a result more people may like to consume traditional Chinese legume foods. Soy milk, tofu and other soy foods may become worldwide foods, and Taiwan may have a chance to export our high quality traditional legume foods in the future.

Taiwan has been importing more than 200 million mt of soybean every year. Most of them are genetically modified soybeans. We understand the benefits of genetically modified soybeans, but we are not sure about the safety or the risk of consuming genetically modified soybeans. At present, our government does not have any regulation on geneticall modified organisms (GMO). The industry uses the imported soybeans. So far there is no evidence that genetically modified soybeans are harmful to human health. If there is any evidence that genetically modified soybeans may cause diseases, the government and the public will be very much concerned.

ACKNOWLEDGEMENTS

I thank Prof. Wei-Hsien Chang very much for his reviewing and correcting the English word by word and Mrs. Hsiang-Wen Chang for her help in preparing the tables.

REFERENCES

Chang, Hsiang-Wen and Wen-Lian Chen, 1999. "Effects of the Application of Hydregen Peroxide on the Preservation of Firm Tofu", *Journal of Food and Drug Analysis*, 7(3): 215-223.

Chen, Steve, 1989. "Principles of Soy-milk Production", in E. W. Lusas, D. R. Erickson, and W. K. Nip (eds.) *Food Uses of Whole Oil and Protein Seeds*, American Oil Chemistry Society.

Chen, Wen-Lian, 1993. "Fermented Soyfoods", *Encyclopedia of Food Science and Technology*, John Wiley and Sons.

Hwang, Sam-Long, Li-Huang Chen, and Wen-Lian Chen, 1998. "Studies on the Processing of Texturized Vegetable Protein using Twin-screw Extrusion: (I) Effect of Processing Variables on the Quality of Texturized Vegetable Protein", *Food Science* 25(3): 331-343.

----------, 1998. "Studies on the Processing of Texturized Vegetable Protein using Twin-screw Extrusion: (II) Effects of Raw Material Formula and Additives on the Quality of Texturized Vegetable Protein", *Food Science* 25(4): 394-405.

Kao, Fuh-Juin and Wen-Lian Chen, 1998. "The Application of Okara and Waste Liquid of Yuba on Cookies", *Food Science* 25(5): 580-590.

Messina M. and V. Messina, 1994. *The Simple Soybean and Your Health*, Avery Publishing Group, Garden City Park, New York, U.S.A.

Smith A. K. and S. J. Circle, 1978. *Soybean: Chemistry and Technology*, the AVI Publishing Company, Inc., Westport, Connecticut, U.S.A.

William Shurtleff and Akiko Aoyagi, 1983. *The Book of Tofu*, Ten Speed Press, Berkeley, Califonia, U.S.A.

3. INDIA (1)

Jarnail Singh
Professor
Department of Processing and Agricultural Structures
College of Agricultural Engineering
Punjab Agricultural University
Ludhiana

INTRODUCTION

Grain legumes occupy an important place in human nutrition due to their higher protein content than cereal grains. They are particularly important for major segment of population in developing countries who cannot afford animal protein due to high costs. Majority of Indians are vegetarians and they depend largely, for a major part of their dietary protein, on grain legumes (pulses). Grain legumes, complement cereals and make an ideal combination to provide protein quality matching that of animal products (Mehta and Singh 1989). Legumes contribute a major portion of lysine in the vegetarian diet. They are also fairly good sources of vitamins like thiamine, niacine and riboflavin and much needed iron, but relatively poor source of calcium and sulphur containing amino acids. Nutritive studies have shown that inclusion of various legumes in the cereal based diet can solve the protein calorie malnutrition and promote growth especially of the underweight children. To achieve optimum nutritional complementarity cereals and legumes need to be eaten in an approximate ratio of 3:1 i.e. 75 gm of rice or wheat and 25 gm of legumes (Narasimha, 1993). Post-harvest technology of grain legumes involves cleaning, storage, milling and packaging operations. Grain legumes are processed and utilized in a number of ways such as dry seeds, fried seeds, cooked dhal etc.

GRAINS LEGUMES GROWN IN INDIA

India grows a variety of grain legumes (Table 1).

Grain Legume Production in India

Grain legume production remained static between 10.6 million mt to 13.7 million mt in the past few decades (Table 2). The factors limiting the production and availability of legumes are climatic and ecological, non-availability of high yielding varieties, proper research support, socio-economic factors and constraints in post-harvest technology.

Protein Content of Grain Legumes

Grain legumes contain about 12-51 percent protein and therefore they are excellent source of protein (Table 3). A wide variation in protein content can be observed not only among species but also between cultivars within species (Swaminathan and Jain, 1973; Jambunathan and Singh, 1980; Singh, *et al.*, 1989; and Mehta and Singh, 1989).

Table 1. Grain Legumes Grown in India

Common Name	Vernacular Name	Common Name	Vernacular Name
Chickpea	Bengal gram	Moth	Moth
Pigeon pea	Arhar or tur, red gram	Cowpea	Lobia
Black gram	Mash or Urd	Cluster bean	Guar
Green gram	Moong or mung	French bean	Frasbean/kidney bean
Lentil	Masur	Soybean	Soybean
Field peas	Masar	Horse gram	Gram (kabuli)

Table 2. Production of Grain Legumes in India

Year	Production (000 mt)
1950-51	8,400
1960-61	12,700
1970-71	11,800
1980-81	10,600
1990-91	13,700
1999-2000	13,600

Table 3. Variability of Protein Content in Major Grain Legumes

Legume	Protein Content (Percent on Dry Weight Basis)
	(N × 6.25)
Chickpea	12.4 – 30.6
Pigeon pea	16.6 – 26.3
Black gram	20.6 – 31.1
Green gram	20.7 – 33.1
Lentil	23.9 – 29.6
Pea	17.2 – 31.1
Cowpea	21.2 – 30.6
Horse gram	22.0 – 23.6
Cluster bean	34.4 – 42.2
French bean	18.8 – 25.9
Soybean	37.0 – 51.0

Nutritive Value of Grain Legumes

Although grain legumes are rich in protein their nutritive value is limited by the deficiency of sulphur containing amino acid (Table 4). Low digestibility is another factor contributing to their poor nutritive value. Besides, most of the legumes in raw form contain a wide variety of anti-nutritional factors or toxic principles. In addition, many of the grain legumes cause flatulence. Fortunately, most of the anti-nutritional factors are heat labile and are destroyed during cooking.

Use of Grain Legumes

Uses of grain legumes in India are as follows:

Table 4. Essential Amino Acid Content of Proteins from Major Grain Legumes
(Unit: gm/16x8N)

Amino Acid	Legumes (range)	Egg Protein
Lysine	4.00 – 11.36	7.2
Threonine	2.56 – 4.96	5.2
Valine	3.32 – 9.44	7.4
Leucine	3.20 – 10.88	7.8
Isoleucine	2.80 – 9.92	6.8
Total sulphur amino acid	1.35 – 4.11	5.3
Tryptophan	0.32 – 1.13	1.5
Phenylalanine	2.40 – 9.70	5.8

Source: Mehta and Singh, 1989.

1. ***Chickpea***

This is a multipurpose pulse crop. The tender leaves as well as the raw grains are used as vegetable. When ripe, the grain is split into two parts and consumed as dhal. Roasted gram alone or in combination with popped rice is also a popular food item. Gram flour is used extensively in the preparation of Indian sweets and snacks.

2. ***Pigeon Pea***

This is largely consumed in the form of split pulse (dhal).

3. ***Black Gram***

It is consumed in the form of dhal (whole grain or split, husked or un-husked). It is the chief constituent of '*Papad*' and '*Bari*' which makes a delicious snack and curry, respectively. In the southern part of the country husked dhal is grounded into a fine paste and mixed with equal quantity of rice flour and allowed to ferment to make *idli* and *dosa*.

4. ***Green Gram***

Green gram is used as whole grain or split, husked or un-husked in a variety of ways. Sprouted seeds are used for preparing curry or a savory dish. 'Mung' pudding ('*halwa*') is very nutritious and is commonly served as dessert. Split and de-husked mung, fried and salted are served as snacks with drinks.

5. ***Lentil***

The grain is used as 'dhal' with or without husk.

6. ***Peas***

Peas are consumed in a variety of ways: the fresh ones (garden peas) are used as vegetables and are processed for canning. The dry one (known as field peas) is used as dhal either as whole grain or in split form.

7. ***Moth***

Moth is consumed as pulse either whole or split. The whole grain is fried and mixed with other savory dishes and served as snacks with drinks.

8. ***Cowpea***

Cowpea is used as 'dhal' either whole or split and as flour. The young green pods are used as vegetables.

9. ***Cluster Bean***

The green and tender pods of cluster beans are used as a favorite vegetable. The green pods are cut into bits and cooked with potatoes that make a delicious dish. Pods preserved after drying are eaten after frying. It is commercially used for gum extraction.

10. ***French Beans***

The green and tender pods are used as a vegetable. The green pods are cut into one cm pieces and cooked with potatoes or cooked with other vegetables. Dry beans are used as pulse (Bolaria, 1982).

Balanced Diet

Balanced diets of moderately active adult Indian men and women as recommended by Indian Council of Medical Research is given in Table 5. Total calorie intake of an adult man and woman is 2,800 kcal and 2,200 kcal per day, respectively.

Table 5. Composition of Balanced Diet of Adult Indian

Food	Recommended Amount (gm/day)	
	Man	Woman
Cereals (rice/wheat)	520	440
Grain legumes	50	45
Meat/fish or	30	30
egg (number)	1	1
Milk	200	150
Oils/fats	45	25
Sugar/molasses	35	20
Roots and tuber (potatoes etc.)	60	50
Green leafy vegetables (spinach etc.)	40	100
Other vegetables	70	40

POST-HARVEST TECHNOLOGY OF LEGUMES

Cleaning

Freshly threshed grain legumes contain foreign materials like straws, twigs, shells, stones, dusts, immature grains and weed seeds. They are cleaned with rotary screen or vibratory screen cleaner cum grader. Lighter impurities are blown off with the help of blower/air aspirator. Large-size impurities are removed with scalper and small-size impurities pass through the sieve and are removed.

Storage

Grain legume production is seasonal. Therefore, storage of grain legumes is necessary to meet the year round demand throughout the year. Safe storage therefore, helps to maintain continuity of supply. Although grain legume production is seasonal processing/milling continues, grain legumes in commercial quantities are stored in modern storage structure i.e. flat godowns and silos so that the loss during storage can be minimized.

Domestic level grain legume storage containers are traditional. The traditional containers are improved and replaced by modern airtight metal bins that are easily available in a variety of sizes. The metal bins can also be easily fumigated. About 80 percent of the storage loss is due to insects, rodents and microorganisms. Grain legumes are specifically attacked by bruchids at the time of maturity itself. At high humidity and temperature (rainy season) conditions bruchids are difficult to control. Farmers cannot store grains even for seed purposes. The loss caused by bruchids may range from 10 percent to 30 percent (Singh and Verma, 1995). Most of the storage loss takes place at farmer's level. Studies are conducted to control insect infestation of pulses using biogas fumigation in metal bins.

1. ***Controlled Atmosphere Storage***

Different atmospheric conditions viz. CO_2 level of 60 percent, 70 percent and 80 percent, O_2 level of 4 percent, 7 percent and 10 percent and N_2 level of 16 percent, 23 percent and 30 percent were evaluated at 0.4 kg, 0.6 kg and 0.8 kg/cm^2 pressure level and air flow rate of 58 ml/min. to control pulse beetle and rice weevil (*S. oryzae*) in green gram. The exposure time was 24 hours, 36 hours and 48 hours. The relative humidity (RH) and temperature were 71 percent and 30 ± 2ºC, respectively. It was observed that mortality occurred at higher CO_2 level and lower levels of O_2.

2. ***Thermal Treatment***

Exposing grain legumes to 70-80ºC temperatures for short duration can control insect infestation. The insects are killed at high temperature.

3. ***Ventilation***

Commercial storage structures should have arrangement for forced ventilation in order to prevent moisture accumulation and development of heat spots in the storage structures

Milling

Milling is a general term and it refers to the reduction of grains into meal or flour. Milling is an overall process and it includes size reduction, hulling, scarification, polishing, sorting, mixing and in some instances, also refers to certain chemical reactions. Through milling outer husks are removed and the grain is split into two equal halves. The kernel tightly holds the husk. Therefore, de-husking poses a problem. The method of alternate wetting and drying is used to facilitate de-husking and splitting of pulses. In India the de-husked split grain legumes are produced by traditional methods of milling. In traditional milling methods the loosening of husk by conditioning is insufficient. Therefore, a large amount of abrasive force is applied for the complete de-husking of the grains that results in high losses in the form of broken and powdered grains. The yield of split pulses in traditional mills is only 65-70 percent in comparison to 82-85 percent potential yield. De-husking is a process, that reduces the fiber content and improves appearance, texture, cooking quality, palatability and digestibility of grain legumes. Pre-milling treatment plays an important role in improving dhal recovery. The proportion of seed coat, cotyledon and embryo in different legumes is given in Table 6.

Table 6. Proportion of Seed Coat, Cotyledons and Embryo in Relation to Whole in Different Legumes

Legume	Proportion of Whole Grain (percent)		
	Seed Coat	Cotyledon	Embryo
Pigeon pea	15.50	83.00	1.50
Peas	10.00	89.28	1.72
Lentil	8.05	89.97	1.98
Mung bean	12.09	85.61	2.30
Cowpea	10.64	87.23	2.13
French bean	8.64	90.37	0.99

Source: Salunkhe, Kadam, and Chawan, 1985.

Pre-milling Treatment

Pre-milling treatments are given to affect the gums present in between seed coats and cotyledon in order to: (a) loosen the husk; (b) ease of milling; (c) reduce breakage; and (d) improve the quality of split. The following four methods are used in pre-milling:

1. ***Dry Method***

The dry method includes application of oil and water. In this method cleaned and graded grains are subjected to pitting to increase soaking. Then pitted grains are mixed thoroughly with 1 percent oil and spread for sun drying in thin layer for 2-3 days. At the end of drying 2.5 percent water is sprayed and mixed thoroughly. For tempering grains are heaped overnight. Then grains are milled with roller machine.

2. ***Wet Method***

In wet method, red earth slurry is applied on pulses. The grains are thoroughly mixed with a paste of red earth after soaking in water for about 12 hours and heaped for about 16 hours. The grains are spread in thin layer in drying yards for 2-4 days. Then dried red earth is removed by sieving. The grains are then milled on power operated stone or emery-coated vertical *chakki*. This method resulted in 95 percent de-husked and 75 percent dhal yield. Wet milling process is popular in South India. This method requires 5-7 days to complete processing for a batch of 6-7.5 mt.

3. ***Thermal Treatment***

The cleaned grain legumes are conditioned in two passes in a dryer (Louisiana State university [LSU] type) using hot air at about 120ºC for a certain period of time. After each pass the hot pulses are tempered in the tempering bins for about six hours. Such hot air preconditioning of grains helps in loosening the husk significantly.

4. ***Chemical Treatment***

The use of chemicals have demonstrated the potential to replace oil treatment to achieve at least the same and in some cases more recovery than traditional methods. Sodium bicarbonate and sodium chloride were used to treat pigeon pea grains. The grains soaked in 4-6 percent sodium bicarbonate solution for 0.5-1.0 hour and dried at 65ºC to 10-15 percent moisture content gave 95 percent hulling efficiency and dhal yield was 80 percent. Possibility of using enzymes for treatment was also studied since some enzymes may break hemicelluloses, pentoses, hexoses etc. present in germ and seed coat, thus enhancing the ease of husk removal. The process is yet to be developed as complete package. Studies have shown that acetic acid (vinegar) was found to be effective for loosening the husk of pigeon pea.

The flow chart of wet and dry milling are shown in Figures 1 and 2. The two basic steps involved in both the processes are: (i) preconditioning of grain legumes; and (ii) milling by de-husking and splitting of the grain into two cotyledons followed by aspiration and size separation using suitable machines.

General Milling Processes:

There is no common processing method for all types of pulses. Some general operations of milling methods are described:

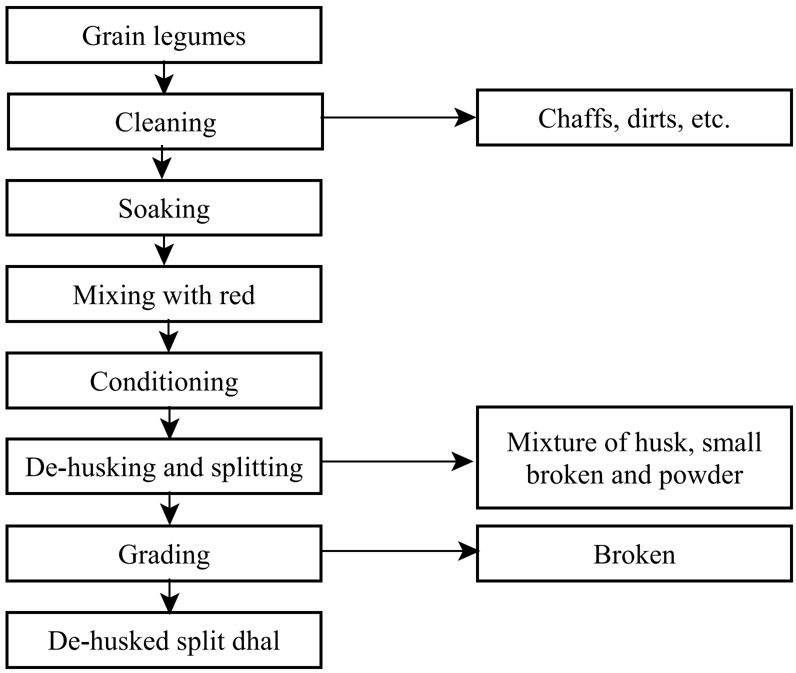


Figure 1. Flow Chart of Wet Milling Grain Legumes

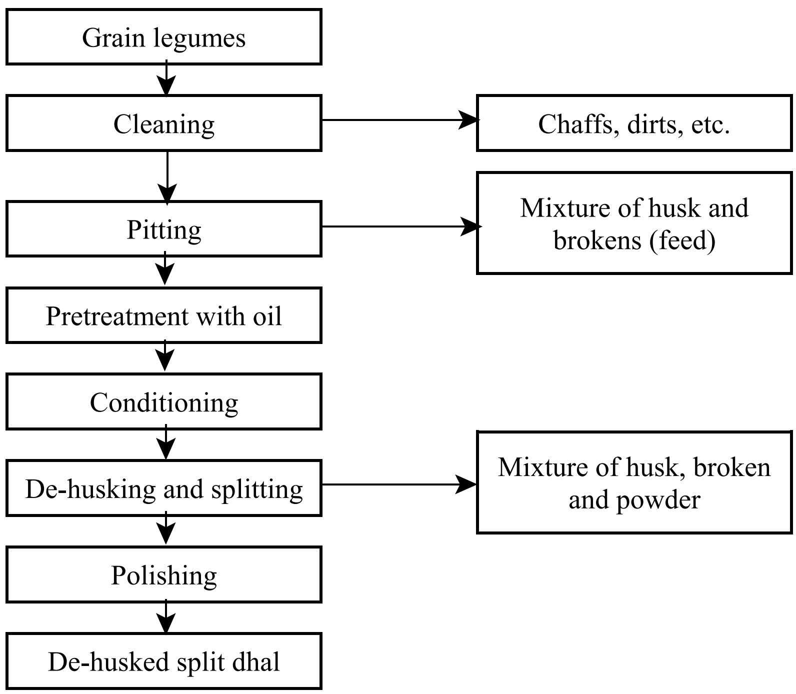


Figure 2. Flow Chart of Dry Milling Process

1. ***Cleaning and Grading***

Grain legumes are cleaned to remove dust, chaff, grits etc. and graded according to size by hand-operated and power-operated cleaners and graders.

2. ***Pitting***

The cleaned grains are passed through an emery roller machine. In this unit, husk is cracked and scratched. This is to facilitate the subsequent oil penetration process for loosening the husk. The clearance between the emery roller and cage (housing) gradually narrows from inlet to outlet. As the material is passed through the narrow clearance, mainly cracking and scratching of husk takes place by friction between grains and emery. Some of the grain legume seeds are de-husked and split during this operation, which are then separated by sieving.

3. ***Pretreatment***

The scratched or pitted grains are passed through a screw conveyor and mixed with some edible oil like linseed oil (1.5-2.5 kg/mt of pulse). Then they are kept on the floor for about 12 hours for oil to diffuse. The different types of pretreatment as recommended are applied in order to have better milling yield.

4. ***Conditioning***

Conditioning is accomplished through alternate wetting and drying of grains. After sun-drying for a certain period 3-5 percent moisture is added to the grains and tempered for about eight hours and again dried in the sun. Addition of moisture to the grains can be accomplished by allowing water to drop from an overhead tank on the grains that are passed through a screw conveyor. The whole process of alternate wetting and drying is continued for 2-4 days until all grains are sufficiently conditioned. Grains are finally dried to about 10-12 percent moisture content.

5. ***De-husking and Splitting***

Emery rollers known as gota machines are used for de-husking of conditioned grains. About 50 percent grains are de-husked in a single operation (in one pass). De-husked grains are split into two halves. The husk is aspirated off and sieving separates de-husked split grains. The tail grains and unsplit de-husked grains are again conditioned and milled as above. The whole process is repeated two to three times until the remaining grains are de-husked and split.

6. ***Polishing***

Polish is given to the de-husked and split grain legumes by treating them with a small quantity of oil and/or water.

Milling Machines

During pre-milling treatment loosening of husk from cotyledons takes place. But removal of husk and splitting of grains is achieved by means of various machines, which work on principles of: (a) compression; (b) shear; (c) abrasion; and (d) impact.

1. ***Chakki or Disc-sheller***

Hand-operated chakkies are used for de-husking and splitting grains since olden times in domestic and traditional milling. It consists of two cylindrical stones – one stationary and the other rotated by means of a wooden handle. Unhusked or full grains are fed from the center and de-husked grain and split dhal is recovered at the periphery of the cylinder. Improved power operated chakkies or emery-coated roller machines have been used for de-husking operation.

2. ***Cylindrical Concave De-husker***

It consists of a tapered carborundum roller. The diameter increases from feeding to discharge end, thus reducing the annular space between the roller and cylindrical screen casing. Reduction in the annular space increases the pressure on the grains and thus gradually increase the de-husking rate as grains move forward. The metal screen casing has a 2-mm diameter circular perforation through which husk and powder is discharged (Singh and Sokhansanj, 1984).

3. ***Rubber Roller Sheller***

It consists of two rollers rotating in opposite directions with different speed. When grains are passed through the rollers, they are subjected to shear and compression leading to husk removal. As husk is more tightly attached to cotyledons in case of legumes, rubber roller sheller can be used only to a limited extent. However, the machine causes minimum scouring and can be used to polish split legumes.

4. ***Huller***

Commonly used Engelburg rice huller can also be used for dhal milling. It consists of ribbed iron cylinder on rotating shaft in a concentric cylindrical housing. Bottom of the housing is provided with slots for removing the husk. It is used for milling black gram and green gram in some South Indian dhal milling industries. In case of difficult to mill grain legumes it causes heavy losses in the form of broken and powder.

Sequence of Operations

Pitting or scratching of grain legumes is done using a roller machine. A worm mixer is used for oiling as well as watering the pitted grains. De-husking is done by power-driven disc type sheller, 'chakki' or emery-coated roller machine, which is known as gota machine. The emery roller is encased in a perforated cylinder. The whole assembly is normally fixed in a horizontal position. The Engelburg type rice hullers are also used for de-husking or to return unhusked grains.

Cone-type polisher or a buffing machine is employed to remove the remaining remants of husk and to give a fine polish to the finished dhal. The cone polisher is similar to the polishing machine used for polishing rice. The buffing machine is fitted with a rotating paddle having leather straps that can remove the last patch of husk and can give a fine polish to the de-husked polisher. Sieves are also employed for grading dhals.

Milling Performance

Grain parameters such as size, shape and moisture content play an important role in deciding the milling performance and quality of milled grains. Milling operations yield dhal (50-80 percent), grits (5-20 percent), husk (10-25 percent) and powder (7-20 percent) depending upon the legume crop and method of milling. Milling performance also depends on other factors viz. pre-milling treatment, energy inputs, handling, storage and machinery. Among them, the type of machinery helps to reduce the losses, decides the conveniences and improves the profit of the user. Techniques for de-husking and splitting are well known for centuries. However, it is important to identify the appropriate system to obtain maximum yield of the product in desired form with ease of operation, optimum energy costs and less drudgery (Kulkarni, 1993). The maximum recovery and recovery of dhal using modern and traditional method is given in Table 7.

Table 7. Maximum Possible Recovery of Splits and Average Dhal (Splits) Yield for Various Food Legumes

Legume	Maximum Recovery of Splits	Yield of Splits by Modern Method	Yield of Splits by Traditional Methods
Bengal gram			
Big grains	88.5	84	74
Small grains	87.5	83	72
Pigeon pea			
Big grains	88.5	85	75
Small grains	85.0	82	68
Green gram	89.5	84	65
Black gram	87.5	83	71
Lentil	88.5	84	76
Cowpea	89.5	84	-

Source: Kurian, 1977.

Air Pollution

The flying dust from material handling and polishing of grains create a lot of dust inside the milling plant. By providing dust collection system at the point of dust generation system makes the atmosphere inside the milling plant dust-free.

Packaging

Grains after cleaning, grading and milling are packed in polyethylene bags of different capacities for sale in the market. The polyethylene bags are sealed to provide modified atmosphere conditions to the product.

TECHNOLOGICAL GAP

(i) Production and productivity of grain legumes in India is static and its availability per capita is decreasing.
(ii) There is a need to improve the post-production technology of grain legumes so that its losses may be reduced to a minimum.
(iii) Traditional milling technology of grain legumes needs to be modernized.
(iv) Milling causes quantitative and qualitative losses. There is a need to develop suitable and efficient processing technology.
(v) Eighty percent of the grain legumes produced is consumed as dhal/fried grains (whole/split/milled). There is a need to develop suitable products from grain legumes.
(vi) There is a need to develop suitable packaging technology for processed grain legumes.

REFERENCES

Bolaria, T. S., 1982. Country reports on the status of grain legume production India, *Grain Legumes Production in Asia*, APO Tokyo.

Jambunathan, R. and U. Singh, 1980. "Grain Quality of Pigeon-pea", *Symposium International Workshop on Pigeon-pea*, Vol. 1, p. 351, 15 December (10), International Crops Research Institute for Semi-arid Tropics, India.

Kulkarni, S. D., 1993. "Development of Food Legumes Machinery in India", *National Seminar on Dhal Milling Industry in India – Its Future Needs*, p. 118-138, National Productivity Council (NPC).

Kurian, P. P., 1977. "Grain Legume Milling Technology", paper presented at FAO Experts Meeting on Grain Legume Processing, Central Food Technological Research Institute (CFTRI), Mysore.

Mehta, S. L. and S. P. Singh, 1989. "Nutritional Quality of Grain Legumes – Present Status", National Symposium on New Frontiers in Grain legumes Research and Development, Directorate of Pulses Research, Indian Society of Pulse Research and Development (ISPRD), Kanpur.

Narasimha, H. V., 1993. "Quality Changes During Processing of Legumes", *National Seminar on Dhal Milling Industry in India – Its Future Needs*, p. 78-90, NPC, New Delhi.

Salunkhe, D. K., S. S. Kadam, and J. K. Chawan, 1985. *Post-Harvest Biotechnology of Food Legumes*, p. 29-52, CRC Press Inc., Boca Raton, Florida, U.S.A.

Singh, D. and S. Sokhansanj, 1984. "Cylinder Concave Mechanism and Chemical Treatment for Dehulling Pigeon Pea", *Agril. Mech. in Asia, Africa and Latin America* 15 (2): 53-58.

Singh, Jai and P. Verma, 1995. *Status of Pulse Milling in India*, p. 22, Central Institute of Post Harvest Engineering and Technology (CIPHET) Ludhiana.

Singh, S. P., S. L. Mehta, and W. C. Singhal, 1989. "Biochemical Approaches in Crop Plant Evaluation", *Indian Journal of Plant Genetic Resources* 1(1&2): 111.

Swaminathan, M. S. and K. K. Jain, 1973. *Nutritional Improvement of Food Legumes by Breeding PAG*, p. 61, UNO, New York.

4. INDIA (2)

Nawab Ali
Project Director
Soybean Processing and Utilization Centre
Central Institute of
Agricultural Engineering
Bhopal

INTRODUCTION

Food is essential for the survival of humans. Cereals and legumes form staple food for majority of the Indian people. Cereals account for about 50 percent of the total dietary proteins of the world (Table 1). The share of food legumes and animal products in total world protein resources is about 25 percent each. The grain legumes containing low oil (1-5 percent) and high protein (20-30 percent) and carbohydrates (50 percent and more) are called pulses and those having high oil (30-50 percent) and low protein (20-30 percent) are known as oilseeds in India. Soybean and groundnut are the two most cultivated legumes of the world and represent roughly 64 percent and 13 percent, respectively of the total world production of food legumes (Table 2). Share of pulses is 23 percent. In India, the pulses are the second major source of dietary proteins (27 percent) after cereals (55 percent) and the share of animal protein 18 percent (Table 3). Pulses are grown on marginal/poor lands and given less input than cereals which are more profitable and versatile.

Table 1. Global Production of Major Food Commodities and Their Contribution Towards Protein Supply in 1998

Commodity	Production (million mt)	Average Protein Content (percent)	Total Protein (million mt)	Share in Total Protein Supply (percent)
Cereals	2,054	8	164	50
Pulses	57	22	13	4
Soybean	158	40	63	19
Peanut	31	20	6	2
Milk	545	4	22	7
Meat	216	16	35	10
Fish	120	16	19	6
Egg	48	16	8	2
Total	3,229		330	100

Source: FAO, 1998.

Table 2. Production of Pulses, Peanut and Soybean During 1998 in India, Asia and the World

(Unit: Million mt)

Region	Pulses	Peanut	Soybean	Total
India	15	8	6	29
Asia	24	21	23	68
World	57	31	158	246

Source: FAO, 1998.

Table 3. Production of Major Food Commodities in India During 1999-2000 and Their Share Towards Protein Supply

Commodity	Production (million mt)	Average Protein Content (percent)	Total Protein (million mt)	Share in Total Protein Supply (percent)
Cereals	187.0	8.0	15.0	54.6
Pulses	15.0	22.0	3.3	12.0
Soybean	6.0	40.0	2.4	8.7
Peanut	9.0	20.0	1.8	6.6
Milk	75.0	4.0	3.0	10.9
Meat	6.5	16.0	1.0	3.6
Fish	5.0	16.0	0.8	2.9
Egg	1.5	16.0	0.2	0.7
Total	305.0	9.0	27.5	100.0

Source: IASRI/Indian Council of Agricultural Research (ICAR), 1999; and Directorate of Economics and Statistics (DOES), 2000.

Pulses are grown as food crops for their protein content and the oilseeds like soybean and groundnut are grown as commercial crops for their oil contents. The oil is extracted either by heat and pressure (mechanically) and/or by solvent extraction. The residual cake/meal, rich in protein, is used mainly for animal and aqua feed. However, where appropriate technology and hygiene control is maintained, the cake/meal can be made edible for human consumption. Legumes are next to cereals in terms of their economic and nutritional importance as human food resources. The ability of legumes to fix atmospheric nitrogen in soil-crop ecosystem is one of their unique and beneficial characteristics among all plant species. In addition to being a relatively inexpensive source of dietary proteins, legumes possess other desirable attributes such as abundance of complex carbohydrates, ability to lower serum cholesterol in humans, high fiber content, low fat content (excluding oilseeds), high concentration of polyunsaturated fatty acids (particularly the essential fatty acids, linoleic and linolenic), long shelf life and the diversity of foods that can be made from them. Legumes also contain several bioactive compounds whose beneficial effects in human health need to be fully exploited.

There has been a decline in real income and purchasing power of the majority of Indian population specially those who are below poverty line and such people are about 40 percent of total population. This has deprived them of the financial access to pulses and animal products for dietary protein. For some reasons, in many other parts of the world especially in the tropics, consumption of pulses is associated with poverty, although it is accepted in India where religion or local/social customs prevent consumption of meat or animal products. Since most legumes contain less than optimal amount of sulphur amino acids, there is a tendency to consider them as nutritionally inferior to meat, fish or egg, in spite of the many health promoting properties of properly processed and cooked legumes. This paper gives a brief account of processing and utilization of pulses, groundnut and soybean in India and suggests the future strategy as to how to make best use of the legumes.

STRUCTURE

The grains of food legumes are similar in structure but differ significantly from each other in size, shape, color and thickness of the seed coat. Legume seeds have two major parts; seed coat and the kernel (embryo and cotyledons). Pigeon pea, chickpea, black gram, green gram and horse gram have a seed coat accounting for 12-15 percent of the total weight of the grain where as it is in the range of 8-11 percent for lentils, French bean, kidney bean, pea, soybean and cowpea (Table 4). On an average, pulses (including soybean) contain 11 percent seed coat, 2 percent embryo and 87 percent cotyledons. The embryo has two parts known as hypocotyl and plumule. Legume proteins are of two types – storage and structural – more versatile and useful in the Indian diets. Storage proteins (70-80 percent) occur within the cells in discrete protein bodies. About 20-30 percent are the structural proteins responsible for cellular activities including synthesis of structural and storage proteins. The cotyledons, account for 93 percent of methionine and tryptophan of the whole seed, while the seed coat is the poorest in these amino acids. The embryo is rich in methionine and tryptophan but it contributes only about 2 percent of their total quantity in the seed (Kapoor and Gupta, 1977). Legume proteins are deficient in methionine and trytophan (Table 5).

Table 4. Different Fractions of Food Legume

(Unit: Percent)

Crop	Seed Coat	Kernel (Cotyledons and Embryo)
Lentil	8.0	92.0
French bean	8.6	91.4
Kidney bean	9.7	90.3
Peas	10.0	90.0
Soybean	10.5	89.5
Cowpea	10.6	89.0
Green gram	12.0	88.0
Black gram	12.5	87.5
Chickpea	12.5	87.5
Horse gram	12.5	87.5
Pigeon pea	15.5	84.5
Average	11.1	88.8

Source: Singh, 1993; and Kurien, 1977.

Table 5. Essential Amino Acid Composition of Pulses Grown in India

Amino Acid	Amino Acid Content in Different Pulses Grown in India (gm/100 gm of Protein)					FAO Reference Protein	Egg Protein
	Chick-pea	Pigeon Pea	Black Gram	Green Gram	Lentil		
Lysine	6.3	6.8	6.5	7.3	7.0	4.2	7.2
Threonine	3.4	3.8	3.9	3.4	3.5	2.8	5.2
Valine	5.5	4.8	5.6	6.9	4.9	4.2	7.4
Leucine	8.2	6.8	7.2	7.7	7.5	4.8	7.8
Isoleusine	6.0	5.7	5.8	6.3	4.3	4.2	7.4
Methionine	1.2	1.1	1.1	1.5	1.9	2.2	3.4
Tryptophan	0.8	0.8	0.5	0.4	1.0	1.4	1.5
Phenylalanin	4.9	9.0	5.5	5.3	7.5	2.8	5.8
Arginine	6.9	5.4	5.7	6.3	-	-	6.7
Histidine	2.3	3.4	2.7	2.7	-	-	2.4

Source: Gupta, 1982.

The carbohydrates in legume seeds range from 24 percent in winged bean to 68 percent in cowpea. Starch is the most abundant in legume carbohydrates and varies from 24 percent in wrinkled peas to 56 percent in pinto beans. Legumes contain an appreciable amount of crude fiber. Cellulose and hemicellulose are the major constituents of crude fiber. It has a hypocholesterolemic effect. Nearly 80-90 percent of crude fiber is present in the seed coat.

CHEMICAL COMPOSITION AND MAJOR NUTRIENTS

The chemical composition of food legumes vary and it is governed by the cultivar, geographical location and growth conditions. Legumes are good sources of dietary fiber and minerals. Legumes are rich in protein, carbohydrates and oil. Protein and lipid contents in different legumes are given in Table 6. They also contain good amount of dietary fiber and mineral. Proteins can be classified into three basic groups: globulins (70 percent), albumins (15 percent), and glutelins (15 percent). These protein fractions include essential and non-essential amino acids. All legume proteins have less than optimal content of sulphur amino acids, cystine and methionine and in some tryptophan is also deficient. Amino acid deficiency can be met by consuming large amount of legumes or by taking a mixture of legumes or by employing the complementary that exists between high sulphur amino acid cereals and legumes, especially the soybean. Digestibility of legume proteins is poor. However, it can be improved through heat-treatments like cooking, autoclaving, roasting, etc. The poor digestibility is due to the presence of protease inhibitors (Tobin and Carpenter, 1978), deficiency of sulphur amino acid (Bressani, 1975), presence of polyphenols and other anti-metabolites and tertiary structure of native proteins. It is important that this less-than-optimal digestibility of legume be taken into consideration when one is attempting to meet nutritional requirements of humans with diets which are essentially legume-based.

The major constituent of pulses is carbohydrates and it ranges from 24 percent in winged bean to 68 percent in cowpea. Starch is the principal carbohydrates and it varies from 24 percent in wrinkled peas to 56 percent in pinto beans. Minor amounts of lower molecular weight carbohydrates such as sucrose and sucrosyl oligosaccharides are present. The oligosaccharides include raffinose, stachyose and verbascose and they are associated with flatulence. It is the major hindrance to large-scale acceptance of legumes as food. Digestible energy coefficient for most legumes as well as mixed diets containing legumes are generally between 85-90 percent of the gross energy of the dry legume seed whereas metabolizable energy values are 75-85 percent.

Table 6. Protein and Lipid Contents of Major Food Legumes

(Unit: Percent)

Food Legume	Protein Content		Total Lipid
	Range	Average	
Chickpea	14.9 – 29.6	22.25	4.99
French bean	21.1 – 39.4	30.25	1.68
Groundnut (kernel)	23.5 – 33.5	28.50	46.70
Peas	21.2 – 32.9	27.05	2.41
Faba bean	22.9 – 38.5	30.70	1.63
Cowpea	20.9 – 34.6	27.75	2.05
Winged bean	29.8 – 37.4	33.60	15.90
Horse gram	18.5 – 28.5	23.50	2.20
Pigeon pea	18.8 – 28.5	23.65	2.19
Green gram	20.8 – 33.1	26.95	2.14
Black gram	21.2 – 31.3	26.25	1.64
Lentil	20.4 – 30.5	25.45	1.17
Rice bean	18.4 – 27.0	22.70	1.00
Cluster bean	19.3 – 27.8	23.55	1.65
Soybean	33.2 – 45.2	39.20	21.30
Moth bean	21.0 – 31.3	26.15	3.90
Lathyrus	22.7 – 29.6	26.15	1.00

Source: Salunkhe, *et al*., 1985.

Dietary fibers are necessary to prevent various diverticular and degenerative diseases. Recommended daily intake levels range between 25-50 gm of fiber. Legumes are excellent sources of dietary fibers. It ranges from as low as 6 percent in peanuts to as high as 25 percent in kidney beans and green gram (Paul and Southgate, 1978; and Kamath and Belavady, 1980). Low dietary fiber intake is linked with increased incidence of cancer of the colon and rectum, diverticular disease, coronary heart disease, diabetes and gallstone in affluent societies of the West (Burkitt and Trowell, 1975). A concentrated source of dietary fiber from soybean is obtained by processing de-hulled and defatted soy flakes. It has 65-75 percent dietary fiber (Salvin, 1988). Only 13 gm of soy fiber can provide 10 gm of dietary fiber in food whereas it takes 23 gm of wheat bran; 58 gm of oat bran; 502 gm of apple; and 735 gm of lettuce to provide 10 gm of fiber. The physiological benefits of soy fiber and other dietary fiber sources are increased fecal bulk and its moisture; reduced plasma cholesterol and positive influence on blood glucose and insulin concentration.

The hypocholeslterolemic effect is attributed to the dietary fiber fraction of legumes (Cummings, 1978; and Hellendoorn, 1979) because of its high content of pectins, gums and galactants. Dietary fiber also absorbs bile salt. It is aided by saponins.

ANTI-NUTRITIONAL FACTORS

Legumes also contain some anti-nutritional factors (ANFs) like trypsin inhibitor and others. These are chemical substances which, although non-toxic generate adverse physiological responses and interfere with the utilization of nutrients. ANFs are protease inhibitors, lectins, goitrogens, antivitamins and phytates, saponins, oestrogens, flatulence factors, allergens and lysinoalanine (Liener, 1981). Some other ANFs are cyanogens, favism factors, lathyrism factors, amylase inhibitors, tannins, aflatoxins and pressor amines. Although only a few legumes may contain all these ANFs, many contain a few of them. Most of the ANFs are heat-labile and since humans only consume legumes after cooking, it would not constitute any major health hazard. Heat stable compounds such as polyphenols and phytates are, however, not easily removed by simple soaking and heating. These could be reduced by germination and/or fermentation. Legumes are rich source of polyphenolic compounds. Till recently, some of these (e.g. tannins), were considered as anti-nutrients due to their adverse effects on protein digestibility. However, nowadays, there is considerable interest in the antioxidant activity of these compounds and in their potential health benefits, especially in the prevention of cancer and cardiovascular disease (Menon, 2000). Dark-colored legumes like red kidney beans, black beans, black gram and soybean have higher amount of these polyphenolic compounds.

PRODUCTION AND PRODUCTIVITY

The total production of food legumes in the world in 1998 was 246 million mt (Table 7). Out of this, pulses account for 57 million mt (23 percent of total food legumes including soybean and peanuts). World production of groundnut was 31 million mt and that of soybean was 158 million mt. In 1998-99 India produced 30.91 million mt of food legumes, out of which pulses were 14.81 million mt (Table 8). The other food legumes are groundnuts, 9.16 million mt; and soybean, 6.94 million mt. The annual production of food legumes in India during 1990s were 30 million mt. In this the share of pulses, peanut and soybean were 15 million mt (50 percent), 9 million mt (30 percent) and 6 million mt (20 percent), respectively. Productivity of pulses, peanuts and soybean in India during 1998-99 was 622 kg/ha, 1,210 kg/ha and 1,100 kg/ha, respectively (Table 9) against the world average yield of 840 kg/ha (pulses), 1,300 kg/ha (peanuts) and 2,240 kg/ha (soybean). Soybean yield in India is very low. Details of yield of food legumes in India during the last few decades are given in Table 10. The yield of pulses in India has increased from 441 kg/ha in 1950-51 to 622 kg/ha in 1998-99 (41 percent). Similarly for peanut, it has increased from 775 kg/ha to 1,210 kg/ha (56 percent). For soybean, the increase in yield has been from 426 kg/ha in 1970-71 to 1,100 kg/ha in 1998-99 (158 percent) (Table 10).

Table 7. World Production of Food Legumes During 1990s

(Unit: Million mt)

Year	Soybean	Pulses	Groundnut	Total
1991	106	56	23	185
1996	130	54	31	215
1997	143	55	30	228
1998	158	57	31	246

Source: FAO, 1998.

Table 8. Production of Food Legumes in India During the Last Five Decades
(Unit: Million mt)

Year	Pulses	Peanut	Soybean	Total
1950-51	8.41	3.48	-	11.89
1960-61	12.70	4.81	-	17.51
1970-71	11.82	6.11	0.01	17.94
1980-81	10.63	5.01	0.44	16.08
1990-91	14.26	7.51	2.60	24.37
1991-92	12.02	7.09	2.49	21.60
1992-93	12.82	8.56	3.39	24.77
1993-94	13.30	7.83	4.75	25.88
1994-95	14.04	8.06	3.93	26.03
1995-96	12.31	7.58	5.10	24.99
1996-97	14.25	8.64	5.38	28.27
1997-98	12.98	7.37	6.46	26.81
1998-99	14.81	9.16	6.94	30.91

Source: DOES, 2000.

Table 9. Yield of Food Legumes in India and the World During 1998-99
(Unit: kg/ha)

Legumes	India	World
Pulses	622	840
Peanuts	1,210	1,300
Soybean	1,100	2,240
Average	977	1,460

Source: FAO, 1998; and DOES, 2000.

Table 10. Yield of Food Legumes in India During 1950-51 and 1998-99
(Unit: kg/ha)

Year	Pulses	Peanut	Soybean
1950-51	441	775	-
1960-61	539	745	-
1970-71	524	834	426
1980-81	473	736	728
1990-91	578	904	1,015
1991-92	533	818	782
1992-93	573	1,049	894
1993-94	598	941	1,086
1994-95	610	1,027	911
1995-96	552	1,007	1,012
1996-97	635	1,138	987
1997-98	567	1,040	1,079
1998-99	622	1,210	1,100

Source: DOES, 2000.

PROTEIN REQUIREMENT AND THE RESOURCES

India's population increased from 238 million in 1901, to 845 million in 1991 and crossed the one billion mark at the turn of this century. The concept of protein requirement has undergone a drastic reorientation by the nutritionists. Since the nutritive value of protein varies according to the amino acid content, the protein requirement are now linked with reference protein in the egg, which is 100 percent utilized in the body. Since all the dietary proteins are not first class, the conversion ratio of a mixed diet containing an animal protein is also taken as 80 percent. A vegetarian diet has a conversion ratio 65 percent of reference protein. It is generally safe to assume that one gram of seed protein per kilogram of body weight (0.1 percent) is required for a balanced diet. For the present Indian population of one billion consisting of children, young, adult and aged persons, the total dietary protein requirement (TPR), @50gm/person/day, is:

$$
\begin{aligned}
\text{TPR} &= 50 \times 1{,}000 \times 365 \text{ mt} \\
&= 50 \times 365 \text{ thousand mt} \\
&= 18.25 \text{ million mt}
\end{aligned}
$$

For six billion people in the world is $18.25 \times 6 = 109.50$ million mt (about 110 million mt). The total protein production of plant and animal origin in the world is about 330 million mt and that in India is 27.5 million mt (Table 11). On a global basis, 75 percent of the protein is derived from plant sources and 25 percent from animal (Table 11). It indicates that there is no shortage of dietary proteins but the problem is that of physical and financial access to these proteins in the developing countries, especially for those who are living below poverty line.

Table 11. Plant and Animal Protein Production in the World During 1999-2000 and the Share of India

(Unit: Million mt)

Protein Source	World	India	India's Share in the World (percent)
Cereals	164	15.0	9.1
Soybean	63	2.4	3.8
Pulses	13	3.3	25.4
Peanuts	6	1.8	30.0
Meat	35	1.0	2.9
Milk	22	3.0	13.6
Fish	19	0.8	4.2
Egg	8	0.2	2.5
Total	330	27.5	8.3

Source: FAO, 1998; and DOES, 2000.

LEGUME PROCESSING

Different operations involved in primary processing of legumes are cleaning, grading, drying/conditioning, storage and milling. Each operation has a definite purpose to achieve. These operations are common to most of the legumes and are briefly described:

Cleaning: It is done to remove impurities. Cleaned grains result in best quality end products and also minimize the unit cost of operation.

Grading: It helps to get a uniform mass of grains facilitating finer adjustment of machines for desirable outputs. It also helps in reducing the cost of operation.

Drying: It is done to condition the grain to a desirable moisture content for milling or storage.

Storage: It is done to meet the daily domestic and commercial requirements of grain legumes till the next crop is harvested.

Milling: It is done to transform grain legumes into products which are fit for humans and/or animals.

PULSES

Pulses are the major dietary protein source in India. As of now, the annual production of pulses in India is about 15 million mt. India is one of the major pulses growing countries of the world sharing about 26 percent of the world pulses production. Per capita per day availability of pulses in India has declined since 1950-51/1960-61 from 60/70 gm to 38 gm in 1998-99 (Table 12). To meet the present domestic requirements, around 15.5 million mt of pulses are required. At present, this is met by import of about 0.5 million mt of pulses, annually. The projected demand of total pulses by 2007 AD has been worked out at 20 million mt and it would be about 30 million mt by 2020 AD.

Table 12. Per Capita Net Availability of Food Grains in India

(Unit: gm/day)

Year	Cereals	Pulses	Total	Per Capita Net Availability of Food Grains (kg/year)
1950-51	334.2	60.7	394.9	144.1
1960-61	399.7	69.0	468.7	171.1
1970-71	417.6	51.2	468.8	171.1
1980-81	417.3	37.5	454.8	166.0
1990-91	468.5	41.6	510.1	186.2
1991-92	434.5	34.3	468.8	171.1
1992-93	427.9	36.2	464.1	169.4
1993-94	434.0	37.2	471.2	172.0
1994-95	460.6	38.1	498.7	182.0
1995-96	447.0	33.2	480.2	175.3
1996-97	471.8	37.5	509.3	185.9
1997-98	417.5	33.2	450.7	164.5
1998-99	428.8	38.6	467.4	170.6
1999-2000*	430.0	40.0	470.0	171.6

Source: IASRI, 1999; and DOES, 2000.

Note: * Estimated.

Production and Yield

The trends in production and yield of pulses at national level show an overall increase (Table 13). Production of total pulses has increased from 8.41 million mt in 1950-51 to about 15 million mt in 1998-99 and during the same period, the yield has increased from 441 kg/ha to 622 kg/ha. The major pulses grown in India are chickpea, pigeon pea, black gram, green gram, lentil, peas and lathyrus (Table 14). Share of chickpea in total pulse production in India is about 45 percent and that of pigeon pea, black gram and green gram are 19 percent, 10 percent and 8 percent, respectively. During 1998-99, India produced 14.81 million mt of total pulses (Table 15). The major States, producing more than 15 percent of total production of pulses are, Madhya Pradesh (24.1 percent), Rajasthan (16.5 percent), Uttar Pradesh (15.3 percent) and Maharashtra (15.2 percent). Other States produce 5 percent or less. Pulses are under severe pressure from other remunerative crops.

Table 13. Production and Yield of Total Pulses in India

Year	Production (million mt)	Yield (kg/ha)
1950-51	8.41	441
1960-61	12.70	539
1970-71	11.82	524
1980-81	10.63	473
1990-91	14.26	578
1991-92	12.02	533
1992-93	12.82	573
1993-94	13.30	598
1994-95	14.04	610
1995-96	12.31	552
1996-97	14.25	635
1997-98	12.98	567
1998-99	14.81	622

Source: DOES, 2000.

Table 14. Production and Yield of Major Pulses in India During 1998-99

Pulse	Production (million mt)	Yield (kg/ha)
Chickpea	6.68	794
Pigeon pea	2.77	799
Black gram	1.41	454
Green gram	1.12	362
Lentil	0.86	641
Peas	0.70	856
Lathyrus	0.40	532
Others	0.87	650
Total	14.81	622

Source: DOES, 2000.

Table 15. State-wise Production and Productivity of Pulses* in India During 1998-99

State	Production (million mt)	Yield (kg/ha)	Percent of Total Production
Madhya Pradesh	3.57	709	24.1
Rajasthan	2.44	526	16.5
Uttar Pradesh	2.27	835	15.3
Maharashtra	2.25	644	15.2
Andhra Pradesh	0.76	487	5.1
Karnataka	0.72	398	4.9
Bihar	0.70	764	4.7
Gujarat	0.63	735	4.3
Tamil Nadu	0.47	463	3.2
Haryana	0.35	827	2.4
Orissa	0.26	357	1.7
West Bengal	0.13	621	0.9
Others	0.26	684	1.7
All India	14.81	622	100.0

Source: DOES, 2000.
Note: * Pulses include chickpea, pigeon pea, black gram, green gram, lentil, peas, cowpea, cluster bean, horse gram, kidney bean and lathyrus.

Through the national agricultural research network under the aegis of the Indian Council of Agricultural Research (ICAR), stable high-yielding pulse/legume varieties resistant to pests and diseases have been developed for various agro-ecological situations and non-traditional areas. Early maturing varieties for green gram and black gram for the spring/summer season after harvest of potato, sugarcane and wheat under assured irrigation and an early maturing variety of pigeon pea for rainfed areas have been developed, causing a drastic transformation in cropping patterns. Weed management is important and affects yield by 25-30 percent during *kharif*. Pre-emergence herbicides are most efficient in controlling seasonal weed flora.

Storage

Storage of pulse grains is done at farmers, traders and industries levels. Appropriate technology for handling and storage of pulses have been developed (Ali and Srivastava, 1993). The safe storage moisture for pulses are 10-12 percent. Storage also affects the cooking quality of whole and split pulses. For small-scale storage of pulses, reasonably airtight metallic bins are quite suitable. Large silos are commercially available for large-scale storage of pulses. Split pulses in 1 kg, 5 kg, 10 kg and 25 kg packages are available in the market at retail shops.

Factors Affecting Milling Performance of Legumes

The milling of legumes is done to transform the grains into split (dhal) without any breakage of cotyledons. The milling characteristics of grains depend on type and variety of the legumes which influence thickness, texture and waxiness of husk; thickness of gum layer binding the seed coat to the kernel; shape, size, uniformity and hardness of the grain; and storage condition. Grain legumes are of various shapes and sizes having different hardness. Some grains are shriveled. All these and similar characteristics of legume seeds play a vital vole in their milling performance and dhal yield and therefore warrant attention during milling.

Processing Technology

About 75 percent of total pulses produced in India are milled into splits (dhal). It is done at domestic, cottage and small- to medium-scale industries. Losses during milling at domestic and cottage levels are high, 10-15 percent. Low-cost machines giving better recovery of splits (dhal) have been developed and need to be popularized. Capacity of such machines is 1-2 mt/day and the cost ranges between Rs.30,000-50,000 (US$800-1,000).

The major operations involved in pulse processing are cleaning, grading, drying, milling, packaging, handling and storage, except where they are used green. Many of the operations are performed at farm level using traditional practices and equipments. Improvement and low-cost technology packages have also been developed for legumes. Hand/power-operated cleaners and graders with replaceable sieves are commercially available. Mechanical dryers using biomass, solar energy and electrical energy are available but sun-drying is the most common practice.

About 10-25 percent of pulses is converted into dhal at the domestic level and the rest sold in the market at low price for conversion into dhal by organized pulse milling industries. Dhal milling is the third largest food grain processing industry in India after rice and wheat milling. Dhal milling basically consists of removal of the pericarp seed coat, which is attached to the cotyledons through a layer of biochemically complex gum. Pre-milling treatment involves loosening the pericarp from cotyledons through chemical, mechanical or heat treatment. In modern machines the pretreatment step is an integral component of the dhal milling plant. There are about 11,000 pulse mills with an average capacity of 10-20 mt per day.

Milling of pulses at domestic level is done by splitting the pretreated pulses between two stone discs (one stationary and the other rotary). Wet and dry methods of pretreatment are practiced for loosening the husk. In the wet method, cleaned and graded pulse is steeped in water for a few minutes to overnight. The steeped pulse is then sundried to about 10 percent moisture. The dried pulse is tempered for 1-5 days before milling. Normally 2-4 milling operations are required to achieve more than 90 percent de-husking.

In the dry method, the cleaned grains are scratched/pitted by abrasion and smeared with oil and water. For easy to mill pulses (chickpea, pea and lentil), oil smearing is not required. These oil-water smeared grains are tempered (stored in a heap) for 1-5 days. The pitting helps in absorption of oil-water which diffuses between husk and cotyledons and thus weakens the gum bond. These treated grains are dried to 10-12 percent moisture before milling. The process of pretreatment and milling continues until de-husking and milling is complete (3-7 passes). The application of edible oil varies from 50-400 gm/100 kg of grain and water from 4 kg/100 kg to 20 kg/100 kg depending upon the legume and region. These practices have evolved through experiences.

The hand-operated stone mills (*chakki*) have a capacity of 30-50 kg/hour with head dhal recovery of 45-55 percent, breakage or 25-45 percent and de-husking efficiency of 80-95 percent. The cost of the machine is low (Rs.500 or US$10-15) and it is locally available. The processing of dhal at the rural level is gradually declining since it is not economical due to low output and poor quality of dhal. There has been a concerted effort to develop a low-cost pulse de-huller, which can be popularized at the village level.

An inverted cone type machine was developed at the Central Food Technological Research Institute (CFTRI), Mysore. The machine eliminates the use of oil and water for pretreatment and, thus, reduces total milling time. The machine consists of an emery-coated inverted metal cone fixed to a vertical shaft rotating inside a conical wire mesh screen. The clearance between the rotor and casing is adjustable according to the size of grains. The capacity of the machine is 50-70 kg/hour at 60-70 rpm and it is operated manually. Power-operated dhal mills also have been developed at CFTRI with output capacity of 150-200 kg/hour. In all these machines pretreatment of pulse grains is not required.

Small capacity burr mills for dhal have been developed at several research centers. These are usually 1-2 hp low-cost machines with dehulling, splitting and aspiration facilities. In these machines stone discs or hard rubber-coated discs are used. De-hulling is by atrrition or abrasion action. The cost varies from Rs.30,000-50,000 (US$800-1,000) with capacity ranging from 100-200 kg/hour. These machines require conventional pretreated (water + oil) grains. A salt treatment method has also been developed for conditioning the grain. The grains are soaked in 6 percent sodium bicarbonate salt solution for 45-50 minutes and dried to 10-11 percent moisture before de-hulling. Salt treatment helps in loosening the pericarp. In some cases the grains are pitted before applying salt treatment or water soaking to hasten the absorption of salt, water or oil.

In spite of the fact that pulse pretreatment techniques have been refined and low-cost mills developed, these have not become popular among villagers for processing of dhal. The pulses are milled by the organized sector only. These units are scattered mostly in North and Central India and adopt dry milling technology. In the south, the wet method of milling is generally adopted and capacity is smaller. The regional distribution of mills is given in Table 16.

Table 16. Region-wise Capacity Distribution of Commercial Dhal Mills in India

Region	Capacity (mt/day)	Power (hp)	Oil Used (gm/100 kg)	Water Used (Ɍ/100 kg)	Working Days per Year
South	5 – 20	70 – 140	150 – 250	1 – 2	260
East	4 – 8	20 – 60	250 – 500	4 – 5	200
Central	10 – 20	65 – 150	200 – 250	1 – 2	260
West	10 – 30	45 – 100	600 – 1,500	2 – 5	200
North	5 – 50	70 – 90	150 – 200	4 – 5	260
Average	5 – 25	50 – 100	250 – 500	2 – 5	240

Source: Singh, 1993.

The commercial dhal mills consist of cleaning and grading units, pitting, pretreatment and drying units, tempering, de-hulling, winnowing, splitting, bagging and packaging units. The cost of the plant depends upon the capacity and the degree of automation introduced for material handling (Table 17).

About 75 percent of total pulses produced are processed by commercial dhal mills. There is no standardization for specifications of various components and methods of oil/water treatment. The dhal milling industries in India have so far remained neglected. One of the reasons may be family ownership of these mills. The working environment is very poor in these industries in respect of dust and noise pollution.

Table 17. Approximate Cost of Commercial Dhal Mills in India

Degree of Automation	Capacity (kg/hour)	Cost (Rs. 000)
Semi-mechanized	350	200
	540– 640	250
	820–1,000	350
Mechanized	500	325
	1,000	375

Source: Singh, 1993.
Note: US$1 = Rs.45 (Indian Rupees).

Pulse Industry

1. ***Home Scale***

It mainly involves loosening of husk and splitting. Different methods are adopted for de-husking. For pigeon pea, it starts with cleaning, washing, sun-drying (one day), cracking of seed coat in manually-operated stone mill, oil treatment (200-400 gm/100 kg), keeping in gunny bags for two days, water application (10-20 percent), sun-drying, milling by hand-pounding or in a stone mill or *chakki*. Alternately, grains are washed and soaked for 2-8 hours followed by sun-drying for one day, heaping overnight, and milling. Or, cleaning, treating with red-earth, heaping overnight with cover, shade-drying (one day) and milling. Either of the processes with little variation, is followed for other pulses. Dhal yield by these processes is very low (65 percent or so).

2. ***Commercial Scale***

Two methods, conventional and modern are in practice. However, most of the dhal mills, still use conventional/traditional methods. The process followed in such mills vary from mill to mill, place to place and State to State and no standard or common process is in practice. Though the sequence of operations such as pre-milling treatment, de-husking, conditioning and splitting is generally common, large variation exists in the steps followed in the operation itself. Operations followed in traditional dhal mills are given as under:

Cleaning and grading	Raw pulses are cleaned by removing dust, dirt, foreign material, off-sized, immature and infested grains and graded. The dockage varies 2-5 percent. It depends on crop, season, etc.
Pitting	Whole pulse grains after cleaning are passed through abrasive roller machine for scratching of seed coat to facilitate the entry of oil/water in the grain during pre-milling treatment. Two to 5 percent grain get de-husked during pitting
Oil and water treatment	Edible oil is applied to difficult to mill pulses for loosening of husk. The quantity of oil used varies from mill to mill and State to State and depends mainly on the type and size of the grains, variety, moisture content, etc. It is estimated that about seven million mt of pulses require oil treatment. The quantity of oil used is estimated to be 21,000 mt (300 gm/100 kg) worth Rs.630 million or US$14 million. Though a major part of this oil forms an edible portion of the product the actual oil consumption is not affected. Hence, saving of such oil by process modification/development is the only answer.

	Water treatment, which varies with crop and place, is given to grains to achieve expansion for loosening of husk through drying when cotyledons shrink in size. More the water applied, longer would be the process/drying time and more energy requirement for drying. Some millers apply water and oil simultaneously. This reduces the total processing time.
Tempering	Treated grains are heaped and covered and left for 12-18 hours. It helps in penetration of oil/water into the cotyledons after oil/water mixing and equilibration of grain temperature after drying in the sun. At some places, wooden/cement tanks are used for tempering the treated grains.
Drying	Normally sun-drying is followed. Drying period varies from one day to five days depending upon weather conditions. Some dhal mills are equipped with dryers for continuous operation of the mill especially in the rainy season and/or unfavorable weather conditions.
De-husking and splitting	De-husking of pulse grains is a preparatory operation for splitting. In case of pulses (green gram, black gram, cowpea) having thin seed coat, there is a tendency to split them before de-husking. This needs many passes for complete de-husking and adds to breakage. De-husking is preferably achieved by subjecting the grains to abrasive force and splitting by attrition and/or impact. Generally 3-9 passes are required for milling of different pulses and this depends on the type of pulse crop, pre-milling treatment, grain size, variety, etc.
Husk separation and grading	Husk is separated with aspirator and sold as livestock feed. Some find brokens go along with the husk and if separated, can yield extra quantity of dhal for human consumption. Grading adds to the quality of the product.
Polishing	Splits (cotyledons)/dhal and some of the pulse grains, namely black gram, green gram, lentil, and peas are polished to add luster and shine to the product. Dhal is polished in different ways such as nylon polish, oil/water polish, color polish, etc. Some consumers prefer unpolished dhal.

A survey of few pulse mills in India, processing pigeon pea, was done (Patel, *et al.*, 2000). The major change found in the presently followed system and the old method is the drying step after pitting and oil treatment/conditioning. In the old method, after every pitting operation edible oil treatment was given and the grains were exposed to sun-drying for one day. Then next day further pitting continued till the whole grain got de-husked. On the other hand, in the presently followed process the sun-drying is not carried out after pitting and oil treatment. But after mustard oil treatment, the grains are stored in a bin for about 24 hours which leads to loosening of husk. Then next day further pitting is carried out. The cumulative removal of material from the grain during the complete process of dhal milling was found to be 28.9 percent on dry weight basis. This resulted into 71.1 percent recovery of dhal on dry weight basis.

In view of the details reported potential for technology upgradation exists in case of pulse milling industry. The ultimate aims of technology upgradation are to get higher recovery of dhal, increased efficiency of existing machines, reduced processed time, air pollution control inside the mill, as well as energy saving in the processing operations.

Utilization of Pulses

Legumes/pulses are utilized alone, milled and mixed with cereals, salted and sweetened. Legumes are consumed in various ways: as immature grain (green, roasted, boiled, fried and crushed and cooked); as mature dried grain (boiled, boiled and fried, cooked as dhal, germinated). De-husked splits (cotyledones) as dhal/sambar or converted into flour and then used in a number of preparations. Processes involved in preparation and use of grain legumes are soaking, cooking, roasting, puffing, extrusion cooking, germination, fermentation, canning and expression and expelling. The utilization pattern of legumes can be grouped as follows.

- Green pulses (fresh, boiled and roasted);
- Sprouted and germinated (boiled and fried);
- Puffed and roasted (spiced/salted);
- Milled and cooked (steamed, boiled and fried); and
- Fermented products (*idli, dosa, dhokla* etc.)

Grain Legume	Utilization Pattern
Chickpea	As immature grains in pod after roasting. De-husked green and tender grains are consumed after boiling or frying or as crushed and cooked snack. Also used in curry. As mature grains, it is used as whole seed or splits (dhal) or flour. The chickpea flour is used for making fermented dish *dhokla* and in a number of fried products/snacks. It is most versatile among pulses.
Black gram	It is used as whole seed or de-husked splits (cotyledons) for making dhal. Black gram is extensively used in fermented products like *idli, dosa*, hopper and *papad*.
Green gram	It is used in curry. Sprouted beans are also consumed. Roasting and frying of whole seeds or splits (cotyledons) is a popular way in India to prepare snack products which are usually spiced. Unspiced products are also available.
Pigeon pea	It is primarily used for making dhal (cooked splits) and *samber* (cooked and spiced splits). Both dishes are soup-like in consistency and appearance and are prepared from de-husked cotyledons that are cooked until tender and seasoned with spices. Sambar contains added vegetables (optional) such as eggplant, drum stick, carrots, tomato, potatoes, green peas, etc.
Peas, lentil, kidney bean, etc.	These are generally used as whole seed for making curry. Dhal is prepared from de-husked peas and lentil.
Crop residue and byproducts	The crop residues like leaves and grain byproducts such as seed coat, germ and broken cotyledons are used as animal feed.

Losses During Milling

In pigeon pea, yield of dhal was found to be only 76 percent against an estimated yield of 84 percent (Khare, *et al*., 1966). The 8-percent loss was in the form of broken and husk including embryo. The loss of peas from birds in the mill and sun-drying yard and rodents in stores were found to be sizable. Infestation by insects also reduces dhal yield. During cotyledon splitting, embryo loss and breakage of edges of cotyledons occur. Method of milling used, greatly influences the loss during milling. In order to reduce the milling loss, it is advisable to clean and grade the grains and perform de-husking and splitting as two different operations and follow improved method of milling developed by various research and development (R&D) organizations. Following needs further attention towards maximizing the yield of dhal.

- Increasing the efficiency of de-husking.
- Adjusting of milling machinery to suit each grain legume.
- Separating husked and unhusked grains properly.
- Proper loosening of gums and mucillages and their influence on grain milling.
- Improving the splitting efficiency of de-husked/pearled grain.
- Recovering and refining the edible portion of byproducts.
- Controlling the noise and dust in dhal mills.

With the above improvements, improved milling efficiency can be expected and better quality dhal can be obtained under hygienic mill environments. Losses during soaking, cooking, germination, fermentation, roasting, baking, etc. also occur. These could be minimized by optimizing the operational parameters for yield and quality of end products.

Consumption Pattern of Pulses and Other Foods

Pulses enjoy the distinction of being protein-rich food and form an important constituent of diets of the people of India. The average level of consumption of various food items, including pulses, and different nutrients derived from them, for rural and urban population groups are given in Table 18 (Rao and Gowrinath Sastry, 1993). Data indicated that:

- Cereals like rice, wheat, and millets are staple foods and constitute the bulk of the foods consumed by the population. Their consumption was more in the rural households than the urban population groups.
- Consumption levels of income-elastic, protein-rich and protective foods such as pulses, milk, vegetables, flesh foods, and oils were much lower in low-income group (LIG) households than in those of high income group (HIG).
- Among the varieties of pulses consumed, pigeon pea, chickpea and black gram (*urd*) were quite common. Of all the types, pigeon pea was the most favored pulse by all the income groups. The share of other less common pulses, such as horse gram, lathyrus, lentil tended to be higher in the rural households.

Nutrient intakes showed a positive relationship with socioeconomic status (Table 19). Intakes of all nutrients were higher among the HIG, while the lowest intakes were seen in slum dwellers (SD). The LIG and industrial labor (IL) groups showed more or less similar level of intake, and always trailed behind the middle income group (MIG), which in turn

Table 18. Average Intake of Foodstuffs in Different Urban and Rural Groups of India

(Unit: gm/capita/day)

Socio-economic Group	Cereals	Pulses	Leafy Vegetables	Other Vegetables	Roots and Tubers	Milk	Fats and Oil	Sugar and Jaggery
(A) Urban								
HIG	316	57	21	113	82	424	46	34
MIG	361	49	21	89	78	250	35	31
LIG	428	42	16	55	66	95	22	28
IL	420	41	13	56	67	98	23	29
SD	416	33	11	40	70	42	13	20
(B) Rural								
All groups	522	37	13	58	51	90	12	23
(C) Balanced diet*	460	40	40	60	50	150	40	80

Source: National Nutrition Monitoring Bureau (NNMB), 1984; and Rao and Gowrinath Sastry, 1993.
Note: * Least cost balanced diet recommended by Indian Council of Medical Research (ICMR) (1981) for adult sedentary male.

Table 19. Average Intake of Nutrients in Different Urban and Rural Groups in India

Socio-economic Group	Protein (gm)	Energy (megajoule)	Calcium (mg)	Iron (mg)	Vitamin A Retinol (: g)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)
(A) Urban									
HIG	73	10.89	1,121	27	881	1.5	1.5	15	98
MIG	63	9.89	821	27	555	1.3	1.1	15	70
LIG	58	9.33	595	27	332	1.3	0.9	15	50
IL	59	9.38	548	26	352	1.4	0.9	16	47
SD	53	8.40	492	25	248	1.3	0.8	15	40
(B) Rural									
All	62	9.90	567	31	270	1.4	0.9	16	40
(C) RDA*	55	10.04	400-500	24	750	1.2	1.4	16	40

Source: Rao and Gowrinath Sastry, 1993.
Note: * RDA = recommended dietary allowance (ICMR, 1981).

followed the HIG. Compared to the levels recommended by the ICMR Expert Committee on Recommended Dietary Allowances in 1981, the daily per capita consumption unit intakes of protein were adequate (above 55 gm) in all the urban socio-economic and rural groups, except SD for whom there was a marginal deficit. The average daily levels of energy intake, however, fell short of RDA (10 megajoules) in all the groups except the HIG. The extent of deficit in the LIG and IL group was around 10 percent, and in the slum population it was about 20 percent.

Apart from the quantitative aspects of consumption, the quality of food consumed is of great importance to health and nutrition. Nutrition experts suggest that in order to be wholesome and nutritionally adequate, the diet has to be balanced. It should contain various types of such foods as cereals, pulses, vegetables, roots, and tubers, not only in adequate quantities but also in the right proportions.

According to the Expert Committee the ratio of the protein derived from the cereals to that obtained from pulses should be between 4:1 or 5:1 so that the protein quality of the diet is not compromised.

The traditional practice of consuming pulses along with the staple food prevalent in the country is thus scientifically sound. However, the quantities of pulses consumed, particularly in relation to cereals, by the households of lower socio-economic groups in the rural and urban areas are not only below the community averages, but also below the prescribed levels in the ICMR's 'balanced diets' for an average Indian. The HIG and the MIG consuming relatively more than the suggested proportion of pulses, the worst off being the rural households and SDs (Rao, *et al*., 1986).

There is a positive relationship between pulse consumption and income. There is also a wide inter-State variations in pulse consumption. The lowest daily consumption of 12 gm was in Kerala, while the highest level of 45 gm was in Karnataka closely followed by Madhya Pradesh. The data also seem to corroborate the observation that the higher pulse-consuming states are also the larger pulse-producing States, notably Madhya Pradesh and Karnataka, and the adjoining States that have vast tracts of semi-arid and non-irrigated crop lands where pulses are cultivated.

Pulse availability during the past several decades, suggest a drop in availability during the 1970s, 1980s and 1990s as compared to 1950s and 1960s. The present (1999-2000) per capita per day net availability of cereals and pulses are 430 gm and 40 gm, respectively (Table 12). It therefore, suggests a higher ratio of cereals to pulses, reflecting diets relatively inferior in protein quality.

GROUNDNUT

Groundnut is also known as peanut, earthnut and monkey-nut. Groundnut is one of the nature's most nutritious seeds and one of the world's most popular and universal crops, cultivated in nearly 100 countries in all six continents. The peanut is one of the major sources of edible oil and proteins for humans and animals. The groundnut is not a true nut but rather a legume much like the bean or a pea (Nwokolo and Smartt, 1996). It is an annual herb, a member of the family *Leguminosae*. India is the second world's largest producer of peanut after China, accounting for nearly 30 percent of total world production and together with China account for about 68 percent of world production (Table 20).

Table 20. World Production of Groundnut in 1997-98

Name of the Country	Production (million mt)
China	10.00
India	8.00
U.S.A.	1.59
Senegal	0.72
Argentina	0.43
Sudan	0.40
South Africa	0.17
Brazil	0.15
Others	4.97
Total	26.43

Source: Soytech, 1998.

Proximate Composition

Groundnut kernel shell represents about 75 percent of the dry weight of the pod (unshelled peanut), where as the shell comprises the other 25 percent. The two fleshy cotyledons comprise 93 percent by weight of the kernel and the germ and testa comprise 4 percent and 3 percent of kernel weight, respectively. The chemical/proximate composition of groundnut components/products is given in Table 21. The cotyledons are the main nutrient storage tissue and are a concentrated source of lipids, protein and dietary energy, whereas the shell is high in crude fiber, a structural carbohydrate. Peanut butter is exceptionally well balanced in nutrient content.

Table 21. Chemical Composition of Peanut and Its Products

(Unit: gm/100 gm)

Constituent	Components/Products			
	Kernel	Cotyledons	Peanut Butter	Defatted Flour
Water	6.5	6.5	1.4	7.8
Protein	25.8	28.0	24.6	55.2
Fat	49.2	50.0	50.0	0.6
Carbohydrate	16.1	15.0	20.7	34.7
Crude fiber	4.9	1.8	2.4	4.1
Ash	2.3	2.3	3.3	4.8
Food energy (kcal/100 gm)	567	564	588	327

Source: United States Department of Agriculture (USDA), 1986.

Groundnut kernels are rich in oil (45-50 percent) and protein (25-30 percent) and have a high energy value. The production of groundnut in India is about nine million mt with an average yield of one mt/ha. Kernels are used for oil extraction, foods and as an ingredient in confectionery products. The residual cake is processed largely for use as animal feed but also for human consumption. The haulms are used as fodder. The major groundnut-producing States in India are Gujarat (28.2 percent), Tamil Nadu (21.4 percent), Andhra Pradesh (21 percent), Karnataka (13.4 percent) and Maharashtra (6.9 percent). State-wise production of groundnut in India is given in Table 22. The highest yields is in Tamil Nadu, 1,632 kg/ha.

Table 22. State-wise Production of Groundnut in India During 1998-99

State	Total Production (million mt)	Yield (kg/ha)
Gujarat	2.58	1,328
Tamil Nadu	1.96	1,632
Andhra Pradesh	1.92	989
Karnataka	1.23	687
Maharashtra	0.63	1,218
Rajasthan	0.36	1,019
Madhya Pradesh	0.26	1,005
Uttar Pradesh	0.08	669
Orissa	0.07	946
Others	0.07	1,166
All India	9.16	1,210

Source: DOES, 2000.

Food Uses of Groundnut

In India about 80 percent of total groundnut production is used for oil extraction and the 20-percent for food/snacks as roasted, salted or fried nuts. Peanut butter has also been developed. Hygienically produced groundnut cake/defatted meal, can be used to prepare acceptable bakery products such as bread, biscuits, cookies, etc. Fortified groundnut flour (5-10 percent) could be used for making such products. The major uses of groundnut are:

Type of Use	Description
Edible oil	Oil is extracted from groundnut kernels using either mechanical expellers or solvent extraction or a combination of both. The crude oil is then refined, bleached and deodorized for use. Cake/meal is used in livestock feed.
Processed kernels	The kernels are roasted/fried/steamed and consumed as snack foods. Sometimes steaming and roasting of pod itself is done and then kernels are taken out manually/mechanically and utilized.
Chikki and *laddu*	Roasted kernels along with jaggery/sugar.
Protein isolates and composite flour	Peanut protein isolates are used in a number of food preparations for protein enrichment. Composite flour is prepared using tapioca flour (75 percent) and peanut flour (25 percent).
Poustik atta (nutritious flour)	It has two formulations. One has 75 percent whole wheat flour, 17 percent tapioca flour and 8 percent peanut flour. It is used where tapioca flour is available in plenty. Second formulation has 90-95 percent whole wheat flour and 5-10 percent groundnut flour. Both the formulations have been accepted by the consumers.
Infant and weaning foods	A nutritionally sound infant food based on peanut protein isolate and skim milk powder has been developed. It has 26 percent protein.
Miltone	It is a milk-like product or milk analog made from 50 percent liquid isolate and 50 percent milk. It has proved successful in school feeding programs.

Research Needs

The extraction of oil using mechanical pressers leaves 6-8 percent oil in the cake. Hence, it is necessary to improve the efficiency to bring down the oil content in the cake to about 3 percent. Such expellers have been developed and are now being promoted. The residual cake/meal is dark grey in color, rich in pigments, and contains phenolic compounds and fiber. It is, therefore, not fit for human consumption. Since the cake/meal contains 40-50 percent good quality protein, it is necessary to refine and make it edible. Roasting parameters need to be optimized. Commercial preparation of groundnut based food products under optimized conditions would help to enhance food uses of groundnut.

SOYBEAN

Soybean is a legume crop originated in China and now it is grown all over the world for its oil and protein. The major soybean growing countries of the world are the United States, Brazil, China, Argentina and India (Table 23). North and South America produce about 80 percent of total world production though most of the germ plasm have come from China. Global soybean production during 1990s has been in the range of 105-155 million mt with an average yield of 2 mt/ha (Table 24). Soybean cultivation in India dates back to 1000 AD. The soybean production in India in 1999-2000 is about 6 million mt with an average yield of 1,000 kg/ha (Table 25). Nearly 64 percent of the total production was in Madhya Pradesh (Table 26).

Table 23. Major Soybean-producing Countries of the World, 1997-98

Country	Production (million mt)	Productivity (mt/ha)
U.S.A.	73.21	2.60
Brazil	28.00	2.22
China	14.50	1.71
Argentina	13.90	2.21
India	5.00	0.90
Others	12.09	2.36
World total	146.70	2.00

Source: Soytech, 1998.

Table 24. World Production of Soybean During 1990s

(Unit: Million mt)

Production Year	Production	Production Year	Production
1990-91	105	1995-96	125
1991-92	108	1996-97	130
1992-93	117	1997-98	147
1993-94	117	1998-99	150
1994-95	117	1999-2000	155

Source: Soytech, 1998.

Table 25. Production of Soybean in India During 1990s and Beyond

(Unit: Million mt)

Production Year	Production	Production Year	Production
1990-91	2.60	1995-96	4.99
1991-92	2.49	1996-97	4.85
1992-93	3.39	1997-98	5.00
1993-94	4.75	1998-99	5.50
1994-95	3.93	1999-2000	6.00
		2019-2020*	25.00

Source: DOES, 2000.
Note: * Estimated.

Table 26. State-wise Production and Yield Soybean in India During 1998-99

State	Production (million mt)	Yield (kg/ha)
Madhya Pradesh	4.47	1,012
Maharashtra	1.47	1,395
Rajasthan	0.89	1,315
Karnataka	0.04	667
Uttar Pradesh	0.02	434
Others	0.05	1,000
All India	6.94	1,100

Source: DOES, 2000.

Soybean is an excellent health food. It contains about 40 percent good quality protein, 20 percent oil, 0.4 percent lecithin, and other nutrients (Table 27) and has a great potential to combat protein-calorie malnutrition in India at an affordable cost. Soy foods are nutritious, economical and provide many health benefits. Use of 5-25 percent of soybean along with cereals gives maximum nutritional advantages. However, due to the presence of some anti-nutritional factors, it requires careful processing to make it fit for human and animal consumption.

Table 27. Nutritional Composition of Soybeans

Nutrients	Proximate Value of Edible Protein (gm/100 gm)
Moisture	8.1
Proteins	43.2
Fat	19.5
Carbohydrates	20.9
Fiber	3.7
Minerals	4.6

Source: Gopalan, *et al*., 1974.

Whole beans or partially/fully defatted cake/meal are used for making various soy-based food and feed products (Table 28). Soybean fortification enhances the nutritive value and functionality of foods and feeds. Soy products like oil, texturized soy protein (TSP), soy milk, soy paneer (tofu), soy yogurt, soy flour, soy-fortified bakery products, and health foods are gaining good acceptability among the people in India because of economic and health benefits. Also the use of soy meal as protein source in poultry, piggery and aquaculture feed is increasing. Soybean Processing and Utilization Center (SPU) at the Central Institute of Agricultural Engineering (CIAE), Bhopal has developed a number of soy-based food products and technology that are being promoted (Table 29). The present day soybean industry has about 265 units which can be grouped as under:

Oil extraction plants	154
Food manufacturing units	60
Equipment manufactures	30
Trading houses	15
Government and other agencies	6
Total	265

Table 28. Soybean Food Potential and Options – Technology and the Products

Soybean Form Used	Technology	Products
Whole soybean (direct use)	Separation, soaking, blanching, boiling, drying, size reduction, fermentation, extrusion, packaging, storage and marketing.	Full-fat soy flour, milk, paneer (tofu) curd, ice-cream, *tempeh*, sauce, sprouted and roasted snack, extruded snack foods, soy-fortified bakery and fermented foods.
Partially defatted soybean (oil and cake)	Mechanical expression, physical refining, enzyme, cooking, size reduction, packaging, storage and marketing.	Oil, margarine, medium fat soy flour, bakery foods, aqua and animal feeds.
Fully defatted soybean (oil and meal)	Solvent extraction, refining, hydrogenation, size reduction, separation and concentration, packaging, storage and marketing.	Oil, *vanaspati*, soy meal, defatted soy flour, lecithin, soy protein concentrate, isolates and hydrolysates, specialty and health foods.
Byproducts of soybean (hull, *okara* and whey)	Dehydration, size reduction, fermentation, separation, packaging, storage and marketing.	Dietary fiber, single cell proteins, citric acid, enzymes, alcohol.

Source: Ali, 1993.

Creation of domestic market for soy meal through its utilization in food, feed and pharmaceutical industry is essential for de-linking foreign dependence of Indian soybean industry. This requires need-based and high quality R&D in the area of soybean processing and utilization. Some of the suggested strategies for value addition and diversified uses of soy meal in domestic and export market are: protein-rich defatted edible soy flour to be used in wheat and chickpea flours for higher protein content and better nutritional quality; soy-based high-quality and cost-effective poultry, aqua and cattle feeds; soy protein concentrates, isolates and hydrolysates to be used in food formulations for infants, children, adult and aged persons; soy-based speciality food for diabetics, lactose intolerants, cancer and cardiovascular disease patients, and export of value-added soy meal for food, feed and industrial applications.

Table 29. Soy Products and Technology Available at SPU, CIAE, Bhopal

Soy Products and Technology (15):	
Soy dhal (processed soy splits)	Soy milk
Soy flakes	Soy paneer (tofu)
Soy flour	Soy yogurt
Soy-fortified biscuits	Soy ice-cream
Soy-fortified bread	*Tempeh*
Soy-fortified muffins	Soy sattu
Soy-fortified bun	*Okara*-based *burfi* and *gulabjamun*
Soy sauce	(sweet desert)
Soybean Processing and Equipment (19):	
Grader	Plate type wet grinder
Manual de-huller	Modified oil expeller
Power-operated de-huller	Low-cost steam generator
Blancher	Soybean cake grinder
Natural convection tray dryer	Dough mixture
Forced convection tray dryer	Loaf volumeter
Multipurpose LSU* type dryer	Lever-type paneer pressing device
Three-roller flaking machine	Screw-type paneer pressing device
Two-stage roller mill for soy flake	Cottage level soy paneer plant
Low-cost single screw forming extruder	
Limited Scale Pilot Production Facilities (5):	
Full-fat soy flour	Soy paneer (tofu)
Partially defatted soy flour	Soy-fortified bakery products
Soy milk	

Source: Ali, 1995; 1997; and 1998.
Note: *LSU = Louisiana State University.

Low-price and highly nutritive soy-based food and feed products ensure economic viability of soybean industry and promises household nutritional security and better health in the near future.

FUTURE STRATEGIES FOR IMPROVEMENTS IN NUTRITIONAL QUALITY OF FOOD LEGUMES

Pulses, peanut and soybean constitute about 13 percent of total seed/grain foods (cereals, pulses and oilseeds) in India and 10 percent at global level. Cereals contain 7-14 percent protein whereas legumes have 20-40 percent. Lysine is the first nutritional limiting essential amino acid in most cereals, tryptophan is the second limiting amino acid in maize and the threonine in other cereals. Legumes are deficient in methionine and cysteine. The major utilization problems of legumes and cereals and their possible causes are given in Table 30. In practice, cereals and legumes are eaten with other foods. The overall protein quality of cereal – legume mixtures is better than that of either protein source alone due to the complementary nature of their amino acid profiles.

Table 30. Utilization Problem of Legumes and Cereals and Possible Causes

Foods	Problems	Causes
Legumes	Incomplete	Limiting amounts of methionine and cysteine
	Incomplete availability of amino acids	Unknown
	Low protein digestibility	Nature of protein (?) protease inhibitors (?)
	Anti-nutritional factors	Protease inhibitors, haemagglutinins, goitrogens, etc.
	Flatulence	Raffinose oligosaccharides, dietary fiber (?), undigestible starch (?)
	Undesirable 'beany flavor'	Lipoxygenases
Cereals	Low protein content Incomplete protein	Limiting amounts of lysine, and in some cereals tryptophan, threonine

Source: Nwokolo and Smartt, 1996.

Since cereals are the major dietary protein source (50 percent) world over, increasing the protein content alone will improve the protein intake of a large number of people, especially those living in developing countries, where protein-calorie malnutrition is prevalent. For instance, an increase of 3 percent protein in rice without a decrease in grain yield will add an additional 2.4 million mt of protein in the diet of Indian rice-eating people, based on 80 million mt of total rice production in India during 1999-2000. Improving the protein quality of rice grain will bring additional significant benefits.

There are three approaches to enhance the nutritional quality of seeds/grain legumes. These are biotechnology, processing and fortification. Biotechnology would help to alter methionine contents of plant seeds/legumes through the use of methionine-rich or methionine-enriched protein genes driven by seed specific promoters. But they should be devoid of allergens. Improving the digestibility of proteins and starch, reducing flatulence, altering fatty acid composition, minimizing formation of undesirable flavors and aroma should also be the future strategy. Processing technologies should help to transform raw grains into useful products with a minimum nutritional loss. Innovative fortification of cereals with legumes to improve protein content quality should ensure nutritional security.

RECOMMENDATIONS

The Government of India is concerned with problems of the dhal milling industries and poor domestic utilization of soybean and its protein products. A number of studies have been sponsored by the Government of India to assess the production capacity, marketing, modernization constraints etc., of dhal milling industry. Major recommendations which could be considered for improving food legume processing and utilization are:

1. Modernization of the dehulling process, especially elimination of use of oils and introduction of mechanical drying to reduce losses during sun-drying.
2. Reduction of processing and handling losses, which presently account for up to 15 percent.
3. Improvement in the working environment within factories by adopting dust and noise control measures.

4. Promotion of dhal processing units in rural areas to reduce cost of production, increase dhal recovery (freshly harvested pulses are easily dehulled) and increase rural employment.
5. Introduction of improved storage structures to reduce losses due to spoilage as well as insect and rodent attack.
6. Modernization of packaging for bulk handling at sales outlets.
7. Promotion of direct food uses of soybean to exploit its nutritional and health benefits.
8. Popularization of use of roasted/fried/steamed groundnut kernels as snack foods. The kernel may be partially defatted.
9. Economic utilization of food legumes processing and use of byproducts in livestock feed and other products.

REFERENCES

Ali, Nawab, 1993. "Diversification of Oilseeds and Their Byproducts Towards Food Uses in India", in R. S. Paroda and M. Rai (eds.) *Oilseeds in Asia-Pacific Region*, pp. 143-160, FAO Regional Office, Bangkok.

----------, 1995. "Global Scenario of Soybean Production, Processing and Utilization", AET 19 (1-2): 18-27.

----------, 1997. "Soybean Food Options", *Processed Food Industry*, 1(2): 9-11.

----------, 1998. "Soy-fortified Wheat Flour", *Processed Food Industry*, 1(10): 16-18.

Ali, Nawab and P. K. Srivastava, 1993. "Conditioning, Storage and Milling of Food Grains and Oilseeds", AET 17(3-4): 1-5.

Bressani, R., 1975. "Legumes in Human Diets and How They Might Be Improved", in M. Milner (ed.), *Nutritional Improvement of Food Legumes by Breeding*, Willy, New York, U.S.A.

Burkitt, D. P. and H. C. Trowell, 1975. *Refined Carbohydrates Foods and Diseases*, Academic Press, London, U.K.

Cummings, J. H., 1978. "Nutritional Implications of Dietary Fibre", *Am. J. Clin Nutr.*, 32:521-527.

Directorate of Economics and Statistics, 2000. *Agricultural Statistics at A Glance*, Ministry of Agriculture, Government of India. New Delhi.

FAO, 1998. *Production Year Book 1998* (Vol. 52), FAO, Rome, Italy.

Gopalan, C., B. V. Rama Sastri and S. C. Balasubramanian, 1974. *Nutritive Value of Indian Food*, National Institute of Nutrition, Hyderabad, India.

Gupta, Y. P., 1982. "Nutritive Value of Food Legumes", in S. K. Arora (ed.), *Chemistry and Biochemistry of Legumes*, Oxford and IBH Publishing Co., New Delhi.

Hellendoorn, E. W., 1979. "Beneficial Physiological activity of Leguminous Seeds", *Qual. Plants Plant Foods in Human Nutrition*, 29:227-235.

IASRI, 1999. *Agricultural Research Data Book*, IASRI/ICAR, New Delhi.

Indian Council of Medical Research, 1981. *Recommended Dietary Allowances (RDA) by the Indian Council of Medical Research (ICMR)*, New Delhi, India.

Kamath, M. V. and B. Belavady, 1980. "Unavailable Carbohydrates of Commonly Consumed Indian Foods", *J. Sci. Food Agric.*, 31: 194-202.

Kapoor, A. C. and Y. P. Gupta, 1977. "Distribution of Nutrients in the Anatomical Parts of Soybean and Different Phosphorus Compounds in Seed and Its Protein Fractions", *Indian J. Nutr. Diet*, 41:100.

Khare, R. N., K. Krishnamurthy and S. V. Pingle, 1966. "Milling Losses of Food Grains – Studies on Losses of Pigeon-pea During Milling", *Bull Grain Tech.*, 4:125.

Kurien, P. P., 1977. "Grain Legume Milling Technology", paper presented to FAO Expert Consultation on Grain Legume Processing, November, CFTRI, Mysore, India.

Liener, I. E., 1981. "Factors Affecting the Nutritional Quality of Soy Products", *J. Am. Oil Chem. Soc.*, 58:406-415.

Menon, Krishnakumari, 2000. *Legumes in Human Nutrition*, 24(2): 21-32.

National Nutrition Monitoring Bureau, 1984. *Urban Survey Report of the National Nutrition Monitoring Bureau (NNMB)*, National Institute of Nutrition, Hyderabad, India.

Nwokolo, E. and J. Smartt (eds.), 1996. *Food and Feed from Legumes and Oilseeds*, Chapman and Hall, London.

Patel, N. C., V. K. Chandegara and M. N. Dabhi, 2000. "Pulse Milling Industry Needs Technology Upgradation", *Business Star*, p. 508, June 2000.

Paul, A. A. and D. A. T. Southgate, 1978. "The Composition of Foods", 4th revised and enlarged edition of *MRC Special Report* No. 297. HMSO, London.

Rao, N. Pralhad and J. Gowrinath Sastry, 1986. "Diet and Nutrition in Urban Areas", *Proc. of the Nutritional Society of India*, 32:91-99.

----------, 1993. "Legume Consumption and Its Implication on the Nutritional Status of the Population in India", *Proc. of a Consultants Meeting on Uses of Tropical Grain Legumes*, held 27-30 March 1989 at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT Centre, Hyderabad, India.

Salunkhe, D. K., S. S. Kadam, and J. K. Chavan, 1985. "Chapter 7: Processing and Utilization", in *Postharvest Biotechnology of Food Legumes*, pp. 109-140, CRC Press, Inc. Boca Raton, Florida, U.S.A.

Salvin, J. L., 1988. "Nutritional Value of Soybean Fibre", in L. McCanny (ed.), *Soybean Utilization Alternatives*, Proc. of a Conference by the Centre for Alternative Crops and Products, 16-19 February, University of Minnesota, St. Paul.

Singh, G., 1993. "Production, Processing and Marketing of Food Legumes and Coarse Grains in India", *Proc. of a Workshop on Marketing and Processing of Food Legumes and Coarse Grains: Effects on Rural Employment in Asia*, held in Serdang, Malaysia 24-27 May.

Soytech. 1998. *Soya Bluebook Plus – The Annual Directory of the World Oilseed Industry*, Soytech Inc, ME 04609, U.S.A.

Tobin, G. and K. J. Carpenter, 1978. "The Nutritional Value of the Dry Bean – A Literature Review", *Nutr. Abstract Rev.*, 48:919-936.

USDA, 1986. "Composition of Food: Legumes and Legume Products", *Agriculture Handbook* No. 8-16, Human Nutrition Information Service, Washington, D.C.

5. INDONESIA

Ignatius Suharto
Dean
Faculty of Industrial Technology
Catholic University of Parahyangan,
H. Adang Kadarusman
Ir. MSc.
University of Pasundan, and
Catharina Damajanti
Dra., MM, Post Graduate on
Master of Management
Bandung

INTRODUCTION

Present Situation and Economic Importance of Legumes

Processing and utilization of legumes begin with research activities at laboratory, continuing onto the pilot plant and ending finally at the commercial unit or the factory. Therefore, there is a need for the establishment of research and development organization in Indonesia and also in other developing countries not only to generate appropriate technology but also to adapt research results and technology transfer to suit local conditions. Research and development organizations should be provided with all modern equipments, financial, technical and qualified human resources and authority to guarantee appropriate outputs. Research results must be transferred to the commercial sector. In order for this to happen, existing traditional legume processing industries must ask themselves:

1. Where is the legume processing industry now in each member countries of APO?
2. Where does the traditional legume processing industry move?
3. How does the traditional legume processing industry get there?
4. What is the next step in legume processing industry in each member countries of APO?

The above questions will be answered through the following objectives presented in this paper: "to study the existing legume raw materials and appropriate technology to obtain low-cost, high protein-rich foods for low-income group people in rural areas in Indonesia and other developing countries".

The Impact of Economic Globalization and the Present Situation of Availability of Legume Raw Materials

The impact of the anticipated economic globalization in 2020 on the development of science and technology in legume processing can be seen in the productivity of the legume processing industry. The higher the knowledge and capabilities of the people involved in the science and technology development, the higher the productivity of the legume processing industry. Productivity is a ratio of output to inputs:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Productivity gain is the rate of change in output with respect to input (Hamid Noori, 1990). This international situation will affect each country differently. In Indonesia, there is a gap between natural resources and human resources development for low-income group in the rural areas. So the pressure of poverty is everywhere. Furthermore, protein-calorie malnutrition is still a major problem in rural areas. This is due to the lack of quantity and quality of high-cost protein-rich foods, method of processing, food habits and also attitudes. However, the main problem is poverty, inequitable distribution of income and natural resources, low legume productivity, and high population growth. A rise in the productivity of the legume processing industry could result in increased economic growth and production efficiency. Legume processing industries can convert raw legumes into value-added products. Productivity can be visualized by the following equation of the production system.

$$P_s = \frac{\sum \text{Output}}{\sum \text{Capital} + \sum \text{Labor} + \sum \text{Others}}$$

The Population Triangle

About 80 percent of the Indonesian population of 200 million in 2000 are in the rural areas which represent mostly low-income group. People in rural areas are still leading old traditional way of life. The rural population needs enough high protein-rich foods to supply daily protein and calorie requirements. Protein-calorie deficiency is still widespread in rural areas. A lack of adequate food and nutrition has a very close relationship to health and education. Protein-calorie malnutrition occurs due to lack of high protein foods and education. Food availability has four components, namely: calories, proteins, fats, and other nutrients. The economy of the Indonesia is still based on the production of primary commodities from agriculture and other natural resources. A more intensive agricultural system has many economic advantages, but it brings about many problems in the food chain system. Diversification of legumes into several high protein products can supply high protein-rich food for low-income group. In the middle of July 1997 until now, the economic crisis is still a major problem in Indonesia. The per capita income decreased from US$1,000 in 1997 to US$800 in 2000. In the present situation, legume processing can act as a platform for strategic development and utilization of locally available legumes as raw material to get low-cost high protein-rich food for low-income group can help to maintain economic growth in Indonesia.

Food availability = Production + Import – Export – Change of Stock

Change of stock is due to mechanical damage and microbial contamination. Legume processing, marketing and consumption system is shown in Figure 1.

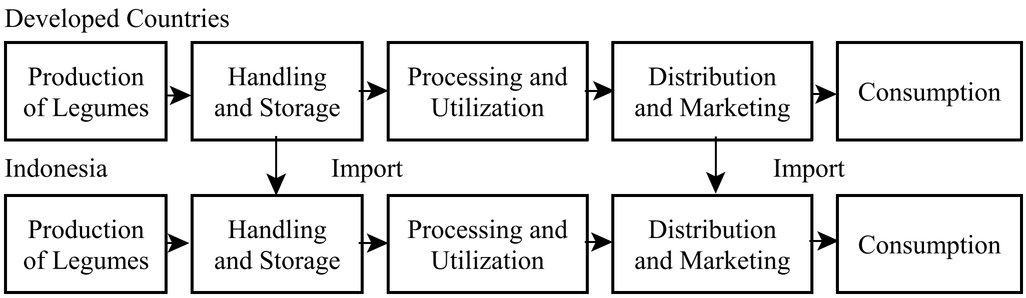


Figure 1. Legumes Chain System

The relationship among legumes and soybean, fermentation and non-fermentation technology, and traditional legume industries, not only bring economic growth, but also improvement in the quality of life of mankind (Figure 2). The higher the total population is, the higher the supply of legume processing and utilization. Therefore, the alternative sources of food supply should be identified. The use of fermentation and non-fermentation technology approaches for legumes will be very useful and is important for the low-income group. Figure 2 shows that improvement in any one component depends on the improvements in the other two. There are strong interrelationships among population, raw material of legumes and the traditional legume processing industries. Therefore, it is not sufficient to identify and understand only one element, but it is essential to look at the full picture in a holistic way. Traditional legume processing is a very small-scale industry but it is essential to develop a dynamic traditional legume processing. Consequently, there will be a need for competition to obtain better price for traditional legume processing. Therefore, the issue is not total population, but how those variables in terms of fermentation and non-fermentation technology, legumes and soybean, and traditional legume processing industry and population relate to available resources. The population problem must deal with the other variables to eliminate mass poverty and protein-calorie malnutrition, to ensure more access to resources. Human resources development can be improved by education to manage those variables. Fermentation and non-fermentation technology offer the better productivity, increased efficiency and decreased pollution through the modern legume processing technology.

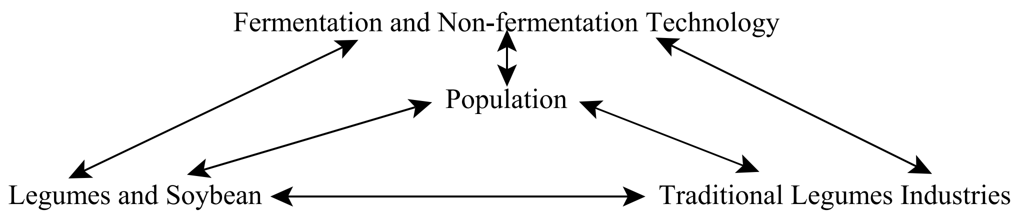


Figure 2. The Population Triangle

The Organo-ware Triangle

The traditional processing and utilization of legumes need technology to process raw material into new product. Due to the increasing demand for large quantities of legume products in Indonesia, it is important to improve the traditional legume processing industry. Technology can be divided into four components, namely: facilities (techno-ware), skills (human-ware), technical knowledge potential (info-ware), and institution (organo-ware) (Figure 3). One of the major traditional legume processing industry challenges of the globalization era is how to focus the integrated approaches of human-ware, techno-ware, info-ware and organo-ware, to increase export containing high technology and also to increase productivity of traditional legume processing industries. Technology is the facilities center of transportation system that can be developed and operated by human-ware using info-ware. Techno-ware cannot be operated without human-ware. Scientific human resource can be produced by the university.

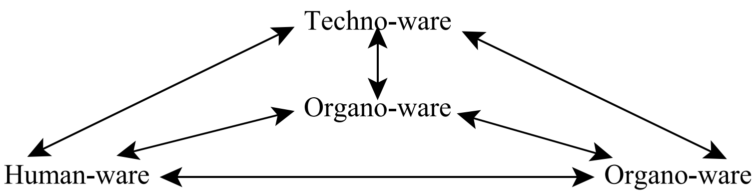


Figure 3. Organo-ware Triangles in terms of Human-ware, Infoware, Techno-ware

DEVELOPMENT OF PROCESSING AND UTILIZATION OF LEGUMES IN INDONESIA

Traditional fermented food products in Indonesia are: *tempe, kecap* (soy sauce), *oncom, tauco*, and yogurt. All these food products are processed by simple methods. Traditional fermented foods are produced using microorganisms such as bacteria, fungi and yeast. Therefore, the roles of bacteria, fungi, and yeast will be focused in this discussion. Some of moulds or fungi which can be used for producing traditional fermented food are as follows.

The isolation and identification of organisms isolated from fermented soybean (*tempe*) are *Rhizopus* sp., *Aspergillus* sp., *Penicillium* sp., *Neurospora* sp., and yeast strain *Trichoderma* sp. Most of the *Rhizopus* sp. strain isolated from *tempe* indicated protease and amylase activity. The protease enzymes produced by *Rhizopus* strain play an important role in hydrolyzing the protein contained in soybean into more digestible amino acids. Amylase is not produced by *Rhizopus solonifer* and *Rhizopus oligosporus*, but produced by *Rhizopus oryzae*. Even though protease plays an important role in *tempe* fermentation, experience has shown that the consumers do not favor *tempe* made from *Rhizopus oligosporus* alone, as compared to *tempe* fermented by mixed cultures. *Aspergillus, Rhizopus* and *Penicillium* are important for preparing soy sauce and *tempe* in Asia. *Rhizopus oligosporus*, and *Rhizopus oryzae* can be used for the *tempe* fermentation. The optimum temperature for *Rhizopus oryzae* is 30ºC. In Indonesia, legumes are important contributors of high protein foods to the daily diet, especially for low-income groups in rural community. There are many well-known varieties of legumes, both non-toxic as well as toxic. The nutritive values of commonly used legumes (soybean, green gram, cowpea, peanut, red kidney bean) were analyzed and the data are given in Table 1.

Table 1. Chemical Composition of Five Indonesian Legumes Purchased from Market

(Unit: Percent)

Legume	Energy (cal)	Moisture	Protein	Fat	Carbohydrate	Fiber	Ash
Soybean (*Glycine max*) (Kacang kedelai)	430	10.3	32.8 (N×5.71)	18.4	34.6	4.1	3.9
Peanut (*Arachis hypogaea*) (Kacang tanah)	585	8.4	24.3 (N×5.46)	45.6	19.3	2.0	2.4
Green Gram (*Vigna radiata* var.) (Kacang hijau)	355	10.6	21.1 (N×6.25)	1.4	64.4	4.4	2.5
Cowpea (*Vigna sinensis*) (Kacang tolo/Kacang tunggak)	345	12.4	22.5 (N×6.25)	1.4	61.1	5.0	2.6
(Red) Kidney Bean (*Phaseolus vulgaris*) (Kacang merah)	355	9.2	22.1 (N×6.25)	1.2	64.3	4.3	3.2

Source: *Annual Report of National Institute for Chemistry, 1997-1998*, ASEAN, LKN-LIPI, 1997-1998.

In general, legumes have a low fat content of about 1-2 percent (peanut and soybean are exceptions).

Fermented Low-cost Protein-rich Foods from Legumes

1. ***Oncom Products***

Oncom fermentation by *Neurospora sitophyla* – Peanut and pressed peanut cake can be used as solid substrate for *Neurospora sitophyla* to produce *oncom*. Fresh *oncom* can be used for the production of *oncom* chip with a 0.2-cm thickness by applying the blanching method and oven-drying at 70-80ºC. The fresh *oncom* is prepared using the following steps: *oncom* slicing, steaming, drying, grinding and sieving through 32 mesh. The *oncom* flour is processed further for preparing meat ball.

2. ***Soybean Tempe Products***

Soybean *tempe* is made by using soybean and *Rhizopus oligosporus* and *Rhizopus oryzae*. Total consumption is about 20,000 mt per week. Soybean *tempe* provide the common people with both economic and nutritional security. Protein content of soybean *tempe* is about 18.5 percent.

3. ***Canned Tempe***

Canned *tempe* has a longer shelf life than the fresh *tempe*. Thermal processing is used in the preparation of second generation of *tempe* to destroy pathogenic microorganism. The heat is applied atleast to destroy *Clostridium botulinum* completely because the spores are most heat-resistant. It is necessary to evaluate the heat penetration at the slowest heating point of *tempe* in the container. The graphical method is simple to observe the efficiency of thermal processing by integrating the temperature-time relationships with sterilizing rate. The area under a lethal value of one, indicates the total lethality of process to be equivalent to the lethal time for any particular temperature. A lethal value of one, indicates that the process equivalent to a Fo value of 2.4 minutes or equivalent of thermal death time of *Clostridium botulinum* at a temperature of 121ºC for container (can) size of 10 cm in diameter, 6 cm in height and the sterilization process is completed with 1 kg/cm^2 of pressure. Microbiological analysis is conducted by calculating the total plate count of canned *tempe* two weeks after storage at 37ºC. The pH value of *tempe* is in the range from 5.2 to 5.8. The inhibitor effect of acids on spoilage organism becomes apparent at pH 5.3, while *Clostridium botulinum* is inhibited at pH 4.5.

The following four *tempe* have been formulated:

i) *Sambal Goreng Tempe* (fried *tempe* with chili sauce);
ii) *Tempe Bumbu Rujak* (*tempe* with coconut milk and other ingredients);
iii) *Bacem Tempe* (boiled *tempe* with brown sugar, salt and other ingredients); and
iv) Steak *tempe*

4. ***Soy Sauce Manufacturing Technique***

Two kinds of soy sauce are known in Indonesia, namely, the sweetened soy sauce and the salty soy sauce. Soy sauce is widely used to enhance the taste of Indonesian foods. At present soy sauce is manufactured traditionally by fermentation process at home industry scale. A general scheme of soy sauce manufacturing using the whole soybean consists usually the following steps: pretreatment of soybean; mold fermentation; brine fermentation; and processing after brine fermentation. The pretreatment usually consists of cleaning, soaking, cooking and draining of soybeans prior to mold fermentation. The problems in manufacturing techniques exist mostly during mold and brine fermentation process, as well as during processing after brine fermentation.

5. ***Tempe Yogurt***

Tempe yogurt can be produced by extracted *tempe* using *Lactobacillus bulgaricus* and *Streptococcus lactis*.

6. ***Benguk Tempe***

This *benguk tempe* (*Mucuna pruriens*), grows on less fertile soil. *Tempe benguk* is cheaper than soybean *tempe*. *Tempe benguk* is consumed as a side dish. *Mucuna pruriens* seeds in Indonesia can be divided into grey, black and spotted seed coat. Protein content of *benguk tempe* is about 10.2 percent (Haryoto, 1995).

7. ***Kecipir Tempe (Winged Bean Tempe)***

The fermentation process of winged bean *tempe* includes washing seeds, boiling for one hour, removing the seed coat, soaking for 24 hours in excess water, and sterilizing for 30 minutes at 121ºC. The substrate is inoculated with *Rhizopus* sp. and incubated at 30ºC for 2-3 days. Protein content of winged bean *tempe* is 17.5 percent (Haryoto, 1995).

8. ***Winged Bean Yogurt***

Winged bean milk can be used to prepare winged bean yogurt using *Lactobacillus bulgaricus* and *Streptococcus lactis*. Winged bean milk is sterilized at 100ºC for 20 minutes and the pH is adjusted to 8.5 by adding NaOH. About 5 gm $Ca(OH)_2$ is added to remove peanut oil taste and also to destroy trypsin inhibitor (Haryoto, 1995).

9. ***Winged Bean Sauce***

Most of the strains which produce strong amylolytic and proteolytic activities are *Aspergillus* spp. There are two fermentations involved, namely; the mold fermentation and the brine fermentation.

The Formulation, Production, and Processing of Low-cost Non-fermented Protein-rich Foods Using Legumes in Indonesia

The most serious dietary problem in Indonesia is lack of protein in adequate quantities, particularly protein suitable for infants, young children and other vulnerable groups. Considering that Indonesia has a high potential to produce protein-rich raw materials, a well-coordinated research program is needed. Research includes development of lowest protein-rich food using oilseed by products and preparation of *tahu*. The focus is on the preparation of infant food for the poor.

MODERN PROCESSING AND UTILIZATION OF LEGUMES IN INDONESIA

By increasing the social welfare of rural people, their demand for food will increase. Therefore, small-scale traditional legume industry should be upgraded to modern legume industry using Codex Alimentarius Commission, ISO 9000 and ISO 14000 (Figure 4).

The mission of the modern legume industry in Indonesia is to produce legume products according to the international standards. The global market for legume products is becoming more competitive and a number of factors will influence the future competitiveness of Indonesia's legume industry. The factors include quality, customer service, consumer acceptance, sanitation and quality system of industrial equipments, quality control and Good Manufacturing Practices (GMP). The legume processing equipment bought from food processing unit vendors is not always designed and constructed according to legume industry sanitation standards. Fermentation and non-fermentation technology development in the modern legume industry may also influence total legume products development.

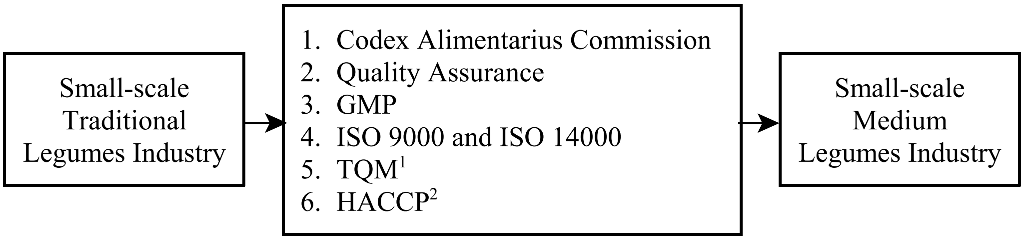


Figure 4. Transformation of Traditional Legume Industry to the Modern Legume Industry as a Passport to International Market

Source: Suharto, 1996.
Notes: [1] TQM = Total Quality Management; and [2] HACCP = Hazard Analysis and Critical Control Point.

Framework for Fermentation and Non-fermentation Technology Development

A framework for fermentation and non-fermentation technology development is shown in Figure 5. The fermentation and non-fermentation technology capabilities are designed and implemented for the modern legume industry. Fermentation and non-fermentation technology development activities are defined. Efforts are made to create new fermentation and non-fermentation technology using new equipments, rather than to improve the existing traditional legume industry. Traditional fermented legumes are derived with the help of microorganism. Therefore, to achieve good fermentation the environmental factors that influence the fermentation processes need to be considered. *Rhizopus* sp. has an optimum temperature of 30-37ºC for its growth. In legume fermentation by controlling oxygen, it is possible to increase microbial growth. *Rhizopus* sp. cannot grow without water. Microbes use moisture from legumes for their growth. Most microorganisms prefer pH values 6.0-8.0 for their growth. More nutrients are needed in the substrate when *Rhizopus oligosporus* and *Rhizopus oryzae* are used as inoculum to prepare *tempe*. *Rhizopus oligosporus* produces more proteolytic enzyme whereas *Rhizopus oryzae* produces more amylolytic enzyme. Under this framework, development of each fermentation technology enriches the knowledge base for production capabilities, fabrication of equipment, economic evaluation, management in engineering, management of technology and environmental management.

General Fermentation and Non-fermentation Technology

The clean legumes as received are dipped in hot water at 80ºC for 30 minutes. A mild heating process at 80ºC is done to facilitate the removal of the seed coat of legumes and further processing. Overheating the legumes will destroy the amino acids lysine and cysteine. A hopper containing the legume seeds is delivered to a peeling machine where the legume seed coat and kernels are transferred to a soaking tank. They are dipped in water containing lactic acid with pH value of 3.5 at room temperature for three hours. The slurry of legume is then sent to separation tank to separate the legume in the hopper. The de-hulled legume is cooled to room temperature and then it is inoculated with *Rhizopus* sp. in the ratio of 3 gm inoculum per kg of legume. The de-hulled legume containing inoculum *Rhizopus* sp. is moved to a stainless steel tray and heaped to a height of 4-5 cm. The stainless steel tray containing raw legume is incubated at 32-35ºC for 24-30 hours. The fresh *tempe* is obtained 24 hours after incubation.

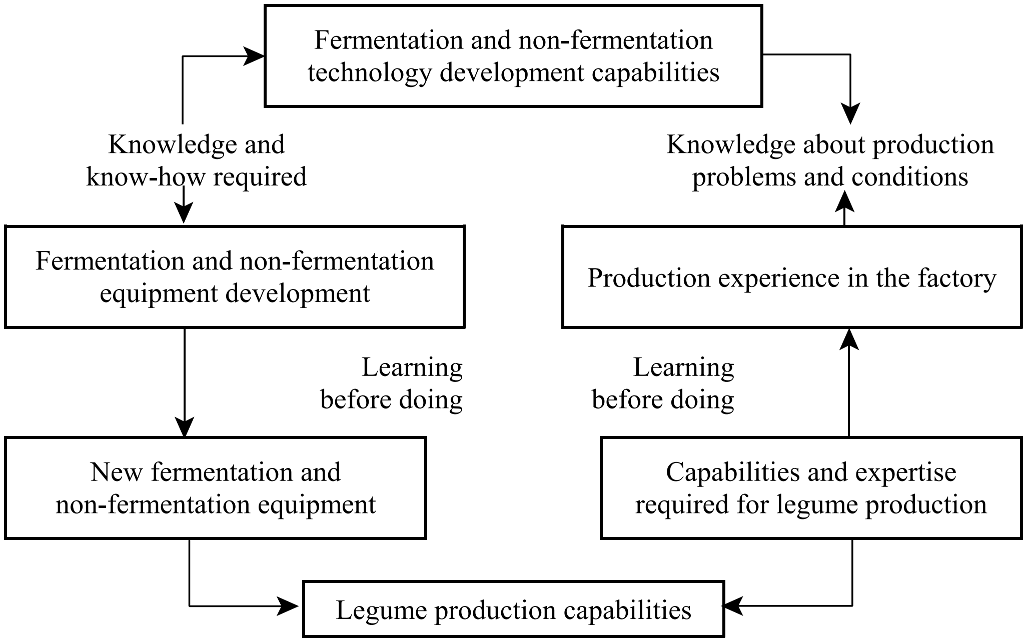


Figure 5. Capabilities and Expertise in Bioprocessing and Equipment in the Modern Legume Industry

"Learning before doing" is carried out to solve activities in a small scale before embarking on large-scale production. Once large-scale legume production starts, additional improvements on electrical and steam problems related to fermentation of legume may occur. Therefore, large-scale legume production may bring about changes in bioprocessing, equipment design, and worker's skill. These problem-solving activities that arise after legume production are termed "learning by doing".

Fabrication of Equipment

The traditional legume industry has been known and disseminated by the Javanese people for several hundred of years as a home level industry. The average capacity is 50 kg legume per day using different types of processing. Fermentation and non-fermentation technology need to be modernized in Indonesia to improve the image of the industry. The traditional legumes industry does not meet the modern quality standards such as ISO 9000, ISO 14000. Biopressing and the use of modern equipment should be disseminated to legume industry in Indonesia to ensure first, second and third generation legume products such as fresh legumes, field *tempe* and legumes flour as well as antioxidants, respectively. The modernization of the traditional legume industry will allow the small legume industry to supply the highest quality legume product to the large modern food industry that uses legume as raw materials for formulating infant food, army food, cholesterol-free food, super snack food to improve the nutritional status (Suharto, 1996). Harmonization in terms of efficiency of production, efficiency of water use, treatment and utilization of legume waste for food and animal feed, the application of ISO 9000, ISO 14000 must be carried out by both traditional legume and the modern legume industry. Such harmonization arises by the use of appropriate legume technology derived from the standardized materials, energy, scientific knowledge, and labor intensity. Labor intensity in the modern legume industry is still the most important element in eliminating social problems. A supply of legume is transported by a belt conveyor into a hopper. The hopper containing legume is transported by electric hoist and dipped in hot water at 80ºC for 30 minutes in the stainless steel tanks. Legume handling equipment is completed with an electric hoist to carry the hopper. The hopper can act as a storage place for intermediate products. A correct foundation design for heavy equipment vibrating machines is an important factor that must be considered and implemented. A peeling machine for soaked legume will separate the seed coat and de-hulled legume. A dipping tank containing water and lactic acid solution is to dip de-hulled legume and seed coat for three hours. Electric hoist can bring this hopper containing seed coat and de-hulled legume to a flotation tank in order to separate the seed coat and de-hulled legume. The de-hulled legume in the hopper is transported through an electric hoist to a retort. A non-agitating batch retort is used to sterilize de-hulled legume at 100ºC for 10 minutes. This retort consists of double jackets which can accommodate the hopper of the de-hulled legume. The retort is vertical or top loading requiring less floor space than horizontal or side loading retort. The sterilized de-hulled legume is transported through a conveyor which can act as cooling system to the mixers. The properties of the sterilized de-hulled legume and inoculum in size, density, surface, moisture content have a tendency to cluster.

FUTURE DEVELOPMENT OF LEGUME PROCESSING AND UTILIZATION

There is a need to develop infant's weaning food using legumes because legumes are cheap, high in protein, and legumes can grow well in most areas. The interaction between university and legume industry should continue using the approach of vertical and horizontal technology transfer.

CONCLUSIONS

The study of legumes was conducted to obtain information on the present status of legumes in Indonesia, with respect to their cultivation, production, processing and utilization, farm management, traditional and modern legume industry. The results can hopefully be used as a directive for improvement of legume processing and utilization in Indonesia. Legumes can be used for the production of low-cost protein-rich fermented and non-fermented foods for low-income people in rural areas. The locally available raw materials in Indonesia such as yellow soybean, black soybean, red bean (*Vigna angularis)*, and *Phaseolus coccineus* L. are used for fermented protein food products utilizing *Rhizopus* sp. and *Neurospora* sp. Fermented and non-fermented legume products can be used for the fortification of staple food in Indonesia to increase the protein content. Formulated non-fermented legume can be made by the extrusion procedure. Formulated food using non-fermented food such as corn-soy-winged bean mix has to be evaluated using nutritive and biological evaluation to obtain the protein efficiency ratio, net protein utilization and biological value. There is a need to develop food for infants using legumes, which in the future can be industrially produced on a large scale.

ACKNOWLEDGEMENT

I would like to thanks to Mr. Teruo Miyake, Director of Agriculture Department, Asian Productivity Organization in Japan and National Productivity Organization in Jakarta who have assisted me to attend the Seminar on Processing and Utilization of Legumes from 9 to 14 October 2000 in Tokyo, Japan.

REFERENCES

ASEAN, 1997, 1998. "ASEAN Project on Soybean and Protein-rich Food", LKN-LIPI, 1997, 1998, *Annual Report*, Bandung, Indonesia.

Haryoto, 1995. "*Tempe* dan Kecap Kecipir", Kanisius, Yogyakarta.

Noori, Hamid, 1990. *Managing the Dynamic of New Technology*, Prentice Hall.

Suharto, Ignatius, 1996. "Global Transfer of Food Technology in Small-scale *Tempe* Industry", in *Proc. of the Second International soybean Processing and Utilization Conference*, pp. 377-381, Bangkok, Thailand.

6. ISLAMIC REPUBLIC OF IRAN

Mohammad Reza Jahansooz
Staff Member and
Secretary of Pulses Research
Faculty of Agriculture
The University of Tehran
Karaj

INTRODUCTION

Grain legumes, after cereals, are the main crops grown in Iran and they play an important role in agriculture and food production of Iran. Legumes have nitrogen fixing ability, and they are relatively a cheap source of protein. Compared to other grains, legumes receive a better price in the market. They are consumed with rice, meat and vegetables in making soups and other kinds of food. They are used to make cookies. Legumes are also utilized as canned food.

Due to the importance of grain legumes, the Government of the Islamic Republic of Iran initiated agricultural development plan. Legumes have a special emphasis in the plan. Several institutions such as Tehran University, the research organization of the Ministry of Agriculture are involved in research on different aspects of grain legumes production.

The area under grain legumes in Iran is around 1,000,000 ha. The most important grain legumes in Iran are: chickpea (*Cicer arietinum* L.), lentil (*Lens esculenta*), different varieties of bean (*Phaseolus vulgaris* L.) such as white, red and spotted; cowpea (*Vigna unguiculata* L.), pigeon pea (*Cajanus cajan*), green gram (*Vigna radiata* var. *radiata* L.), black gram (*Vigna mungo*), pea (*Pisum sativum*) and field bean (*Vicia faba*). In this report, growth in production and consumption, problems and issues in processing, utilization of legumes, research and innovations in improving production, and future prospects of legumes are presented.

ARABLE LAND AND THE PRODUCTION OF GRAIN LEGUMES IN IRAN

Despite the yearly fluctuations, the area planted to grain legumes had an increasing trend (Figure 1).

In 1979, the area under grain legumes was 207,000 ha, while in 1999 it increased to 935,000 ha. Some of the possible reasons for this growth were: higher price of grain legumes compared to other field crops, increase in demand for grain legumes, and it is a major source of protein for people.

According to the statistics in 1992, about 1,120,000 ha was planted to grain legumes. However, due to surplus production and lack of export opportunities, the cultivated area decreased for the three subsequent years. Since 1995, the increase in the price of grain legumes resulted in resumption of growth of cultivated area.

Chickpea, common bean and lentil were the major crops with 574,560 ha, 114,615 ha and 19,563 ha, respectively. About 81.9 percent of the cultivated land is rainfed.

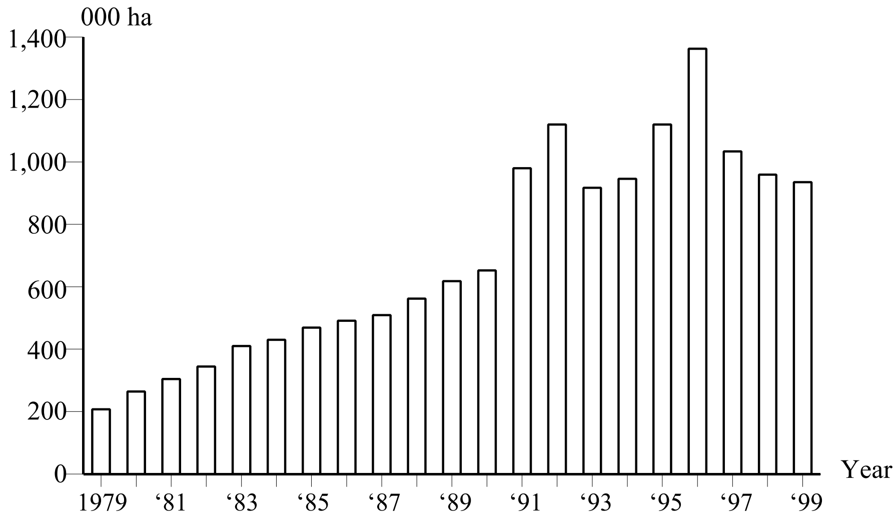


Figure 1. Area Planted to Grain Legumes

Irrigated Areas

In 1998, 173,602 ha of legumes were irrigated in contrast to 114,876 ha in 1989. In 1992, a maximum of 269,516 ha of legume area were irrigated (Figure 2).

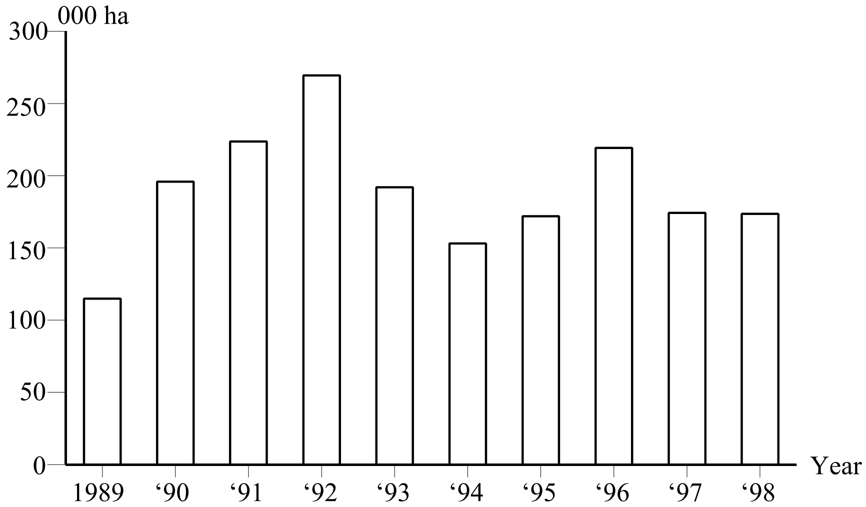


Figure 2. Irrigated Areas under Grain Legumes

Rainfed Areas

The grain legumes are mostly grown under dryland conditions in Iran (Figure 3). Grain legumes occupy about 15 percent of the total cultivated dryland. From 1989 to 1998, the grain legumes area in the dryland increased slightly (Figure 3).

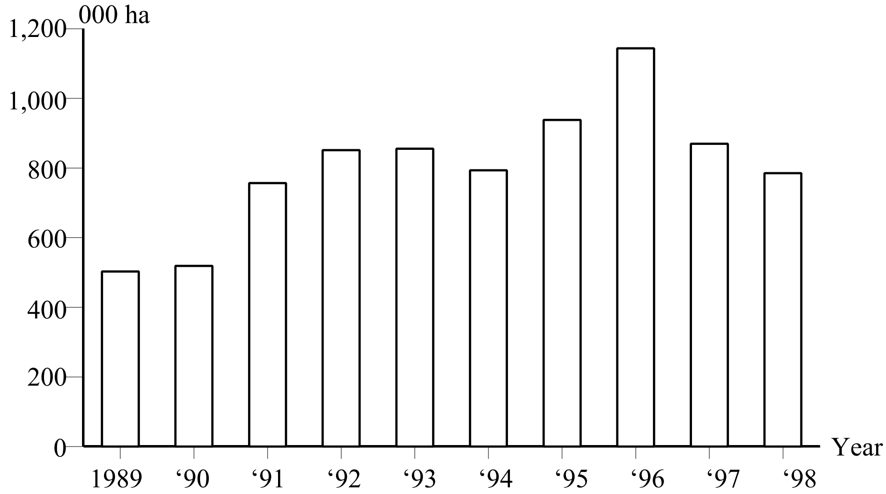


Figure 3. Rainfed Areas Under Grain Legumes

Legume Production in Iran

There was an increasing trend in grain legumes production in Iran from 1989 to 1998 (Figure 4). The increase in legume production has been mainly due to the increase in planted area.

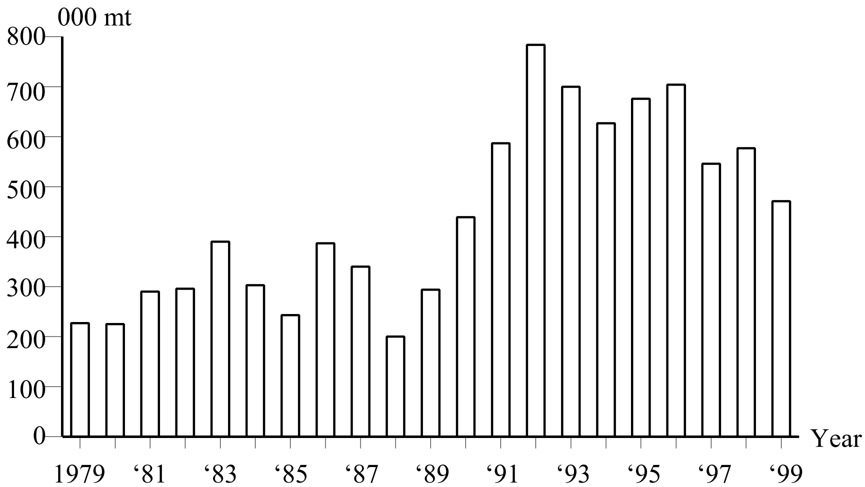


Figure 4. Grain Legumes Production

Irrigated Grain Legumes

The production of irrigated legumes was around 250,013 mt in 1998. Irrigated legume production in Iran had a positive growth (Figure 5). The average yield of legumes is around 500-600 kg/ha (Figure 6). The average yield of irrigated legumes was 1,029 kg/ha in 1989 and it increased to 1,440 kg/ha in 1998 (Figure 7). The average yield of irrigated legumes was more stable than rainfed legumes (Figure 7). The average yield of different legumes under rainfed and irrigated condition is given in Table 1.

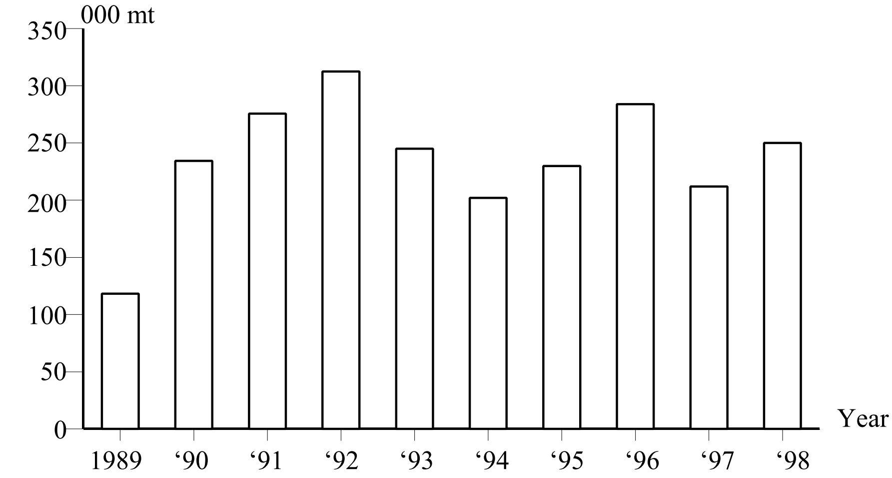


Figure 5. Grain Legumes Production Under Irrigation

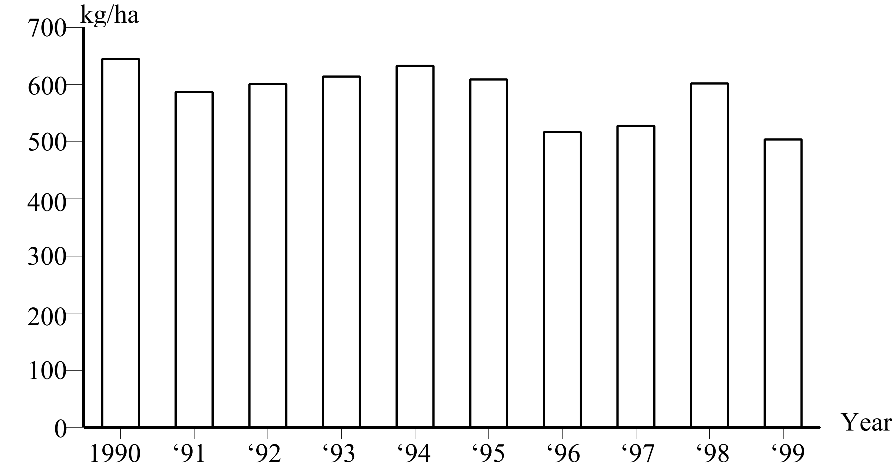


Figure 6. Average Yield of Grain Legumes

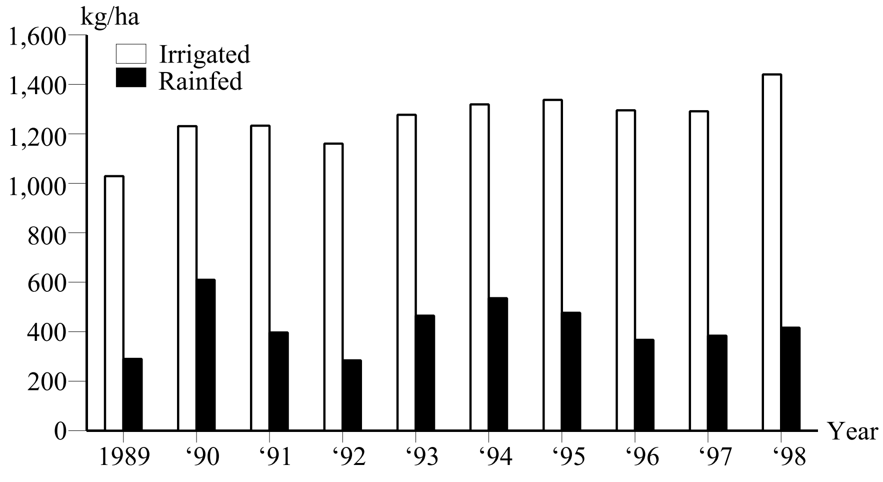


Figure 7. Average Yield of Irrigated and Rainfed Grain Legumes

Table 1. Average Yield Range of Rainfed and Irrigated Grain Legumes

(Unit: kg/ha)

Crop	Rainfed	Irrigated
Chickpea	261 – 482	1,015 – 1,412
Lentil	285 – 530	931 – 1,166
Common bean	561 – 1,659	1,144 – 1,655

Rainfed Grain Legumes

The yield of grain legumes is very much affected by rainfall. Therefore, in dry years, the production of grain legumes dramatically decreased (Figure 8). Due to the large share of rainfed grain legumes, the rainfall has considerable effect on the total production of grain legumes in Iran.

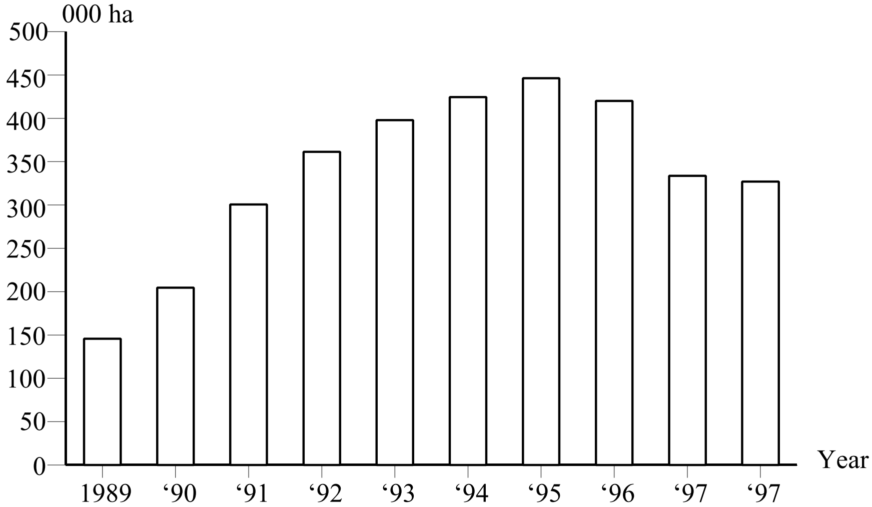


Figure 8. Grain Legume Production Under Dryland Conditions

EXPORT AND IMPORT OF GRAIN LEGUMES IN IRAN

The amount of legumes imported by Iran is decided by the domestic production, world market price and government policies. From 1989 to 1998, Iran imported about 74,531 mt. In 1993, 1996 and 1997 there were no imports.

UTILIZATION AND CONSUMPTION OF GRAIN LEGUMES IN IRAN

Grain legumes are the second major source of food after cereals. They are consumed with rice, meat and vegetables, mainly for making soups. They are also used in preparing cookies.

Chickpea is the most important food legume in Iran. Demand for chickpea has increased steadily with population growth and reduction in per capita availability of other sources of protein. A popular chickpea dish is *abgosht*. In *ghymeh khoresht*, a traditional delicacy eaten with rice, a desi-type chickpea, mainly in the form of split pea is used.

The food industry sector of Iran produces only 4,340 mt of canned peas, 3,250 mt of green bean and 17,197 mt of pinto bean, which is much less than what is directly used by people.

Legume consumption fluctuated between 4.6 kg/caita/year in 1988 to 9.1 kg/capita/year in 1997 (Figure 9).

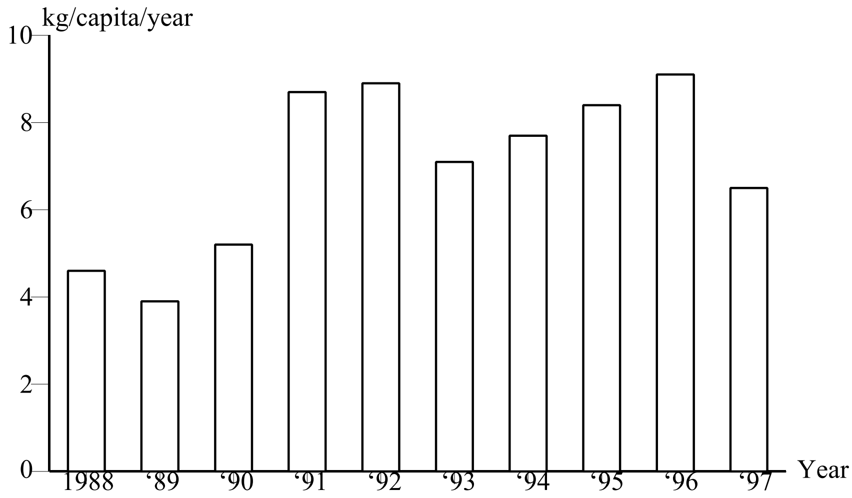


Figure 9. Legume Consumption

PROBLEMS AND ISSUES IN PROCESSING AND UTILIZATION OF GRAIN LEGUMES

Nearly 82 percent of grain legumes in Iran are produced under rainfed conditions. The distribution and the total rainfall under semi-arid conditions are very unpredictable. Therefore, farmers take risk in producing grain legumes.

Lack of sufficient number of planting and harvesting machines, lack of varieties resistant to biotic and abiotic constraints are other problems in grain legume production. Due to high price of grain legumes (up to seven times greater than cereals) in market, and the cultural and social role of grain legumes in the diet of Iranians the canned grain legumes are not so popular in Iran.

RESEARCH ACTIVITIES AND INNOVATIONS IN IRAN

The new era in grain legumes research started with a "Grain Legume Project" in Tehran University in 1968. Pure line selection commenced from 14,000 native and imported lines of different grain legumes. The general goals of grain legume project in Iran are:

1. Increase the yield by increasing the number of pods per plant;
2. Improve the quality traits such as palatability, cooking properties and the amount of protein;
3. Incorporate disease, pest, cold and drought resistance;
4. Select for early maturity (especially for dryland conditions);

5. Identify suitable plant type for mechanical harvesting; and
6. Select non-shattering.

The breeding methods used to improve the above mentioned characteristics include: introduction of new varieties, bulk and pure line selection, hybridization and selection using pedigree, bulk, single seed descent and back cross method; mutation; and application of plant biotechnology and genetic engineering.

The ongoing grain legume project has introduced a number of varieties in the past three decades.

Today many other institutions such as Ferdowsi University, the research organization of the Ministry of Agriculture, the Atomic Energy Organization are working on different aspects of grain legumes production.

FUTURE ROLE OF LEGUMES IN FOOD PRODUCTION

In recent years, Government of the Islamic Republic of Iran has established a few developmental plans in agriculture sector. The basic goals of these plans are:

A) The qualitative goals:
   i. Improving the quality of legumes as a food substitute for meat through new varieties.
   ii. Improving the shape, color, taste and marketing value of the grain legumes.
   iii. Introducing new varieties with resistance to biotic and abiotic constraints.

B) Two options are considered to address the quantitative goals:
   i. Increasing the cultivate area – The area under different grain legumes should increase from 959,000 ha in 1998 to 1,068,000 ha in 2004. The irrigated and rainfed areas should increase 19,500 ha and 89,500 ha, respectively. In the second option, the devoted areas to grain legumes should increase from 959,000 ha to 1,048,000 ha. The irrigated and rainfed areas should increase 19,500 ha and 69,500 ha, respectively. In the second option, the total production of grain legumes should increase by aiming higher yields per unit area than the first option. For example, chickpea cultivation can be introduced to fallow land in rainfed zones, which are under fallow-cereal rotations.
   ii. The second option is increasing the yield per unit area.

Considering the first option, the yield of irrigated chickpea should reach from 1,234 kg/ha to 1,270 kg/ha, and with the second option it should reach 1,543 kg/ha. The yield of rainfed chickpea should reach from 391 kg/ha to 406 kg/ha, and with the second option it should be 488 kg/ha.

With the first option, the yield of irrigated lentil should change from 999 kg/ha to 1,037 kg/ha, and with the second option, it should reach 1,500 kg/ha. The yield of rainfed lentil should reach from 425 kg/ha to 448 kg/ha and with the second option, it should reach 485 kg/ha.

Considering the first option, the yield of common bean should reach from 1,576 kg/ha to 1,663 kg/ha and with the second option, it should reach 1,747 kg/ha.

In the case of other grain legumes with the first option, the yield should reach from 1,099 kg/ha to 1,146 kg/ha, and with the second option, it should reach 1,400 kg/ha.

To improve the yield, the following agronomic methods are proposed: appropriate seed rate, application of fertilizer and use of farm machinery. Crop insurance policy will be introduced. In case of chickpea, a type of sowing, which is called *Entezari* will be encouraged. Field surveys are being made to examine the potential for expanding the areas under *Entezari* system in different provinces.

The Ministry of Industry has issued several licenses for construction of new food legume processing factories. They are expected to produce 1,550 mt of canned pea, 1,770 mt of green bean and 10,240 mt of chickpea. The Ministry is also planning to improve packing and storage of grain legumes. Moreover, the Ministry is considering to establish different biotechnology institutions. International collaboration such as the current APO seminar, gives an opportunity to gather more information on processing and utilization of legumes, and other activities which will have direct effect in improving the quality and quantity of food and nutrition in Iran.

7. REPUBLIC OF KOREA

Suk-Ha Lee
Assistant Professor
Division of Plant Science
Seoul National University
Suwon

Legumes are a major source of dietary proteins and calories in the world. In Korea, rice has been the major cereal crop since ancient times. Legumes are an important source of protein when animal proteins become scarce.

Legume crops are cultivated in small areas along the bunds of rice field or in mountain slopes. Efforts were made to have self-sufficiency in legumes.

Traditionally soybean, adzuki bean, mung bean, groundnut, peas, cowpea, and others, have been grown and rotated with other crops. The biological nitrogen fixation ability of legume crops may help maintain or enhance soil fertility.

Agriculture in Korea, at present, faces the following problems: 1) rapidly decreasing rural population that is aging; 2) high dependency on rice technology; 3) low degree of self-sufficiency in food; and 4) increased environmental concerns in rural areas.

This paper describes the current status on socio-economic trends, production, demand, utilization, major research achievements, and future role of legumes in food production and agricultural development in Korea. In addition, food-safety issues arising from genetically modified plants are also presented.

SOCIO-ECONOMIC TREND

During the last 40 years due to progressive economic growth, great changes have occurred in Korea. The structure of Korean agriculture has also changed dramatically. From 1960 to 1970 more than 70 percent of the population in Korea were engaged in agriculture, forestry, fishery, and sericulture. Afterwards most population moved and are now concentrated in the secondary and tertiary industry due to the movement in national economy. Using 1980 as the base the farm population decreased by 39 percent and 61 percent, respectively in 1990 and 1999 (Table 1).

Table 1. Major Economic Indicators of Korean Agriculture

Economic Indicators	1980	1990	1999
Farm population (000)	10,827	6,661	4,210
Agriculture share of total population (percent)	28.4	15.5	9.0
Cultivated land area (000 ha)	2,196	2,109	1,899
Land area per farm (ha)	1.01	1.19	1.37
Land utilization ratio (percent)	125	113	111

The proportion of agriculture sector has fallen from 28.4 percent in 1980 to 9.0 percent of the total population in 1999. Such decrease in agricultural population has caused labor shortage in rural areas. The labor shortage resulted in remarkable increase in wage rates which in turn significantly decreased land utilization. The land utilization ratio was 136 percent in 1973, and has decreased to 125 percent and 111 percent in 1980 and 1999, respectively (Table 1). Agriculture's share of the GNP declined dramatically between 1980 and 1999.

The total land area in Korea is about 9,927 ha. Most of the total land area is forest land. About 20 percent of the total land area is arable. The average farm size per farm household, where paddy and upland crops are grown, was only 1.37 ha in 1999. The increase in the farm size from 1980 to 1999 is likely due to the decrease in the number of farms rather than the actual increase in farm area.

The income gap between rural and urban areas has to be solved. To increase income of rural people, priority should be given to increase their income from agriculture. The gross and net income from soybean, maize, and groundnut in 1998 were compared with other cash crops (Table 2). Although the cash crops such as red pepper and sesame require more labor than food crops, farmers prefer cash crops due to higher income from cash crops. Income from soybean and groundnut production were fairly low when compared to that of red pepper. Due to low income, the acreage of legume crops decreased.

Table 2. Comparison of Average Income of Soybean, Groundnut, Maize, and Rice, with Other Cash Crops in Korea, 1998

Crops	Yield (mt/ha)	Gross Income (A)	Management Cost (B)	Net Income (A – B)	Labors (hour/ha)
			(₩ 000)		
Soybean	1.53	3,747	1,113	2,634	504
Maize	6.13	3,846	1,402	2,444	560
Groundnut	2.27	6,590	2,504	4,086	764
Rice	4.82	9,317	2,612	6,705	286
Sesame	0.52	4,814	1,105	3,709	715
Red pepper	2.24	17,540	3,766	13,774	1,781

Note: Exchange rate: US$1 = ₩1,203 (Korean Won).

LEGUME PRODUCTION, DEMAND, AND SUPPLY

In 1965 when the international trade of legumes was limited, Korea was 100 percent self-sufficient in legume production. However, industrial development led to rapid decline in legume area and production (Table 3). Compared to 1980 area under mung bean and adzuki bean decreased more than 60 percent resulting in 55 percent and 60 percent decrease in production, respectively. During the same period soybean area and production decreased only 35 percent and 23 percent, respectively (Table 3). These decreases were mainly due to low income from legumes compared to red pepper. Yield per unit area of legumes has increased through the improvement of new legume varieties and improvement of cultural techniques.

Table 3. Area, Production and Productivity of Legume Crops in Korea

Crop	Year	Acreage (000 ha)	Yield (mt/ha)	Production (000 mt)
Soybean	1980	188	1.15	216
	1985	156	1.50	234
	1990	152	1.53	233
	1995	105	1.52	160
	1999	85	1.95	166
Adzuki bean	1980	32	0.91	29
	1985	24	1.00	24
	1990	22	1.05	23
	1995	18	1.06	19
	1999	12	1.08	13
Mung bean	1980	6	0.83	5
	1985	6	1.00	6
	1990	5	1.00	5
	1995	3	1.00	3
	1999	2	1.00	2
Groundnut	1990	12	1.50	18
	1995	9	1.89	17
	1999	7	1.71	12
Others	1980	16	0.94	15
	1985	14	1.07	15
	1990	9	1.11	10
	1995	7	1.14	8
	1999	7	1.14	8

Among all the legume crops, soybean is the most important crop in Korea. In 1965, Korea was self-sufficient in soybean production. The domestic demand for soybean was more than doubled in a decade. The demand for soybean grew significantly to reach a peak of 1.855 million mt in 1997. The domestic production slumped to an all time low of 156,000 mt (Table 4). Low cost of imported soybean and high cost of domestic soybean were the major factors for the above trend. In 1999, Korea produced 166,000 mt of soybean. It is less than 10 percent of the domestic requirement. Therefore, more than 90 percent of the domestic demand was met by import from the United States and China.

Adzuki bean, mung bean, kidney bean as well as cowpea are considered as minor legumes and are produced in limited area.

During the last 20 years, the total demand (or consumption) increased from about 733,000 mt in 1980 to 1,644,000 mt in 1998, while the national production decreased from 257,000 mt to 156,000 mt during this period. Recently, Ministry of Agriculture and Forestry in Korea launched a national soybean production program to increase the domestic production of soybean for food use in the future.

Total soybean consumption in Korea is projected to be 1.87 million mt in 2004, of which 1.276 million mt will be for animal feed, while 486,000 mt and 92,000 mt will be for industrial use and human food, respectively.

Table 4. Total Production, Demand, Supply, and the Ratio of Self-sufficiency of Soybean in Korea

(Unit: 000 mt)

Year	Production (A)	Import	Supply	Consumption (B)	Self-sufficient Ratio (A/B) (percent)
1965	163	0	163	163	100.0
1970	229	36	272	266	86.1
1975	319	61	410	372	85.8
1980	257	417	777	733	35.1
1985	254	885	1,226	1,130	22.5
1990	252	1,092	1,382	1,253	20.1
1995	160	1,435	1,826	1,558	10.3
1996	160	1,467	1,889	1,618	9.9
1997	156	1,628	2,059	1,855	8.4
1998	156	1,359	1,719	1,644	9.5

IMPORT AND EXPORT OF SOYBEAN IN KOREA AND IN THE WORLD

Major soybean producing countries in the world are the United States, Brazil, Argentina, and China. These four countries account for nearly 90 percent of the world soybean production. The European Union (EU) is the largest importer of soybean in 1997 (15.5 million mt) (Table 5). It is interesting to note that Japan, China, and Korea in Asia, are also major soybean importers. The United States is the largest exporter of soybean. Rural Economic Research Institute in Korea reported that the current trend in international soybean import and export will continue in the next decade.

Table 5. Current Status of Soybean and Future Prospects of World Trade

(Unit: Million mt)

	Import					Export			
	1997	2000	2003	2007		1997	2000	2003	2007
EU	15.5	15.8	15.5	15.3	U.S.A.	26.7	27.4	28.2	29.9
Japan	4.9	5.0	5.1	5.1	Argentina	2.1	1.7	2.0	2.5
Mexico	3.1	3.8	4.2	4.8	Brazil	7.0	7.7	7.7	8.1
China	3.0	3.9	4.5	5.4	China	0.2	0.2	0.1	0.1
Korea	1.6	1.5	1.6	1.7					
Total	37.6	40.2	41.5	44.3	Total	39.4	40.2	41.5	44.3

Korea is one of the major importers of soybean in Asia. Soybean import increased over the years (Tables 4 and 5). Due to improved standard of living in the past 20 years, the meat consumption in Korea has increased. Increase in soybean import in Korea was mainly due to high demand for animal feed as well as for human consumption. As shown in Table 6, out of the total imported soybean, 80 percent was used as animal feed while only 20 percent is used for food and other uses.

Table 6. Yearly Change of Soybean Import in Korea

(Unit: 000 mt)

Year	Food and Others	Animal Feed	Total
1985	130	755	885
1990	195	897	1,092
1995	249	1,186	1,435
1998	271	1,088	1,359

MAJOR SOY-FOOD TYPE

Soybean seed is rich in protein and oil and is extensively used for human consumption. Recent revelation of health benefits of soybean in the diet has stimulated widespread consumption of soybean foods. In Korea soybeans are used in a large variety of ways, such as soybean curd, soy milk, soybean sprout, fermented food products, and soybean cooked with rice.

Soybean Curd

Soybean curd is a popular product prepared by precipitating the protein using calcium or magnesium salt to boiled soy milk, followed by pressing out the whey. Genotypic differences in the yield and quality of soybean curd have been reported. The major difference in quality was noted in the texture of soybean curd. Curd hardiness was influenced by salt concentration, phytic acid content, and the ratio of 7S and 11S globulin in soybean seed. Soybean cultivars with a dark hilum are undesirable for soybean curd production. Cultivars with high protein content are necessary to produce high protein soybean curd and to obtain higher curd yield.

A major quantitative trait locus (QTL) for seed protein content that accounts for approximately 50 percent of the protein was found in the variety *Danbaekkong*. This QTL in *Danbaekkong* can increase the seed protein by 3 percent. This QTL can be utilized to develop soybean variety for making curd or soy milk in the future.

In 1997 a total of 131,000 mt of soybean was used in Korea for soybean curd production.

Soy Milk

Soybean milk is a traditional soybean product and is widely consumed in Korea. However, it is unacceptable to some people due to its beany flavor and objectionable after-taste.

In manufacturing soybean milk, heat treatment has been used to remove the beany flavor. The beany flavor is due to the oxidation of linolenic acid by lipoxygenase during soy milk production. Soybean seed lipoxygenase isozymes have been eliminated genetically through breeding using soybean germ plasm provided by Dr. Kitamura.

Daidzein, genistein, and saponin were other compounds identified to be responsible for the objectionable bitter taste. There is genotypic difference for the composition and content of these chemical compounds. Most commercial cultivars appear to be well-suited for soy milk production except for the beany and bitter tastes. A yellow hilum is preferred. Through industrial process, beany flavor has been eliminated. The bland soy beverage has become a well-established commercial product in Asian countries such as Hong Kong, Japan, Singapore, Taiwan, and Thailand. The bland beverage is also popular in Korea. In 1997, an estimated of 27,000 mt of soybean was used for soy milk producion.

Soybean Sprout

Soybean sprouts are popular food in the Orient, especially in Korea. Sprouted soybean is a year-round vegetable.

In Korea soybean sprouts are generally prepared by the following procedure: i) soybean seeds are soaked in water at room temperature for 4-5 hours, washed, and spread in several layers in a tray with small holes at the bottom for water drainage; ii) the tray is then covered with a cloth and placed in a dark room; iii) seeds in the tray are watered 3-4 times a day; iv) after 6-7 days at room temperature, the sprouts reach a length of about 8 cm; and v) they are then washed, de-hulled, and are ready for serving. Sprouting results in the rapid disappearance of oligosaccharides, raffinose, and stachyose, that normally cause flatulence.

Small-size seeds, <12 gm per 100 seeds are preferred for sprout production. Small seeds germinate better and yield more sprouts than large seeds. The most important traits of soybean sprouts include good hypocotyl length, good germination and water absorption rate, and high sprout yield.

Soybean genotypes differ in sprout yield, hypocotyl length, and percent seed germination. Although there were significant genotypic variation in traits associated with soybean sprout, soybean breeders have neglected selecting for germination-related traits to improve sprout production. Selection for these traits has been limited due to multiple gene control, as well as the time-consuming and expensive procedures for measuring these traits. In addition, the quality determination of soybean sprout requires a large amount of seed and it is a destructive procedure.

In 1997, a total of 61,000 mt of soybean seed was used in Korea for soybean sprout production.

Soybeans for Cooking with Rice

Soybean is soaked in water for several hours prior to heating, then the soybean is mixed with rice and boiled. Such soybean and rice combination provides a nutritionally balanced diet (carbohydrate from rice and protein and fat from soybean). Higher seed sugar content, large seed size (more than 300 mg/seed), green seed embryo, black seed coat and rapid moisture imbibition ability are preferred traits of soybean for cooking with rice.

Soybean Utilization

Soyfood processing companies in Korea prefer imported soybean due to its low price compared to domestically produced soybean. However, consumers for home-made soysauce and soy paste, and some soybean processing companies will purchase and use domestically-produced soybean. The demand for domestically-produced soybean is expected to gradually increase due to the public controversy over genetically modified agricultural products.

The total amount of soybean used for food use in Korea in 1997 was 486,000 mt. Of which about 33 percent was domestically produced and 67 percent was imported (Table 7). The home-made food utilized 23 percent while the processed food used 77 percent of the soybean (Table 7).

Rapid mechanization of soy-food manufacturing industry occurred in the last half of this century in Korea. The development of soybean food industry was closely associated with those of many other industries. Depending on the types of soy-food industry, the size of enterprise was determined. A total of 83 enterprises were involved in producing soy sauce which accounted for about US$0.32 billion. Six hundred enterprises for soybean curd, four for soy milk, and 2,300 for soybean sprout accounted for US$0.60 billion, US$0.11 billion, and US$0.40 billion, respectively (Table 8). It is obvious that a large number of small enterprises produce soybean sprouts compared to those of soy milk.

Table 7. Food Uses of Soybean in Korea, 1997

	Soybean Amount (000 mt)	Ratio (percent)
Total supply	486	100.0
Domestic	160	32.9
Imported	326	67.1
Utilization styles	441	100.0
Food	97	22.0
Industrial uses	344	78.0
– Soybean curd	131	29.7
– Soy sauce	92	20.9
– Soy milk	27	6.1
– Soy sprout	61	13.8
– Others*	33	7.5

Note: * Include military, official supplies, soybean meal and other uses.

Table 8. Number of Industrial Companies and Market Value of Different Soy Products

Use	Number of Companies	Market Value (₩ 10 billion)
Soy sauce	83	32
Soybean curd	600	60
Soy milk	4	11
Soybean sprout	2,300	40

Note: US$1 = ₩1,203.

DEVELOPMENT OF SOYBEAN VARIETIES

Soybean breeding for improving food quality in Korea is restricted to selection for single-gene characters such as elimination of seed lipoxygenases or modification of 7S and 11S globulins in soybean seeds. Recently, QTL associated with cooking and food processing qualities of soybean have been identified.

Joint research between crop scientists and food scientists have identified important characters of soybean seeds according to the soy-food type. Soybean germ plasm and segregating population have been screened for these characters.

With the World Trade Organization Agreement as well as diversification of soybean utilization in Korea, research priority is the development of soybean varieties based on soy-food types. Only nine soybean varieties for soy sauce and two for soybean sprout production have been developed in the 1980s. A total of 44 new soybean varieties have been developed since the early 1990s, of which 18 varieties were to make soy sauce, 13 for soybean sprout, seven for cooking with rice, and six for use as vegetable soybean (Table 9).

Table 9. Soybean Varieties Released in Korea

Soy-food Type	1970s-80s	Early 1990	Late 1990	Total
Soy sauce	Jangyup Hwanggeum Baegun Saeal Bokwang Dankyung Muhan Jangsoo Danwon	Malli Taekwang Sinpaldal 2 Doyoo Samnam Soyang Keumkang Danbaek Jinpum	Alchan Dajang Jinpum 2 Daewon Jangmi Sodam Songhak Ilmi Daewang	27
Sprout	Eunha Namhae	Bukwang Kwangahn Pureun Hannam Myungoonamul Iksannamul Sobaeknamul	Pungsanmul Somyungnamul Paldo Sowon Doremi Dawon	15
Soybean for cooking with rice	-	Geomjung 1	Geomjung 2 Ilpumgeomjung Sunheuk Jinyul Heukcheong Galmi	7
Vegetable soybean	-	Keunol Hwaumput Hwasungput Seokryangput	Geomjungol Saeol	6
Total	11	21	23	55

FOOD SAFETY ISSUES FROM THE USE OF GMO

Biotechnology is often cited as a panacea to feed the growing population and to protect the environment. Indeed, the potential for higher yields and a reduction in the use of pesticides and herbicides through biotechnology lend credence to the claim. However, due to food safety, consumer groups have been against GMO (genetically modified organisms) food products in Korea.

More than half of the soybean varieties developed recently by private seed companies in the United States have a roundup ready gene, indicating that it is beneficial to soybean growers. In the United States, total acreage with GM soybean has increased from 1,500,000 ha in 1996 to 6,500,000 ha in 1998. Korea imports more than 90 percent of its soybean from major soybean-producing countries such as the United States and therefore, most of the soybean for human consumption in the near future will be GM soybeans.

Consumer groups are pressing for mandatory labeling of bioengineered foods in Korea. Labeling of GMO products has now been accepted by the government. Labeling of GMO products is required for soybean, corn, and soybean sprout by March 2001, and for potato by March 2002. If more than 3 percent of GMO was used to make foods, mandatory labeling is required.

A number of private companies rather than government research institutes in Korea have developed and are marketing kits for use by grain-importing companies and others to identify GMOs. There are two scientific methods in commercial use for detecting genetically modified field crops. One method involves testing for specific proteins that have been incorporated through biotechnology into a crop. The other is based on the detection of DNA sequence inserted into the crop. However, currently, there is no single, rapid or inexpensive test to verify whether a crop or crop sample is free of genetic modification.

Benefits from biotechnology will accrue slowly but steadily for farmers, food designers and ultimately, consumers, as bioengineering becomes more widespread. Regulations may help consumer acceptance. Public should be better educated and better informed about the *pros and cons* of biotechnology.

8. MALAYSIA

Norijah Mohd Nor
Assistant Agriculture Officer
Department of Agriculture
Kompeks Pertanian Bukit Temiang
Beseri Perus

INTRODUCTION

Malaysia is a tropical country situated in the middle of South East Asia. It covers an area of about 330,400 km^2 occupying Peninsular Malaysia on one side and the East Malaysia, which comprises the states of Sabah and Sarawak in northwestern coastal area of Borneo Island. Peninsular Malaysia is separated from East Malaysia by 720 km of South China Sea. Malaysia has tropical rain climate. The mean temperatures during day/night are 32ºC and 22ºC, respectively. The average rainfall is about 2,540 mm per year, with a maximum of 5,088 mm and a minimum of 1,650 mm. Humidity is always high and ranges between 70 percent and 98 percent. The supreme Head of State is Yang Di Pertuan Agong and the Head of Government is the Prime Minister. The population of Malaysia is about 23 million.

Major Crops in Malaysia

Oil palm, rubber, cocoa and coconut are the four major estate crops occupying 2.06 million ha, 1.18 million ha, 0.42 million ha and 0.32 million ha, respectively. Rice is the staple food and it is cultivated in 0.6 million ha. Tobacco, fruits, pepper and pineapple are other crops.

PRESENT SITUATION AND ECONOMIC IMPORTANCE OF LEGUMES IN MALAYSIA

Legumes play a limited role as a contributor to employment, income generation, import substitution and export promotion in Malaysia's agricultural development. The important legumes in Malaysia are groundnuts, soybeans, vegetable legumes, broad beans, lentil, chickpea, red bean, kidney bean, cover crops, and forage legumes. The main objective of this report is to assess the current situation and future prospects of major legumes production and import.

Groundnuts

1. ***Currents Situation***

In Malaysia, groundnuts are grown by smallholders in the states of Kelantan, Terengganu, Kedah, Perak and Johor. The area planted to groundnuts declined from 5,000 ha in 1980s to 286 ha in 1998. As a result, the production also declined from 2,795 mt in 1994 to 1,287 mt in 1998 (Table 1).

Table 1. Acreage and Production of Groundnut (1994-98)

Year	Area (ha)	Production (mt)
1994	621	2,795
1995	505	2,273
1996	224	1,008
1997	471	2,120
1998	286	1,287

Note: Average yield = 4.5 mt/ha.

The main reasons for the decline in area planted to groundnut are:

a. shortage and high labor cost for planting and harvesting.
b. more profitable crops replacing groundnut.
c. lack of storage facilities.
d. cheap imported groundnuts.

2. ***Import and Export of Groundnuts***

The demand for groundnuts is on the rise, especially in the past five years. The domestic production cannot meet the demand. Therefore, the demand was met by import. The import and export value of groundnut between 1995 and 1999 steadily increased (Table 2).

Table 2. Import and Export of Groundnut (1995-99)
(Unit: RM*)

Year	Export	Import
1995	565,995	57,673,414
1996	1,250,549	71,547,792
1997	2,136,673	76,139,818
1998	4,729,816	77,863,302
1999	5,276,425	79,533,102

Source: Department of Statistic, Malaysia.
Note: * RM = Malaysian Ringgit.

Groundnut products are also imported. In 1999, the total value of groundnut products imported was about RM12 million (Table 3), compared to the export value, which was only about RM2 million.

Table 3. Malaysia's Import and Export of Groundnut Products (1995-99)
(Unit: RM)

Year	Total Import		Total Export	
	Groundnut Oil Fractions	Oil Cake	Groundnut Oil Fractions	Oil Cake
1995	6,515,358	6,796,850	48,760	19,075
1996	7,052,708	6,026,763	40,708	0
1997	8,197,143	6,589,675	64,565	112,496
1998	11,016,234	5,604,430	0	0
1999	11,697,252	243,320	2,320,661	38,722

3. ***Prospects***

Groundnut cultivation faces several constraints. First, labor shortage and high labor cost; second, if the operations are to be mechanized, then the production area has to be increased to lower the cost; and third, finding a suitable, large and contiguous land area for mechanized groundnut cultivation.

With a yield of 2.5 mt/ha. and if the farm-gate price is RM1.00-1.20/kg, groundnut production could be profitable provided the cost of production is less than RM1.00/kg (Anon, 1988). A new cultivar, MKTI – a cross between Virginia type (early bunch) and Spanish (Mat Jam) has been developed by Malaysian Agricultural Research and Development Institute (MARDI) and it has a yield potential of 3.2 mt/ha (Lee, 1991). Its yield potential and acceptance among farmers remains to be seen.

The potential and prospects for groundnut appear to be in secondary production. The growing snack food industry serves as an excellent market avenue for roasted groundnuts, both shelled or unshelled in various flavors. The other avenue is in the peanut butter production.

Soybeans

Malaysia does not produce soybeans. Its demand therefore is fully met by its import. The soybean is imported mainly for making soy milk, bean curd and related foodstuff.

The values in Table 4 show that the export and import of soybeans are increasing every year, with the value of export much lower than the import for each year.

Table 4. Value of Import and Export of Soybean (1995-99)

(Unit: RM)

Year	Export	Import
1995	8,438,047	331,381,608
1996	15,878,564	326,460,313
1997	17,450,507	433,978,076
1998	32,738,918	515,355,666
1999	60,450,715	552,655,425

Source: Department of Statistic, Malaysia.

Malaysia also imports a large amount of soybean products. In 1999, the total cost of soybean products imported was RM663 million while the export value was only RM390 million. Table 5 shows the values of export and import of soybean products for the year 1995-99.

1. ***Prospects***

Malaysia will continue to be a net importer of soybean and its products. Even though there is a potential for import substitution, production of soybeans in Malaysia will be a problem due to labor shortage and high labor cost. Therefore, soybean production in the present system is economically inviable. New cost-effective technology is needed for soybean production. Soybean can also be produced as a vegetable for human consumption. Malaysia can also opt to be a secondary producer of soybean products. The popular products processed from soybeans are soy sauce, soybean milk, soybean curd, soybean oil and soybean meal. The potential and prospects for this business appear very encouraging.

Table 5. Malaysia's Import and Export of Soybean Products (1995-99)

(Unit: RM)

Year	Total Import			Total Export		
	Soybean Oil Fractions	Flour and Meals of Soybeans	Oil Cake of Soybeans	Soybean Oil Fractions	Flour and Meals of Soybeans	Oil Cake of Soybeans
1995	192,000,242	550,680	6,054,961	68,720,819	1,021,440	259,152,115
1996	193,452,836	1,052,063	5,443,819	89,182,390	1,216,118	442,957,669
1997	254,267,735	5,201,100	5,666,915	202,818,229	2,242,597	531,768,739
1998	478,350,431	5,690,380	18,065,615	304,515,061	19,826,131	420,356,437
1999	360,559,120	4,508,232	25,662,531	228,091,171	6,167,121	418,957,040

Other Legumes

Many kinds of beans and peas belong to this group. Table 6 show the value of import and export of other beans for the year 1995 –1999.

Petai

The area planted to *petai* in Malaysia increased from 1994 to 1999. *Petai* is most popular in Malaysia and is usually planted together with other fruit trees.

Table 7 shows the area planted to *petai* (*porlia specous*) from1994 to 1998.

THE MAJOR USES OF LEGUMES IN MALAYSIA

Groundnuts

Most of the raw groundnuts (*Arachis hypogaea*) produced in Peninsular Malaysia are marketed in the form of fresh, unshelled nuts. The groundnuts are processed into dried and salted nuts and boiled – ready to be consumed. Other uses of groundnuts in Malaysia are:

a. groundnut oil – mainly used for domestic consumption. It is used in the production of margarine and peanut butter.
b. cookies such as biscuits and cakes.
c. used as basis in producing local delicacies such as *rojak* (Malaysian), *pecal*, and *satay* gravy etc.
d. used in small-scale industries (cottage industry) to make the local products such as *tempeyek* and snacks.

Soybean

Soybean (*Glycine max*) is used as a side dish served with rice, as a beverage, as a vegetable or as a cooking oil. In addition soybean can also be utilized for animal feed. More specific uses of soybean in Malaysia are:

a. soy drink – the processing of soybeans into soy drink can be done at home or on a large scale (industrial). In this process, soybeans are soaked overnight whereby the bean size will be increased. The bean is then blended and water is added. After filtering with the muslin cloth, the soy drink is boiled with sugar.

Table 6. Malaysia's Imports and Exports of Other Legumes (1995-99)

(Unit: RM)

	Peas, Dried, Shelled	Chickpeas, Dried, Shelled	Beans excluding Broad Beans and Horse Beans, Dried, Shelled	Lentils, Dried, Shelled	Broad Bean and Horse Bean, Dried, Shelled	Other Legumes, Dried, Shelled	Flour and Meal of Dried Legumes	Bran, Sharps etc. Leguminous Plants
Import								
1995	6,438,073	5,625,736	40,710,375	1,251,868	2,233,329	14,467,170	503,277	3,061,840
1996	7,192,304	5,968,172	42,382,710	1,345,617	3,148,674	14,046,034	376,205	-
1997	7,127,676	5,645,798	43,629,103	1,058,102	1,693,706	15,413,971	1,231,977	5,661
1998	6,757,203	6,826,248	57,219,853	540,400	2,228,347	14,484,439	640,519	686
1999	7,444,108	8,864,654	73,644,145	596,600	1,832,131	14,181,548	689,146	-
Export								
1995	857,636	722,791	240,845	2,000	22,594	665,180	39,710	61,985
1996	1,173,311	703,896	469,045	-	97,654	550,071	119,420	-
1997	897,808	380,864	810,643	9,434	108,657	423,610	31,279	-
1998	443,481	118,839	1,473,864	40,885	91,620	683,365	-	-
1999	525,891	29,300	3,939,530	166,595	214,773	1,974,330	25,389	-

Source: Department of Statistic, Malaysia.

Table 7. Area Planted to *Petai* (1994-98)

(Unit: ha)

	1994	1995	1996	1997	1998
Area	880	1,139	1,457	1,662	1,860

b. side dish with rice – examples include *tempe* (fermented soybean cake), *tauhu* (soybean curd), *taucu* (soybean paste) and *kicap* (soy sauce).
c. bean sprouts – popular as a local vegetable and can be produced in shortest duration (in about four days). Production is year-round and is promoted as a cottage industry. It has both domestic and export market.
d. vegetable-meat substitute – soybeans are a good source of high quality protein and therefore used as a meat substitute for vegetarians. It comes in various flavors and sold in supermarket.
e. baby formula and cookies.
f. vegetable soybeans are also produced and used in hotels for Japanese tourists. Domestic market is also expanding.

Mung Beans

Mung bean (*Vigna radiata*) or green gram is locally called *kacang hijau*. It serves as a valuable protein source for the people with rice-based diet. Traditionally, mung bean is cooked either whole or sprouted. Dry beans are usually prepared as soup, or cooked with sugar as a snack or dessert. Mung beans are also sprouted and cooked as a vegetable in combination with meat, shrimp and fish.

Vegetable Legumes

Examples are sweet peas, long beans, french beans, four-angled bean and *turi* (*Sesbania grandiflora*). They are consumed as a vegetable along with rice.

Legumes as Cover Crops

Cover crops such as *Colopogonium cearulum, Colopogonium muconoides, Centrosema pubescens* and *Pueraria javanica* are mainly grown in oil palm and rubber estates. Cover crops are important because they can prevent soil erosion, fix nitrogen and add organic matter to the soil. It is estimated that an average of 2,671 mt of cover crops valued at RM15.2 million is imported per annum into Malaysia.

Legumes as Animal Feed

Legumes are rich in protein and therefore serve as excellent animal feed. Common legumes grown in Malaysia are:

a. *petai belalang* (*Leucaena leucocephala*) – important as green forage for animals year-round with high protein content (22.9 percent). It can be dried to produce 15-20 mt/ha per year.
b. *Arachis pinto* – grown as a cover crop and also as a source of protein for animals. Gross protein content is 15.6-18.7 percent.
c. *peuro* (*Pueraria phaseoloides*) – grown as a cover crop and also as an animal feed. Its dried product per ha per year is estimated at 5-10 mt with gross protein content of 17.3 percent.

Legumes in Forestry

The tallest tree in Malaysia is a legume; *tualang* (*Koompassia excelsa*), and it is the highly priced Malaysian timber. Others are *merbau* (*Intsia palembanica*) and the edible legume forest fruit, *petai* (*Porlia specous*). *Petai* is an important legume in Malay culture.

It is often consumed raw, boiled, or cooked with other ingredients to be served with rice. Besides its multinational value, it is proven to have medicinal value such as prevention of high blood pressure and diabetes.

Other Legumes

Sweet pea (*Pisum sativum*) is also used for making bean sprouts. Bean sprouts are popular vegetable in Malaysia.

PROBLEMS/ISSUES THAT AFFECT THE PROCESSING AND UTILIZATION OF LEGUMES IN MALAYSIA

Processing Problem

1. Availability of suitable machinery for specific process.
2. Technology know-how on processing itself.
3. Handling of machinery.
4. Proper storage to extend the shelf life of the beans.
5. Packaging.
6. Insufficient amount of raw materials for continuous processing – due to import.
7. Increase in price of raw materials.
8. Labor shortage.
9. Low quality of raw material.

Utilization

1. Lack of awareness, understanding and knowledge of nutritional value of legumes for example, very few realize that soybean is an excellent source of protein.
2. Ethnic preference – eating habits of different races. For example, *taucu* from soybean is only popular among Chinese in Malaysia.
3. Believes and taboos – for example, eating groundnuts can cause stomach upset.
4. Reluctance to try a new kind of food or to change eating habits.
5. Supply of product/raw material is only concentrated in urban areas. Not always available in rural areas due to lack of distributor; low demand for legume products in rural areas; for example, soybean oil.
6. High price of the products.

PROCESSING OF FOOD LEGUMES

Processing of different legume products are shown in Figures 1-5.

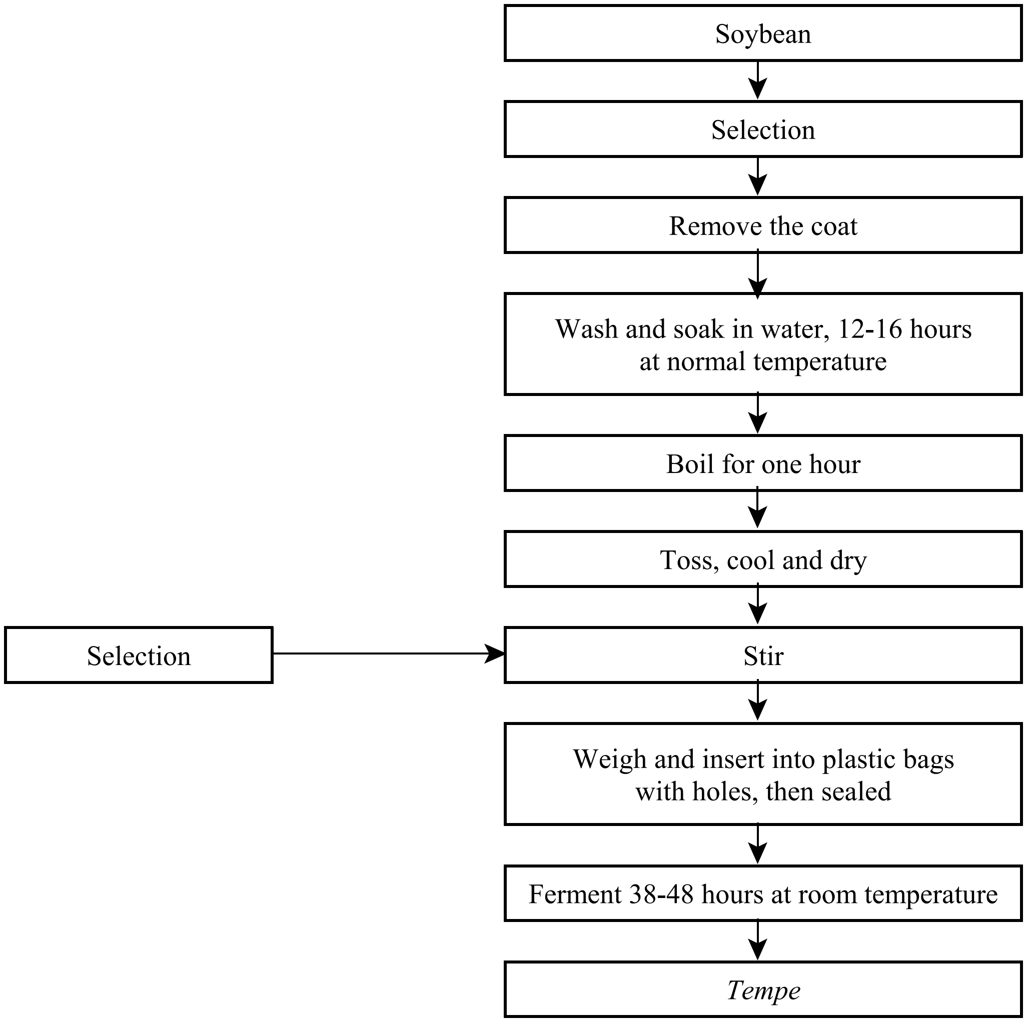


Figure 1. Production of *Tempe* (fermented soybean cake)

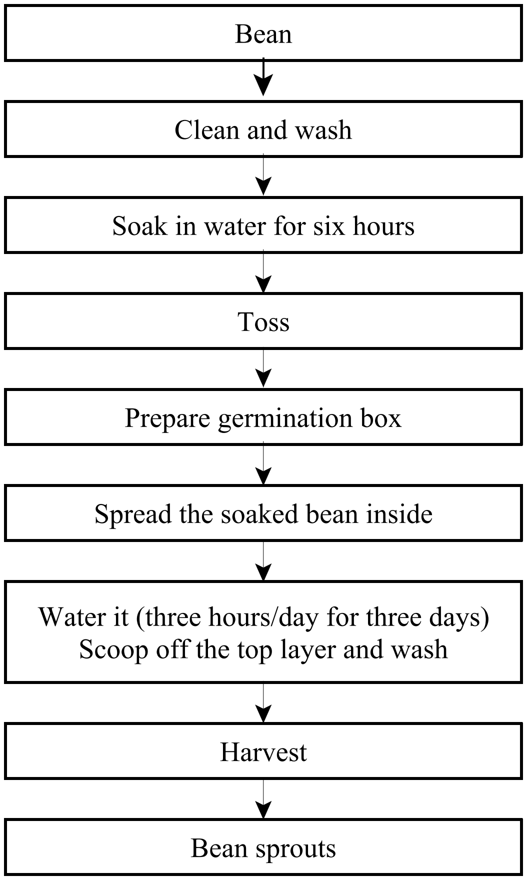


Figure 2. Processing of Bean Sprouts

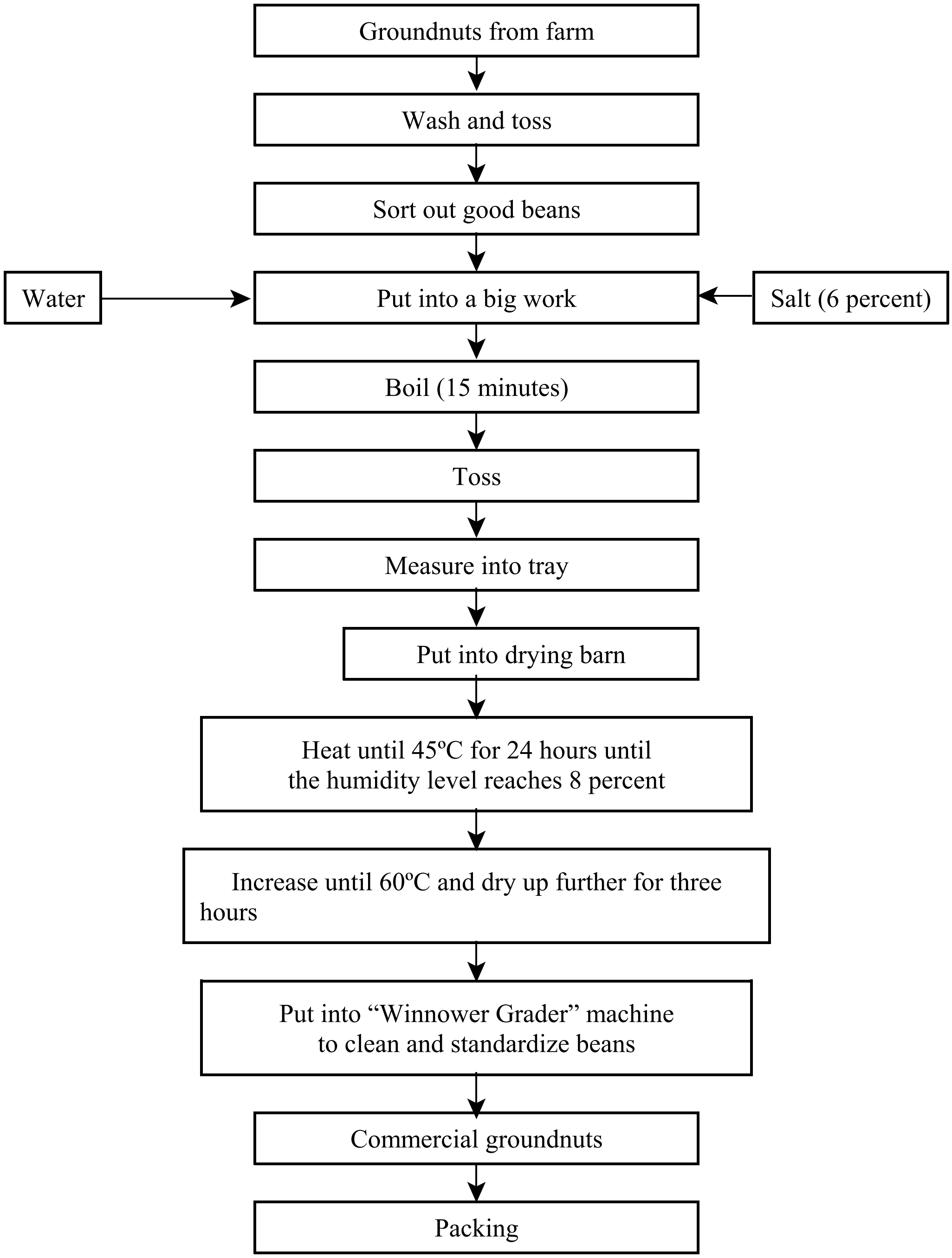


Figure 3. Processing of *Menglembu* Groundnuts

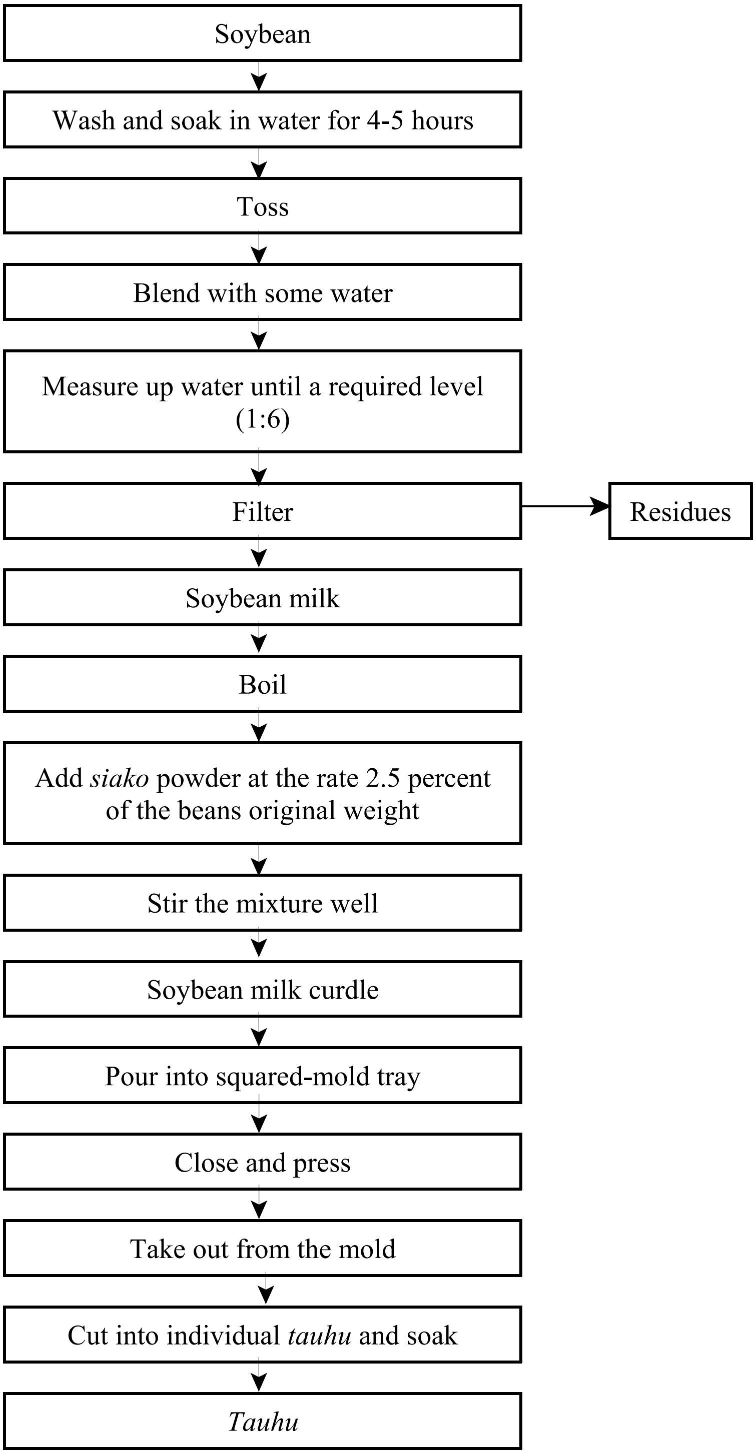


Figure 4. Processing of *Tauhu* (soybean cake)

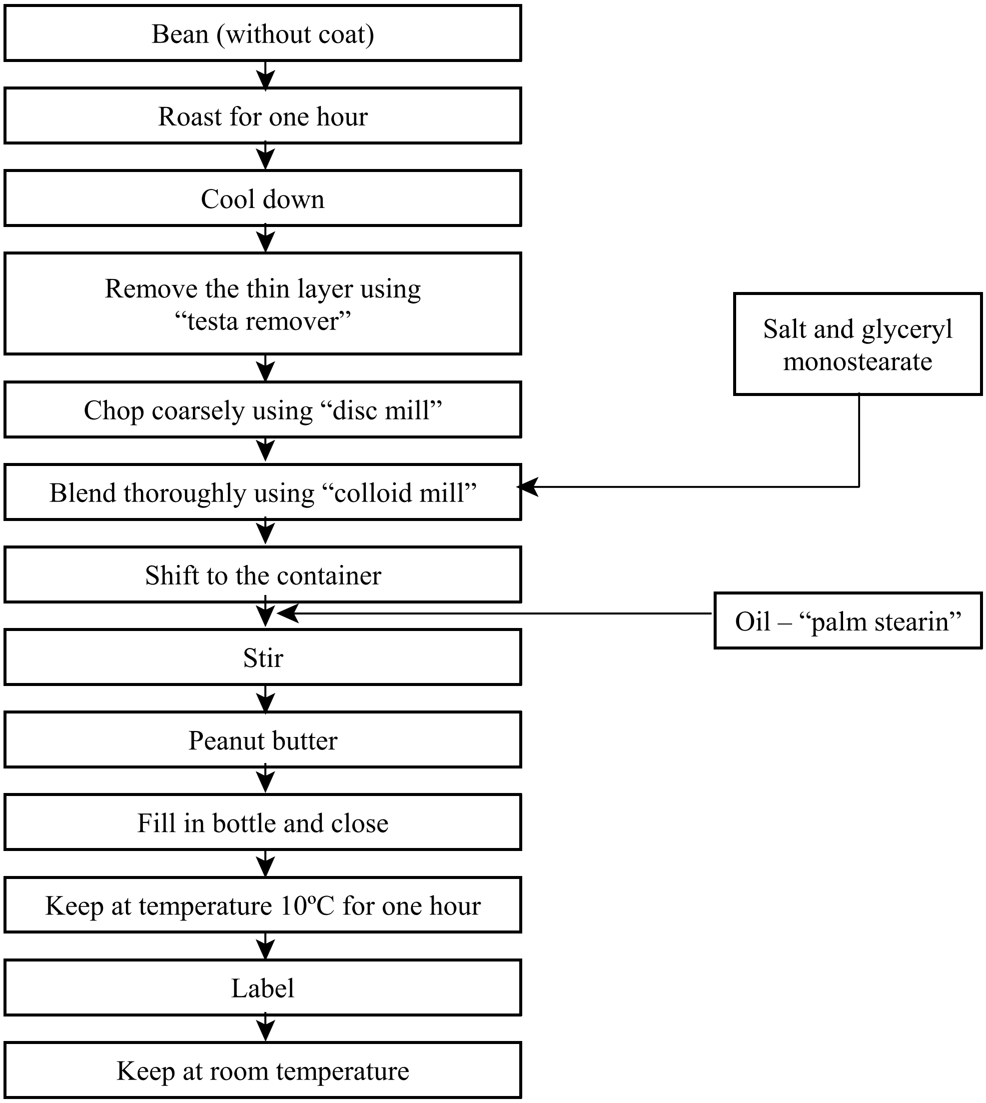


Figure 5. Processing of Peanut Butter

PRESENT MAJOR INNOVATIONS IN TRADITIONAL AND MODERN PROCESSING AND UTILIZATION

From manual, mechanical processing of soybean drink and '*taufu-fa*' has been introduced to hasten and enhance production. Grinding and filtration are done by the same machines.

For *tempe*, the traditional way to break the bean before fermentation process is by using 'Wooden Ponder'. The same 'Wooden Ponder' has been used for grinding mung bean to make mung bean flour. Mung bean flour is normally used for making traditional cakes. Now, most *tempe* producers are using stone grinder/miller to break the soybean or to grind the mung bean. Stone grinder is one of the most popular equipment used by the small producer. Stone grinder has been used for other beans, like lentils (dhall), black bean, red bean and groundnuts – either to make fine flour or to crush the bean.

For heat treatment (heating process), the small producers still using gas burner to boil the soybean extract. For medium-scale producers, normally they use steam injector to boil the extract, which is much faster.

For *taufu* or *taufu-fa*, curdling process, *siako* is replaced by GDL (Gluco Delta Lactone) by most producers.

FUTURE ROLES OF LEGUMES IN FOOD PRODUCTION AND AGRICULTURAL DEVELOPMENT

In the future, legumes play an important role in food production due to its contribution to protein nutrition. Legumes can be a substitute for animal protein. Area planted to vegetable legumes such as French beans, long beans, groundnuts and soybeans may expand. To reduce the import bill, some of the legumes will be grown extensively. Soybeans can be processed as animal feed. Legumes will continue to serve as cover crops in rubber and oil palm estates.

Genetically modified organism (GMO) plants have not been introduced to Malaysia due to opposition and concern from consumers.

REFERENCES

Anon, 1988.

Lee, 1991.

9. MONGOLIA

Enkhtaivan Gombosuren
Head
Department of Food Processing and Services
Institute of Food Technology
Mongolian Technical University
Ulaanbaatar

INTRODUCTION

Mongolia lies in the northern part of the Central Asia plateau, and completely landlocked between the Russian Federation and China.

The climate is defined as continental semi-arid with exceptionally sharp variation in temperature not only during the seasons but also in the course of a day. Unfavorable climatic conditions severely affect the food system.

About 80 percent of the land is suitable for agriculture, especially for animal husbandry, while 10 percent is forest, mostly on steep slope and only very little arable land. It is constrained by a short 90-day growing season, with sharp temperature fluctuations, that can cause severe losses.

Mongolia is one of the most sparsely populated countries in the world. The 1999 population was 2.4 million with an average growth rate of 2.5 percent (1985-91) down to 1.4 percent in 1997.

Mongolia has more than 32 million heads of animals. About 76 percent of the agricultural outputs, and 48 percent of the GDP are produced by animal-husbandry sector, and 41 percent of the country's manpower is in the agricultural area.

The national staple food is relatively simple with meat and meat products as well as milk and dairy products. But, according to a survey by the National Research Center, the Mongolian diet is dominated by meat and flour products. Between 1993-96, 56 percent of the total average daily energy intake was from flour products, 15.4 percent from meat and meat products, 15.2 percent from butter, 7.7 percent from milk and milk products, 1.7 percent from rice, 1.5 percent from potatoes, and 1.3 percent from sugar.

GROWTH IN PRODUCTION AND CONSUMPTION OF LEGUMES IN MONGOLIA

According to Chinese written records, legumes, especially soybeans were cultivated as early as 2800 B.C. These documents give detailed information on cultivation, strains, harvesting, preservation, and use of soybeans together with other major crops such as wheat, barley, and millet. The place of origin is usually given as East Asia. But it seems likely that primitive Chinese discovered that the beans of wild soy plants were edible and gradually improved them into a cultivated crop through strain selection.

The Mongolians have had a long tradition of herding the cattle, hunting the wild animals and cultivating crops in the steppes since ancient times. There are many historical evidences that prove our ancestors, the Khunnu, would cultivate crops. For instance, from foundries from the Khunnu graves, burials and ruins agricultural tools, were revealed by anthropologists.

In chapter 152 of "*Mongolian Secret History*" it was noted that "… The Mongolians living near the Selenge river banks were breeding agriculture …" They would cultivate mainly grains, buckwheat, barley, black beans, green beans and harvest effectively, and cook various delicious meals based on the careful studies of each one.

Legumes are cultivated differently from place to place and used as food for cattle. Soybean, green beans, and black beans were very popular and oil was also extracted from them. Besides, they were used as fillers in cookies, flour and concentrate. The Mongolians used soybeans and green beans for nutrition and medication. The significance of them was mentioned in the ancient books and sutras. In "*Genuine History of Meals and Drinks*", soybeans were noted as delicious and treatment tools for cancers and other diseases. Green beans were considered to be delicious cold meals and as vessel and vein penetrators. Soybeans were considered to make bones bigger and were fed to young cattle. To use them as fodder they would grind them and make flour or mix them with wheat and other crops.

During the socialist period with centrally planned economy legumes were not used for food, instead they were used for cattle as fodder. Fodder protein deficiency can be solved properly by cultivating the legume crops. In 1970-80 agriculture and veterinary scientists conducted a number of scientific researches on agro-technics of legumes and cultivation of soybeans. Many resolutions and decisions were proved to intensify the bean cultivation, and increase the area for soybean.

The convenient territory for cultivating soybean seeds is the Khalkh River land. In this area from 1970 soybeans were cultivated in 63-930 ha, the yield was 300-450 kg/ha. According to the experiments, a soybean variety, Salut-216 originated from Amur region of Russia was the best and it gave 1,980 kg/ha.

The reasons for the low yield of soybeans are:

1. Less precipitation, deficiency of moisture (humidity), and lack of proper irrigation system.
2. Extremely continental climate (semi-arid), soybean sprouts require more heat and they cannot stand the spring and fall cold.
3. Lack of weed control methods.
4. Improper harvesting results in 30 percent or 150-200 kg/ha loss of seeds.

In 1983, the Ministry of Agriculture planned to cultivate soybeans in more than 10 prefectures as Govi-Altai, Khovd, Selenge, Dornogovi and provided guidelines for cultivation and harvest. For this purpose about 40 mt of seeds were imported from abroad. Generally, soybeans are used in many different forms as forage crops. On the other hand, in soybean *Rhizobium* fixes the atmospheric nitrogen and it improves the soil structure and fertility.

In 1973, the resolution was approved by the Cabinet of Ministers, Mongolia (MPR), and it was on "Possession of the Khom Strait of Zavkhan Prefecture". During that time, a project of 32 million Tugriks (Mongolian money) (US$3 million) was appropriated to address the problems of cultivating soybeans and using them as food and fodder. As a result, during the project implementation, the malnourished children gained 2 kg weight after they consumed soy milk for a month.

Since the country shifted from the planned economy to a free market system it has faced a lot of difficulties, and there has not been any progress in soybean cultivation, production and consumption since then.

Mongolian Government gives significant importance in increasing the production of plant products. In the program of Mongolian Government it is stated "… give the great opportunities to the research study on composition, physical, chemical and technological characteristics of different types of crops, development of new technology on the research basis and production of eco-friendly, foods to satisfy customer's demands …"

Acclimatization of rye has become very important for Mongolia. New production technology is urgently needed so that assorted new bakeries can be developed using small-size flour mills. For this purpose, the effective and rationale use of grains like rye, barley, buckwheat etc. (except wheat) must be reconsidered.

In our situation, conducting research to develop products and introducing the results (outputs) into practice is essential.

The technology and the methods to enrich meat and dairy products using soybean proteins have become very popular in highly developed countries.

Protein in soybeans is 30-40 percent; in meat, 18-22 percent; and in fish, 17-20 percent. It is obvious that soybeans have more protein than meat.

Outcomes of the Study

- More than 10 products (recipes) and technologies will be created and introduced into practice using the new food crop.
- Rye-processing and flour-producing technologies will be developed on the basis of research on physical, chemical, and technological characteristics and composition of rye flour and rye acclimatized in the Mongolian soil.
- The recipes and technology for bread production will be improved.
- Technical instructions and standards for various products will be developed.
- At Darkhan Agricultural Institute, research to develop new product using wheat, millet and processed rice will be established.
- Technologies and recipes for making and preserving flour from soybeans, green beans and peas will be developed.
- Technologies and recipes of soybean protein concentrates and oil will be developed with the help of small factories.
- New advanced technology to enrich meat and dairy products using vegetable oil (plant oil) will be developed. The technology to produce soy milk and dairy products will be developed.

In the above mentioned directives, a project on small food processing factory will be developed. Trainings and conferences will be conducted according to the Law on Technology Transfer in Mongolia.

The outcomes of the above mentioned measures will enable us to process new food crops and to compete in the market, produce competitive products and thereby, the people will be provided with opportunities to consume domestic quality and reliable food.

NEW ADVANTAGES AND ADVANCES OF THE PROJECT

- In recent years, private sector and the agriculture sector have cultivated a lot of various beans, ryes, wheats, soybeans and peas but the problems of using them scientifically as food have not been solved.
- To remedy the situation using scientists from domestic and international sources technology based factories will be established to produce quality food products.
- Nutritious food product technology will be developed and introduced using small factories.
- Ways of heat processing, drying, pressing and purifying soybeans and peas will be developed. Research will be focus on the preservation and protection of the raw materials and the ready made products. Physical, chemical and microbiological properties will also be studied.
- New recipes and technology will be developed. Based on their specific characteristics and chemical composition, new crops such as rye, and oat will be used for food production. New outcome of the project will be licensed according to the Patent Law.

Economic, Scientific and Social Significance of the Project

- On the basis of the strategic concepts of the scientific organizations plant originated raw materials will be studied within the government program of Mongolia.
- The traditional technology will be combined with scientific and eco-friendly technologies.
- Competitive and eco-friendly products will be produced.
- Advanced technologies will be introduced into practice.
- Legumes will be preserved properly within the "Green Revolution Program".

PROCESSING AND UTILIZATION OF LEGUMES

Food and Agriculture Organization (FAO) of the United Nations and UNICEF have frequently emphasized that production and food use of soybeans in the world should be promoted not only in oriental countries, but also in other countries all over the world since it is one of the most important protein source.

When sufficient soybeans are produced to play an important role in the diets of Mongolians, making them palatable and attractive presents some problems. From various trials in the past several decades, several avenues were explored. One is to increase protein content and nutritional value by adding soybeans as traditional local diets. Another method is to employ soybeans or products made from them as traditional foods. The next method is to eat foods made directly from soybeans as a substitute, attempts to simulate other foods.

Soy Milk Technology

In 1980-1982, as a result of scientific research conducted at the Veterinary Institute "Soymilk Technology" was experimented and developed.

The technology consists of the following stages: checking soybean seeds; cleaning; soaking; drying; pressing; dissolving; boiling; and draining.

1. ***Checking Soybean Seeds***

TN-51-451-71 is strictly followed. The cleaned seeds should be 95 percent pure, the moisture is 14 percent. Damaged seeds are not used for 1 kg of seeds, other seeds could be 25, weeds no more than 15 pieces.

2. ***Cleaning***

The seeds are cleaned by OBP-20, OS-4, 5 type cleaning machine and the dust is removed and cleaned. Small-size seeds – smaller than 3 × 15 mm, can be drained manually.

3. ***Soaking***

After cleaning, seeds are washed 1-2 times. The soybean seeds are put into a bucket and soaked in 25-30ºC water for 16-18 hours. To soak the seeds, 3 liters of water are necessary for 1 kg of seeds. The level of water must be 3-4 cm higher than the seed surface.

4. ***Drying***

After that seeds are sifted and spread over the flat boards and dried for 1-1.5 hours, it helps to remove seed coat easily.

5. ***Pressing***

To press seeds tools such as meat pressing machines can be used.

6. ***Dissolving***

To extract thick and fat milk like cow's milk pressed seeds are dissolved in water 10:1 (10 liters of water:1kg of seeds). Depending on the thickness, the amount of water can vary.

7. ***Boiling***

The dissolved liquid is boiled for 10-15 minutes. The milk-like product will be ready when it is boiled and the odor and strange taste disappear.

8. ***Draining***

The boiled liquid is sifted at 70ºC to a bucket and the remains are washed and sifted with hot water. As the liquid becomes similar to cow's milk, it is called "soy milk". One kg of soybeans yields 8-10 liters of milk.

According to the research, soy milk contains 4.1 percent of protein, 3.5 percent of fat, and 3.2 percent of carbohydrates. Soy milk can be broadly used for tea, cheese, yogurt, curds and dried milk.

Soy Cheese Technology

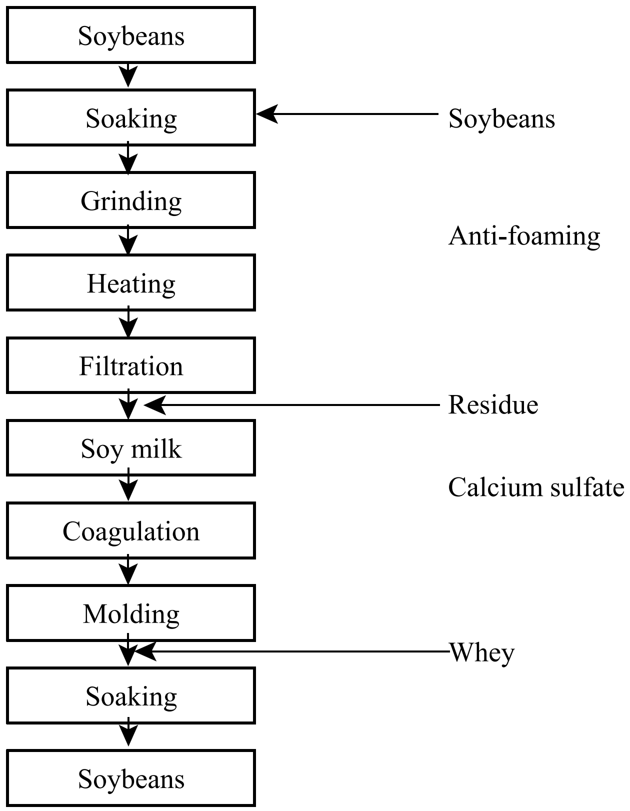
Soy milk cheese is one of the important products that contains most protein and fat. Dried cheese has 55 percent of protein and 28 percent of fat.

In order to make cheese, milk is extracted from soybean seeds. Making cheese consists of the following stages: preparing coagulating agent; cooling the milk at a certain temperature; shifting the curd; pressing; and cutting.

Preparation Stage

Calcium sulfate is used to coagulate the milk. The amount of calcium sulfate depends on the amount of milk. For example, for 10-15 liters of milk 4-5 liters of calcium sulfate is used. To prepare calcium sulfate 4-5 liters of fresh water are poured into an enamel saucepan and calcium sulfate is added 3-4 times by a table spoon, then stirred well and let it stand. In this way, calcium sulfate is used to coagulate the milk. Whey or a rennin ferment can also be used as the coagulating agent.

Milk is boiled, drained and then cooled till 50ºC. While cooling, the film is removed 2-3 times. This helps soy milk to coagulate well.



Flow Chart of Cheese Production

1. ***Coagulation***

For 10 liters of milk, cooled at a certain temperature, two-third of the calcium sulfate liquid is slowly poured along the saucepan wall. After 2-3 minutes, it is stirred slightly. If milk is not fully coagulated, the rest of the prepared liquid is added slowly bit by bit. In this way, soybean milk is coagulated and the coagulated casein is formed, while the liquid is separated above the curd.

2. ***Draining***

The curd is drained (sifted) and the liquid is extracted. The curd is taken away and some salt is added to improve the taste.

3. ***Pressing and Cutting***

The curd wrapped in cotton (40 × 60 × 10 cm) is put in a box without bottom and pressed with the cover that could fit inside the box. Five to 10 kg weight will be placed on the cover and the cheese is ready in 3-4 hours. Two kg cheese is made from 1 kg soybean seeds with 55 percent moisture. Cheese yield can be different depending on the soybean variety and other factors.

4. ***Preserving in Water***

The ready-made cheese is kept in cold water and preserved in a cool place. Heating and freezing can damage the quality of cheese. Where there is no refrigerator cheese can be preserved only for three days.

Cheese can also be made using dry method.

Cheese is used for food and also added to vegetable soup or as a main course in meals. Cheese can be prepared in workshops, restaurants, canteens, coffee shops and homes.

Fodder Production Technology from Soybean

Soybean has an important role for increasing production of protein and strengthening the fodder supply.

The seeds of soybeans, as well as other parts of the plant are rich in protein.

Soybean is a useful fodder for all domestic animals when it is in the form of green fodder, grass, grass flour, sediment, milk fodder and so on. Good result was shown during the experiment to feed weak animals. Based on the results of the research and experiment a new technology to prepare fodder, which substitutes milk, using soybean has been developed. The following steps should be taken during the processing: checking the seed; cleaning; milling and powdering; mixing and enriching; and packing and transporting.

1. ***Checking the Seed***

Soybean seeds can be used to prepare milk fodder. Receipt of seed should be conducted according to the standard TN-51-451-71. The purity should be at least 95 percent and the moisture should be 14 percent. One kg of seed may contain 10-25 seed of other plants, 5-15 seeds of waste plants but no weed seed is permitted.

2. ***Cleaning***

Winnowing machines such as OVP-20 and OS-4, 5 should be used to clean the seeds from chaff. The small size of seeds can be winnowed using the net not exceeding diameters of 3 × 15 mm.

3. ***Milling and Powdering***

Winnowed seeds are powdered by machines BDM and KDU-2. During the process, the net with the diameter of 1.5 – 2 mm is installed in the machine and the size of soybean in the box should be regulated gradually. As bean flour contains huge amount of protein and oil, the powdering process should be repeated one or two times. Also this kind of flour can be used as fodder for offspring.

4. ***Mixing and Enriching***

Fifteen kg of wheat flour, 5 kg of glucose or sugar, 2.5 kg of salt and organic substances will be added for each 100 kg of prepared fodder. 20M-1 machine is used to prepare fodder under the condition of farm and agricultural station. A piece of cloth is placed on the ground and the ingredients are mixed with hand. The mixing process should be done. When mixing the fodder with water, 20-25 gm fish oil or marmot oil, 10-25 gm Terramycin can be used.

5. ***Packing and Storing***

Prepared fodder should be packed in a paper bag not exceeding 15-20 kg and in sacks not exceeding 25-30 kg. A label including manufacturer's name, date, weight and supervisor code is glued on the bag or sacks.

6. ***Storing and Transporting***

Powdered fodder should be stored in a warehouse with temperature not exceeding 10ºC on the shelves at a distance of 10-15 cm from each other. During transportation water, dampness and dust should be avoided.

10. NEPAL

Hari D. Lekhak
Associate Professor
Central Department of Botany
Tribhuvan University
Kathmandu

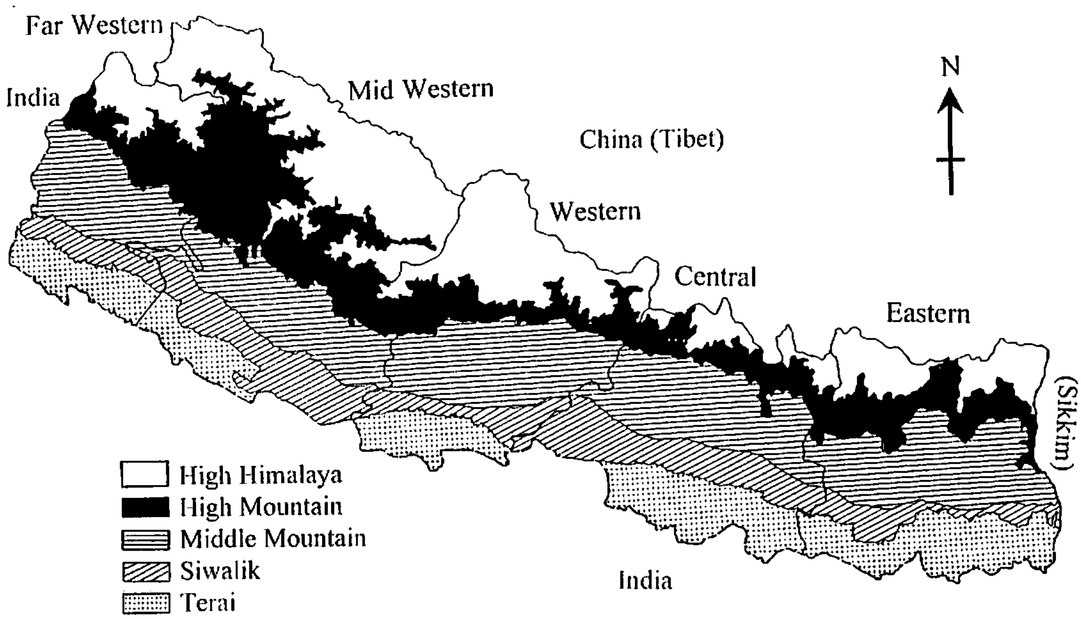


Figure 1. Physiographical Regions of Nepal

Legumes of Nepal

Leguminosae or *Fabaceae* is one of the three largest and important families of the flowering plants in Nepal and it comprises about 650 genera and 18,000 species (almost 8 percent of all vascular plants). This family shows a great range of diversity, existing as trees, shrubs, herbs and climbers. Of the three sub-families *Mimosoideae* and *Caesalpinoideae* are tropical whereas *Papilionoideae* is distributed widely from tropics to alpine.

The legumes are economically important as a source of food, fodder, green manure, fiber, medicine and ornamental plants. They are regarded most for their ability to fix free atmospheric nitrogen in their root nodule through symbiosis.

Recent report on the legumes of Nepal describes 97 genera including 19 introduced genera with 350 species including 269 native and 46 introduced and 35 uncertain species (Shrestha, 1999). *Papilionoideae* is the largest sub-family with 80 genera and 297 species followed by *Mimosoideae* with nine genera and 25 species and *Caesalpinoideae* has eight genera and 26 species. Following 16 legumes taxa are found exclusively in Nepal. Most of them are distributed in the subalpine and alpine zones.

1. *Astragalus nakaoi* Kitam
2. *Astragalus stipulatus* var. *phulchokiensis* H. Ohashi
3. *Caragana brevispina* sub sp. *tenzingii* Vass
4. *Caragana campunulata* Vass
5. *Colutea multiflora* Ali
6. *Crotalaria kanaii* H. Ohashi
7. *Indigofera trifoliata* var. *nepalensis* H. Ohashi
8. *Millettia nepalensis* R. N. Parker
9. *Oxytropis arenae-ripariae* Vass
10. *Oxytropis fasciculiflorum* Vass
11. *Oxytropis graminetorum* Vass
12. *Oxytropis morenarum* Vass
13. *Oxytropis nepalensis* Vass
14. *Oxytropis torrentium* Vass
15. *Oxytropis williamsii* Vass
16. *Sophora moorcroftiana* var. *nepalensis* Kitam

Introduced Species of Legumes

Many species of legumes of economic importance have been introduced in Nepal which are mostly cultivated in Terai or Mid Hills for firewood, fodder, grain legume, vegetable, fruit, fiber and ornamental purposes. About 16 genera of exotic legumes are monotypic (with only one species). Following are the important introduced species.

Table 1. Introduced Legume Species of Nepal

Scientific Name	Common Name	Use*
Vitna mungo (L.) Hepper	Black gram	F
Vitna radiata (L.) R. Wilczek	Green gram	F
Vigna umbellata (Thunb.) Ohwi and Ohashi	Rice bean	F
Vigna unguiculata (L.) Walp.	Cowpea	F
Acacia decurrens Willd.	Silver wattle	O
Acacia fanesiana (L.) Willd.	Sweet acacia	O
Acacia melanoxylon R. Br.	Black wood acacia	O
Erythrina blakei Hort.	Coral tree	O
Erythrina crista-galli L.	Cockspur	O
Erythrina variegata L.	Indian coral tree	Fd
Phaseolus coccineus L.	Runner bean	F
Phaseolus lanatus L.	Lima bean	F
Phaseolus vulgaris L.	Garden bean	F
Sesbania bispinosa (Jacq.) W. F. Wight		Fd
Sesbania grandiflora (L.) Poir	Agasthi sesbania	Fd
Sesbania sesban (L.) Merr		Fd

... To be continued

Continuation

Scientific Name	Common Name	Use*
Arachis hypogaea (L.)	Peanut	F
Canavalia ensiformis (L.) Dc.	Sword bean	F
Clitoria ternetea L.	Butterfly pea	F
Cyamopsis tetragonoloba (L.) Tanbert.	Cluster bean	Fd
Delonix regia (Hook.) Raf.	Peacock flower	O
Glycine max (L.) Merr	Soybean	F
Lablab purpureus (L.) Sweet	Lab-lab bean	F
Lens culinaris Medikus	Lentil	F
Leucaena leucocephala (Lam.) D. Wit	Ipil-ipil	Fd
Lupinus pubescens Benth.		O
Macrotyloma uniflorum (Lam.) Verdc.	Horse gram	F
Pisum sativum L.	Garden pea	F
Pithecollabium bigeminum (L.) C. Maritus	Madras thorn	O
Stylosanthes guinensis (Abul.) Sw.		F
Tamarindus indica L.	Tamarind	O
Wisteria sinensis (Sims.) D.C.	Chinese wisteria	M
Mimosa pudica	Sensitive plant	M
Senna tora	Senna	M
Trifolium repens L.	White clover	Fd

Note: * F = food; Fd = fodder; O = ornamental; and M = medicinal.

Uncertain or Doubtful Species

The taxonomic identity of the following legume species in Nepal are uncertain due to lack of supporting evidence:

Four species each of *Astragalus* and *Crotalaria*
Three species each of *Caragana* and *Indigofera*
Two species of *Cajanus*

Economic Importance

Through screening 140 legume species in Nepal have been found to have potential economic importance (Shrestha, 1999). The number of species used for various purposes are as follows: food, 18 species of grain legumes or pulses; fodder, 28 species; vegetables and fruits, 24 species; green manure, 16 species; fiber, nine species; medicine, 63 species; ornamental, 14 species; timber, 20 species; miscellaneous use, 18 species; and oilseed, six species.

Grain Legumes

Grain legumes are significant in Nepalese agricultural economy. They are important as food and also for restoring the soil fertility through N fixation. Grain legume crops can be grown even in N deficient marginal lands. More than a dozen leguminous crops are cultivated in Terai as well as hilly regions throughout the year. Grain legumes have adjusted well to mixed/inter, sequential or relay cropping system.

Grain legumes rank fourth in terms of area and production after rice, maize, and wheat. Grain legumes cover 10.5 percent of the total cultivated area of Nepal. They are cultivated in 308,008 ha with a total production of 228,840 mt and an average productivity of 734 kg/ha (Ministry of Agriculture and Cooperatives, 1999). The major legume crops of Nepal are given in Table 2.

Table 2. Important Legume Crops of Nepal

Scientific Name	Common Name	Vernacular
Lens culinaris Medikus	Lentil	Masuro
Cicer arientinum L.	Chickpea	Chana
Lathyrus sativus L.	Grass pea	Khesari
Cajanus cajan (L.) Millsp.	Pigeon pea	Rahar
Vigna mungo (L.) Hepper	Black gram	Mas
Vigna unguiculata (L.) Walp	Cowpea	Bodi
Vigna radiata (L.) R. Wilczek	Mung bean	Mungi
Vitna umbellata (Thumb) Ohwi and Ohashi	Rice bean	Mashyang
Macrotyloma uniflorum (Lam.) Verdc.	Horse gram	Gahat
Glycine max (L.) Merr.	Soybean	Bhatmas
Phaseolus vulgaris L.	Garden bean	Simi
Phaseolus lunatus L.	Lima bean	Ghyu simi
Lablab purpureus L. Sweet	Bean	Tate simi
Vicia faba L. var. equina	Hose bean	Sano bakula
Vicia faba L. var. faba	Broad bean	Thulo bakula
Vicia angustifolia L.	Black pod vetch	Kutuli Kosa
Pisum sativum L.	Garden pea	Thulo Kerau
Pisum sativum L. var. arvense	Field pea	Sano Kerau

Distribution of lentil, pigeon pea, black gram, soybean, chickpea, mung bean, phaseolus beans and grass pea in Nepal is based on agro-ecological domain (Table 3).

Table 3. Distribution of Legume Crops in Different Agro-ecological Zones

Agro-ecological Zone	Crops
Terai	Lentil, pigeon pea, chickpea, horse gram, grass pea, mung bean, cowpea, phaseolus bean
Mid Hills	Black gram, soybean, horse gram, lentil, rice bean
High Hills	Rice bean, phaseolus bean, field pea

Source: Nepal Agriculture Research Council, 2000.

Lentil, chickpea and grass pea are cultivated as winter crops and the rest as summer crops. Legumes in order of importance and production in Nepal are: lentil, chickpea, grass pea, black gram, pigeon pea and soybean. However, HMG Nepal has imposed a ban on the cultivation and marketing of grass pea since 1991-92 owing to the presence of a neurotoxin ODAP [3-(N-Oxayl)-L-2, 3 diaminopropionic acid] that causes neurological disorder called 'lathyrism' in human beings on its prolonged consumption.

The consumption of grain legumes in Nepal is about 10 kg/caput/annum which is very low as compared to the standard FAO recommendation of 18 kg protein/caput/annum (50 gm protein/caput/day).

Area, production and productivity of major grain legume crops in Nepal from 1988/89 to 1997/98 are presented in Table 4.

Table 4. Area, Production and Productivity of Different Grain Legumes in Nepal Over Years, 1988/89-1997/98

(Unit: Area = ha; production = mt; and productivity = kg/ha)

Crops		1988/89	1997/98	Percent Increase
Lentil	Area	120,360	162,390	+34.92
	Production	74,360	113,520	+52.66
	Yield	618	699	+13.11
Chickpea	Area	28,830	19,280	-33.13
	Production	17,090	13,512	-20.94
	Yield	593	701	+18.21
Pigeon pea	Area	17,920	26,020	+45.20
	Production	12,260	18,978	+54.80
	Yield	684	729	+6.58
Black gram	Area	17,730	27,030	+52.45
	Production	10,070	17,674	+75.51
	Yield	568	654	+15.14
Grass pea	Area	38,580	26,344	-31.72
	Production	19,810	14,303	-27.80
	Yield	513	543	+5.85
Horse gram	Area	8,770	10,309	+17.55
	Production	4,350	5,626	+29.33
	Yield	496	546	+10.08
Soybean	Area	20,710	21,245	+2.58
	Production	11,680	15,533	+32.99
	Yield	564	731	+29.61
Others*	Area	12,830	17,952	+39.92
	Production	7,060	12,104	+71.44
	Yield	550	674	+22.55
Total area		265,730	310,570	+16.87
Production		156,680	211,250	+34.83
Yield		590	680	+15.25

Source: Nepal Agriculture Research Council, 2000.

Note: * Field pea, cowpea, broad bean, phaseolus bean, rice bean, mung bean, etc.

Distribution of area and production of major grain legumes are shown in Figures 2 and 3, respectively.

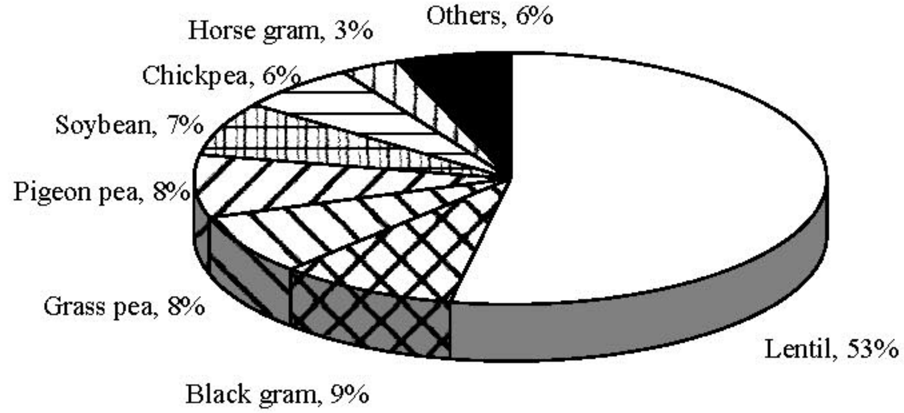


Figure 2. Distribution of Acreage Under Different Grain Legumes in Nepal, 1997/98

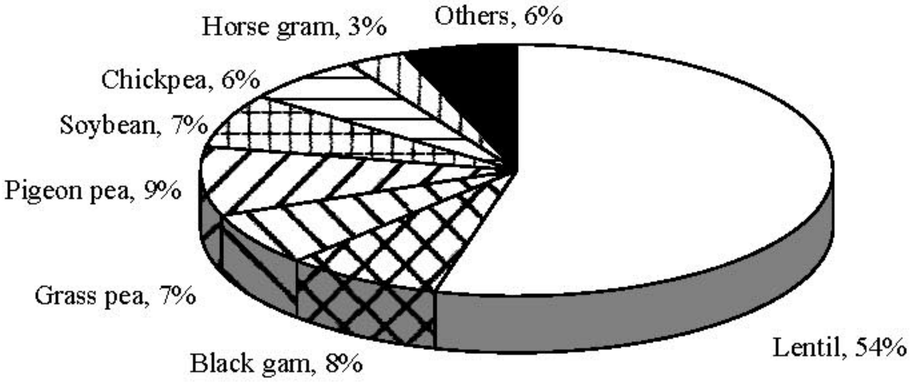


Figure 3. Distribution of Grain Legumes Production in Nepal, 1997/98

Utilization
of Legumes in Nepal

Green pods and seeds of many legumes are used as vegetables. Dry seeds are used as 'dal' or for processing. Since most of the grain legumes are used for the same purpose, the general as well as specific use of some major legumes are described below.

1. ***Lentil***

(a) Being more nutritious and easily digestible it is consumed as 'dal' (split or whole, husked or de-husked seeds are cooked in boiling water, added with spices and salt, soup is often fried with animal or plant fat) and consumed with rice or chapati.

(b) Young pods are used as green vegetable.

(c) *Dalmoth* – A snack prepared from water-soaked germinated seeds which are fried in vegetable oil, spiced and salted. Either sold open or is packed with preservatives for marketing.

(d) Straw used as feed for cattle.
(e) It is a major export commodity.

2. ***Cowpea***

(a) Green pods are used as vegetable.
(b) Dry seeds are consumed mixed with other vegetables as a curry.
(c) Water-soaked seeds fried in cooking oil, spiced with salt and consumed as snacks.

3. ***Chickpea***

(a) Green seeds are used as vegetable.
(b) Dry seeds are eaten raw after soaked in water for sometime. It is also boiled, roasted or fried, spiced and salted and consumed as a snack.
(c) Split seeds are used for the preparation of 'dal' or 'dalmoth'.
(d) Flour is called '*beshan*' and is used for the preparation of snacks called *pakauda, bari*, sweets etc.
(e) *Beshan* is added to wheat, maize or other cereal flours as a protein supplement.

4. ***Black Gram***

(a) It is popular in Nepalese hills and used as 'dal' (seeds whole or split, husked or dehusked).
(b) Flour is used to make '*papad*' (a thin dry papery sheet prepared after adding spices and salt) which are packed and marketed. They are deep fried in oil.
(c) "*Masyora*' (flour balls are prepared after mixing with a paste of rhizomes of coco-yam (*Colocasia esculenta*) and giant taro (*Alocasia indicum*) mixed with spices and salt), dried balls are packed and kept for future use or marketed.
(d) Water-soaked seeds are ground and the paste is mixed with spices and salt and patties from them are fried in oil. The snack is called '*bara*'.
(e) Sprouted seeds are consumed as a vegetable or used in soup.
(f) Straw is fed to the cattle.

5. ***Broad Bean***

(a) Green pods are usually used as vegetable.
(b) Roasted seeds are used as snacks.
(c) Dried seeds are used both as vegetable and 'dal'.
(d) Broad bean has two varieties in Nepal.
   (i) *Vicia faba* L. var. *faba* (broad bean): large seeds
   (ii) *Vicia faba* L. var. *equina* (horse bean): small- or medium-sized seeds. This is grown in Terai as a pulse (dal) crop.
(e) Seeds of small variety are fed to the cattle, especially horse.
   It is well known that disease 'favism' (acute anemic condition) is caused by uncooked or partially cooked broadbeans or from inhaling pollen of this plant.
(f) Dairy cattle and poultry feed and fodder.
(g) Rich in edible oil.

6. ***Mung Bean***

(a) Dry seeds are used as 'dal' (split or whole, husked or de-hushed).
(b) De-husked and split seeds are used for making '*dalmoth*'.
(c) Flour is used for making '*papad*', and other snacks like *pakauoda*, porridge, etc.
(d) Being nutritious and easily digestible its soup and dal is recommended to sick people.

7. ***Pigeon Pea***

(a) It is considered as an important tasty dal.
(b) Green seeds are used as vegetable.

(c) Split seeds are used for making *dalmoth*.
(d) Dry stem are used for making baskets meant for construction work.
(e) Dry stems are used as firewood.

8. ***Soybean***

Soybean has recently attained importance as a food and industrial crop based on the biochemical composition of its seed.

(a) Green seeds are used as vegetable.
(b) Green pods boiled with little water are very much liked by village people as snacks (green beans from shelled boiled pod are delicious).
(c) Fried seeds make a favorite snack either alone or mixed with pop corn.
(d) Water-soaked seeds are fried with vegetable oil, and spices and salt are added to make a delicious snack.
(e) Soybean seeds are partially heated and oil is extracted. This oil is extensively used for edible and industrial purposes.
(f) Soy milk is of particular value for the infants and adults who are allergic to cattle milk.
Soy milk is also used as cattle milk for the preparation of curd, butter milk, cheese and other milk products. 'Tofu' preparation has been recently introduced in Nepal which in gaining much popularity among the urban populace as a source of vegetable dish.
(g) Soy flour is prepared from high quality yellow beans. It is used as an additive or extender to cereal flour which are deficient in protein.
It is also used for making biscuits, cakes and other bakery products, beverages, infant food and food for diabetics as a supplement with other cereal flours. Soybean flour is used for making soy-nuts (small spherical salted balls made from the flour and dried) which are cooked mixed with other vegetables as a curry and consumed with rice or *Chapati*.
(h) Soy sauce is prepared from fermenting germinated seeds.
(i) Soybean meal or cake left after the extraction of oil is used in formulating feed for poultry and livestock.

Processing of Legumes in Nepal

Nepal has no major legume processing industry so far. Legume-based industries are categorized as cottage and small-scale industry whose production mostly depends on the traditional technology. Following are the products of these industries.

(1) Pulse: Splitting and de-husking. Grit separation is done in small mills for marketing and export.
(2) Oil extraction: Soybean is employed for this purpose using traditional technology.
(3) Flour: Chickpea, black gram, mung bean and soybean.
(4) *Dalmoth*: Lentil, chickpea, mung bean and garden pea.
(5) Soy-nuts and black gram nuts.
(6) Soy milk, soy sauce.
(7) Feed for poultry and livestock.

DISCUSSION

Winter legumes in Nepal are more important than summer legumes in terms of area and production. However, summer pulses are more in Hills and Mountains where they meet the dietary protein need of the Hill people and contribute to the sustainability of the agricultural system. Lentil, pigeon pea, chickpea, grass pea, cowpea and mung bean are major pulses produced and consumed in Terai whereas black gram, soybean, cowpea and horse gram are grown mostly in the Hills and Hill Valleys.

The area, production and yield/ha of most of the grain legumes have steadily increased in the recent years. However, the area and production of chickpea and grass pea have declined. Chickpea is regarded as a low grade pulse and therefore it has less demand and the market price is also lower compared to lentil and pigeon pea which are considered as high grade pulses. Due to the presence of toxin that causes athyrism HMG of Nepal banned the cultivation and marketing of grass pea since 1991-92. As a result, the area and production of grass pea gradually declined. In spite of the ban, grass pea is still cultivated by many poor farmers in their marginal lands since it withstands adverse conditions. It is also resistant to disease and it is easy to grow with minimum inputs. These poor farmers do not realize the effect of the toxin causing lathyrism.

Lentil is cultivated in 53 percent of the total legume area and of the total grain legume production, 54 percent is lentil (Figures 2 and 3). During the fiscal year 1997/98 and 1998/99 Nepal exported pulses (mainly lentil) valued at US$1.51 million and 1.29 million, respectively (Ministry of Finance, 2000). In terms of production, pigeon pea, black gram and soybean rank second, third and fourth, respectively. Although, soybean cultivation shows an increase in yield by 29.6 percent and production by 32.98 percent, yet, there is insignificant (2.58 percent) increase in acreage (Nepal Agriculture Research Council, 2000).

Data presented in Table 4 shows average yield/ha of the major grain legumes increased by 5.84 percent to 40.72 percent, respectively. From 1988/89 to 1997/98, it is mainly due to expanded irrigation facilities and availability of seeds of improved varieties (Nepal Agriculture Research Council, 2000).

Although cultivation of grain legumes showed a positive trend, it has not reached its full potential due to the following factors.

(1) Hill agriculture in Nepal has become a concern of female population due to the migration of male population to the cities and towns or to industrialized alien countries for employment.
(2) Grain legume crops are mostly grown on marginal lands.
(3) Non-availability of quality seeds in time, place and also in quantity as needed.
(4) Lack of adequate field testing of suitable improved varieties for different agro-ecological zones.
(5) Unstable production, erratic market price, and inability of farmers to take risk.
(6) Heavy loss during storage due to lack of know-how and facilities.
(7) Grain legumes of industrial value such as soybean are given low priority because the farmers do not get adequate opportunity to sell their product due to fewer number of processing factories and lack of proper transportation.
(8) The most unfortunate factor which hinders the innovation of legume-based industry in Nepal is the socio-cultural taboo which still prevails in the society. People consider that chickpea is the ‘food of horse’ and soybean is the ‘food of poor people’. Although, educated affluent people of the society are well aware of the dietary value of these crops, still they hesitate to consume the pulses.
(9) Legume-based industries have a low profile in Nepal because the government has categorized them as cottage and small-scale industry.
(10) Lack of application of modern technology in legume processing industries.

Considering the above constraints, it is high time for the government and people of Nepal to seriously transfer the modern technology from friendly developed countries to promote cultivation and processing of grain legumes so that people of Nepal can have nutritional security. It will also strengthen the national economy.

Draft document of the Department of Agriculture (Table 5) provides present and future scenario regarding the demand, area of cultivation, production and productivity of grain legumes from 1996/97 to 2020. It speculates that by 2020 the demand will increase by 5.24 percent per year whereas the production will increase only by 4.2 percent per year, thus creating a negative balance (Department of Agriculture, 1996). Therefore, to fulfill this forseen gap, we will have to change the choice of the crop, land use system and the management of irrigation facilities. It is therefore suggested that soybean cultivation in Terai and inner Terai should be enhanced, because these areas have great potential. Soybean processing industries should be established keeping in view the increasing trend and preference for consumption of soybean oil. Proportion of soybean oil import is high and there is also a growing demand for oil cakes for feed industry.

Table 5. Projected Area, Production, Productivity, Demand and Supply of Grain Legume for 1997/98-1999/2000

Year	Demand (000 mt)	Area (000 ha)	Production (000 mt)	Productivity (kg/ha)	Balance (000 mt)
1996/97	194.4	313.2	223.4	713*	29.0
1997/98	204.6	314.7	232.3	738 (680*)	27.7
1998/99	214.6	316.7	241.4	762 (743*)	26.8
1999/2000	219.7	317.7	251.0	790	31.3
2000/01	234.5	319.2	261.0	818	26.5
2005/06	289.0	327.1	314.2	961	25.2
2009/10	329.0	335.5	353.4	1,053	24.4
2010/20	450.0	342.3	474.5	1,386	24.5
Average annual growth rate (percent)	5.24	0.4	4.7	4.2	

Source: Department of Agriculture, 1996.
Note: * Productivity achieved.

There is no bio-safety issue in Nepal since genetically engineered soybeans have not been introduced so far.

Finally, keeping in view the existing status of grain legume utilization and processing in Nepal there is an urgent need for diversification and commercialization. In this context, the present seminar will help disseminate/exchange information on the diverse use of legume and it is hoped that information and technical know-how thus acquired/disseminated could inspire and encourage industrialists and farmers in Nepal. Legumes can significantly contribute towards food and nutritional security.

REFERENCES

Department of Agriculture, 1996. "Area, Production and Productivity Projection", a draft document of the Department of Agriculture, Kathmandu, Nepal.

Ministry of Agriculture and Cooperatives, 1999. *Statistical Information in Nepalese Agriculture*, Agricultural Statistics Division, HMG/MOAC, Kathmandu, Nepal.

Ministry of Finance, 2000. *Economic Survey Fiscal Year 1999/00*, HMG/MOF, Kathmandu, Nepal.

Nepal Agriculture Research Council, 2000. *Annual Report of National Grain Legume Research Project (NGLRP), 1998/99*, Kathmandu, Nepal.

Shrestha, K. K., 1999. "Diversity and Phytogeography of Legumes in Nepal", in T. C. Majpuria and R. K. Majpuria (eds.), *Nepal Nature's Paradise* pp. 595-620, M. Devi Gwalior.

World Bank, 2000. *Entering the Twenty-first Century*, World Bank Report, 1999/00.

11. PAKISTAN

Saeeda Raza
Senior Scientific Officer and
Programme Leader
Food Technology and Research Labs
National Agriculture Research Centre
Pakistan Agricultural Research Council
Islamabad

INTRODUCTION

Food legumes are the economical source of protein, calories, some vitamins and minerals. Legumes are essential components in the diet of 700 million people in the world. Legumes are the richest source of protein among vegetable foods, and they are consumed in relatively large amount when foods of animal origin are expensive or in short supply, and where religion or social circumstances prevent or restrict the consumption of meat.

Food legumes have several direct and indirect beneficial effects on agriculture. They improve soil fertility through N fixation. In cereal-legume system legumes help improve the yield, reduce weed population and break the biotic pest and disease cycles in cereal crops.

Legumes also have medicinal properties. For example, alfalfa sprouts, flowers and leaves act as diuretic, lower cholesterol, balance hormones, alleviate anaemia, colon or digestive disorders, skin problems and ulcers. Chickpea seeds are astringent, anti-bilious; fried seeds are diuretic and also for diabetic management. Lentils help to counteract constipation and other intestinal problems. Lentils are also poulticed on ulcers or on slow healing sores.

Out of 13,000 species in the family Leguminosae, 18 species are extensively cultivated and consumed in certain parts of the world depending upon agricultural conditions and income levels. Both raw and cooked food legumes have been consumed traditionally either alone or combined with cereals and other food groups. It is well established that the proteins of food legumes and cereals are nutritionally complementary in respect of S-containing amino acids and lysine, and a balanced blend or mixture of both grains has a greater nutritional value than either ingredients alone.

The biological utilization of the nutrients is interfered by various anti-nutritional factors present in legumes. The poor digestibility of proteins and inhibitory effects for absorption and utilization of calcium, iron and zinc are due to the presence of proteinase inhibitors, polyphenols (tannins) and phytic acid in legumes. Legumes are mostly consumed after processing. Processing detoxifies the toxins and improves the palatability.

In Pakistan cereals, wheat, rice and in some areas maize constitute the bulk of the average diet. The food legumes are of strategic importance for economy and for nutrition of both human and livestock. Agriculture in the country is confronted with the dual problem of low productivity of important grain legumes, stagnant and or declining productivity of rice-wheat cropping system (RWCS), the predominant cropping system in Pakistan. The main reason for this decline in productivity and utilization of legumes is the emphasis laid on improving the crop yield of cereals, production, storage and processing limitations. In Pakistan the primary processing such as de-hulling, splitting, grinding, puffing, parching and toasting are common prior to consumption.

The per capita availability of pulses in Pakistan is 7.03 kg/annum for 1998-99 (Government of Pakistan, 1999-2000). Legumes contribute 8 percent protein, 8 percent calories (additional 8 percent from oils) and 6 percent iron to average diet in Pakistan (Figure 1).

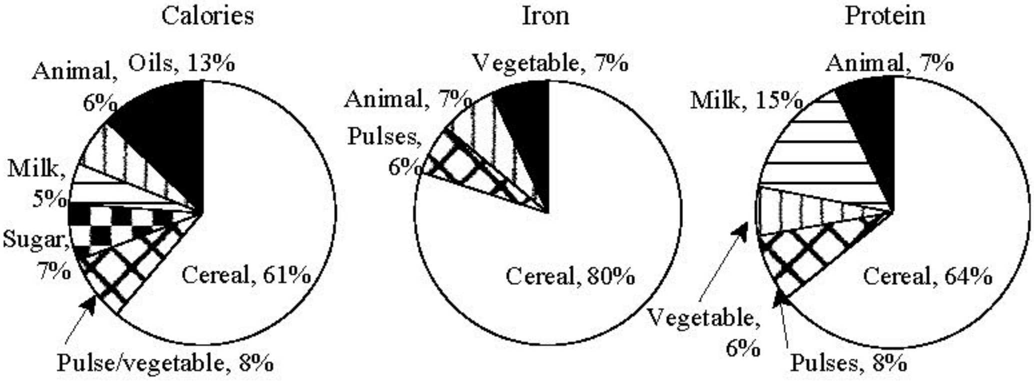


Figure 1. Contribution of Pulses to Calories, protein and Iron to the Diet in Pakistan Compared to Other Sources

AREA, PRODUCTION AND PRODUCTIVITY OF LEGUMES IN PAKISTAN

Ecologically, Pakistan can be divided into three legume-producing regions. The northern region has high rainfall where both rainfed and surface irrigation facilities are available. The central region has highly fertile soils but the climate is mostly aided by surface irrigation system. Legumes are also grown under rainfed conditions in some areas of this region. In the southern region rainfall is scanty and agriculture is totally under irrigated conditions. The two crop growing seasons are *Kharif* (summer) and *Rabi* (winter). Major *rabi* legumes are chickpea, *khesari* (lathyrus), peas and lentil while *kharif* crops are mung and mash. In addition to these pigeon pea, cowpea, moth bean, common bean and faba bean are minor pulses grown in extremely small areas. All these legumes occupy an area of approximately 1.5 million ha (11.1 percent of total cultivated area) and contribute about 4 percent of the total grain production of the country.

The main fodder legumes are *khesari* (lathyrus), berseem (*Trifolium alexandrum*), senji (*Melilotus alba*), moth bean, cluster bean (*Cyamopsis tetragonoloba*) and *Sesbania aculeata*. Sesbania and berseem are also used as green manure crops on 5 percent of the total cultivated land area.

Abiotic and biotic stresses such as drought and diseases are the major risks in food legume crops. Due to their erratic behavior farmers hesitate to cultivate legumes in large areas and in better lands. As a result, the area and production of legumes remained almost static (Table 1). The production of pulses in Pakistan did not meet the demand in the past and therefore, the demand is met by import from different countries. In 1997-98 the production of chickpea and mung bean was satisfactory. However, the production of other pulses should be improved. The overall change in production from 1998-99 to 1999-2000 was -4.4 percent for chickpea (gram), 7.4 percent for lentil (*masoor*), 3.1 percent for mung and -7.2 percent for mash (Government of Pakistan, 1999-2000). There is decrease in production of chickpea and mash while production of lentil and mung increased. The cultivated area for chickpea increased from 1,076,900 ha to 1,088,800 ha, for lentil it decreased from 57,800 ha to 56,500 ha, for mung increased from 199,500 ha to 200,300 ha and for mash the area decreased from 45,800 ha to 41,500 ha over the past decade.

Table 1. Area, Production and Yield of Pulses in Pakistan During 1986-87 to 1998-99

Year	Area (000 ha)	Production (000 mt)	Yield (kg/ha)
1986-87	1,522	791	520
1987-88	1,222	556	455
1988-89	1,395	642	460
1989-90	1,496	769	514
1990-91	1,538	732	476
1991-92	1,420	706	497
1992-93	1,453	547	376
1993-94	1,481	614	415
1994-95	1,511	778	515
1995-96	1,599	919	575
1996-97	1,575	832	528
1997-98	1,565	1,007	643
1998-99	1,531	951	621

Source: Government of Pakistan, 1998-99.

Production of chickpea, lentil, black gram, *khesari*, and mung bean has either remained stagnant or has declined over the past decade. Area and production of mung has increased in recent years due to the introduction of short duration uniformly-maturing varieties grown under canal irrigation. Cultivation of lentil and black gram was mainly concentrated in Sialkot, Narrowal and Rawalpindi districts. Due to availability of irrigation water in traditionally rainfed areas of Sialkot, the farmers have shifted from pulses to wheat and rice cultivation since the farmers consider cereals as more stable crops than pulse.

AGRO-CLIMATOLOGY AND LEGUME PRODUCTION

In Pakistan there are four major seasons – winter, spring, summer and autumn. Out of the total area of 79.61 million ha, only 20.40 million ha are under cultivation. Approximately 80 percent of the cultivated area is irrigated and the rest is rainfed (Government of Pakistan, 1997-98). Because of the extensive and complex network of canal irrigation, over a level ground area, serious problems of salinity and sodicity have developed in the same area. In cultivated areas summer average night/day temperatures are 27-45ºC (May to July) and winter average night/day temperatures are 5-20ºC (December to January). Sometimes temperature exceeds 45ºC and drops down to below 0ºC causing heat and cold stress problems to crops.

Grain legumes are generally cultivated throughout the country but they are mainly relegated to marginal soils of rainfed areas except mung. Legumes are regarded as those that require minimum agricultural inputs and labor. They are largely confined to subsistence farming. Large-scale cotton farmers seldom grow grain legumes.

Groundnut is mainly grown as a rainfed sole crop during the summer monsoon period. Occasionally it is intercropped with sorghum or maize, and wheat usually follows groundnut in winter.

Groundnut area decreased from 102,000 ha in 1995-96 to 97,000 ha in 1998-99 causing a reduction in production from 112,800 mt in 1995-96 to 104,000 mt in 1998-99. Average yield also decreased from 1,103 kg/ha to 1,067 kg/ha in 1998-99.

PRODUCTION CONSTRAINTS

Biotic and abiotic stresses affecting the vegetative growth and/or reproductive phase result in decreased yield.

Biotic Constraints

1. ***Chickpea***

1) Diseases

   a) Ascochyta blight (*Ascochyta rabie*), a foliar disease causes 15-50 percent yield loss.

   b) Fusarium wilt is a serious disease of chickpea causing annual loss of about Rs.12 million.

   c) Root rot and wilt is a complex of diseases caused by several fungi. Wet root rot of chickpea is perhaps more common in areas where chickpea is grown after rice.

2) Insect pests

   a) Pod borer (*Helicoverpa armigera*) is the most damaging insect and has considerable economic importance in Pothohar region and in Sindh province.

   b) Semilooper is another pest of chickpea but is of less economic importance.

3) Weeds

   Chickpea is sensitive to weed competition during seedlings and early vegetative growth. Weeds cause considerable losses to the crop. The yield reduction due to weeds is 42-75 percent (Weed Program, National Agricultural Research Centre).

2. ***Lentil***

1) Diseases

   a) Ascochyta blight may cause 30-40 percent reduction in lentil production.

   b) Rust (*Uromyces viciae fabae*) of lentil occurs in the foothill districts, where precipitation is high.

   c) Vascular wilt (*Fusarium oxysporum*) is a disease commonly observed in most of the lentil growing areas where the temperature is high. It causes an average of 5-10 percent yield loss.

2) Insect pests

   The lentil crops suffer little from insect damage. Mild attack of spiny lentil pod borer has been observed.

3) Weeds

Weed infestation is one of the most important constraint of lentil cultivation in Pakistan. The slow growth habit of lentil allows fast growing weeds to smother the lentil crop and this result in 10-80 percent yield reduction.

3. ***Mung Bean and Black Gram***

1) Diseases

Both crops are infected by several diseases caused by fungi, bacteria, viruses and nematodes. Among them, yellow mosaic virus (MYMV), cerospora leaf spot, bacterial blight and charcoal rot are more common and serious in Pakistan which reduce grain yield by 16-20 percent in mung bean and 12-14 percent in black gram (Bashir and Malik, 1998). A severe epidemic of charcoal rot, a serious disease of both crops, may cause 100 percent yield loss.

2) Insect pests

Hairy caterpillar is the most important insect pest of mung bean and black gram. It feeds on leaves and causes 30-40 percent loss in grain yield. White flies effect is through transmission of viral disease (MYMV) rather than any direct effect on yield reduction.

3) Weeds

Mung bean and mash bean are sown at the beginning or during the rainy season, hence weeds could heavily infect these crops. On an average 10-20 percent yield reduction can be attributed to weeds.

4. ***Khesari (Lathyrus)***

It is less affected by biotic stresses than other legumes. Foliar and root diseases and insect pests cause only minor yield losses (Johansen, *et al*., 1994), but weed problem can be serious when the crop is grown for grain.

5. ***Groundnut***

1) Vertebrate pests

Main biotic constraint is vertebrate pest, e.g. rats, birds, wild boar and porcupines.

2) Diseases

Fungal pathogens cause early and late leaf spot.

3) Insects

Thrips, jassids and aphids are important pests.

Abiotic Constraints

Risk of crop failure due to abiotic stresses is high. Following are the main abiotic constraints prevailing in Pakistan:

1. ***Drought Stress***

Generally grain legumes are grown under rainfed conditions. Occasionally scattered and erratic rainfall distribution occurs and chickpea and lentil suffer from drought stress during the vegetative as well as reproductive stage. *Khesari* (lathyrus) is a relatively drought-resistant legume and produces more reliably than other legumes under drought conditions (Johansen, *et al*., 1994; and Haqqani and Arshad, 1995).

2. ***Excess Soil Moisture***

Mung bean and black gram are usually affected as they are sown at or before the onset of the monsoon. Chickpea following rice can encounter excess soil moisture. *Khesari* (lathyrus) is tolerant to water-logged conditions.

3. ***Frost Damage***

When temperature drops suddenly from 15ºC to below 0ºC as in Thal region the frost damage occurs. In 1992-93 such situation occurred and the production dropped by 32 percent.

4. ***Nutrient Deficiency***

In Pakistan chickpea is usually limited by phosphorus (P) deficiency and the crop responds positively to P fertilizer application. Iron deficiency can be observed in some varieties and it affects the yield.

5. ***Salinity and Sodicity***

All legumes grown in the country except lathyrus are sensitive to saline and sodic soil conditions. The germination of seeds is poor and the plants die prematurely at the seedling stage. In moderately saline and sodic soils, the grain yield is drastically reduced.

SOCIO-ECONOMIC CONSTRAINTS

In Pakistan food legumes have usually been associated with poor soils, poor people and rainfed agriculture. They are subject to a host of biotic and abiotic stresses and thus become risky crops, hence farmers prefer staple cereal crops and cash crops rather than food legumes. The socio-economic constraints are as follows:

Risk

Farmers consider legumes a risky crop since both biotic and abiotic stresses affect the crop.

Low-income Status

Legume farmers are generally poor and have low purchasing power which hinders their adoption of improved production technology. Due to lack of awareness, the growers do not realize the significant role of pulses in farming systems.

Credit Facility

Poor farmers are unable to purchase high quality improved seed or other inputs needed due to lack of credit facilities.

Organization Linkages

The linkages between education, research, extension and the farmers have remained tenuous which leads to low production of legumes.

Absence of Support Price and Marketing

Except for chickpea, support price for food legumes are non-existent. Cereals and some cash crops have support price. Large fluctuations in market price for legumes discourage farmers to grow them. Farmers also have to sell the crops immediately at a very low cost due to lack of proper storage facilities.

Mechanization

Lack of quality mechanization poses difficulties for planting and pre- and post-harvest operations.

Lack of Improved Seed Production and Dissemination Infrastructure

Although improved varieties of chickpea, lentil, mung bean and black gram have been released by pulse breeders for commercial cultivation in Pakistan, the seed supply corporations concentrate only on production of cereals seed. Since pulses are considered as minor crops, they are ignored by seed agencies. Both multinational private sectors and national seed companies are interested only in hybrids.

EFFECTS OF ABIOTIC STRESS ON PULSE PRODUCTION (1987-99)

Until 1986-87 chickpea production increased to reach 583,000 mt and thereafter it drastically decreased to 372,000 mt (-36 percent) due to severe drought in the main chickpea growing areas. Similarly the year 1992-93 was also crucial in the context that chickpea crop once again got a sort of severe fall and its production decreased to 340,000 mt (-42 percent) because of pest damage in Thal region. The year 1997-98 had a prolonged drought that curtailed chickpea production from 680,000 mt to 554,000 mt (-20 percent). The entire pulse sector rises and falls with the rise and fall of chickpea production resulting in the need to import pulses to meet the domestic requirement.

CONSUMPTION AND PER CAPITA AVAILABILITY

Import of pulses in 1996-97 was lower (79,907 mt/Rs.1,133 million) because of bumper chickpea crop and satisfactory mung bean production. But there is an increase in import from 1997-99 (162,500 mt/Rs.2,687 million). The per capita availability of pulses (Table 2) indicates that it has increased from 5.00 kg/annum (1990-91) to 7.03 kg/annum (1998-99) and is attributed to increase in production of legumes.

Table 2. Per Capita Availability of Pulses in Pakistan During 1990-91 to 1998-99

Year	Availability (kg/annum)
1990-91	5.90
1991-92	5.60
1992-93	6.34
1993-94	4.62
1994-95	5.19
1995-96	6.15
1996-97	5.85
1997-98	6.32
1998-99	7.03

Source: Government of Pakistan, 1998-99.

Pulses constitute 5 percent of the national diet (Figure 2). FAO *Food Balance Sheet* (FAO, 1992-94) indicates that the total domestic legume supply was 814 mt, of which 629 mt are locally produced, and 208 mt are imported. About 22 mt are exported. It provided 604 mt for human food, 131 mt for animal feed, 64 mt for seed and 15 mt for other uses. Out of 2,400 calories required, pulses provide 44 cal/day; out of 58.9 gm of total protein 2.6 gm supplied by pulses and of the 62 gm of total daily fat consumption pulses contribute 0.3 gm/day.

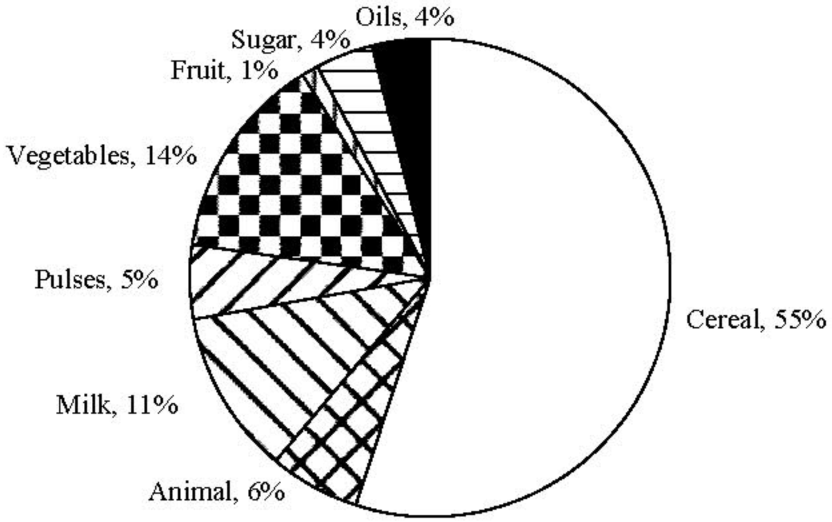


Figure 2. Percentage of Food Groups in National Diet

PROCESSING AND USES OF LEGUMES

Traditionally legumes are consumed either as vegetables in the form of green immature seeds (e.g. sweetpea, chickpea) or mature dried seeds. The hard seeds are used after several processing procedures. These are de-cortication or de-hulling, splitting (*dal* production), boiling, roasting, puffing, frying, germinating and fermenting or others. These processing methods contribute to improved product as well as nutritional quality. Extrusion cooking, textured vegetable products, quick cooking products, weaning food and beverages are some of the technologies that have good potentials to improve the utilization of food legumes. There is also a growing trend to market legume products as value-added snack items. Other less-explored but potentially promising avenues include the use of components of legumes as therapeutics in dairy industries and as food preservatives. Leaf protein concentrates also offer scope for use as a protein source for livestock and humans. Commonly consumed legume products are given in Table 3.

Traditional Chickpea Processing

1. ***De-hulling***

De-hulling legume seed to prepare *dal* involves pretreatment to loosen the seed coat from cotyledons, splitting and de-husking. Inefficient traditional household milling techniques (*chukkis*) yield 63 percent *dal* and commercial milling yields 70 percent *dal* (Malik, 1980). Household processing of chickpea into *dal* reduces the level of protein, calcium, iron, thiamine, riboflavin and niacin (Pushpanma, *et al.*, 1983). De-cortication is accomplished by dry heating, drying or pre-soaking. Moistened legumes are parched, toasted or roasted on flat pans over a fire, the husk becomes brittle and is easily cracked. The husks are removed by light pounding and winnowing. During this type of thermal de-cortication some gelatinization of starch occurs and some of the anti-nutritional or toxic effects of the legumes are partially or wholly eliminated.

Table 3. Products of Legumes Commonly Consumed in Pakistan

Name of Legumes	Product	Ingredients
Chickpea		
A) Fresh, green seeds (*desi*)	Boiled	Water, salt
	Roasted	Salt
	Curry	Meat, vegetable, spices, oil
B) Whole seeds (*desi* and *kabuli*)	Puffed	Salt or coated with sugar
	Curry	Oil, spices, onion, garlic
	Pulau	Rice, spices, oil
	Chaat	Spices, green chilies, coriander, onion and curd or tamarind
	Salted *channa*	Salt (deep fried until crispy)
C) Split Seeds or *Dal* (*desi* chickpea)	*Dal*	Salt, red chilies, fried onion
	Khichri	Rice, oil, onion, salt, spices
	Shami kabab	Meat, spices
	Halwa	Milk, oil, sugar
	Salted *dal*	Salt and spices
D) Flour or basin	*Pakora*	Batter with spices, onion and potato
	Halwa	Roasted with ghee or oil, sugar, dry fruit
	Dal sawayan	Thick batter, noodles, salt
	Basini roti	Mixed with wheat flour
	Dahi pakorey	*Pakora*, curd, salt and spices
	Dahi boondi	Batter oil, boondi, curd, spices
Lentil (*masoor*)	*Namkeen dal*	Oil, salt
	Boiled *dal*	Spices, water
	Soup	Rice, water, salt, spices
	Khichri	Rice, oil, salt, spices
Green Gram (mung bean)	*Dal*	Spices, salt-fried onion
	Khichri	Rice, salt with or without oil
	Mungochian	Spices, dipped into prepared curry
	Baryan	Soaked *dal*, paste, mixed with spices, sun-dried (they can be stored for a long time in airtight packing), cooked in curry
	Dahi bhalley	Soaked *dal*, black gram (mash bean) and *basen* (chickpea flour), spicy curd
	Sweet boondi	Small droplets of slurry deep-fried and soaked into sugar syrup for a short-time and air-dried
	Noodles	Soaked *dal* slurried, filtered through muslin clothes. Sedimented to remove protein or acidified (used as animal feed) starch paste is extracted as thread into hot water rapidly cooled
	Sprouts	Germinated seeds
	Namkeen dal	*Dal*, oil, salt
Black Gram (mash, *urd*)	*Paaper*	Flour, salt
Pea (*muttar*)	Mixed *sabzi*	Other vegetables
	Muttar qeema	Meat, salt, spices
	Muttar gosht	Meat, curry, vegetables
	Muttar pulau	Oiled and spiced rice
	Salad	Peas, other vegetables, salt, spices
	Sprouts	Germinated seeds
Peanut, Groundnut	Roasted	Salt, sugar, peanut butter

2. ***Puffing***

Puffing of chickpea improves its flavors, modifies its texture and helps in dry or wet grinding. For puffing seeds are soaked in water and then roasted on heated sand at 200-500ºC for 1-2 minutes. The roasted chickpea is generally rubbed against a coarse surface to break the husk, which is then removed by winnowing. Grains with 12-14 percent husk content are good for puffing.

3. ***Grinding***

Whole chickpea or *dal* is ground to flour, known as *basen*. The eating quality of many chickpea flour-based products depend on flour composition, the degree of fineness of grinding, mesh grades and cooking conditions.

4. ***Germination***

Germination allows whole beans to be eaten in a palatable form. The sprouts or hypocotyl emerges through the seed coat, which is usually split open during this process. It facilitates cooking by loosening the seed coat and it makes available vitamins and iron, improves the digestibility, and nutritive value of legumes protein is also improved. Soaking and germination reduces the anti-nutritional factors.

Utilization of Chickpea

Green seeds are used as a vegetable. It is mixed with meat, other vegetables to make curries, with rice to make "*pulau*" and after shelling the roasted pods and the seeds are used as a snack.

The most common method is boiling, either in an open pan or pressure cooker to reduce cooking time. Seed size is important since it affects such processing operations as cleaning, de-cortication and sugar coating. *Kabulis* are preferred to *desis*. Split seeds or *dal* is cooked until tender and soft depending upon the desired texture of the finished product. *Dal*-based products are widely used in home and on commercial scale to make curry, *khichri* (rice + *dal*), etc.

In Pakistan chickpea is a major ingredient in snacks, such as *pakoras* and in sweets. It is also used in ground meatball preparation and for coating fried fish and chicken pieces. *Dal sawayan* (noodle-shaped) are also salted and deep-fried. Chickpea flour is also blended with wheat flour to bake *basini roti*, a bread commonly consumed by diabetic patients.

Many of the procedures adopted in product development have certain beneficial effects as reducing anti-nutritional factors, flatulence sugars, softening of husk and increasing palatability and aroma of the product.

Nutritive Value of Products

In practical dietetics, nutritive value and availability of dietary constituents are more important in cooked food than in raw foods. The ingredients of *desi* and *kabuli* chickpea products and their nutrient contents are given in Table 4. About 50-100 percent of daily calcium requirements of adult males and females can be provided by 100 gm of dry chickpea on dry weight basis. Roasted chickpea (100 gm) a *missi roti* can meet 50-100 percent of the daily requirement of iron of adult male.

Nutritive Value of Chickpea-based Meals

The composition of some chickpea-based meals, commonly used in Pakistan and their nutrient contents are given in Table 5. A meal containing wheat bread and *dal* can provide 12 percent of total calories from protein, 55 percent from carbohydrate and 18 percent from

Table 4. Chemical Composition (Dry Basis) of Some Pakistan Chickpea Products

Product	Protein*	Fat	Carbohydrate	Crude Fiber	Ash	Energy	Ca	P	Fe
	(gm/100 gm)					(kcal/100 gm)	(mg/100 gm)		
Curry *sabat channa*	17.7	12.6	60.9	4.4	4.4	428	360	315	5.3
Curry *dal channa*	20.3	12.8	60.9	1.6	4.4	440	226	273	3.9
Missi roti	14.6	3.1	75.9	4.1	2.3	389	239	284	6.9
Pakoray	17.2	12.4	53.4	11.1	5.9	395	239	243	7.2
Chaat	19.3	5.3	68.2	3.9	3.3	398	328	279	5.8
Halwa basen	8.9	21.8	63.7	4.4	1.2	490	247	126	3.8
Bhunay chanay	21.1	5.0	60.3	10.6	3.0	370	268	264	8.2

Source: Khan, *et al*., 1995.
Note: * N × 6.25.

Table 5. Chemical Composition (Dry Basis) of Chickpea-based Pakistan Meals

Meal	Protein*	Fat	Carbohydrate	Crude Fiber	Ash	Energy	Ca	P	Fe
	(gm/100 gm)					(kcal/100 gm)	(mg/100 gm)		
Wheat bread +									
Chickpea *dal*	14.3	9.3	65.0	1.2	2.3	1,978	392.0	196.0	7.6
Khichri	11.4	18.6	60.7	1.5	1.7	2,137	51.3	184.7	3.5
Halwa Suji **+**									
Besan	7.0	18.2	71.7	0.9	0.7	2,124	32.9	82.1	2.1

Source: Khan, *et al*., 1995.
Note: * N × 6.25.

fat while for *khichri* 10 percent of total calories is derived from protein, 48 percent from carbohydrate and 32 percent from fat. *Halwa* provides 6 percent of the total calories from protein, 57 percent from carbohydrate and 32 percent from fat. It is evident that the first two meals compare favorably with characteristic of a well-balanced diet (10-15 percent calcium from protein, 55-70 percent from carbohydrate and 20-30 percent from fat). The protein values of wheat bread and chickpea *dal* meal and of *khichri* alone are adequate to meet the protein requirement of children of 4-9 years and adult (Table 6).

Table 6. Protein Quality of Pakistani Chickpea-based Meals

(Unit: Percent)

Meals		True Digestibility	Biological Value	Net Protein Utilization	Net Dietary Protein Calories
Wheat Bread +	Chickpea *dal*	92	66	60	7.3
	Khichri	92	71	65	6.1
Halwa Suji +	*Besan*	99	75	74	4.3

Source: Khan and Eggum, 1978 and 1979.

Utilization of Green Gram (Mung)

Green gram ranks second in production (90,500 mt in 1998-99). It is nutritious with high digestibility and is free from flatulence due to low content of raffinose and stachyose. Green gram is valuable in the preparation of infant weaning foods.

Mung bean is often eaten whole after soaking and boiling. It is milled or split to make *dal. Dal* is also ground into flour, or paste mixed with spices, chopped onion, green peppers, and deep-fried into balls and then steamed into already prepared curry "*mungochian*". They are also dipped into spiced curd "*dahi bhalley*". Sweet balls are also prepared by mixing jaggery or cane sugar. Thread noodles from mung bean starch are also prepared. Paste (slurry) prepared from soaked seeds are filtered through muslin clothes, protein is separated from starch by sedimentation or prepared by acidification. The protein fraction (gluten) is used as animal feed. The starch paste is extruded as thread into hot water, where it is gelatinized, rapidly cooled by passing into cold water and is air-dried to 13-14 percent moisture. Mung bean sprouts are eaten as a salad vegetable or steamed, stir-fried or boiled and used as an addition to many oriental dishes. Sprouted mung beans are candied by immersion in concentrated solution of honey or cane sugar. De-hulled seeds are deep-fried and salted to make snacks. Paste of *dal* mixed with spices, and made into small balls that are sun-dried to make *biryani*.

Utilization of Black Gram (Mash, *Urd*)

Black gram may be eaten whole or split, husked or unhusked, as *dal* or as flour. The protein in *urd* flour has particularly desirable baking characteristics, due to the presence of a gelatinous globulin with glycoprotein fractions. The flour is used to prepare thin crisps or puffed fried paste products, and to make spiced ball and biscuits used in sweet meat. Very thin pastes mixed with rice paste or alone are spread on clothes or plastic sheets and are sun-dried to make crispy "*paaper*" which are then deep-fried.

Utilization of Lentil, Red *Dal* or *Masoor*

Lentils are used, mainly in the form of *dal*, in the preparation of legume pastes and soups. Flour prepared from ground seeds may be added to cereal flours, in the preparation of infant food and in baked products. *Khichri* is often prepared from lentil *dal* flavored with fried onions and curry leaf.

Utilization of Pea (*Muttar*)

Mostly used as a green vegetable, with other vegetables, with meat and minced meat. Deep-fried seeds are used as snacks and cooked with rice to make "*muttar pulau*". It is also used in salad after boiling and frying. Germinated seeds are good source of ascorbic acid (vitamin C) and vitamin B complex.

Utilization of Peanut (Groundnut)

Groundnut is roasted and widely used in Pakistan as a snack. It is also used in confectionery and baked products. Over 300 uses of groundnut have been developed as food, feed and in the manufacture of industrial products. These products have not been popularized because groundnut production in Pakistan is low (104,000 mt in 1998-99), and mostly utilized as oilseeds.

Utilization of Soybean

Soybean has been introduced to Pakistan in the early 1970s. Soybean is mostly used as an oilseed. Some products introduced in the 1980s are soy-nut, tofu, milk, curry, soy *pakora, halwa, chaat, dal*, but most people did not like them due to beany flavor, flatulence and problems of longer cooking time.

NON-FOOD/ALTERNATE USES OF LEGUMES

Chickpea

Chickpea starch is used in textile industry and in the manufacture of plywood. Indigo-like dye is obtained from chickpea leaves. The stems and leaves have high concentration of maleic, malonic, citric and oxalic acids that are used in medicine.

Chickpea straw contains almost twice the amount of protein when compared with cereal straws. Seed coats obtained during de-hulling are also utilized as animal feed.

As a folk medicine leaves yield an acid exudate that is used as an aphrodisiac. It is also used for the treatment of bronchitis, diarrhea, dysentery, snake bite, and sunstroke.

Lentil

It is a valuable green manure and used as a forage crop. Husks, dried leaves, and stems are used as livestock feeds. Seeds are used as commercial starch for textile and printing industries.

Medicinally it is used for constipation and other intestinal problems. It is also poulticed on ulcers and slow healing sores.

Black Gram

Whole plant is used as a forage crop and as a green manure. Mature seeds/husks are used as livestock feed. Seeds contain a substance that is used in the food processing industry as emulsifiers, and as stabilizer for foams.

Green/Golden Gram (Mung Bean)

Whole plant is grown as a green manure, hay or cover crop. Husks are soaked and used as cattle feed. Seed is used as poultry feed. Seeds are used externally and internally for paralysis, rheumatism, liver complaint, and cough syrups. Roots are considered to be narcotics.

Groundnut

Hay is valued as a livestock feed. Pelleted groundnut vines are superior to Bermuda grass in digestible nutrients and possibly as a source of carotene. The shell is mainly used as a fuel. Other uses are as filler for fertilizers, mulch for growing plant, litter for poultry houses, abrasion for polishing steel, and aluminum insulation for farm building.

DEVELOPMENTS/INNOVATIONS IN TRADITIONAL AND MODERN PROCESSING

Many traditional processing, especially for *dal* production, have been improved for more *dal* recovery and to have better quality. More than 70 percent of total seed is converted to *dal*. Improvements in *dal* milling depend upon characteristics of locally available grains and climatic conditions.

The husk adhere to cotyledons by a layer of gum and lignin which is removed by sun-drying, after the seed coat is loosened using small amount of water or oil may be applied directly to the grains. Alternatively the grains may be soaked in water for several hours to condition them. The conditioned grains are coated with slurry of red soil and sun-dried for 2-4 days. The soil is removed by sieving before they are de-hulled.

The conditioned seeds were decorted by mortars, or in hand-operated wooden or stone "*chukkis*". Now modern abrasion milling machines have been produced and are periodically modified to have better quality of *dal*. De-husking and splitting are done separately by sharp edges. Water or oil is added to condition the de-husked grain and to loosen the binding between the cotyledons, that are split in an impact type splitting machines. This technique yields maximum "splits" as unbroken, clean, polished *dal* with minimum loss of grain as broken pieces and powder.

VALUE-ADDED PRODUCTS

Many legume products have been commercially developed, that are delicious, nutritive and economical. The most important among them is the weaning foods. In Pakistan imported or multinational company products are not affordable to majority of the people. Therefore, researchers have developed many types of weaning foods and their nutritive values have been determined.

The legumes with high protein in combination with cereals have positive effect on children's health. Germinated seeds are easily palatable, nutritious and easily digestible. Two recent weaning foods prepared by nutrition and Food Technology Research Labs (FTRL). Nepal Agricultural Research Council (NARC)/Pakistan Agricultural Research Council (PARC), Islamabad is named *Pulcelac* and *Cepulac*. Both are mixtures of rice and different pulses. They were tested on children of 6-12 months of age at PIMS for a period of six months. Weight, height and hemoglobin level were recorded and compared with other commercially available baby foods like *Cerelac, Farlac*, etc. The children who had *Pulcelac* and *Cepulac* were found to be physically and mentally healthier than those who were fed with commercial formula. FTRL-developed foods are 10 times cheaper than the commercial ones.

Elderlac

An instant, lentil-rice-vegetable soup prepared by FTRL mainly for old age people is liked by all age groups as a soup. The name given to this instant soup is "*Elderlac*" i.e. old aged, and it is easily prepared, highly digestible food and due to the presence of vegetable fibers it also controls constipation.

Chickpea Milk

FTRL has also prepared chickpea milk in powdered form and given to children of age 4-12 months. The children not only gained weight but when fed to infants with persistent diarrhea, they astonishingly recovered within 7-10 days. The important study was that they were not lactose-intolerant babies.

FUTURE ROLE OF LEGUMES IN AGRICULTURAL DEVELOPMENT

Wheat and rice are important in Pakistan consequently RWCS dominates the farming system. The continuous RWCS lowers soil nitrogen (N), phosphorus (P), boron (B) and zinc (Z_n). Balanced application of fertilizer nutrients to realize the appropriate levels of yield is a considerable drain on farmers resources in view of their prices and limited availability.

To sustain the long-term productivity of RWCS, inclusion of a legume in the system will be very valuable. The beneficial effects of including legumes in cereal-based cropping system, whether as a succeeding or companion crop depends upon the type of legume, the purpose for which it is grown and the management practiced.

Winter Legumes-based RWCS

Chickpea, lentil and *khesari* (lathyrus) are grown after rice with residual moisture. Chickpea and *khesari* fit very well into RWCS in Sindh and Baluchistan as an alternative to wheat. Bhatti (1987) reported that a rice-chickpea rotation gave maximum monetary return followed by rice-lentil and rice-*khesari*. *Khesari* seeds can be broadcast even in the standing water after rice harvest. Farmers can grow short duration, non-aromatic rice from June to September and chickpea from end of September to early December. The relay cropped *khesari* can also be used as an effective green manure for a seedling wheat crop. Berseem besides being a valuable fodder also improves soil fertility and provides an excellent form of weed control for subsequent rice and wheat crops. Recently practiced system of intercropping berseem with sugarcane and plowing in the leftover fodder berseem as green manure improved the soil fertility.

Summer Legumes-based RWCS

Mung bean and mash bean as a summer crop can be grown in about two and a half months from the first week of May to the 2nd week of July. "*Sesbania aculenta*" is the potential green manure legume for the RWCS in Pakistan. The response of sesbania as a green manure can be measured in terms of grain yield and it is more pronounced in rice rather than in wheat. However, the use of green manure crops has gone out of practice due to the high cost of labor, shortage of irrigation water and difficulty fitting these crops in the prevailing cropping system.

Biological Nitrogen Fixation

Surveys conducted on N_2 fixation of chickpea, lentil, mung bean and black gram revealed that the proportion of N_2 fixed by chickpea was 75 percent (1994-95) and 81 percent (1995-96), 78 percent for lentil and 47 percent for mung bean and black gram (Aslam, *et al*., 1997; and Shah, *et al*., 1999). Development of short duration high-yielding and disease-resistant legumes cultivar could prove valuable in improving the production of these crops as well as improving the soil health and quality. Pulse scientists in Pakistan have released following improved varieties during 1980-95: eight chickpea; three lentil; six mung bean; and three mash (black gram). Stable sources of resistance/tolerance in chickpea (Dashat, Parbat and Hamsafar) for ascochyta blight and in mung bean (mung bean NARC-1) against fungal diseases and MYMV have been found. One variety of lentil Shiraz-96 and two varieties of chickpea Parbat-2000 and Hamsafar-2000 with high-yield have also been released.

Through adopting new technologies, growing stress-resistant varieties and inter-cropping RWCS with legumes the productivity of legumes will be increased, which in turn is expected to improve the overall economy of the country (Table 7).

REFERENCES

Aslam, M., I. A. Mahmood, S. Ahmed, M. B. Peoples, and D. F. Herridge, 1997. "Surveys of Chickpea N_2 Fixation in the Potohar and Thal Areas of the Punjab, Pakistan", in *Extending Nitrogen Fixation Research to Farmers' Field: Proceedings of International Workshop on Managing Legumes Nitrogen Fixation in the Cropping Systems of Asia*, pp. 353-360, 20-24 August 1996, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Asia Centre, India.

Bashir, M. A. and B. A. Malik, 1988. "Diseases of Major Pulse Crops in Pakistan", *Tropical Pest Management – A Review*, Vol. 34, No. 3, pp. 309-314.

Bhatti, I. M., 1987. "Rice-Wheat Cropping systems Report, Sindh, Pakistan", in *Proceeding of the 8th Asian Rice Farming System Working Group Meeting*, pp. 185-195, International Rice Research Institute, Los Baños, Philippines.

Government of Pakistan, 1997-98. *Agriculture Statistics of Pakistan*, Ministry of Food, Agriculture, Cooperatives and Livestock, Economic Wing, Islamabad.

----------, 1998-99. *Agriculture Statistics of Pakistan*, Ministry of Food, Agriculture, Cooperatives and Livestock.

----------, 1999-2000. *Economic Survey*, Finance Division, Economic Advisor's Wing, Islamabad.

Haqqani, A. M. and M. Arshad, 1995. "Crop Status and Gene Diversity of Grass Pea in Pakistan", in R. K. Arora, P. N. Mathur, K. W. Rieley and Y. Adan (eds.) *Lathyrus Genetic Resources in Asia: Proceeding of Regional Workshop*, pp. 59-65, 27-29 December 1995, Raipur, India, International Plant Genetic Resources Institute (IPGRI), Office for South Asia, New Delhi, India.

Table 7. Economic Outlook of Pulses Production, Consumption, Import and Export, During 1997-98 to 2009-10

(Unit: 000 mt)

Year	Population (million)	Human Consumption	Seed Waste	Total Requirement	Production	Deficit Surplus
1997-98	139.3	445.8	191.0	636.8	618.2	-18.6
1998-99	143.0	457.6	196.1	653.7	643.5	-10.2
1999-2000	144.8	469.8	201.3	671.1	668.8	-2.3
2000-01	150.6	481.9	206.5	688.5	695.2	6.7
2001-02	154.4	484.1	211.7	705.8	722.7	16.9
2002-03	158.2	506.2	217.8	723.2	751.3	28.1
2003-04	162.0	518.4	222.2	740.6	781.0	40.4
2004-05	165.9	530.9	227.5	758.4	811.8	53.4
2005-06	169.7	543.4	232.9	776.2	843.8	67.6
2006-07	173.7	555.8	238.2	793.1	878.9	85.8
2007-08	177.6	568.3	244.6	811.9	914.1	102.2
2008-09	181.5	580.8	248.9	829.7	950.4	120.7
2009-10	185.4	593.3	254.3	847.5	990.0	142.5

Sources: *Kitchen Crops of Pakistan – Pulses, 1996-97*; and Ministry of Food, Agriculture, Cooperatives and Livestock.

Johansen, C., B. Baldev, J. B. Brouwer, W. Erskine, W. A. Jermyn, L. Lijuan, B. A. Malik, A. A. Miah, and J. N. Silim, 1994. "Biotic and Abiotic Stresses Constraining Productivity of Cool Season Food Legumes in Asia, Africa and Oceania", in F. J. Muehlbauer and W. J. Kaiser (eds.) *Expanding the Production and Use of Cool Season Food Legumes*, pp. 175-193, the Netherlands Kluwor Academic Publisher, Dordrecht.

Khan, M. A. and B. O. Eggum, 1978. "The Nutritive Value of Some Pakistani Diets", *J. of Sci. Food and Agriculture*, Vol. 28, pp. 1069-1075.

----------, 1979. "Effect of Home and Industrial Processing on the Protein Quality of Mash Beans", *J. of Sci. Food and Agriculture*, Vol. 30, pp. 369-376.

Khan, M. A., N. Akhtar, I. Ullah, and S. Jaffery, 1995. "Nutritional Evaluation of Desi and Kabuli Chickpea and Their Products Commonly Consumed in Pakistan", *International Journal of Food and Nutrition*, Vol. 46, pp. 215-223.

Malik, B. A., 1980. *Grain Legumes Production in Asia*, country paper presented in Symposium on Grain Legumes Production, 9-15 November 1980, Chiang Mai, Thailand, APO, Tokyo, Japan.

12. PHILIPPINES

Olivia M. Del Rosario
University Researcher
Institute of Food Science and Technology
University of the Philippines
at Los Baños (UPLB)
College, Laguna

INTRODUCTION

Among the legumes, mung bean, peanut and soybean play important role in the life of Filipino people (PCARRD-IDRC, 1992). They contain low-cost, high-quality protein. Legumes can supplement or substitute the daily protein requirement, which we usually obtain from expensive animal and marine sources. With the advent of neutraceuticals, phytochemicals and interest of people for low cholesterol diet, the consumption of legume is expected to increase.

Another advantage of legume is that it can be grown in different parts of the country and they have short maturity duration. It is an ideal crop for inclusion in cereal-based farming systems. Fertilizer application is not required for legumes since they fix atmospheric N through bacterial symbiosis.

However, domestic production of legumes is not enough to meet the growing local demand. Therefore, the country has to import to narrow the gap between supply and demand. Recently, the government through the Department of Agriculture has prepared a research, development and extension program for legumes with the aim of promoting local production and minimizing import.

LEGUME PRODUCTION

Area Planted with Legumes

The area planted to mung bean, peanut and soybean is shown in Figure 1. From 1991 the area planted to peanut increased from 39,060 ha to 47,642 ha in 1995. However, in 1996 and 1998, the area declined significantly (28,737 ha and 24,700 ha, respectively). For mung bean, the area planted increased marginally from 34,259 ha to 36,420 ha in 1997 but declined to 34,600 ha in 1998. For soybean, the area planted (2,000 ha) did not change from 1991 to 1997.

Supply of Legumes

Mung bean production showed a downward trend from 1991 to 1993 and then recovered in 1995 and remained constant at around 27,000 mt until 1998 (Figure 2) (NSO, 1999). Import of mung bean showed an increasing trend. The amount of import equaled the total produced domestically.

Local production of peanut (Figure 3) showed increasing trend from 1991 (31,398 mt) to 1994 (36,574 mt). However, in 1996 the production began its decline to reach 24,954 mt in 1998. The decline in production is attributed to reduction in the area planted to peanut from 47,647 ha to 28,737 ha. Import of peanut increased since 1991 (Figure 3). In 1994, the amount of peanut imported surpassed the local production. Soybean has the lowest local production (Figure 4) among the three legumes. Soybean production from 1991 to 1998 ranged from 1,480 mt to 2, 979 mt. Soybean production was much higher in the late 1970s and 1980s ranging from 6,000 mt to 8,000 mt. Decline in local soybean production is due to reduction in area planted.

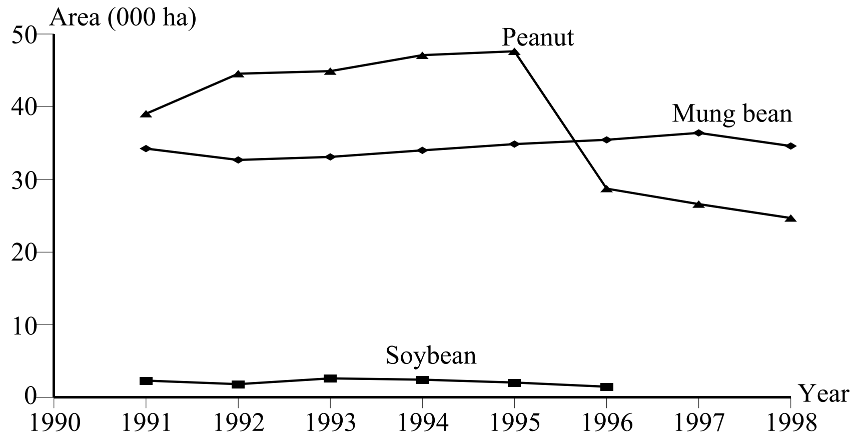


Figure 1. Area Planted to Legumes

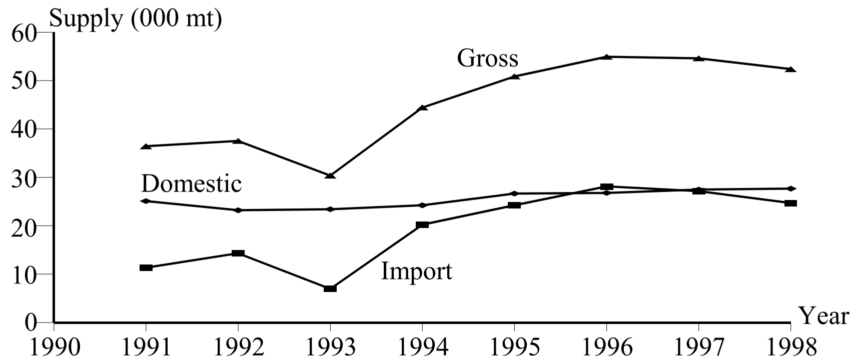


Figure 2. Mung Bean Supply

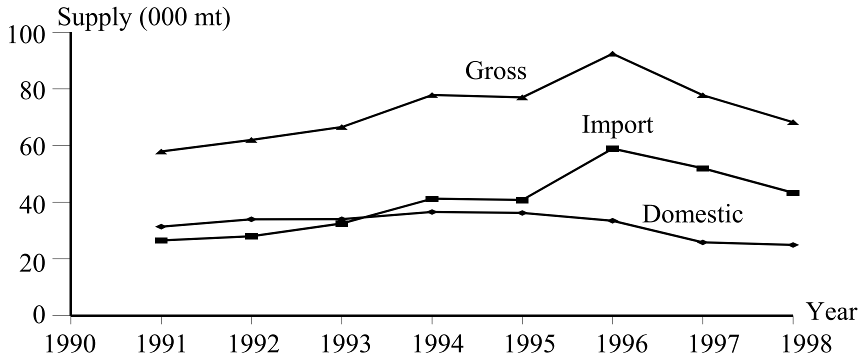


Figure 3. Peanut Supply

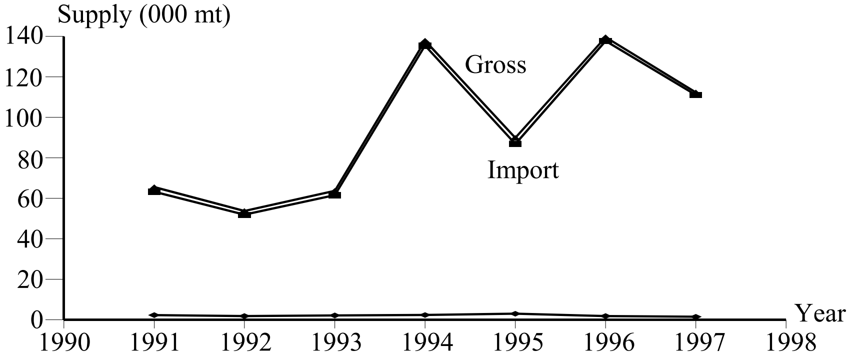


Figure 4. Soybean Supply

LEGUME CONSUMPTION

Mung bean consumption increased from 1990 to 1997 (Figure 5). As of 1997, the per capita consumption of mung bean is around 720 gm/year or 2 gm/day, which is still low. Per capita consumption of peanut (Figure 5) did not change much from 1992 to 1998, which is around 1,200 gm/year or 2.5 gm/day. Consumption of soybean was much lower compared to other legumes. Per capita consumption of soybean increased from 1990 (0.32 gb/day) to 1997 (1.14 gm/day).

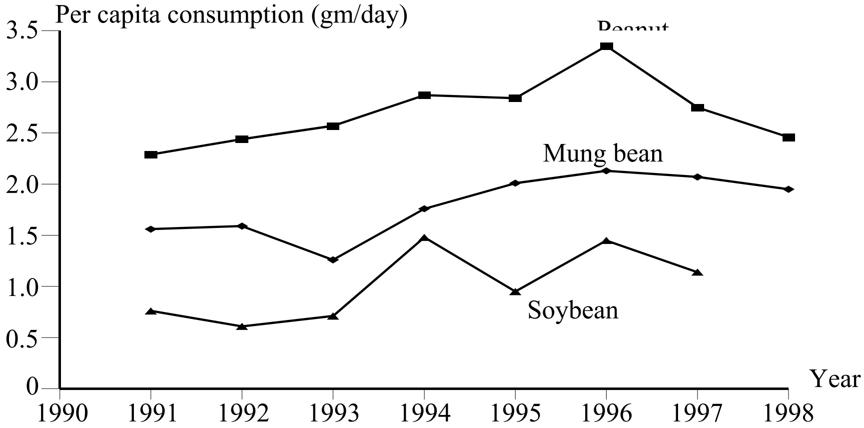


Figure 4. Soybean Supply

PRODUCTION CONSTRAINTS

Import of large quantities of legumes by the Philippine legume industry is due to inadequate local production. Lack of quality seeds for planting and the farmer's perception of low farm gate price are two major factors for decrease in area and production of legumes (National Legume Committee, 2000).

The annual value of imported beans alone is ₱3 billion (US$66,670,000). If processed products like bean noodles and soybean meal, and soybean oil are included, the value would amount to ₱14 billion (US$311,000,000) annually.

Legume production is concentrated in a few selected areas. As a result, unexpected disturbances in these areas can affect the national supply.

Mung bean is grown as a cash crop in rice-based farming system. It is planted during the dry season either after the first rice crop towards the end of the year or after the 2nd rice crop at the early part of the year. In view of this locally produced mung bean is only available during the first half of the year and traders resort to importation to provide the mung bean requirement for the second half of the year.

Peanut is grown as a cash crop in corn-based farming system. Peanut production areas are characterized by distinct wet and dry season. Peanut is planted after corn during dry season. In view of this, if the farm gate price of corn is higher, the farmer can easily shift their production to corn. In some areas, peanut production declined due to higher price for corn. El Niño phenomenon affected some of the peanut plantations in 1997-98 resulting in reduced production.

Area planted to soybean is small and therefore low domestic production. Shortage of technical experts as well as improved technology also contributed to the problem.

Lack of quality seeds and poor seed storage technology are other problems. Farmers buy expensive imported unknown varieties in the retail market for planting. Imported mung bean varieties are not adapted to local conditions. In addition, the farmers could not store their own seeds due to potential infestation by storage pests and rapid deterioration of seeds in storage. Without proper storage, the seeds lose their viability in less than six months.

Another problem is low profitability. The average rate of return for mung bean was 42 percent, based on the 1997 BAS (Bureau of Agricultural Statistics) survey of Ilocos Norte, Pangasinan and Tarlac. The average rate of return for peanut was only 17 percent. The situation aggravated by low farm gate price, high labor requirement for harvest and post-harvest operations and high harvest and post-harvest losses.

Farmer's attitude is also another problem to establish a stable market. In 1989 Land Bank contract farming section and Nestle, Philippines had a joint venture for soybean production. With the help of Philippine Council for Agriculture, Forestry and Natural Resources Research Development (PCARRD), Nestle, Philippines contracted the farmers to produce soybean with a guaranteed price. However, after harvest farmers sold their produce to other traders who offered higher farm gate price.

PROCESSING AND UTILIZATION OF LEGUMES

Mung Bean

The following are the traditional products from mung bean: mung bean noodles "*sotanghon*", mung bean sprout "*togue*", filling material for moon cake "*hopia*" and other baked products, boiled mung bean, and toasted mung bean.

1. ***Mung Bean Noodles "sotanghon"***

The process involves the production of starch from soaked mung bean (Sin and Del Rosario, 1974; and Frias and Del Rosario, 1987). Precooked starch is added to the raw starch and formulated to form slurry and extruded to form threads, which are cooked in 95ºC water. The wet noodles are placed in cold storage for sometime to strengthen them and then sun-dried. However, local production of mung bean noodles declined due to the cheaper imported bean noodles.

2. ***Mung Bean Sprouts "togue"***

Sprouted mung bean (Estioko, 1986; and PCARRD, 1991) is prepared by soaking the mung bean overnight in water and then draining. The swollen seeds are placed in jars or bamboo baskets, lined with banana leaves. The seeds are kept in the dark and watered every four hours for three days. After three days, the seedlings are harvested and de-hulled by placing the sprouts in plastic tray and then soaking it in a basin of water to allow the seed coat to float and it will be removed. Sprout is consumed after boiling or as an ingredient in spring roll or sautéd vegetables. The problem with mung bean sprout is its perishability. In public market it is usually sold in unrefrigerated condition.

3. ***Moon Cake/Buchi Filling***

Moon cake or "*hopia*" and "*buchi*" are very popular dessert and snack food. Mung bean is first soaked in water overnight, cooked in water, seed coat is removed and cooked until pasty and then sugar is added. The sweetened mung bean is placed inside a dough prepared from wheat flour for "*hopia*" and dough prepared from rice flour or sweet potato flour for "*buchi*" and then baked or fried. The problem with moon cake filling is the removal of hulls.

4. ***Boiled Mung Bean***

Boiled mung bean is used in many dishes like soup with mung bean noodles, either with other vegetables, or a meat or shrimp garnishing. Boiled mung bean is a popular dish on Fridays, and during Lent, wherein Filipinos, especially Catholics abstain from eating meat. Since boiled mung bean is perishable, housewives used to prepare it by directly boiling the dry seeds, which usually take 45 minutes to one hour to cook.

5. ***Toasted Mung Bean***

Mung bean is cleaned and toasted until brown. It is added in boiled glutinous rice with coconut milk and sugar. The dish is called "*sinugaok*" or "*tutong*" which is specially eaten as dessert or as snack. Toasted mung bean is not commercially available.

Innovations on Processing and Utilization of Mung Bean

1. ***Quick Cooking Mung Bean***

The process involves cleaning and sorting of mung bean, then soaking for 12 hours in 2 percent sodium tripolyphosphate solution, draining and air-drying for two hours and roasting for 1.5 minutes in 1:10 (mung bean:sand ratio) at initial temperature of 250ºC (Del Rosario, 1989). The seed coats are readily removed by hand after roasting. The estimated cooking time of this quick-cooking legume is four minutes, which is much shorter than the usual 45 minutes to one hour cooking time to prepare boiled mung bean. However, there was no taker of technology, probably due to the fact that raw mung bean is already expensive in the local market and also due to the absence of commercial scale roaster (Del Rosario and Gloria, 1987).

2. ***Baby Food/Snack Food***

A market survey in the Philippines revealed the absence of a low-cost baby food in the market. Those available are expensive and manufactured from imported raw material. The process involves preparation of mung bean flour, formulation with coconut milk, skim milk, sugar, water and rice flour, mixing, extrusion, and grinding. Biological value, net protein utilization and digestibility index were comparable to the control diet, skim milk (Del Rosario, *et al.*, 1987).

When this extruded product is not ground, and is cut into pellet, it is called snack food. However, extending the technology to the private entrepreneurs is a problem since, nobody wants the invest on imported machines like extruder.

3. ***Mung Bean Sauce***

The process involves soaking of mung bean in water, boiling (8-10 minutes) until soft. Draining, cooling, mixing of roasted wheat flour, inoculation and incubation for 3-4 days at room temperature, stirring daily, mashing and aging, harvesting and pasteurization. The chemical components of soybean and mung bean sauces were similar with respect to specific gravity, total sugar and total extract obtained. Sensory evaluation of the sauces from mung bean showed higher scores for aroma, flavor and overall acceptance over soybean sauce though the differences were not statistically significant (Divina, 1983). Commercial application did not succeed since mung bean is more expensive than soybean.

4. ***Ready-to-eat Sweetened Rice and Toasted Mung Bean (tutong or sinugaok)***

This was developed by Ready Food Company. It is an instant soup, a mixture of sweetened glutinous rice, mung bean and coconut milk. The product is packed in laminated plastics. The package may or may not be heated before consumption. However it is not locally available. It is produced by the company for export to countries like Saudi Arabia, the United States, etc. where there are large Filipino populations.

Soybean

Traditional soybean products may be classified into non-fermented and fermented.

1. ***Non-fermented***

a. *Soybean curd (tofu)*

Two types of soybean curd are produced in the Philippines, the soft (*toho*) and the hard curd (*tokwa*). The process involves the preparation of soy milk by boiling, cooling to 70-75ºC and addition of coagulant like calcium sulfate. After coagulation, the curd is placed in mold lined with cheesecloth and pressed to remove some of the water. The soft and the hard soy curd are produced by varying the length of pressing time or varying the weight for pressing used.

Most of the cottage industries producing tofu are situated in Metro Manila such that most of the tofu available in the provinces or rural areas are at least a day old. Tofu are transported without refrigeration. In view of this, tofu undergo deterioration giving off aroma. Such deterioration is the cause for limited acceptance of tofu by most of the consumers, especially the younger generation.

One company is producing soft soybean curd in tube and in plastic container. The curd is set in the container which make use of calcium sulfate and delta gluconolactone as coagulant.

b. *Soybean milk*

Soybean milk is an introduction from the Chinese that involves the extraction of milk from pre-soaked soybean. The extract is boiled, and sugar and vanilla are added and then packed in plastic. The former Department of Food Science developed the process for Philsoy in which the hot formulated milk is filled in bottles and sterilized. Currently, instead of packaging the milk in bottles, it is now filled in plastic bags, cooled and kept frozen.

The P.U.C. Health Foods Adventist University of the Philippines came out with canned soy milk called Soya Supreme. Nestle Philippines, Inc. introduced to the local market another powdered milk called Twin, which is mixture of soybean milk and cow's milk.

c. *Taho*

This is a special type silken tofu in which the water is not pressed out of the curd. It is eaten with caramelized sugar and flavorings like vanilla, and lemon. The soybean milk is cooked at about 70-80ºC. Calcium sulfate coagulant is added and allowed to set. *Taho* is served by scooping the curd and adding sugar syrup with sago, vanilla, and lemon. Calcium sulfate may be substituted with agar-agar to form the gel. The use of agar-agar, as gelling agent allows the manufacturer to place the product in ice cream cups. It can also be flavored with preserved jackfruit (*langka*), yam (*ube*) etc. Nestle Philippine produced *taho* in cups.

d. *Tahure*

After the preparation of soybean curd "*tokwa*", the cubed material is salted and soy sauce and *Taosi* are added. This is used as an ingredient in sautéd fish or meat and vegetable.

e. *Yuba*

Yuba is the edible film produced from soybean milk. The milk is heated in an open kettle at about 90-95ºC without boiling and stirring. The film is allowed to form on the surface of the milk. It is harvested when the right thickness is attained and hung to dry. It is used as a wrapper in fish sausage called "kikiam."

f. *Soybean coffee*

It is prepared by roasting cleaned soybean. It is used as a substitute for coffee.

g. *Miso*

The local miso is not fermented. It is produced by cooking soybean until soft, ground to a paste, salt and vinegar are added to taste. It is commonly used in different fish stew (sinigang,) or as a dip sauce (pesa).

2. ***Traditional – fermented soybean products***

The most popular fermented soybean products are soy sauce, tausi and tahure. These products are usually used as condiments for cooking.

a. *Soy sauce*

Soaked soybeans are cooked and then coated with roasted wheat flour. Boiled rice, inoculated with *Aspergillus oryzae* is then added. The mixture is incubated until it is covered with molds. Then it is placed in brine to continue fermentation for 6 months. The filtrate from the fermented mass is the soy sauce. It is then pasteurized, formulated and bottled. Since the commercial method of soysauce preparation involves a long process, protein hydrolyzate at present is used to make soy sauce.

b. *Tausi*

The process is similar to the preparation of soy sauce except that fermentation time is about two months only and, the brine solution added is just enough to cover the bean. The whole fermented mass is called Tausi. It is used in sautéed dishes of fish and pork.

c. *Tahure*

Preparation of tahure involves cutting of soybean curd (tofu) and inoculation with *Actinomucor elegance*. It is placed in brine containing ground red rice (*angkak*). It is called *sufu* in Japan.

Innovative Processing and Utilization of Soybean

1. ***Soybean Ice Cream***

Soybean ice cream, is prepared from soybean milk. It is promoted by Accelerated Soybean Processing and Utilization Project (ASPUP). There are three cooperatives producing soybean ice cream in Northern Luzon. The long process with soy milk preparation hinders the adoption by small cooperatives. Unlike ice cream from cow's milk, they just dissolve the skim milk and does not need extra equipment such as grinder and filter.

2. ***Textured Plant Proteins from Full-fat Soy Flour***

Textured plant proteins from full-fat soy flour was developed at the Institute of Food Science and Technology, UPLB. Full-fat soy flour was texturized by thermoplastic extrusion, using a locally-fabricated extruder (Del Rosario, 1999).

3. ***Dried Soybean Residue (Okara as Meat Extender)***

The residue from soybean milk preparation is now used as extender in meat products (PCARRD, 1996). A small company toasted okara with wheat flour and sold as meat extender like textured vegetable protein.

4. ***Soybean Spread (Peanut Butter-like Spread)***

Peanut butter-like soybean paste, which could be used as sandwich spread was developed at the Institute of Food Science and Technology (Kalaw, 1992).

5. ***Tofu as Meat Extender in Meat Products***

Soybean curd is used in fresh and smoked sausage and meat loaves (Reyes, 1999).

Peanut

Traditional peanut products can be classified into peanut in shell and shelled peanut (Chavez, *et al*., 1995; R. R. Del Rosario, *et al*., 1995; O. M. Del Rosario, 1998; and Department of Agriculture Regional Field Unit No. 2, 1998).

1. ***Peanut in Shell***

a. *Fresh boiled peanut*

Usually available during harvest season. Peanut in shell is soaked in water to remove the adhering soil and then cooked in water for 30-45 minutes. Salt, 30-45 gm-salt/liter of water is used. Vendors with pushcart or "pedicab" sell this product in the streets of Manila.

b. *Roasted in shell peanut*

Cleaned and sanitized pebbles or sand are used for roasting. Others use stationary oven. For commercial operation, a cylindrical thermostatically-controlled rotary roaster is used. Roaster temperature is 150-190ºC and peanuts are roasted for 20-45 minutes.

2. ***Shelled Peanut***

a. *Fried peanut with or without skin commonly called <u>adobo</u>*

Peanut is deep-fried in oil with garlic then drained and fine salt is added.

b. *Dry roasted peanut*

Instead of frying in oil, the peanut is baked in oven. When ground, it is used in Filipino cuisine "*kare-kare*", a dish of tripe, tail or pork leg mixed with fresh vegetables cooked in peanut sauce. It could be used for topping for "*Lumpiang sariwa*" (sautéd vegetables).

c. *Sugar-coated peanut*

Prepared with refined sugar, condensed milk, water and margarine. Sugar syrup and condensed milk is thickened and peanut is added and cooked until the crystalline sugar forms a coating around the peanut.

d. *Peanut brittle*

It is characterized by its brittle texture. Peanut may be whole or ground. Peanut, corn syrup, sugar and water are cooked until stiff thread is formed and then baking soda and margarine is added to enhance the brittleness of the product. Others do not use baking soda, instead, the product is rolled into a very thin sheet.

e. *Peanut butter*

It is a form of sandwich spread. The process involves grinding the roasted peanut, and mixing with sugar, margarine or oil and salt. Due to the expensive price of peanut, other companies add roasted rice during grinding to lower the cost of production.

f. *Peanut cake*

A form of snack food, also called as brain food. Made by preparing sugar syrup, which is moldable and filling it with sugar/peanut mixture, then rolling it with pressure to embed the peanut and sugar before crystallization.

3. ***Innovative Processing and Utilization of Peanut***

a. *Cracker nut*

It is a finger food. Roasted peanut is covered with dough and then baked giving the product the crunchy texture. It comes in different flavors like barbecue, adobo, hot and spicy, etc.

b. *Peanut sauce mix or <u>kare-kare</u> mix*

It is produced by McCormick Philippines. It is a dry mixture of ground peanut, rice flour that is ready to use peanut sauce mix for Filipino food called *kare-kare*. It eliminates the hassle of grinding the peanut and rice together.

c. *Peanut milk concentrate*

It is developed by extracting the milk from peanut and adding sugar. It is then cooked to concentrate, forming a condensed milk like product. For consumption, two to three tablespoons of the concentrate is diluted to 200 mℓ for a ready-to-drink milk (Reyes, 1992).

d. *Peanut film*

It is similar to yuba of soybean.

FUTURE ROLE OF LEGUMES IN FOOD PRODUCTION AND AGRICULTURAL DEVELOPMENT OF THE PHILIPPINES

The growing population and the economic crisis in the country would further move to increase the demand for legumes. This will provide the people with low-cost nutritious food from legumes. The increasing awareness of people concerning nutrition and health of legumes especially soybean encourages other institutions to conduct research on legumes. Research focus is on the improvement of traditional processing methods and products to increase acceptability and nutritional value and development of new processing methods and products from legumes for village level and small-scale industry.

The government through the Department of Agriculture and its other agencies will promote the increase in domestic production of legumes. The current National Research, Development and Extension Agenda for legume aim to expand production by increasing the area planted with legumes, provide quality seeds for planting, improve the profitability of legume production and improve the income and nutritional status of legume-growing regions. A network of seed production and distribution system will be developed. Appropriate and cost-effective seed storage systems will be in place. Rhizobial inoculants will be provided. So far the use of genetically modified seeds to improve legume production has not been studied.

The increase in local production of legumes will not only provide low-cost nutritious food for the people but also encourage establishment of small-scale industries. This will eliminate the large importation of legumes which cost millions of dollars on the part of the Philippine Government. Increased legume production will help stabilize the Philippine economy.

REFERENCES

Chavez, L. L., D. G. Sonido, and S. Y. de Leon, 1996. *Peanut Products: A Manual of Procedures*, UPPCHEF, Inc., Diliman, Quezon City.

Del Rosario, O. M., 1998. Country report on Gender Role in Peanut Sector for Household Security, 7-10 April, Bangkok, Thailand.

Del Rosario, R. R., 1989. "Processing and Utilization of Legumes with Particular Reference to Mungbean in the Philippines", paper presented in Consultants Meeting in Use of Tropical Grain Legumes, 27-30 March 1989, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Center, India.

Del Rosario, R. R., D. M. Flores, O. M. Maldo and N. S. Sabiniano, 1987. "Development of Rice-Mungbean Based Baby Food", *Phil. Journal of Food Science and Tech.* 2 (1&2), 95-109.

Del Rosario, R. R., O. M. Del Rosario, and N. Ohwada, 1995. *Leaflets on Peanut Processing*, IFST, UPLB.

----------, 1999. "Texturization of Soybean Using a Locally Fabricated Extruder", Ph.D. thesis, IFST, CA UPLB.

Department of Agriculture, 1998. *Region 02 Technoguide: Peanut Tugegarao*, Regional Field Unit No. 2, 1998.

Divina, R. D., 1983. "Influence of Varieties of Mungbean on the Quality of Mungbean Sauce", M.S. thesis, IFST, CA, UPLB.

Estioko, O., 1986. "Production of Mungbean Sprout", B.S. thesis, IFST, CA, UPLB.

Frias, M. G. and R. R. Del Rosario, 1987. "Mungbean Starch Extraction and Some Factors Affecting Quality", B.S. thesis, IFST, UPLB.

Kalaw, R. D., 1992. "Production of Peanut Butter-like Product from Soybean", B.S. thesis, IFST, CA, UPLB.

National Legume Committee, 2000. *The National Research Development and Extension Agenda for Legumes*.

National Statistics Office (NSO), 1999. *Statistics Handbook of the Philippines*.

PCARRD, 1991. The Phil. Recommend Mungbean.

----------, 1992. *Legume and Nutrition Annual Report*, IDRC (International Development Research Center).

----------, 1996. *Great Flavor of Soybean*, Book Series No. 155, Technology Application and Promotion Institute (TAPI)-Department of Science and Technology (DOST).

Reyes, D. 1992. "Processing of Peanut-milk Concentrate", B.S. thesis IFST, CA, UPLB.

Reyes, V. B., 1999. "Utilization of Soybean and In Fresh, and Smoked Chicken Sausage", B.S. thesis, IFST, CA, UPLB.

Sin, I. S. and R. R. Del Rosario, 1974. "Studies on Processing of Local Noodles", M.S. thesis, IFST, UPLB.

13. SRI LANKA

Nandanie Daya Ediriweera
Head
Agro and Food Technology Division
Industrial Technology Institute (ITI)
Colombo

INTRODUCTION

Legumes are one of the most important sources of food, in terms of carbohydrate, protein (20-40 percent) and in some cases oil (1-40 percent). The raw dry legumes uncooked are not consumed in Sri Lanka. Cooking and pre-cooking parameters for legumes vary widely. Except peanuts, legumes for human consumption invariably involves some rehydration and application of heat.

PRODUCTION AND CONSUMPTION

Vegetables are the major source of protein in the diet of Sri Lanka (Figure 1). Among the vegetables, grain legumes provide the major source of protein in Sri Lanka. Grain legumes cultivated in Sri Lanka are, cowpea, (*Vigna unguiculata*), green gram, (*Vigna radiata* Wilczek), soybean, (*Glycine max* L.), groundnut (*Arachis hypogaea* L.) and black gram (*Vigna mungo* L.)

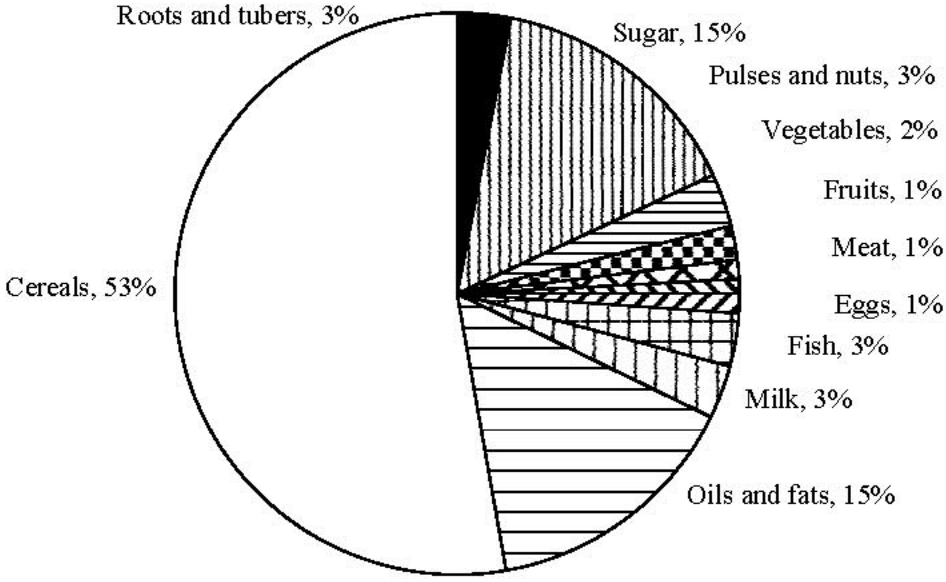


Figure 1. Per Capita Availability of Calories from Cereals, Pulses and Other Sources

Grain legumes were freely imported prior to 1970. Since 1970, foreign exchange difficulties and increasing world market prices progressively reduced the imports of grain legumes. As a result, the local cultivation of grain legumes increased. Consequently, efforts on production research have been intensified.

The area cultivated and production of grain legumes over the last decade is given in Figures 2 and 3. The area and production of green gram and cowpea declined sharply while the decline in soybean was small. The area and production of groundnut was static.

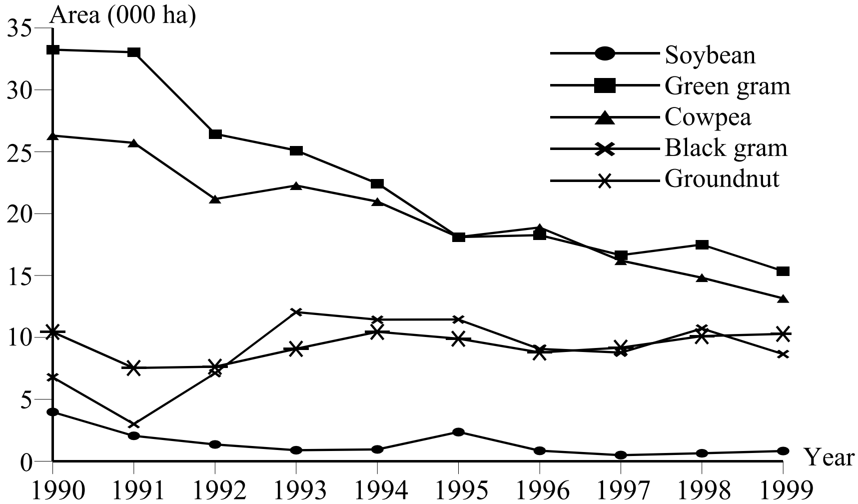


Figure 2. Area Under Grain Legumes from 1990 to 1999

Source: Department of Census and Statistics.

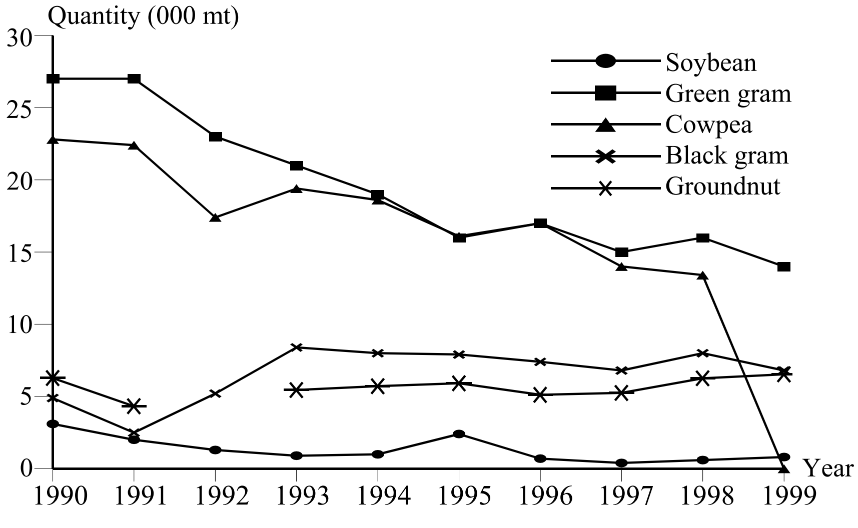


Figure 3. Production of Legumes

Source: Department of Census and Statistics.

The area under grain legumes dropped from 80,000 ha to 37,500 ha during the last decade. Production also declined from 58,000 mt to 35,000 mt. In contrast import of all legumes increased tremendously from 32.600 mt to 4,446,000 mt.

The emergence of open economy and free trade policies as well as low productivity of legumes are two major factors responsible for the decline in domestic production of legumes. Domestically produced grain legumes in Sri Lanka failed to offer a competitive price to the consumer and a decent return to the farmer.

Import of soybean has been around 15,000 mt during the years 1991-94, decreased in 1995, and increased in subsequent years. Dhal (*Lens culinaris*) and groundnut are the most popularly consumed legumes, which are imported over the last decade. The quantities imported have increased from 5,000 mt to 4,500,000 mt. Green gram and cowpea are the other important legumes. Soybean is the least preferred. The total supply of different legumes and the quantities used for food is shown in Figure 5. The difference between supply and consumption as food is that used as seed, and wastages.

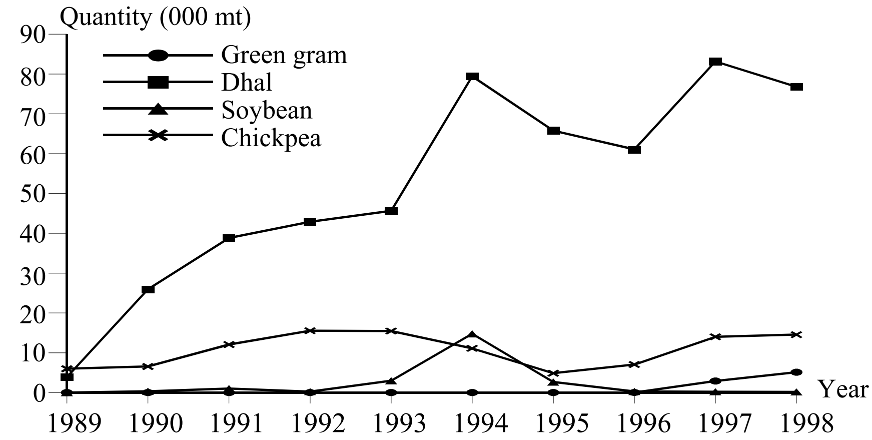


Figure 4. Imports of Legumes

Source: Department of Customs.

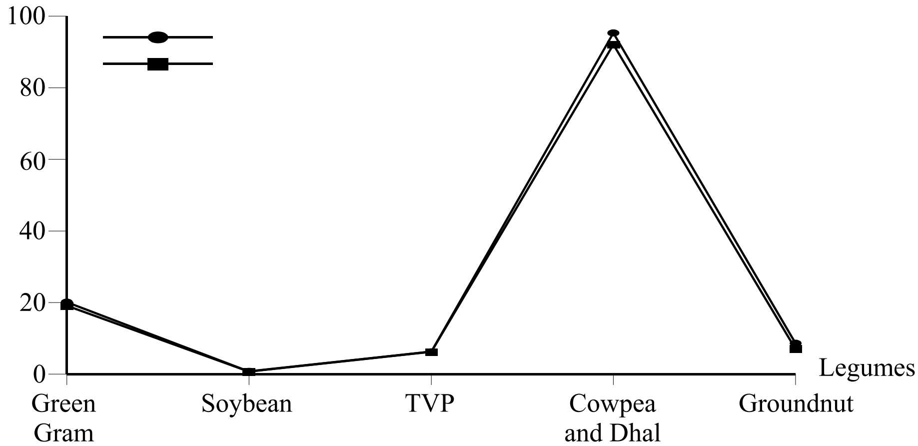


Figure 5. Supply and Consumption of Legumes, 1998

Source: *Food Balance Sheet*, 1994-98.

Per capita availability of legumes and protein from vegetables and animals are given in Figures 6 and 7.

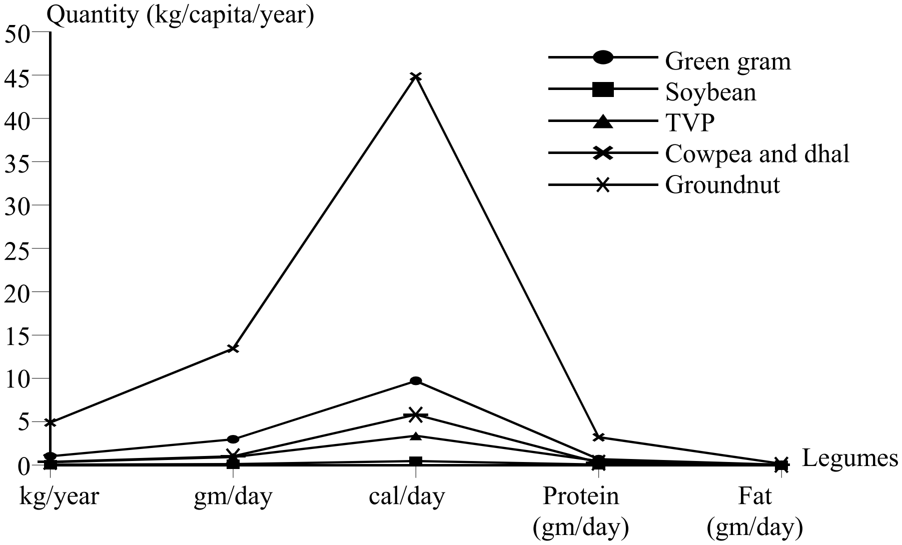


Figure 6. Per Capita Availability of Legumes in 1998

Source: *Food Balance Sheet*, 1994-98.

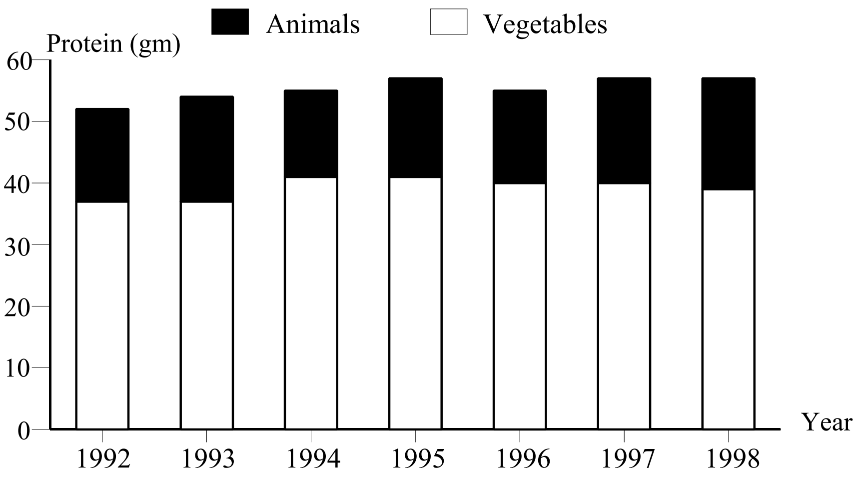


Figure 7. Per Capita Availability of Protein by Source, 1992-98

USES OF LEGUMES

Legumes serve as an excellent source of high quality protein in Asian diets. Lentils, green gram and groundnuts are popular food items in the Sri Lankan diet. Use of simple, nutritious, low-cost legume foods, providing both calorie and protein for children has long been well recognized.

Green gram is used either in the split form or in the grain form. Split lentils and cowpea are used to make a curry spiced with chilies and spices and is consumed with rice. Grain legumes high in protein content, is a natural supplement to cereals. Legumes are deficient in methionine and cystine but rich in lysine while cereals are deficient in lysine but have adequate methionine and lysine, complement each other in providing a balanced diet.

Black gram is usually used to prepare various breakfast/dinner and snack preparations, such as *thosai, idli, wade, papadam*, etc. Black gram flour or slurry is blended with rice flour, wheat flour and other spices for making the above preparations. Value-added black gram products such as flour, and instant mixes for other preparations are commercially manufactured and are available in the market.

Groundnut is a very popular snack. Groundnuts are roasted with or without salt and sometimes mixed with spices such as chilies. Roasted and fried groundnuts are also used in the preparation of snack mixtures. Green gram and cowpea are also boiled and eaten with grated coconut for breakfast. Curried sprouted green gram is also popular. Green gram flour is used for making a variety of sweets. In all these preparations green gram and lentils are preferred to other beans, since they can be cooked easily and the people are traditionally used to consuming them.

Chickpeas are generally used in the boiled form as a breakfast food. Soybeans are the least consumed as beans (0.04 kg per year). This is mainly due to the time and energy required to prepare soybean and due to its undesirable beany taste and flavor. Texturized vegetable protein (TVP) from soybean has been accepted by consumers. The supply of TVP has been steady at 6,190 mt in 1994, to 6,250 mt in 1998. Soybean oil is used as a source of vegetable oil in the preparation of dishes. Soybean flour is used in the manufacture of weaning food, and for enriching the bakery products. Fermented products such as soybean sauce, *natto* and *tempe* are used to a limited extent. Green pods of grain legumes are used as vegetables. These are lima bean (*Phaseolus lunatus*), winged bean (*Psophocarpus tetragonalobus*), and string bean (*Phaseolus vulgaris*).

PROCESSING PROBLEMS AND ISSUES

The decline in production of legumes in Sri Lanka over the past decade retarded the development of processing techniques due to decreased investments.

Pre- and post-harvest losses of grain legumes should be minimized. Although it is a complex problem requiring multidisciplinary approach, there is a need to combine the current and innovative technologies to minimize the problem. Various pests and microorganisms attack the legumes or legume products after harvest, in storage, during transportation to the market, etc. A loss of approximately 10-15 percent has been reported for legumes. The application of pesticides results in chemical residues in the food that are extremely hazardous to health.

Temperature, moisture, and oxygen content influence the post-harvest storability of legumes. Establishment of efficient and effective post production storage system should complement the integrated sustainable crop production system. An integrated, environmentally friendly, safe pest management system, and proper pre- and post-harvest handling of the corps, would minimize the post production losses and would improve the quality of legume grains for utilization.

National level planning and coordination of research is required. Development of such coordination would identify the major constraints and the research needs. Lack of practical application of research results and lack of market orientation of production and processing are other constraints. Improper post-harvest management of peanuts, results in the accumulation of aflatoxins through fungal infection. It is a serious problem in marketing peanuts. Therefore, quality control measures for peanuts beginning from the farm and subsequently through harvesting, curing, shelling, storing and manufacture of value-added products should be implemented.

Peanuts are semiperishable legume and could be stored for long periods under optimum conditions. But under unsuitable storage conditions, discoloration, and development of rancidity develops rapidly due to insect and fungal attack and become inedible within a short time.

INNOVATIVE TRADITIONAL/MODERN UTILIZATION TECHNOLOGIES

Innovations made in recent years are based on traditional consumption patterns. New products are formulated using a blend of ingredients in order to provide better nutrition, wholesomeness, taste characteristics and convenience to the consumer. These products are commercially manufactured on a small/medium scale partially utilizing modern technologies. These products can be categorized into weaning foods, protein-rich foods, and milled products (flour). Instant breakfast mixes, curry formulae, snack foods, etc. are other value-added products.

Nutritious Supplementary Foods

1. ***Thriposha***

Thriposha is a product manufactured by extrusion cooking of maize and soybeans and blending with a fortified product called Instant Corn Soya Milk donated through USAID.

The product *Thriposha* in the national language signifies the combination of triple nutrient values. It is distributed free of charge through maternal child health centers, clinics, hospitals, primary and pre-schools, plantation estates, and social service institutions. It is a nutrition intervention program by the Ministry of Health.

The '*Thriposha*' contains about 20 percent protein, 6 percent fat, 60 percent carbohydrates, 5 percent moisture and 380 kcal/100 gm.

2. ***Samaposha***

Thriposha (pro soy-product) is an off white powder manufactured using maize, rice, soybean and green gram. It is a 100-percent natural product free from chemical additives, flavors, colorings and preservatives. It can be used as a breakfast cereal and for the preparation of traditional sweets.

Its proximate composition is: 19.6 percent protein; 6.7 percent fat; 64.4 percent carbohydrates; 1.5 percent fiber; and it provides 396 kcal/100 gm. It is fortified with vitamins and minerals.

3. ***Milkee***

Milkee (pro soy-product) is a soy-powder prepared for cooking. It is a medium fat soy-flour containing 48 percent protein and 8 percent fat.

4. ***Prosoya – Protein Food***

Soybean grits, 100 percent natural product, free of chemicals, flavors, coloring or preservatives. It is a product recommended for consumption in a curried form. It is used as an ingredient in the preparation of breakfast food, salads, vegetable/meat/fish curry. The product has a protein content of 40 percent, 9.7 percent fat, 5.4 percent fiber and 366.9 kcal/100 gm.

5. ***'Nestle' Cereal Green Gram***

Cereal green gram is a product prepared from whole wheat, rice and green gram and enriched with vitamins. It is a breakfast cereal. It can be consumed by mixing with warm milk or water. It has a proximate composition of 1.5 percent fat, 10.3 percent protein, 75.6 percent carbohydrates, 7.1 percent dietary fiber, 2.6 percent minerals, 3.0 percent moisture and 356 kcal/100 gm.

6. ***Positha – An Infant Weaning Food***

Positha is a product developed by ITI. The ingredients are rice, mung bean, groundnut, sugar, vitamins and minerals. The product is an off-white powder with the taste and flavor characteristics of roasted ingredients. The average composition of the product is 15.5 percent protein, 7.0 percent fat, and 70.4 percent carbohydrates. It provides 406 kcal/100 gm. The product is packed in two sachets.

The contents of the two sachets are mixed with boiled cooled water or milk to form a smooth paste and cooked over a slow fire for approximately 2-3 minutes until the desired texture is obtained.

7. ***Instant Soy-products***

These products were developed at ITI. Canned soybean in curry form is commercially manufactured.

8. ***Canned Soybean in Curry Form***

It is a 100-percent natural product free of chemicals. The ingredients are soybeans, curry powder, curry leaves, coconut milk, green chilies, chili powder, ginger, onion, garlic and salt. The proximate composition of the product is 21.0 percent protein, 9.29 percent fat, and 31.2 percent total solids.

9. ***Canned Soybean Sprouts in Curry Form***

It is also a product free of chemical additives. The ingredients are sprouted soybean, curry powder, curry leaves, coconut milk, green chilies, chili powder, ginger, onion, garlic, and salt. Proximate composition of the product is 33.6 percent protein, 24.7 percent fat, 5.2 percent total ash, and 4.8 percent crude fiber.

10. ***Canned Soybean 'Tofu' in Curry Form***

The product, with extended shelf life of tofu, in curry medium is prepared using spices, curry leaves, coconut milk, curry powder green chilies, chili powder, ginger, garlic and salt. The proximate composition of 100 gm of canned tofu on wet basis is 20 percent protein, 23 percent fat, 0.2 percent total ash and 13 percent total solids.

11. ***Canned Soybean Cutlets in Curry Form***

Soybean cutlets are formulated using soybean, garlic, onion and salt. Curry medium is prepared using coconut milk, spices, onions, garlic, herbs, salt, tomato and hydrogenated vegetable fat.

12. ***Instant Mixes – 'Thosai Mix' and 'Idli Mix'***

Instant mixes of black gram flour, rice flour and wheat flour are commercially manufactured for the preparation of '*Thosai*' and '*Idli*' which are used as a main meal for dinner.

13. ***Texturized Vegetable Protein***

It is an extruded product prepared from defatted soybean flour with the addition of flavor. It contains approximately 50 percent protein.

14. ***Milled Products – Black Gram Flour***

Milled black gram flour is used in the preparation of '*thosai*', '*Idli*' and other snacks.

15. ***Blended Milks***

(a) Soy milk blended with cow's milk is packaged in bottles or in flexible pouches and sold in the market.

The technical know-how for the manufacture of canned/bottled blended milk of good organoleptic quality suitable for consumption have been developed by ITI for commercialization. The ratio of saturated to unsaturated fatty acids in cow's milk and soybean milk are 61-39 percent and 14 percent and 86 percent, respectively. The blended soy milk has the advantage of more balanced fatty acid composition.

(b) Soy milk blended with coconut milk in bottles or in flexible pouches for cooking purposes.

The technical know-how for the manufacture of canned/bottled blended milk of good organoleptic quality suitable for cooking purposes have been developed by ITI and transferred to industry for commercialization. This product has the advantage of a more balanced fatty acid composition of 71.8 percent saturated fatty acids and 28.2 percent unsaturated fatty acids compared to 91.6 and 8.4 percent in coconut, and 14 percent and 86 percent in soybean, respectively.

FUTURE ROLE OF LEGUMES IN FOOD SECURITY AND NUTRITION

It is well known that legumes are important crops in terms of food security, nutrition, agricultural development, and enhancement of economy. They rank next only to cereals. Legumes are generally grown on poor land and given less attention than cereals. Legumes and cereals supplement each other in the field and in providing wholesome nutritive food and high quality protein. They are also useful as rotation crops that improve soil fertility. Legumes therefore, play an important role in our agricultural system.

Cereals are converted both domestically and industrially into a variety of edible products than legumes. A better knowledge and appreciation of the functional properties of important legume constituents is essential for utilization and processing of legumes in the most advantageous manner. Functional properties of protein except for soybean protein is hardly known. Some of the functional properties of practical importance are water binding capacity, solubility, gel formation, lipid binding, foam evaluation, etc.

Legumes can contribute towards improving the economy through industrial processing and value addition. In considering industrial processing legumes high in lipids such as soybean, groundnut and those low in lipid content should be differentiated.

Manufacture of extruded products using composite mixtures of cereal and legume flour would provide a different range of nutritious snack products to the consumer. The composition of cereal/legume blend plays a vital role in the nutritional and functional characteristics of final products produced by extrusion. Development of these products should take into consideration the local food habits and preferences of each country.

Food legumes play an important role in the nutrition of vegetarian population. The nutrient composition of legumes is given in Table 1. Although soybean has proteinase inhibitors which lowers the digestibility of legume proteins, they are often partly destroyed during cooking.

Table 1. The Nutritional Composition of Different Legumes

	Cowpea	Dhal	Black Gram	Green Gram	Soybean	Groundnut (roasted)
Energy (kcal/100 gm)	323	343	347	334	432	340
Moisture (percent)	13.4	12.4	10.9	10.4	8.1	1.7
Protein (percent)	24.1	25.1	24.0	24.0	43.2	26.2
Fat (percent)	1.0	0.7	1.4	1.3	19.5	39.8
Carbohydrate (percent)	54.5	59.0	59.6	56.7	20.9	26.7
Ca (mg)	77	69	154	124	240	77
P (mg)	414	298	385	326	690	370
Fe (mg)	5.9	0.8	9.1	7.3	11.5	3.1
Vitamin A (mcg)	-	-	-	-	-	-
Carotene (mcg)	12	270	38	94	426	-
Thiamine (mcg)	510	450	420	470	730	390
Riboflavin (mcg)	200	200	200	270	390	130
Niacin (mcg)	1.3	2.6	2.0	2.1	3.2	22.1
Vitamin C (mg)	0	0	0	-	-	-

Source: *Tables of Food Composition*, World Health Foundation of Ceylon.

The fatty acids in legumes are mostly unsaturated fatty acids. Oleic acid is predominant in peanuts whereas linoleic acid is most abundant fatty acid in soybean.

Legume sprouts are used for human consumption in the orient for centuries, and their health promoting effects are now well recognized. In terms of proximate composition, sprouts contain more protein than non-sprouted seed.

Green pods of legumes such as lima bean, string bean, and winged bean are used as vegetables. Green pods of soybeans are popularly used as a vegetable in Japan. Vegetable soybean may have potential in Sri Lanka for use in salads and other food preparations.

The green seeds of many legumes are used as an ingredient in cereal-based recipes. Green peas are the most popular among these legumes and used in Sri Lanka to a limited extent. Vegetable soybeans can find a similar use.

One of the major industrial food uses of legume is oil. In its natural state it is not commercially acceptable. Oil must be extracted and refined to ensure optimum processing quality for intended uses.

Confectionary coatings – A blend of a fat with sweetener and other solids, which is solid at room temperature but melts near mouth temperature is often used to coat various food items. Such blends are called confectionary coating.

Salad oils – Oils for use in various kinds of salad dressings and spreads have two prime requirements, namely good oxidative stability and resistance to crystal formation at refrigerator temperatures.

Lecithin with less than 1 percent moisture is obtained by drying the sludge from de-gumming the oil.

Isolated Soy Proteins (ISP)

ISP are high quality protein food. ISP are the major protein fractions of soybeans obtained in high purity from high quality de-hulled soybeans after oil extraction. ISP offers nutritional, functional and economical advantages, while maintaining the desirable sensory qualities necessary for consumer acceptance.

Legume Protein Flour and Concentrates

Soybean grits, defatted soybean flour, low fat soybean flour, and full fat soybean flour are presently imported and used for the manufacture of weaning foods, texturized vegetable protein, etc.

Feed

Soybean meal after oil extraction is properly processed and used as animal feed.

Safety Issues

Pesticide residues, genetically modified seeds and fungal toxins are the main food safety issues concerning the utilization of legumes. Presently monitoring schemes are non-existent. However, limited laboratory facilities are available for testing pesticide residues and fungal toxins. Genetically modified foods are not allowed in Sri Lanka.

CONCLUSION

Food legumes containing 20-40 percent protein and 1-20 percent fat, 30-60 percent carbohydrates and with energy values ranging from 320 kcal to 435 kcal/100 gm, are supplementary to the cereal-based diet in Sri Lanka in providing a good quality protein. These vegetable proteins are offered at lower cost than animal proteins and are affordable to the poor in the country. Legumes are traditionally well accepted by the people and therefore play an important role in fulfilling the nutritional security of the country.

Therefore, there is a great potential for Sri Lanka to develop an efficient production and post-production system for developing the legume industry that will contribute to the socio-economic development of the country.

14. VIETNAM

Le Thanh Hiep
Laboratory Manager
Post Harvest Technology Institute
Ho Chi Minh City

INTRODUCTION

Vietnam is a tropical country and its climatic condition is favorable for year-round crop production. Agriculture plays an important role in Vietnam's economy. Of the total population 76.5 percent is rural. About 78.9 percent (42.6 million) of the labor is also rural. Of the total land area 22.2 percent is cultivated. The agriculture sector provides about 30 percent of the national economy (Lan, 1999). Development of leguminous crops in Vietnam has enabled diversification of crops and diet of the people. A detailed report on the leguminous crops in Vietnam is lacking. This paper is one of the comprehensive reports on popular leguminous crops in Vietnam.

PRODUCTION AND CONSUMPTION

Among the numerous legume crops in the family Leguminosae only a few are commonly used and they play an important role in agricultural production in Vietnam. They are groundnut, soybean, mung bean, red cowpea, black mung bean, and white pea. A few others used as vegetables are snap bean and snow pea. The area planted to groundnut and mung bean and their production in relation to other crops from 1968 to 1973 are shown in Table 1. The area, production and the yield per unit area of legumes in relation to other crops from 1976 to 1994 are shown in Tables 2, 3, and 4. Groundnut and soybean continue to be the major crops with an increasing trend in area, production and productivity. Northeast South and North Central Coast are the two major groundnut growing areas (Table 5). On the other hand North Vietnam, Mountain and Midland, and South Vietnam are the major soybean growing areas (Table 6). Among the industrial crops groundnut ranks first and soybean ranks fourth.

Soybean

Vietnam has a long history of cultivating soybean (Louriro Runphius, 1773). Vietnamese people used a number of processed soy-foods such as tofu, soy milk, soy sauce, soy paste, soy curd, etc. and they provided part of the protein in their diet. They also used soybean for animal feed.

On a worldwide basis, the area planted to soybean in Vietnam is only 0.21 percent of the total world area for soybean. However, the soybean area in Vietnam increased to 121,000 ha in 1995 from 39,400 ha in 1976 (Figure 1). The average yield per ha in 1997 was 1,100 kg compared to 525 kg/ha in 1976 (Figure 2). Similarly the total production reached more than 120,000 mt in 1995 compared to only 20,700 mt in 1976 (Figure 3). Nearly 77 percent of the total soybean area is concentrated in four main regions: Mountain and Midland; Red

Table 1. Area and Production of Main Crops in South Vietnam Before 1975

(Unit: Area = ha; and production = mt)

Crop	1968		1970		1973	
	Area	Production	Area	Production	Area	Production
Paddy	2,393,800	4,366,150	2,510,700	5,715,500	2,830,000	7,025,000
Rubber	105,750	34,000	105,800	33,340	68,340	19,500
Fruit	32,340	221,880	32,920	219,435	42,850	282,000
Coconut	29,905	110,705	32,250	118,450	33,640	84,168
Sweet potato	34,520	234,685	32,860	219,750	40,100	279,800
Cassava	35,130	260,190	30,800	215,710	47,780	279,700
Sugarcane	15,265	401,070	11,620	335,720	17,400	539,900
Groundnut	29,680	32,055	30,240	32,185	39,200	44,800
Corn	28,730	31,760	28,640	31,435	39,600	50,000
Mung bean	21,405	13,360	26,600	11,095	14,854	10,600
Coffee	10,000	3,000	9,340	3,925	8,870	5,120
Tea	7,660	4,770	8,215	5,545	7,380	5,890

Source: Nguyen, 1989.

Table 2. Area of Main Crops, 1976-94

(Unit: 000 ha)

Crop	1976	1980	1985	1990	1991	1992	1993	1994
Total area	7,040.9	8,251.0	8,556.8	9,040.0	9,409.7	9,752.0	9,978.7	10,130.8
Paddy	5,297.3	5,600.2	5,703.9	6,027.7	6,302.7	6,475.1	6,559.4	6,598.4
Corn	336.6	389.6	397.3	431.8	447.6	478.0	496.5	535.0
Sweet potato	248.9	450.0	320.0	321.1	356.1	404.9	387.1	343.7
Cassava	234.5	442.9	335.0	256.8	273.2	283.8	278.0	279.4
Vegetables	230.9	298.6	199.0	426.1	425.2	445.0	475.5	495.4
Cotton	7.6	6.5	13.7	7.9	16.1	19.2	11.5	14.0
Sugarcane	74.5	109.8	143.2	130.6	143.7	146.0	143.2	164.8
Peanut	97.1	106.1	212.7	201.4	210.9	217.3	217.2	246.6
Soybean	39.4	48.8	102.0	104.0	101.1	97.3	120.1	219.8
Tea	36.6	46.5	50.8	59.9	59.9	62.8	63.4	70.5
Coffee	18.8	22.5	44.6	119.3	115.0	103.7	101.0	118.0
Rubber	76.6	87.7	180.2	221.7	220.6	212.3	242.4	251.3
Fruit trees	92.6	185.6	213.0	281.2	271.9	260.9	270.0	315.9

Source: MARD.

Table 3. Yield of Main Crops, 1976-94

(Unit: quintal*/ha)

Crop	1976	1980	1985	1990	1991	1992	1993	1994
Paddy	22.33	20.80	27.83	31.89	31.13	33.34	34.81	35.66
Corn	11.49	11.01	16.89	15.54	15.01	15.65	17.77	18.71
Sweet potato	59.65	53.72	55.55	60.07	60.02	64.04	62.12	61.85
Cassava	77.43	75.03	87.76	88.62	89.86	90.48	88.13	86.97
Vegetables	121.97	98.82	151.51	75.68	75.58	75.08	73.28	75.59
Cotton	2.89	3.23	3.21	3.54	5.16	6.67	4.43	4.29
Sugarcane	400.86	396.99	388.25	413.30	426.65	440.89	431.79	449.09
Peanut	10.31	8.97	9.52	10.58	11.13	10.43	11.94	12.19
Soybean	5.25	6.58	7.75	8.33	7.91	8.22	8.80	5.65
Tea	4.70	4.52	5.55	5.38	4.96	5.18	5.36	5.39
Coffee		16.18	8.03	5.37	6.83	6.92	10.52	13.14
Rubber	5.25	4.68	2.66	2.61	2.90	3.11	3.96	4.80

Source: MARD.

Note: * 1 quintal = 0.1 mt.

Table 4. Production of Main Crops, 1976-94

(Unit: 000 mt)

Crop	1976	1980	1985	1990	1991	1992	1993	1994
Paddy	11,827.2	11,647.1	15,874.8	19,225.1	19,621.9	21,590.3	22,836.0	23,528.3
Other cereals	1,665.9	2,759.0	2,263.5	2,263.5	2,367.6	2,624.3	2,665.0	2,670.2
Sub-total	13,493.1	14,406.1	18,138.3	21,488.6	21,989.5	24,214.6	25,501.0	26,198.5
Corn	386.8	428.8	671.0	671.0	672.0	747.9	882.2	1,001.0
Sweet potato	1,484.6	2,417.6	1,777.7	1,929.0	2,137.3	2,593.0	2,404.8	2,125.7
Cassava	1,815.7	3,323.0	2,939.8	2,275.8	2,454.9	2,567.9	2,450.0	2,430.0
Vegetables	2,816.3	2,950.7	3,015.0	3,224.9	3,213.7	3,340.9	3,484.5	3,744.7
Cotton	2.2	2.1	4.4	2.8	8.3	12.8	5.1	6.0
Sugarcane	2,986.4	4,358.9	5,559.7	5,397.7	6,130.9	6,437.0	6,183.2	7,401.0
Peanut	100.1	95.2	202.4	213.1	234.8	226.7	259.3	300.6
Soybean	20.7	32.1	79.1	86.6	80.0	80.0	105.7	124.2
Tea	17.2	21.0	28.2	32.2	29.7	32.5	34.0	38.0
Coffee		36.4	35.8	64.1	78.6	71.8	106.3	155.0
Rubber	40.2	41.0	47.9	57.9	64.0	66.1	96.1	120.5

Source: MARD.

River Delta (Pham, 1996; and Ngo, *et al*., 1999), Central Highlands and Northeast South (Figure 4). On the other hand, the production was dominated in Mountain and Midland, Red River Delta, Central Highlands and Mekong River Delta (Figure 5). The highest per ha yield is 2,100 kg from Mekong River Delta in the south (Ngo, *et al*., 1999). Soybean is cultivated in the spring (February to May – 29.7 percent production), summer (June to August – 31.3 percent) and autumn (September to November – 22.1 percent) seasons (Pham, 1996; and Ngo, *et al*., 1999).

The per capita availability of soybean in 1995 in Vietnam was 1.1 kg/year against 10.5 kg for Indonesia and 0.4 kg for the Philippines. At present, soybean is used in the following manner in Vietnam.

a. Traditional processed food: tofu, soy paste, soy sauce, soy milk and soy curd
b. Vegetable oil, shortening and mayonnaise
c. Extrusion cooking and micronizing
d. Animal feed
e. Fertilizer

Table 5. Production and Area of Peanut by Provinces

Province	Production (000 mt)			Area (000 ha)		
	1995	1996	1997	1995	1996	1997
Red River Delta	23.2	31.8	34.6	17.7	22.2	22.1
Northeast	35.0	39.1	35.3	35.8	36.5	35.2
Northwest	4.9	4.9	5.7	5.8	5.6	5.2
North Central Coast	72.6	68.7	77.9	64.0	63.4	62.9
South Central Coast	27.5	28.4	31.2	26.4	24.3	24.9
Central Highlands	23.6	25.3	21.4	22.5	23.2	19.8
Northeast South	120.5	127.6	119.1	72.7	71.1	66.3
Mekong River Delta	28.1	26.2	27.7	15.0	16.5	14.9
Whole country	335.4	352.0	352.9	259.9	262.8	251.3

Source: General Statistical Office, *Statistical Yearbook 1997*, 1998 (Vietnamese).

Table 6. Specifications for Export of Soybean

Traits	Grade I	Grade II
Moisture, percent max	13	14
Impurities (stones, metallic particles, leaves, insects, other seeds), percent max	0.3	0.5
Damage (mold, swollen, germinated, etc.), percent max	1.5	2.5
Defected (immature, small, shrunken, etc.), percent max	5	9
Perfect, not less than	90	85
Color: fresh – yellow, no strange smell		

Source: Dong Thap Province, *Soybean – Local Standard 61 TCV-2-85*, 1985 (Vietnamese).

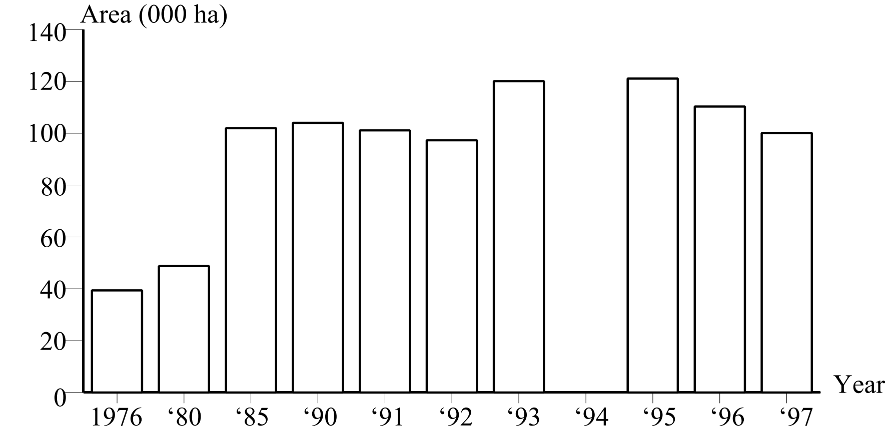


Figure 1. Sown Area of Soybean, 1976-97

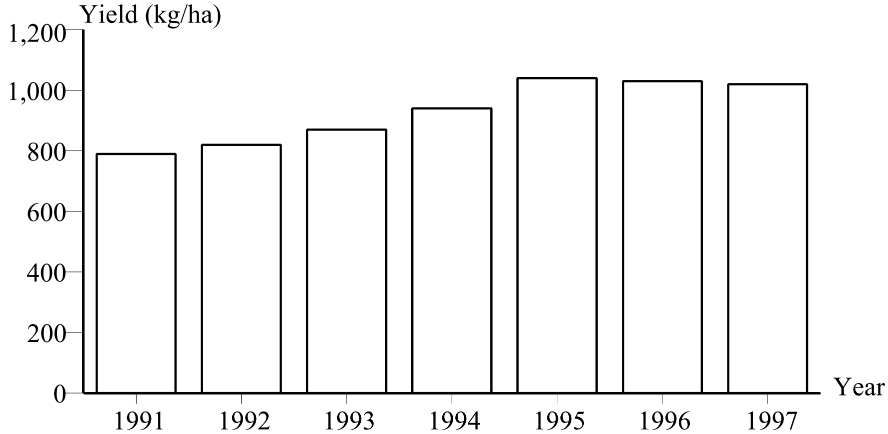


Figure 2. Yield of Soybean, 1991-97

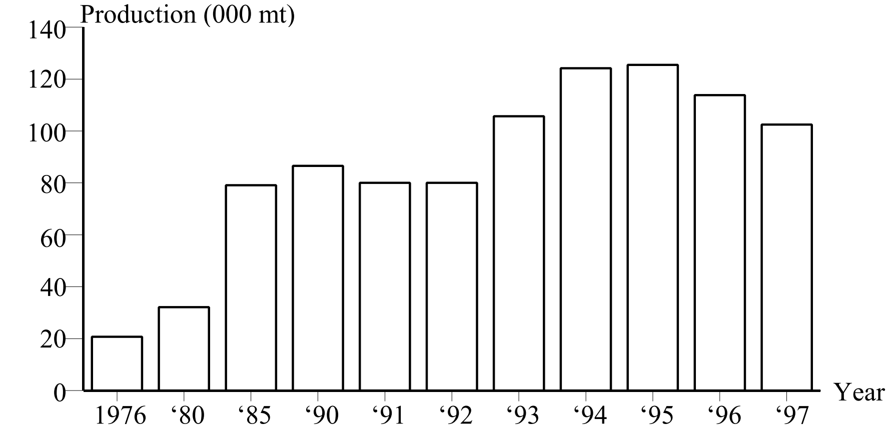


Figure 3. Production of Soybean, 1976-97

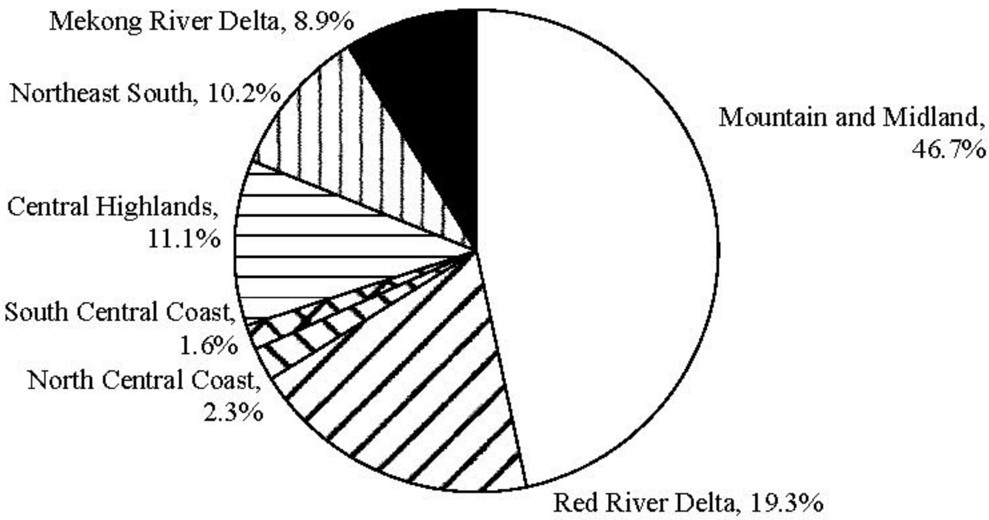


Figure 4. Soybean Area by Provinces, 1997

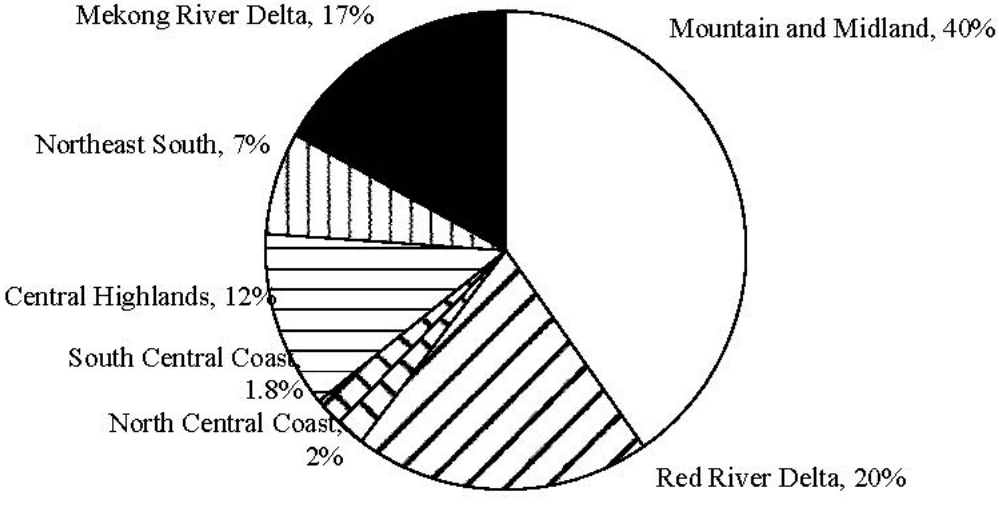


Figure 5. Soybean Production by Provinces, 1997

The Communist Party has resolved that "Soybean should be developed strongly to enhance protein supply for humans and animals to improve soil and to become an important export commodity".

The quality specifications for export are shown in Table 6.

Groundnut/Peanut

Groundnut occupies an important position as a source of oil and protein for Vietnamese people. Prior to 1975 groundnut ranked Eighth in area and production (Table 1) and the average yield was only 1,100 kg/ha. In 1972, South Vietnam exported only 6 mt of groundnut (Nguyen Khoa Chi, 1989). The area planted to groundnut, average yield and production increased gradually over the years. In 1993-94, the area increased to 246,600 ha compared to 160,000 ha in 1985 (Figure 6). The average yield and production increased to 1,400 kg/ha and 350,000 mt in 1997 compared to 850 kg/ha and 95,000 mt in 1980, respectively (Figures 7 and 8). The average yield is higher in South Vietnam compared to the North (Vo, *et al*., 1995).

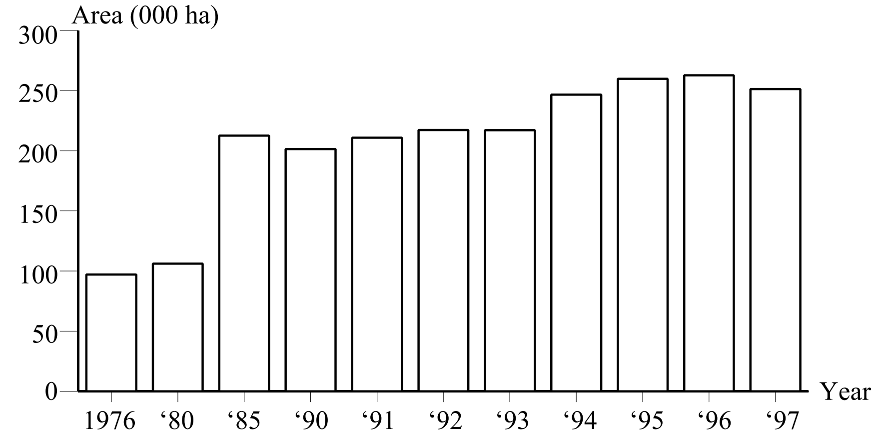


Figure 6. Sown Area of Groundnut, 1976-97

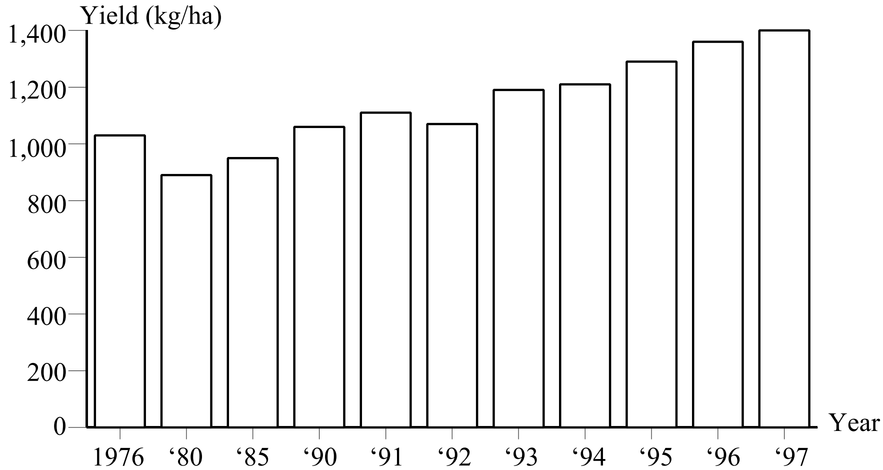


Figure 7. Yield of Groundnut, 1976-97

The three major groundnut growing and producing areas in Vietnam are Northeast South, North Central Coast and North East (Figures 9 and 10). The last two regions have about 30-35 percent of the total area with an average yield of 1.2-1.5 mt/ha.

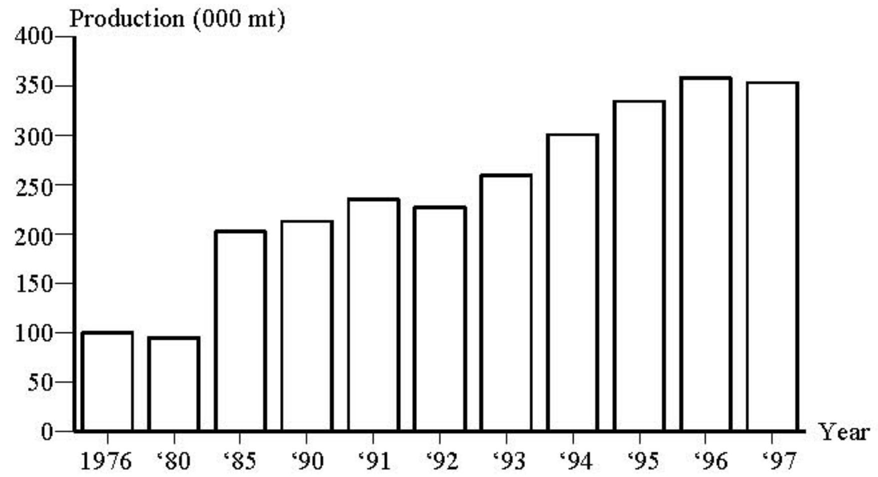


Figure 8. Production of Groundnut, 1976-97

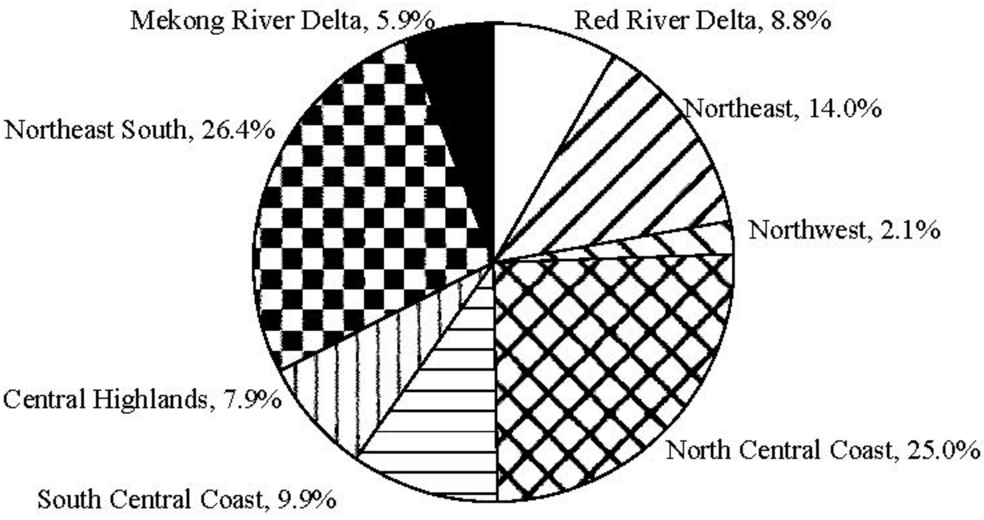


Figure 9. Groundnut Area by Provinces, 1997

Groundnut is cultivated in the spring (as a main crop) and autumn seasons (for seed production). Groundnut varieties planted in Vietnam belong to Spanish type (FAO, 1993).

Traditionally groundnuts are used directly as food as boiled, roasted (with or without salt), peanut butter, peanut milk and cooked with glutinous rice. It is also used as an ingredient in the manufacture of biscuits, candy, sweet soup, traditional cake and vegetarian foods. Groundnut is also fermented to make tofu, sauce and paste.

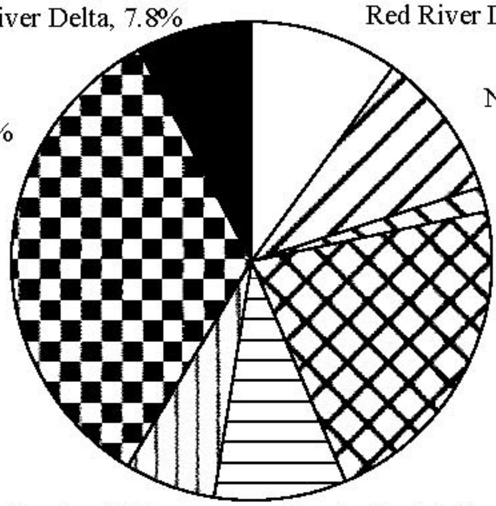


Figure 10. Production of Groundnut by Provinces, 1997

About 20-25 percent of the total production is used for oil extraction (Phan, 2000). A total of 9,000 mt per year is domestically used for oil extraction. The Grade I oil is used for food, canning and as medicine; Grade II is used for soap making; and Grade III is used as engine oil and for lighting (Phan, *et al.*, 1986). One hundred kg of groundnut gives Grades I, II and III oil at 18 kg, 8 kg and 6 kg, respectively. It also gives 60 kg groundnut cake. Groundnut husk, stem and leaves are used either as animal feed or as green manure.

Among the legumes in Vietnam, groundnut is the most important export crop. Vietnam exports about 40 percent of its total production (about 90,000-100,000 mt/year). Groundnut is exported to Hong Kong, Singapore, Japan, and China. The price of Grade I is US$670/mt (Phan, 2000). Since 1996, Vietnam also exports crude groundnut oil to Japan (95 mt in 1997), peanut paste to Hong Kong, a small quantity of peanut candy to Singapore and France, and roasted peanut to Korea. The major quality specifications for groundnut kernels for export are given in Table 7. Due to the stable quality of groundnut oil, its export to Japan is steadily increasing. However, it is difficult to adhere to the permissible aflatoxin levels in peanut paste. As a result, its export to Hong Kong is unstable.

Table 7. Specifications for Export of Groundnut (Kernel)

Traits	Grade I	Grade II	Grade III
Moisture, percent max	9	9.5	
Foreign matter, percent	1		
Count, nuts/100 gm	220-240	300-320	320-350
Aflatoxin, ppb max	3-5		
Defective, percent	6-8		

Mung Bean

Mung bean is a common legume crop in Vietnam. In the country side, the following mung bean dishes are always used: mung bean cooked with glutinous rice; sweet mung bean soup; mung bean sprouts; and mung bean cake. Mung bean is nutritious and has high economic value. Mung bean is suitable for both domestic and export market since it is widely consumed and the prices are quite stable (Pham, 1999). Mung bean is commonly cultivated in the Delta Region, Midland to Highland from the North to the South. Mung bean can be planted throughout the year. It is considered as a minor crop. Vietnam has about 50,000 ha and the average yield is about 590 kg/ha. The yield is higher in the South than in the North and in some Mekong Delta areas the yield is as high as 1,000 kg/ha. The following factors are responsible for the low yield:

- Mung bean is normally planted in poor soil, without irrigation and without management inputs.
- Farmers use seeds of local varieties and seed quality is poor. There is no agency to produce and provide good quality seeds.
- Farmers provide very low investment. Average investment is only US$13.9-14.3 while for groundnut it is US$24.6-26.4. For intensive inputs for mung beans, farmers should invest US$37.5.
- Farmers lack management information.

Mung bean is primarily used as food in the domestic market. The direct use of mung bean includes sweet soup, cooked with glutinous rice, mung bean gruel, cake, beverages, and ice cream. The processed mung bean products include flour, vermicelli, and sprouts. Mung bean is one of the ingredients in nearly all traditional cakes. The by-products of mung bean processing (hull, sludge) are used as animal feed. The stem and leaves are used as green manure.

Since the varieties are not pure and the quality is not up to the standard, there is very little export. For export, the purity for Grades I and II should be 94 percent and 89 percent, respectively with 14.5 percent moisture content. The acceptable level of defects for Grades I and II will be 4 percent and 8 percent, respectively.

Black Mung Bean, Red Cowpea and White Pea

The above three crops are very minor crops. They are planted in small areas scattered around the country. They are generally used in processing sweet food. The direct use includes sweet soup, gruel, cooked with glutinous rice and sweet meat. They are used as ingredients in traditional cake. Nutritious flour is also prepared. They are used as green manure. A small quantity of red cowpea is exported.

Leguminous Vegetables

A number of leguminous crops are used as vegetables (fresh, boiled, fried or steamed). The commonly used vegetables are snap bean, snow pea, wing bean, and string bean. Normally they are planted in the household farm or home garden and are sold to the market by farmers. They provide additional income to the farmers. Some of the above vegetables are also included as ingredients in instant and canned foods. At present, export of leguminous vegetables is negligible.

Other Leguminous Crops

Other leguminous crops in Vietnam include horse gram, velvet bean, sword bean, wing bean (Mekong Delta), lima bean (South Vietnam and Red River Delta), hyacinth bean, (Central Highland), *siratro* (Northeast South), *bort* (North Vietnam) and sesbania (Mekong Delta for paper pulp). All of them are planted in small areas in scattered localities and used in very small quantities primarily as animal feed and as green manure.

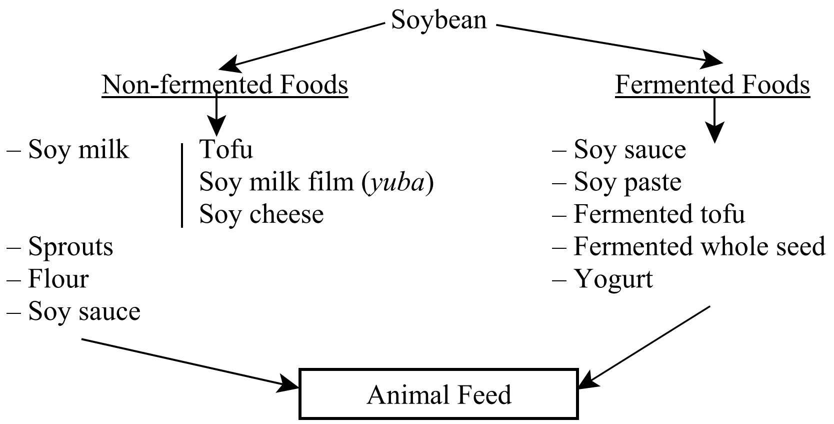
The chemical composition of some of the Vietnamese legumes and by products from processed legumes is given in Tables 8, 9, 10 and 11.

TRADITIONAL PROCESSING AND UTILIZATION OF LEGUMES

Processing of legume results in value addition. Processing creates job opportunities. Processing helps in product diversification and makes it attractive to consumers.

Soybean

Soybeans are processed either with or without fermentation as shown below:



The names of fermented and non-fermented soy foods are given in Tables 12 and 13.

Fresh Soybean Curd (Tofu)

As raw material soybeans with ivory-white shell, white meat, uniform and round bean are prepared (Watanabe, *et al*., 1984). The procedure is shown in Figure 11.

Soy Milk (Watanabe, *et al*., 1984)

The ingredients for soybean milk preparation are:

- Soybean: 0.3 kg (fresh, light color, round, thin hull)
- Water: 5 R
- Sugar: 0.7 kg
- Salt: 0.1 kg

The procedure is shown in Figure 11.

Table 8. Chemical Composition of Some Vietnamese Legumes

Crop	Dry Matter (%)	Crude Protein (%)	Lipid (%)	Fiber (%)	Non-protein (%)	Ash (%)	Ca (%)	P (%)	Energy (kcal/kg)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)
Acacia	25.7	7.0	1.2	3.6	12.5	1.4	0.38	0.07	658	10.12	39.99	8.81	
Kudzu	18.5	3.4	1.2	4.6	7.1	2.2	0.20	0.04	373	9.42	40.53	2.94	62.91
Stylo grass	20.1	4.1	0.4	3.3	10.7	1.6	0.40	0.04	480	13.60	63.55	2.97	100.02
Snap bean	87.4	21.2	4.1	4.0	54.6	3.5	0.23	0.53	2,840	55.76	6.38	15.38	
Horse gram	88.7	21.8	3.2	5.1	55.3	3.3	0.52	0.10	3,191				
Black mung bean	88.7	23.7	2.5	4.9	53.9	3.7	0.19	0.42	3,135	42.40	20.58	9.67	183.87
Canavalia gladiata	86.0	24.5	2.2	8.9	46.6	3.8			2,502				
Burk	89.2	22.0	4.1	8.6	51.2	3.3	0.19	0.30	2,544	33.72	11.33	8.15	94.19
Velvet bean (*bort*)	87.6	23.9	5.3	8.1	47.1	3.2	0.39	0.50	3,022				
Wing bean	88.0	27.8	15.8	6.4	34.3	3.7	0.27	0.37	3,171				
White pea	87.9	22.1	2.1	4.8	55.3	3.6	0.27	0.48	2,757	42.37	12.57	7.30	
Lima bean	87.1	19.9	1.9	3.8	57.9	3.6	0.09	0.33	2,747				
Hyacinth bean	88.1	22.0	1.4	7.1	54.5	3.1	0.19	0.43	2,731	41.58	14.54	11.98	
Mung bean	88.6	23.7	1.9	4.3	55.2	3.5	0.24	0.42	2,979	38.98	12.40	9.48	193.24
Snow pea										30.35	17.96	7.34	108.41
Red cowpea										39.87	11.47	8.38	
Soybean	88.5	37.0	16.3	6.4	23.9	4.9	0.29	0.56	3,757	46.28	25.58	12.83	142.48
– Central Coast	92.0	39.1	18.2	8.5	21.0	5.2	0.46	0.74	3,917	62.19	18.40	18.95	
– Northeast South	91.4	36.9	18.0	10.8	20.6	5.2	0.44	0.46	3,839	46.06	29.98	10.14	81.53
– Red River Delta	91.5	37.1	12.3	9.3	27.2	5.6	0.20	0.56	3,646	39.89	21.23	35.87	183.91
– North Central Coast	86.2	37.1	16.4	6.2	21.8	4.7	0.29	0.67	3,687	32.24	26.63		152.57
– North Mountain	86.5	38.9	15.8	5.8	21.6	4.4	0.22	0.63	3,703	38.23	16.69		82.78
– Highlands	90.5	37.3	18.2	6.8	23.3	4.8	0.36	0.77	3,895				
– North Midland	86.5	35.6	13.7	4.3	27.5	4.9	0.20	0.24	3,611	50.00	34.17	19.03	167.81
– VT 74	88.8	39.0	15.0	5.9	23.9	5.0	0.19	0.15	3,736				
Groundnut	92.4	27.9	44.6	2.7	14.8	3.4	0.12	0.38	5,041				

Source: Nguyen, *et al*., 1992.

Table 9. Chemical Composition of By-products from Vietnamese Processed Legumes

(Unit: Percent)

Products		Dry Matter	Crude Protein	Lipid	Fiber	Non-protein	Ash	Ca	P	Energy (kcal/kg)
Defatted SBM		89.0	44.7	1.5	5.1	31.2	6.5	0.28	0.65	3,326
Groundnut cake		90.1	45.4	7.0	5.3	26.6	5.8	0.17	0.53	3,306
Mung bean sludge:	Dry	88.0	18.0	1.5	14.0	52.0	2.5	0.20	0.10	2,284
	Wet	14.3	2.8	0.7	2.4	8.1	0.3	0.08	0.06	383
Tofu sludge:	Dry	85.1	23.8	8.8	13.5	33.5	5.5	0.31	0.19	2,183
	Wet	16.1	4.7	2.1	2.6	6.0	0.7	0.10	0.12	429
Soy sauce residue:	Chemistry	37.5	10.9	5.8	5.1	4.8	10.9	0.17	0.20	944
	Microbiology	21.6	9.3	1.5	5.5	4.4	0.9	0.11	0.04	593

Source: Nguyen, *et al*., 1992.

Table 10. Amino Acid Composition in Vietnamese Legumes

(Unit: gm/kg)

Legume	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Stylo	2.97	1.10	2.30	2.30	2.10	0.71	2.97	1.98	-	2.53	0.31	2.10	4.25	5.28	2.20	2.42	1.79	1.98
Snap bean	8.44	4.10	6.76	11.64	9.85	-	8.62	6.97	-	7.61	3.54	6.45	14.19	25.97	6.22	7.37	5.07	8.76
Black mung bean	15.28	6.95	8.29	15.88	12.85	2.94	12.50	8.70	-	8.59	4.03	6.44	21.90	36.22	7.93	3.54	6.22	10.70
Red cowpea	14.05	6.88	9.12	12.71	13.11	3.70	13.33	7.28	-	8.35	-	7.03	21.70	35.11	7.83	5.65	6.66	9.50
Snow pea	25.50	9.30	11.00	14.20	15.50	2.60	11.90	9.30	1.60	11.40	2.70	10.20	18.50	31.60	10.20	-	6.60	7.50
Velvet bean	12.81	6.06	10.47	12.65	13.65	2.99	13.28	10.13	-	11.40	-	7.98	22.09	28.36	12.90	12.18	11.23	9.95
White pea	13.02	6.30	9.29	12.47	11.32	2.29	13.16	7.64	1.82	8.88	1.29	9.03	22.25	37.79	7.96	7.49	5.95	12.05
Soybean	22.93	8.85	15.61	20.22	21.50	5.43	17.88	12.75	3.75	13.35	7.00	13.07	31.08	46.11	12.66	14.91	13.33	16.40
Hyacinth bean	13.74	5.85	7.48	12.15	12.07	2.90	11.58	8.31	2.02	8.64	2.76	8.19	23.37	33.22	7.86	8.59	7.51	11.61
Mung bean	15.84	6.64	9.20	14.73	14.08	2.80	14.52	7.86	2.13	10.66	3.32	8.48	24.22	38.24	8.70	8.27	7.46	10.35
Groundnut	22.75	6.24	9.75	12.89	9.49	3.96	17.51	8.89	3.48	10.86	3.34	9.31	30.07	26.33	12.49		13.83	19.00

Source: Nguyen, *et al*., 1992.

Notes: 1. Arginine; 2. histidine; 3. isoleucine; 4. leucine; 5. lysine; 6. methionine; 7. phenylalanine; 8. threonine; 9. tryptophan; 10. valine; 11. cystine; 12. alanine; 13. aspartic; 14. glutamic; 15. glycine; 16. proline; 17. tyrosine; and 18. serine.

Table 11. Nutritional Composition in 100 gm Edible Portion of Some Leguminous Vegetables in Vietnam

Crop	Snap Bean	String Bean	Snow Pea	Sprouts
Moisture (percent)	80.0	83.0	81.0	86.5
Protein (percent)	5.9	6.0	6.5	5.5
Carbohydrate (percent)	13.3	8.3	11.0	5.3
Fiber (percent)	1.0	2.0	1.0	2.0
Ash (percent)	0.7	0.4	0.5	0.7
Cal/100 gm	75	59	72	44
Ca	26.0	47.0	57.0	38.8
P	122.0	16.0	43.0	91.0
Fe	0.7	1.6	0.8	1.4
Carotene	1.0	0.5	-	-
Vitamin B_1 (mg)	0.34	0.29	0.40	0.20
Vitamin B_2 (mg)	0.19	0.18	-	0.13
Vitamin PP (mg)	2.6	1.8	-	-
Vitamin C (mg)	25	3	-	10

Source: Tran, *et al.*, 1995.

Table 12. Names of Fermented Foods from Soybean in Asian Countries

English	Soy Sauce	Soy Paste	Fermented Tofu	Fermented Whole Seed	Soy Pulp
Vietnamese	Núôc túóng	Túóng	Chao	Túóng d|c	
Japan	Shoyu	Miso		Natto, Hama-natto	
China	Jiang you	Jiang	Doufuru	Douchi	
Korea	Kang Jang	Doen jan Kochujang		Chung-kook-jang	
Thailand	Siiu dam, wan	Tauchieo	Tauhuyi	Thuanao	
Malaysia	Kecap	Tauco		Tempeh	
Indonesia	Kecap	Tauco		Tempeh	Oncom
Philippines	Tayo	Tao si	Tahuri		

Source: Erickson, 1989; and FAO, 1993.

Table 13. Names of Non-fermented Soybean Foods in Asia

English	Vietnam	Japan	China	Korea	Thailand	Malaysia	Indonesia	Philippines
Fresh soybean	oâu nành	Edamame	Mao dou	Put kong				
Soy milk	Séa oN	Tonyu	Doujiang	Kongkook, Doo You	Namtauhu	Suukedallai	Suukedelai	
Soybean curd (fresh)	oâu hé	Tofu	Dou-fu	Doo bu	Tauhu	Tau-foo	Tahu	Pokwa
Deep-fried	oâu hé chiên	Aburage, nama-age						
Frozen-dried								
Soy milk film	oâu phù trúc	Yuba	Dou fu pi			Fu chok	Fu chok	
Soy cheese	Tàu hé non		Douhua		Tauhaui		Taho	
Toasted soy flour	Bôt oN rang	Kinako	Dou-fen	Kang ka rau			Bubuk kadele	
Soybean sprouts	Gía oN	Daizu moyashi	Huang dou ya	Kong na moal	Thuangok huato		Taoge	Toge

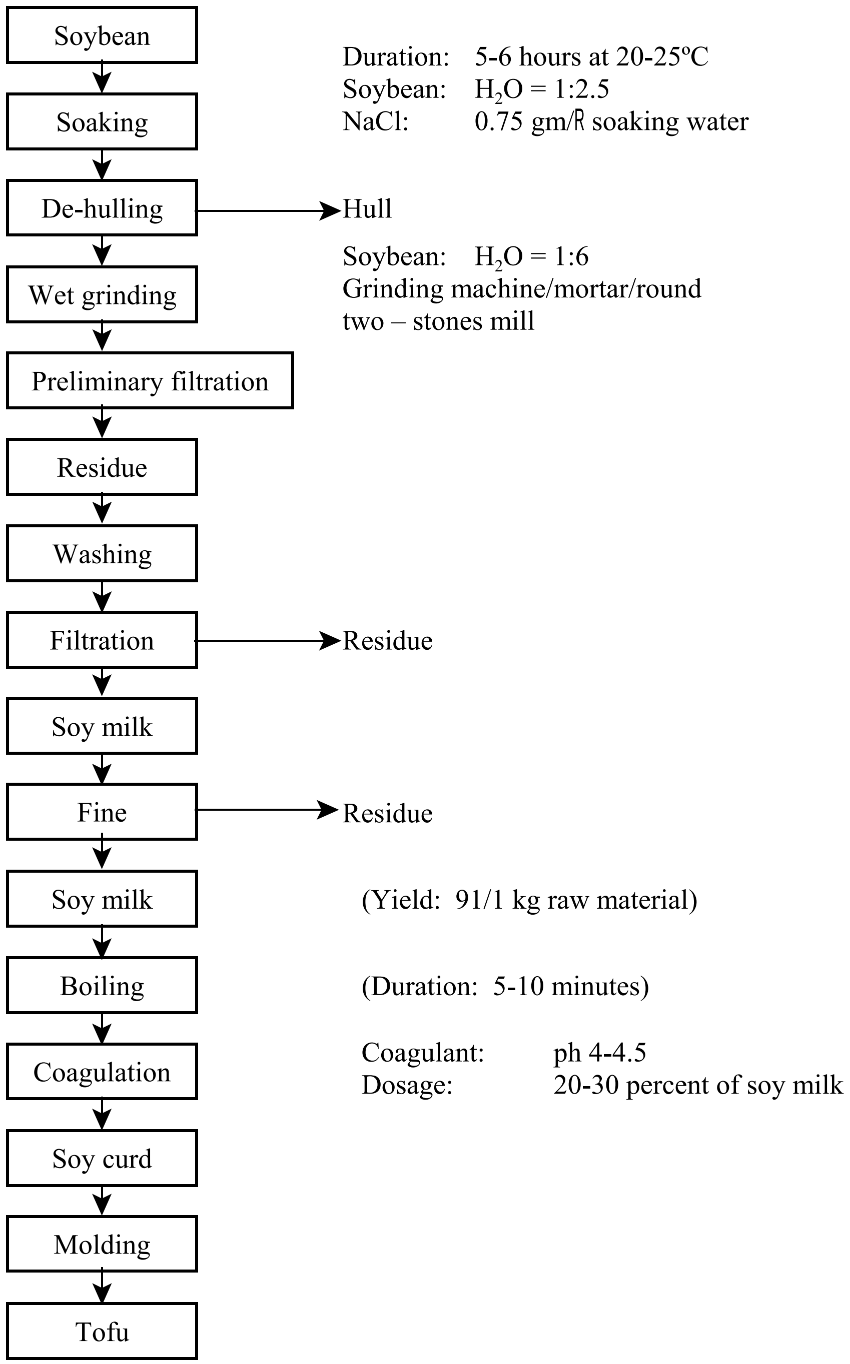


Figure 11. Procedure of Tofu

Yield: One kg raw material yields 2.8-3 kg tofu and 1.5-1.6 kg residue (for animal feed).

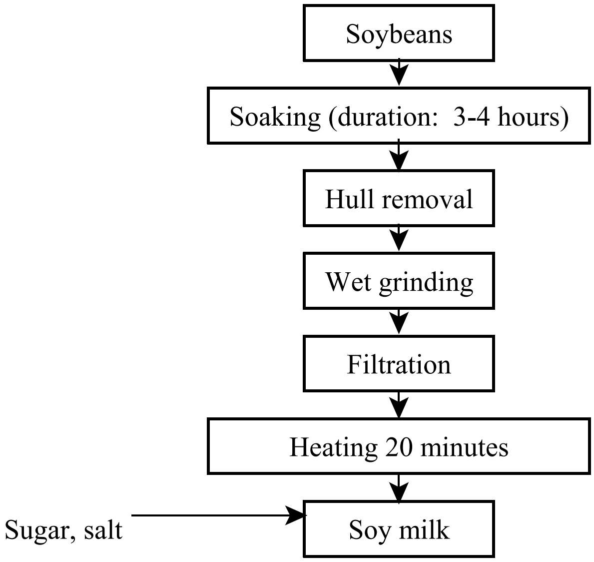


Figure 12. Procedure of Soy Milk

Soy Milk Film/Soy Liquid Sheet (*Yuba*) (Watanabe, 1984)

Yuba is made from soy milk. In a cast iron/copper pan, soy milk is heated but not quite to the boiling point. When the film forms on the liquid surface, it is lifted off with two bamboo sticks and is dried partly or entirely (sun-dried). Heating of the milk is continued till it produces another film, which is removed and dried. As one film after another is lifted off, the protein and fat content of the milk drops. The outcome of this is weaker films of poor quality. To prolong the productivity of the process, from time to time, fresh soy milk is added.

One kg soybean yields 550 gm dried "*yuba*".

Soy Bean Sprouts (Watanabe, 1984)

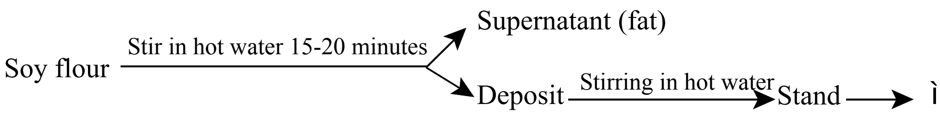
Soybeans with a 100-seed weight of less than 10 gm are soaked in water at room temperature for 12 hours. Then they are spread out in a thin layer on a perforated rack or at the bottom of a strainer on which a damp cloth has been spread out. The whole thing is placed in a dark room at room temperature. Twice a day the beans are sprayed with sufficient water. After 3-5 days the sprouts may reach a length of 3-5 cm.

One kg of soybean yields 7-9 kg bean sprouts.

Roasted/Toasted Soy Flour (Watanabe, 1984)

The procedure includes the following steps:

a) Beans ÿ crushing ÿ soaking in 3-4 hours ÿ draining ÿ roasting ÿ milling ÿ Roasted Full-fat Soy Flour
b) Beans ÿ washing, cleaning ÿ sun-drying ÿ crushing ÿ milling ÿ Roasted Full-fat

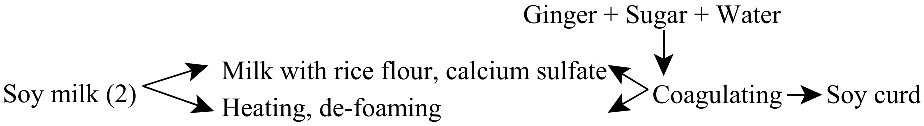


ì Supernatant
Deposit ÿ squeeze ÿ sun-dry ÿ Defatted Soybean Meal

Soy flour is used to make soy flour milk (mix with sugar, water), soy flour cake (mix with sugar, coconut milk), and soy flour wafer.

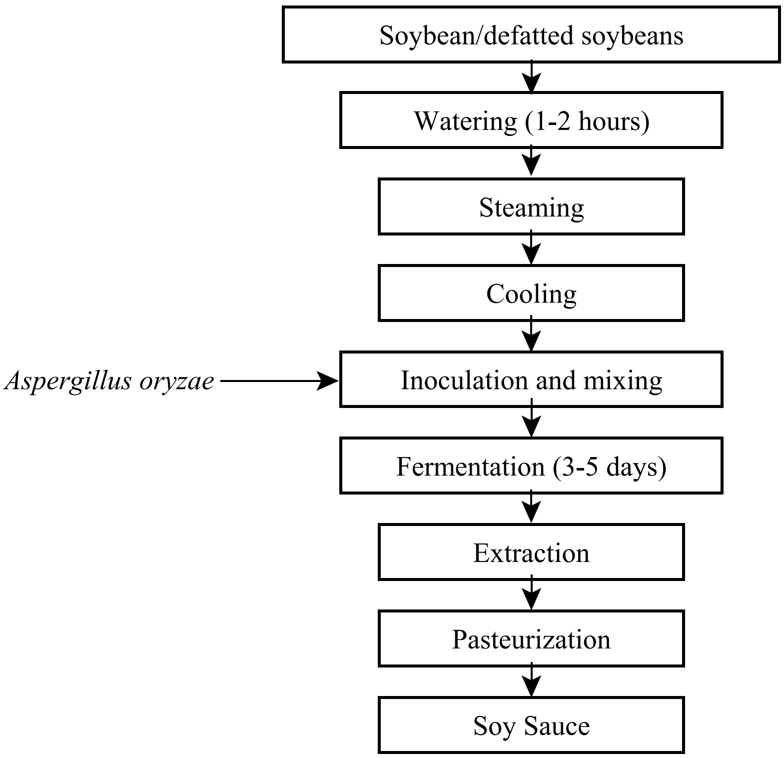
Soy Curd (Quang, 1988)

Soybean curd is prepared as follows:



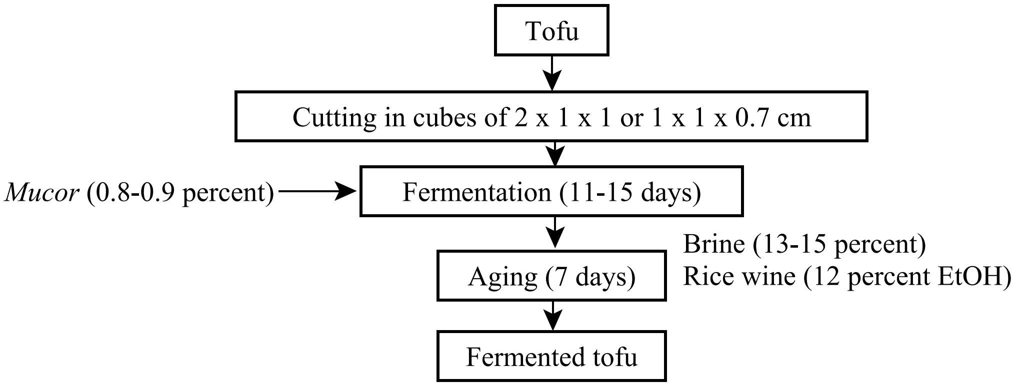
Soy Sauce (Watanabe, 1984)

The ingredients include soybean cake (or defatted soy beans), 10 kg; and salt, 8-9 kg. The output is 30 liters of soy sauce with 10-13 gm N/ℝ. The procedure is:



Fermented Tofu (Pham, 1996)

The raw materials are soybean, alcohol, mould (*Mucor*). Chemical composition of "*Chao*" is water (67-70 percent), total nitrogen (2-2.3 percent), ammonium nitrogen (0.2-0.5 percent), (nitrogen) formaldehyde (0.8-0.9 percent), salt (5.8-6 percent), and lipid (8-9 percent). The procedure is:



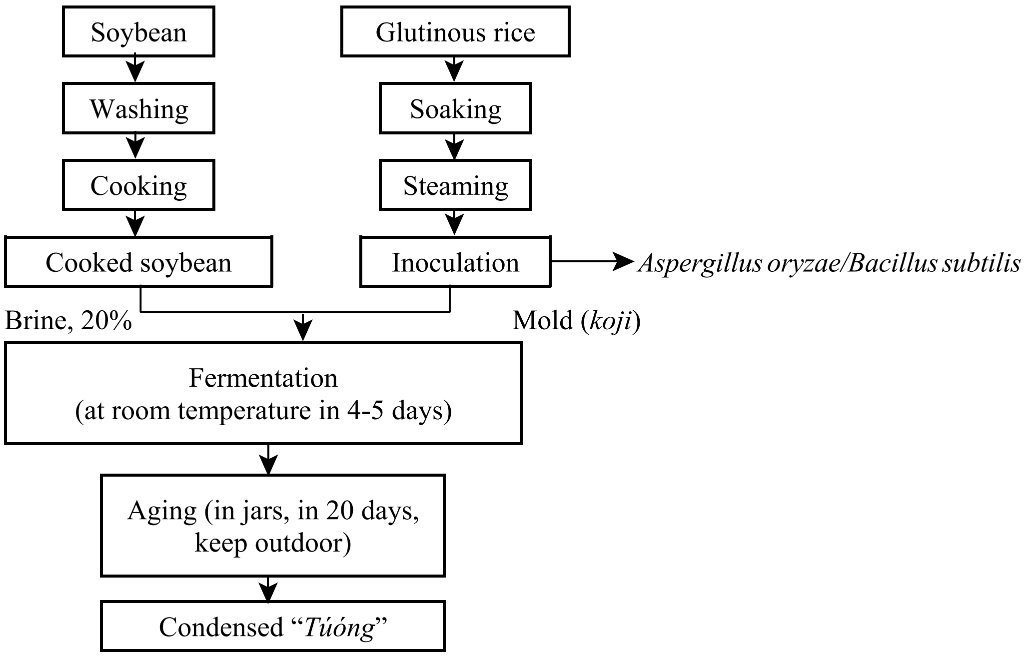
Fermented tofu is used directly or in making "*Chao*" sauce, as an ingredient of noodle and as an ingredient of noodle seasoning.

Soy Paste (Watanabe, 1984)

"*Túóng*" is a traditional seasoning in Vietnam. In the countryside, every house has got a soy paste jar. Nearly everyone knows how to make "*túóng*". The famous brand names are: *Túóng Bân, Túóng Cú oà* (in Red River Delta); and *Túóng Nam oàn* (in Central).

1. ***Condensed Túóng***

The raw materials include soy bean (5 kg), glutinous flour (1 kg), salt (0.12 kg), and water (6 ℓ). The product is a dense, sweet and salty taste (rather sour). The procedure is:



2. ***Diluted Túóng***

a) *In the North Vietnam*

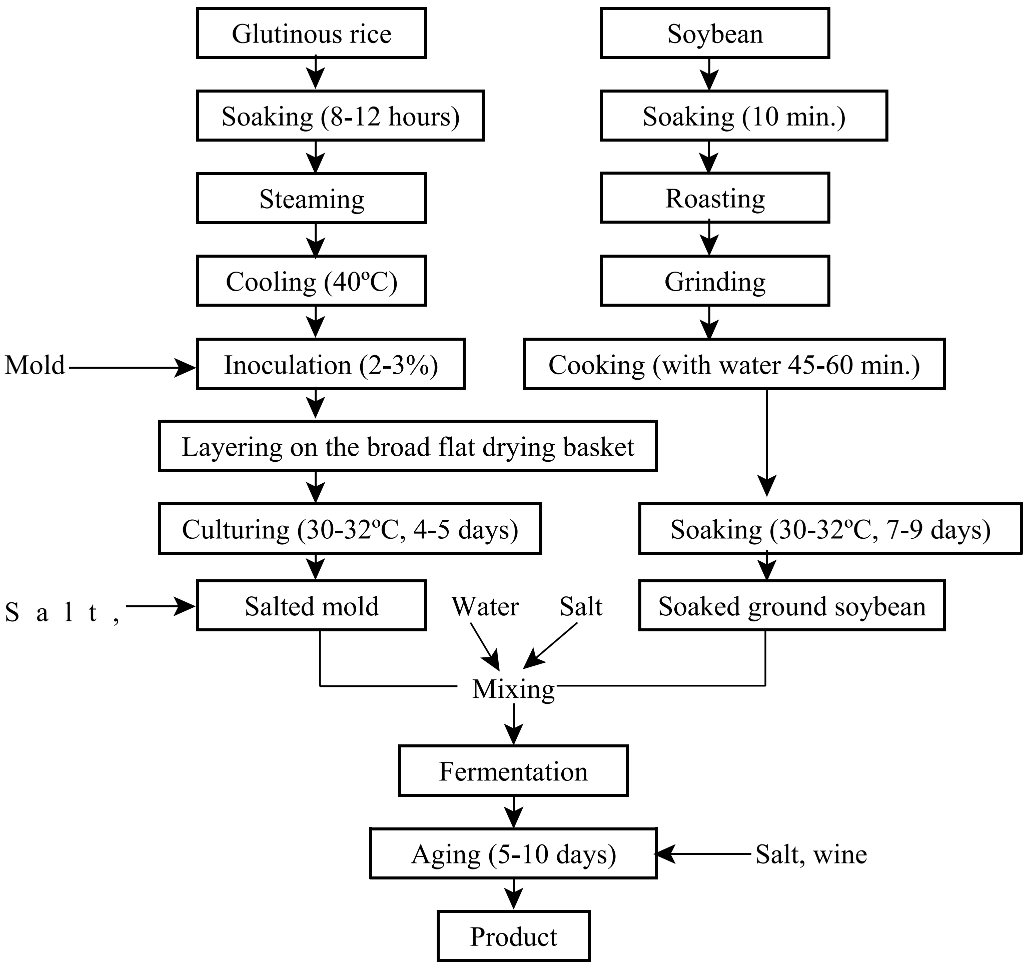
The raw materials include (kg):

	Waxy Rice	Soybean	Salt	Water (ℝ)
"Túóng" Bân	33	12	16	100
"Túóng" Cú oà	30	9	13	100

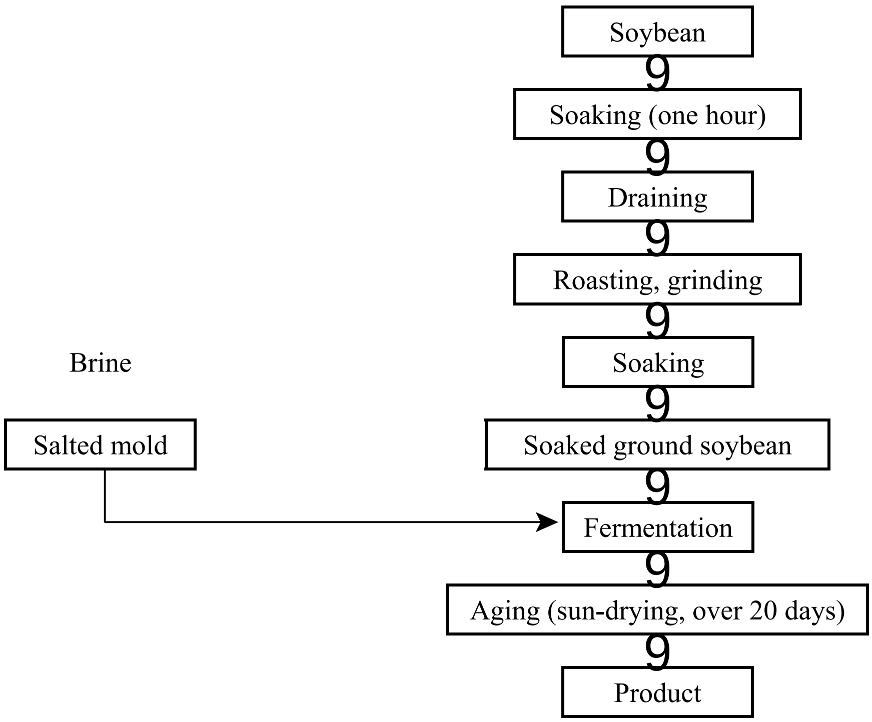
The product is yellow with good smell and sweet and sour taste.

Nutritive value is protein (4.5 percent), lipid (0.8 percent), carbohydrate (16.8 percent), mineral (14.2 percent), salt (13.7 percent), vitamin B_1 (450 unit/100 gm product).

The procedure is:

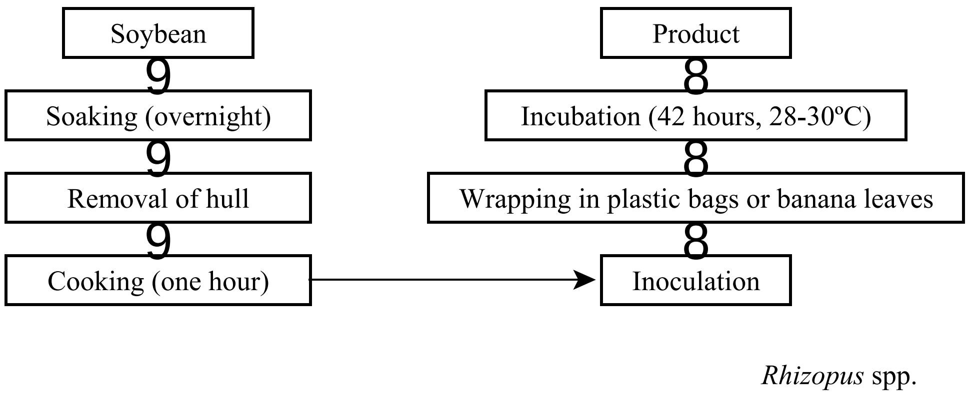


b) *In the South Vietnam*



Fermented Whole Seed/Whole Soybeans (Watanabe, 1984)

The raw material is soybean (small seed size). The product is: moisture (64.7 percent); protein (18.3 percent); lipid (2.78 percent); and carbohydrate (12.7 percent). The soybeans are fully covered by a white mold with characteristic good smell. The procedure is:



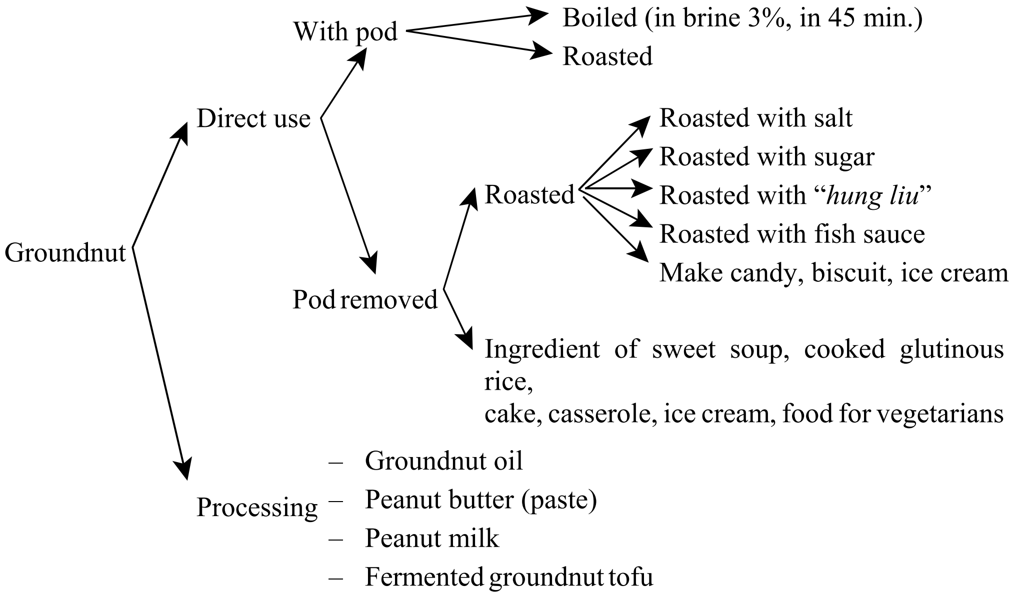
Yogurt (Thio, 1971)

One liter of soy milk is boiled for a few minutes and then is left to cool to room temperature. Then 80 mℓ of yogurt culture is well suspended in the milk.

The suspension is kept at room temperature for 15-18 hours. As the yogurt made with soy milk has a low carbohydrate content, addition of sugar is customary.

Groundnut (Thio, 1971)

Processing and utilization of groundnut in Vietnam is shown below:



Groundnut is one of the most popular food in Vietnam. It is the daily food for working class, vegetarians; it is the cheap food for poor people; and it is one of the simplest food to use with beer. Groundnut is used in most Vietnamese dishes. In some dishes, it is a very important additive, which enhances the delicacy of food. For example, roasted groundnut used in sweet soup, rice vermicelli, and cooked glutinous rice.

Production of Groundnut Paste/Butter (Nguyen, 1989)

The procedure is: groundnut ÿ roasting at 160-170ºC ÿ cooling ÿ removal of hull ÿ grinding ÿ mixing with sugar, salt ÿ Groundnut Paste/Butter (Bo dau phon)

Production of Groundnut Oil in Small-scale Industry (Nguyen, 1989) (Figure 13)

The procedure is as follows:

Groundnut with pod ÿ removal of pod ÿ kernel ÿ crushing ÿ grinding ÿ paste ÿ steaming ÿ cool pressing ÿ Crude Oil Grade I ÿ Settling ÿ Refined oil

9

Residue ÿ hot pressing (at 50-60ºC) ÿ Crude Oil Grades II and III

9

Residue (cake) ÿ animal feed, fertilizer

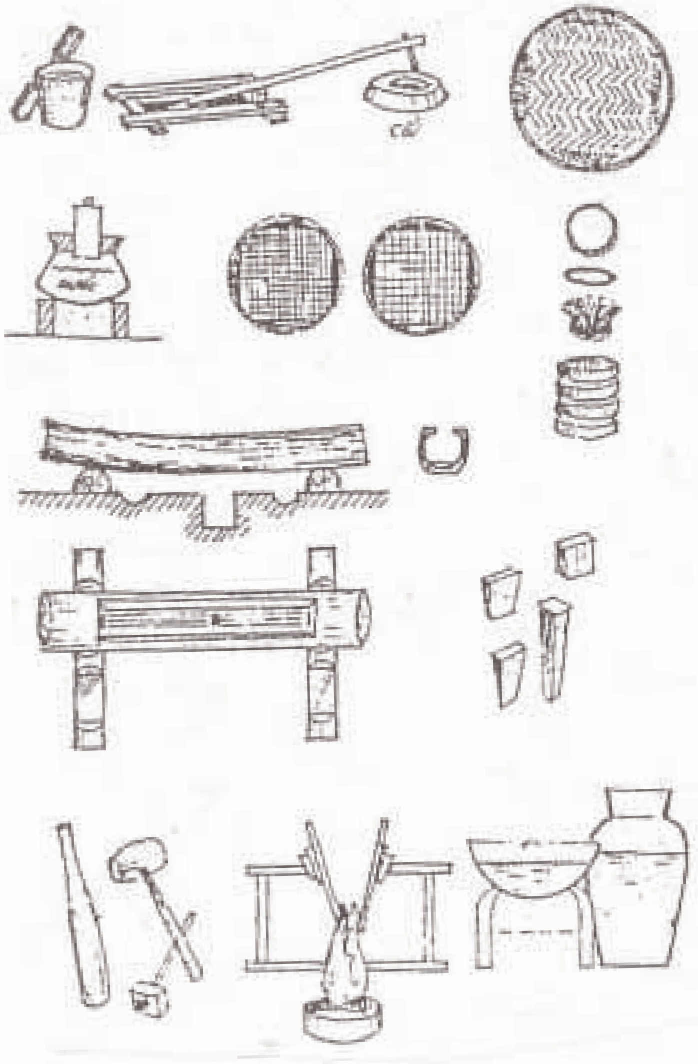


Figure 13. The Small Industry Tools for Pressing Crude Groundnut Oil

Source: Nguyen, 1989.

Production of Groundnut Tofu (Ngac, 1983)

Groundnut tofu is not so popular as soybean tofu. The procedure is as follows: Groundnut → removal of hull → soaking at 20°C in 6-8 hours → wet grinding (1 kg groundnut/10 ℓ water) → crude groundnut milk → filtration → fine groundnut milk → boiling → add $CaSO_4$ → coagulation → decanting → groundnut curd → molding → groundnut tofu.

Production of fermented tofu from groundnut (*"Chao dau phong"*) (Ngac, 1983)

The procedure is as follows: The procedure is as follows: Groundnut → groundnut milk → groundnut tofu → inoculate with mold → fermentation → add brine, wine → aging → fermented tofu from groundnut

Yield: 1 kg groundnut ÿ 0.85 kg ground groundnut
1 kg ground groundnut ÿ 1.5-1.6 kg groundnut tofu (moisture, 70-72 percent)
9
2.2-2.4 kg fermented tofu from groundnut

Mung Bean

Processing and utilization of mung bean in Vietnam are as shown below:

Direct use
- Whole bean (cooked)
- Broken bean

Gruel
Sweet soup
Glutinous rice
Traditional cake
Cake
Beverage ("milk"), ice cream

Processed
- Sprout
- Vermicelli
- Flour

Production of Vermicelli (Nguyen, 1984) (Figure 14)

Vermicelli is produced using the following procedures:

Stone mill

Mung bean
9
Coarse grinding
9
Broken bean
9
Soaking (3-4 hours)
9
Removal of hull
9
Milling
9
Filtration → Residue
9
Water ← Settling (6-10 hours)
9
Wet flour
9
Sundrying
9
Dried mung bean flour

Dried vermicelli
8
Sun-drying
8
Washing
8
Fresh vermicelli
8
Molding and cooking (2')
(press through sieve into hot water
8
Mixing
8
90 gm dried flour → Cooked flour
8
Cooking
8
100 gm dried mung bean flour + 1.5 R water

Yield: 100 kg mung bean flour ÿ 70-75 kg vermicelli.

Figure 14. Making Vermicelli from Mung Bean in the Traditional Way

Source: Nguyen, 1985.

Sprouts (Nguyen, 1984)

The raw material includes good quality fresh mung bean with yellow meat; small and undamaged beans without foreign matter.

The procedure is as follows: Mung beans are soaked for two hours in water. Then they are mixed with one spoon of $CaSO_4$. They are crushed by hand to thin the bean. Next they are soaked overnight (use 100 R water for 10 kg beans) to absorb water and then drained. The drained beans are covered by a cloth for about one hour for germination. Husk ashes are poured into a perforated container in a layer of 10 cm thickness then beans are poured onto the layer of ash. And next a thin layer of ash again and finally, all of them are covered by jute or banana leaves. On the top, bricks are used for pressing (maximum 15 bricks) to limit the extra development of length of sprouts. Every three hours, beans are sprayed with water. On the second day, when the sprouts begin to show, they are sprayed with coconut water. Three days later, sprouts can be harvested (Pham, 1999).

Yield:	1 kg mung bean
Product:	Length of stem: 3-5 cm; of root #1.5 cm; of leaf #3 mm.
	Width: 2.5-3 cm
	Color: white (stem); light brown (root); yellow (bean and leaves)
	Smell and taste: natural
	Texture: brittle (crispy)

Dishes made from sprouts are:

Sprout pickle – sprouts (1 kg) + salt (20 gm) + sugar (30 gm) + vinegar or lemon juice;
Sprout in brine – sprouts (10 kg) + salt (0.5 kg) + water (10 R) + chili (0.1 kg) + carrot (0.5 kg) + onion (0.5 kg) + garlic (0.1 kg).

Production of Mung Bean Flour (Pham, 1999)

Procedure is as follows: Dry mung bean ÿ washing in water ÿ draining ÿ roasting to yellow bean, good smell ÿ keep warm for about one hour ÿ removal of hull (by crushing) ÿ grinding ÿ separating (by sieving) ÿ fine mung bean flour.

Mung bean flour is used to make cake, beverage and ice cream.

Beverage (or mung bean milk): mung bean flour (0.15 kg) + sugar (0.25 kg) + vanillin (0.5 gm) + boiled water (1 R).
Ice cream: mung bean flour (0.1 kg) + sugar (0.4 kg) + *pao* flour (25 gm) + vanillin (5 gm) + condensed milk (50 gm) + water (1 R).
Cake: mung bean flour (1 kg) + sugar (1.2 kg) + fat (0.7 kg) + vanillin

Use of Mung Bean in Making Traditional Foods (Pham, 1999)

A number of intermediate materials (IM) are prepared from mung bean.

1) Mung bean flour is mixed with fat, sugar and they are moulded ÿ IM.
2) Mung bean ÿ soaking (5-6 hours) ÿ removal of hull ÿ washing ÿ steaming ÿ mixing with vanillin ÿ keep cool ÿ molding ÿ IM.

IM is used as raw material to make: steamed mung bean cake; baked mung bean cake; steamed 5-layers cake; and candy. IM is condensed in sugar then is made round and is sun-dried.

Mung bean is also used in cooked glutinous rice.

1) Cooked glutinous rice is covered by steamed and ground mung bean and fat, mixing and crushing by hand until cooked glutinous rice grains are separated (Figure 15).
2) Cooked glutinous rice + steamed and ground mung bean + fat.
3) Steamed and ground mung bean is pressed between two layers of cooked glutinous rice.

All of them are put on the banana leaves.

Mung bean is also used in sweet soups.

1) Whole bean sweet soup: bean (200 gm) is cooked with sugar (200 gm).
2) Ground bean sweet soup is cooked from steamed and ground mung bean with sugar.
3) Bean is cooked with sugar, "*dao*" flour.
4) Steamed and ground mung bean + sugar + "*tháo quả*" + sesame seed.
5) Cooked mixture of mung bean, sugar, tapioca, flour, lotus seed, peanut, mushroom, dried coconut.
6) Cooked mixture of steamed mung bean, pumpkin, sugar, tapioca starch, ginger.

Mung bean in traditional cake: Mung bean is an important ingredient (make filling while coating is with cooked rice flour or cooked glutinous rice flour or cooked glutinous rice) in moon cake, etc.

Other beans

Like mung bean, other beans (black mung bean, red cowpeas, white pea ...) is used to make flour or to make traditional dishes such as:

C use in cooked glutinous rice: black mung bean, red cowpeas.
C use in sweet soup: black mung bean, red cowpeas, white pea.
C use in traditional cake: baked, steamed from black mung bean, red cowpeas; filling.
C Use in sweet meat: white pea.

PROCESSING AND UTILIZATION OF VIETNAMESE LEGUMES – NEW TECHNIQUES

Production of Edible Oil and Oil-based Products from Soybean and Groundnut Using Modern Industry

1. ***Processing of Refined Oil***

The raw material is crude soybean oil or crude ground nut oil.

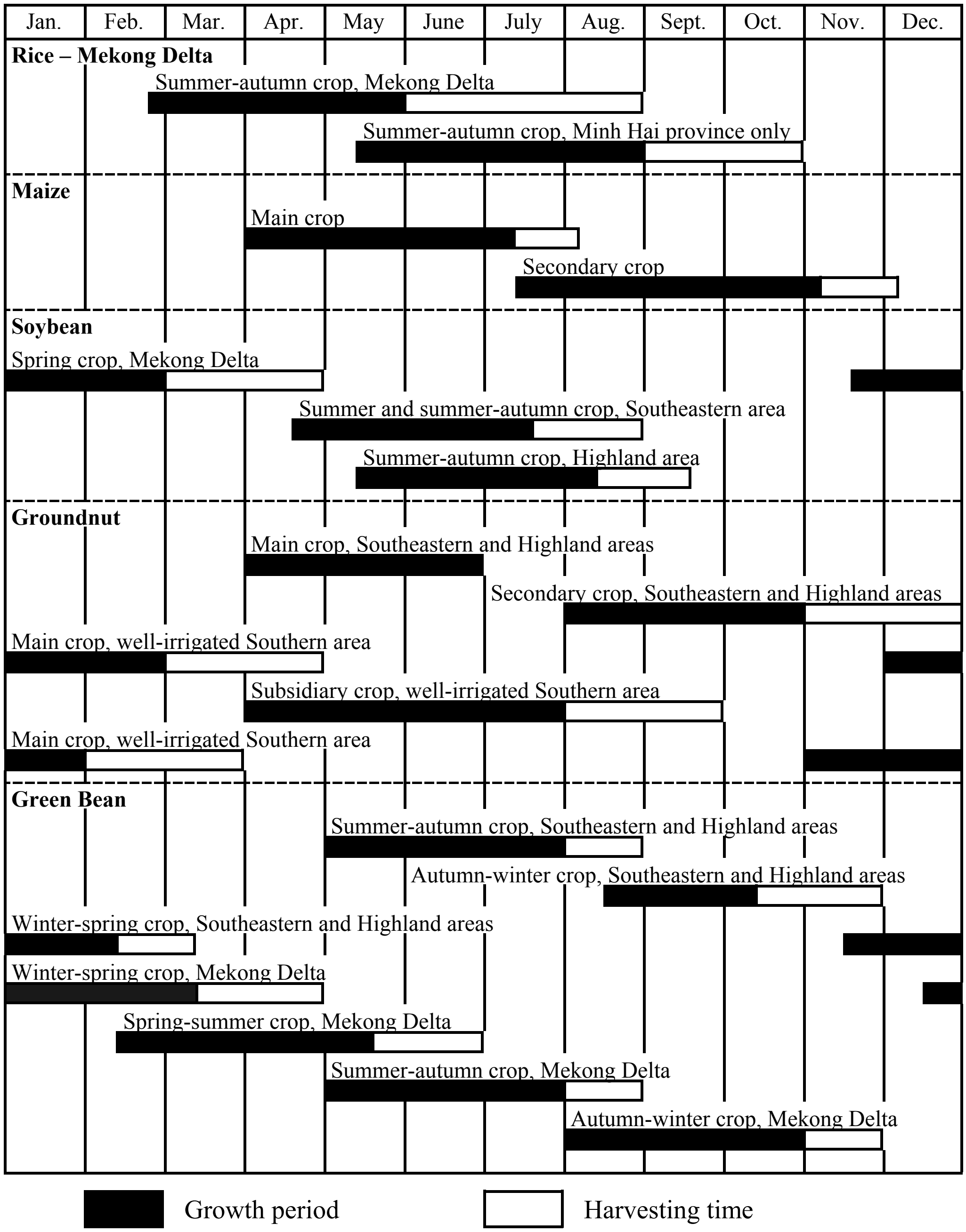
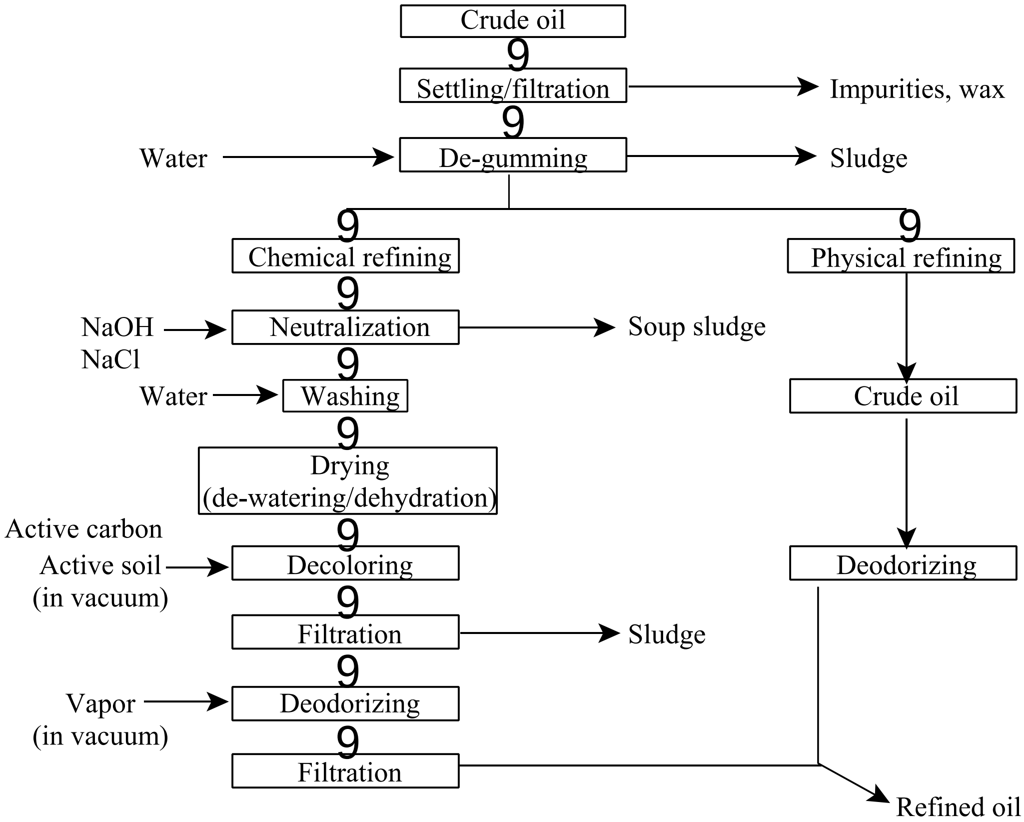


Figure 15. Seasonal Pattern of Crop Production and Harvesting in Southern Vietnam



2. ***Processing of Crude Groundnut Oil*** (Nguyen, 1989)

The procedure is:

Groundnut ÿ Husking ÿ Classification and fanning — Pod (husk) ÿ Fuel; Kernel

Kernel ÿ Rolling ÿ Grinding ÿ Steaming ÿ Wrapping ÿ Pressing

Groundnut cake — Crude oil

3. ***Production of Vegetable Oil in Vietnam*** (Phan, 2000)

Capacity of oil pressing of VOCARIMEX (National Company for Vegetable Oils, Aromas and Cosmetics of Vietnam) with seven factories is 218,000 mt of raw material per year and it utilizes 40 percent of domestic oilseed and meets 40 percent of the market requirement.

Gross output of groundnut oil is 9,000 mt per year (potential: 80,000 mt of crude oil per year).

Gross output of crude soybean oil is 15,000 mt per year from 102,000 mt raw material.

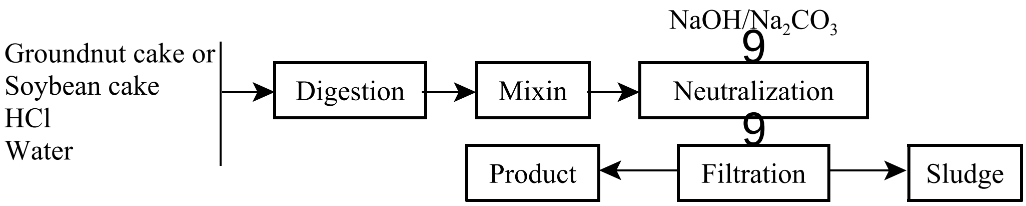
4. ***Production of Other Products*** (Phan, 2000)

The other products include:

– *cooking oil*: mix of refined coconut oil + ground nut oil + other oils.
– *dressing oil*: use refined oil with low acid value (AV), light color and clear.
– *margarine, shortening*: from refined soybean oil + groundnut oil + other oils.
– *oil used in production of canned food*: using refined groundnut oil with very low AV.
– *defoamer used in production of MSG, tofu*: from groundnut oil.
– *groundnut cake, soybean cake*: used in the production of seasonings, soy sauce, animal feed.
– *crude groundnut paste*: for export.

Production of Seasoning Sauce (Chemical Method) (Ngac, 1983)

The seasoning sauce is produced as follows:

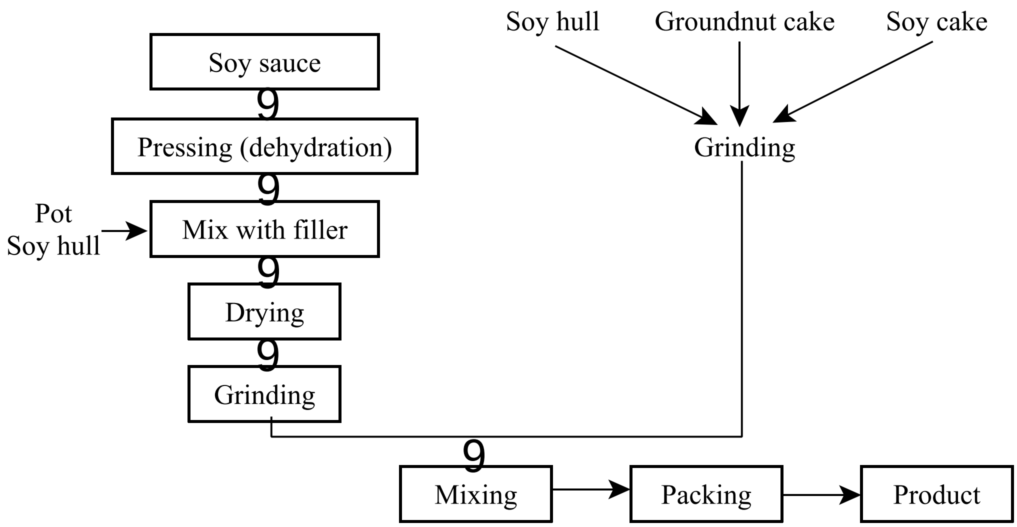


Production of Animal Feed (Ngac, 1983)

1. ***Imperfect Feed***

The raw materials are the by-products of processing of soybean, groundnut, cereals ... such as groundnut cake, groundnut sludge, groundnut pod (husk), soybean cake, soybean hull, tofu sludge, soy sauce sludge ...

The procedure is:



2. ***Perfect Feed***

The raw materials are:

– By-products from processing of legumes.
– By-products from processing, other products such as fish meal, bran, maize, and vitamin.

The procedure is:

Raw material
9
Intermediate product
9
Cleaning → Impurities
9
Drying → Grinding → Sieving → Mixed animal feed

Production of Canned Food

1. ***Groundnut Kernel Fried in Vegetable Oil (Groundnut Oil)*** (Quach, *et al*., 1996)

The raw materials are: groundnut kernel, dry, fat, not damaged by molds or insects; moisture, #10 percent; diameter of kernel, $7 mm; refined groundnut oil, AV#2; salt.

The procedure is:

Raw material ÿ Classification ÿ Groundnut:
Grade 1 (N$11 mm)
Grade 2 (N=9-11 mm) — Drying to a moisture of 2-3 percent (at 75-80ºC for 7-8 hours)
Grade 3 (N=7-9 mm)

9
Grade 4
(N<7 mm)

Dried groundnut ÿ removal of hull ÿ selection ÿ sound de-hulled kernel ÿ frying in oil (at 170-175ºC in 3-4 minutes) ÿ Selection ÿ Mixing with salt (1 percent of nut) ÿ canning ÿ product

9
Defects

Formulation: for 1,000 kg product

– Sound kernel: 1,300 kg
– Refined groundnut oil: 100 kg
– Salt: 11 kg.

2. ***Roasted Peanut Kernel in Can*** (Nguyen, *et al*., 1973)

(a) *Salted-roasted peanut*

Raw material ÿ classification ÿ temperature raising (to 40ºC) ÿ mixing with brine (240 gm/R NaCl) ÿ drying (at 100ºC) ÿ roasting ÿ scenting with spices (0.5 percent) ÿ selection ÿ canning ÿ product

<u>Spices</u>
– Chinese anise flower: 8-10 parts
– Clove: four parts
– Cinnamon: eight parts
– *Thao qua*: one part

(b) *Sweet-roasted peanut kernel*

The procedure is the same with the above, but saccharin solution (6 gm/R; ratio of solution:peanut = 1:12) is used instead of brine.

(c) *Roasted peanut*

Raw material ÿ classification ÿ roasting ÿ washing ÿ drying (at 80ºC in one hour) ÿ selection ÿ canning

Yield (for 1,000 kg product of each)

Raw Material (kg)	Roasted Peanut	Sweet Roasted Kernel	Salted Roasted Kernel
Peanut Grade I	1,250		
Kernel Grade I		1,520	1,150
Salt			25
Saccharin		0.5	
Spices		5.0	5.0

3. ***Mung Bean Sprouts Pickle*** (Tran, *et al*., 1995)

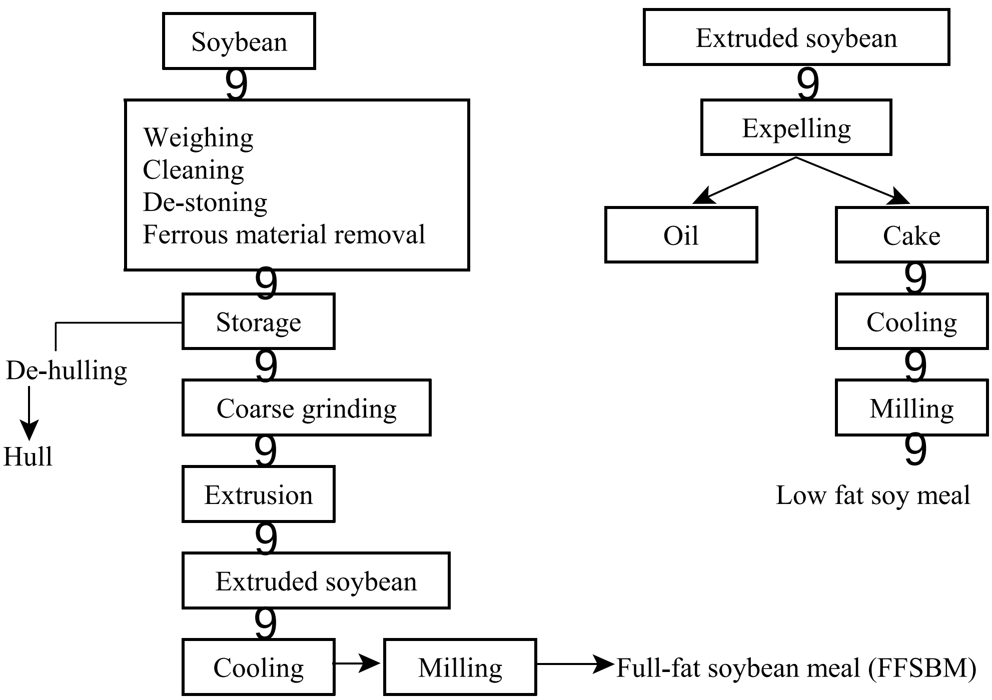
Raw material: sprouts with length of 5 cm, width of 3 mm.

The procedure is: Sprouts ÿ selection ÿ washing ÿ draining ÿ scalding in citric acid 0.1 percent at 80-85ºC in #1 minute ÿ quick cooling to room temperature ÿ mixing with spices (garlic, chilies, pepper) and pickle medium (salt, sugar, acetic acid) in which solid part is 55-60 percent of net weight ÿ canning (NW = 850 gm) ÿ pasteurization 15-10-25/100ºC.

4. ***Natural Mung Bean Sprouts*** (Tran, *et al*., 1995)

Sprouts ÿ scalded sprouts ÿ quick cooling ÿ mixing with brine 1-2 percent ÿ canning ÿ pasteurization 15-10-25/115ºC.

Application of Extrusion-cooking in Processing Soybean and Other Beans



1. ***In Bich Chi's Factory*** (Dong Thap Province)

Single screw extruder from the United States is used. Extrusion at 135ºC; 600 lb/inch^2; duration, 30 seconds.

The products prepared are:

(a) *Nutritious flour*: Rice and soybean ÿ extrusion ÿ extruded product ÿ milling ÿ mixing with sugar, milk powder ÿ finished product.

(b) *Mixed flour*: Raw material (brown rice + soybean or corn + soybean) ÿ extrusion ÿ milling ÿ mixed flour.

(c) *Flour from soybean, mung bean, black mung bean, red cowpeas, mix of five kinds of bean*: Whole seed ÿ extrusion ÿ milling ÿ flour product.

2. ***In Post Harvest Technology Institute (PHTI) – Ha Noi***

Research to produce FFSBM using twin-screw extruder was made by themselves (PHTI, 1999).

The objective is to produce FFSBM in Vietnam to replace the imported FFSBM for use as animal feed (300,000 mt per year are imported).

The product is extruded at a temperature of 150ºC with a moisture of 19 percent at a speed of 410 rpm.

The quality of the product ("V74"), in comparison with the foreign product is given below (percent):

Product	Moisture	Protein	Soluble Protein	Lipid	Ash	Density (kg/m^3)
Raw Material						
VT74	11	35		16	4.8	
USA (Grade 2)	11	38		17	4.5	
Product						
V74	5.64	36.64	30.08	15.8	5.62	550
Intra-Pro FFS	8	38	33.50	18	4.5	561

Protein and fat content of researched product is lower than that for the foreign product, possibly due to poor quality of raw material used in the research.

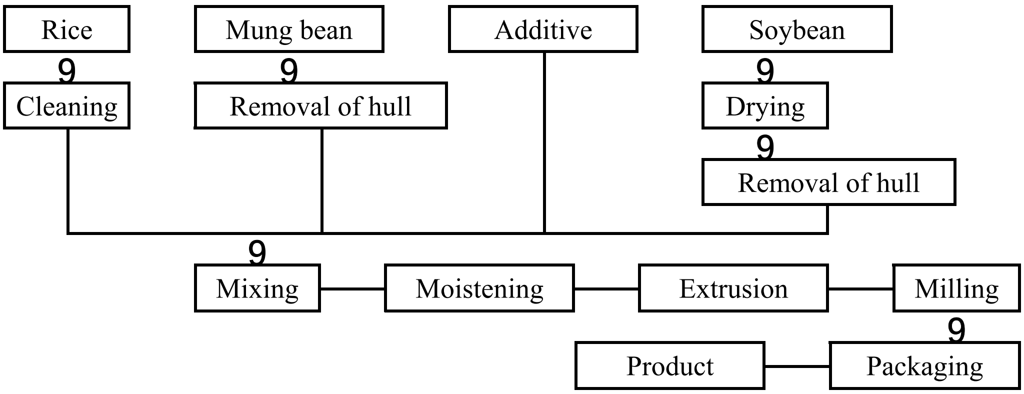


Figure 16. Production of Instant Nutritious Powder for Infants

Source: PHTI, 2000.

Production of instant black mung bean meal is: Black mung bean ÿ washing ÿ extrusion ÿ drying ÿ milling ÿ mixing with other ingredients ÿ packaging ÿ product.

3. **In FIRI – Ha Noi: Production of Baby Food** (Truong, 1994)

The objective is to create a new low-cost weaning food by extrusion cooking for babies in rural and highland areas with high quality using local available raw material solve the malnutrition problem in Vietnam.

The raw materials are rice, corn, soybean, mung bean, potato, malto-dextrin, milk, animal protein, vitamins, and minerals.

The products are:

– The common type (cheap) can be supplied for all the children and expectant women belonging to middle and lower income groups in rural areas.
– Special type can be used for highly malnourished children.

They can produce 60 kg/hour.

Production of Soy Milk in Industry Scale with Automatic Processing Line
(using imported technology and machines in Vinamilk, tribe co-companies)

The product is a "non-beany" soy milk. Based on the airless cold grinding of soybeans, lipoxygenase enzyme is kept dormant until it is inactivated by heating the soy milk.

Yield: 400-500 R/hour or 1,500-2,500 R/hour.

Research Activities of PHTI – Ho Chi Minh City in Processing and Utilization of Legumes

PHTI-HCMC (Ho Chi Minh City) was founded in 1988 as an institute belonging to Ministry of Agriculture and Rural Development. Located in South Vietnam, the largest agricultural production area in the whole country, PHTI has itself rapidly determined its position in a market economy and got the confidence of the society. Research and Development (R&D) activities concentrated on post-harvest technology to serve the rich Mekong Delta and Northeast South regions. The research and development of post-harvest processing and utilization of legumes is an important objective of PHTI-HCMC.

1. ***Research on Production of Instant Vermicelli from Mung Bean Starch***

(a) *Procedure*: Mung bean ÿ soaking (four hours) ÿ removal of hull ÿ grinding ÿ settling/filtration ÿ mung bean starch ÿ mixing ÿ gelatinization ÿ molding ÿ drying ÿ packing ÿ product

(b) *Data on processing*:
   – Ratio of mung bean:starch = 1:1.5
   – Gelatinization temperature: 85-90ºC
   – Gelatinization duration: 15 minutes
   – Yield: 50 kg mung bean ÿ 10 kg starch ÿ 7 kg vermicelli

(c) *Research to reduce the cost of product* – Vermicelli produced from mung bean has the best quality, but it is expensive. To reduce the cost, research has replaced a part of mung bean with potato starch and canna starch.

(d) *Formulation*: Mung bean/potato starch/canna starch = 20/60/20 percent
   – Gelatinization temperature: 105ºC
   – Duration: 10 minutes

- Gelatinization and drying is performed on the belt-spreader (using saturated vapor) and drier made by PHTI-HCMC. Molding is performed using thread-making machine.

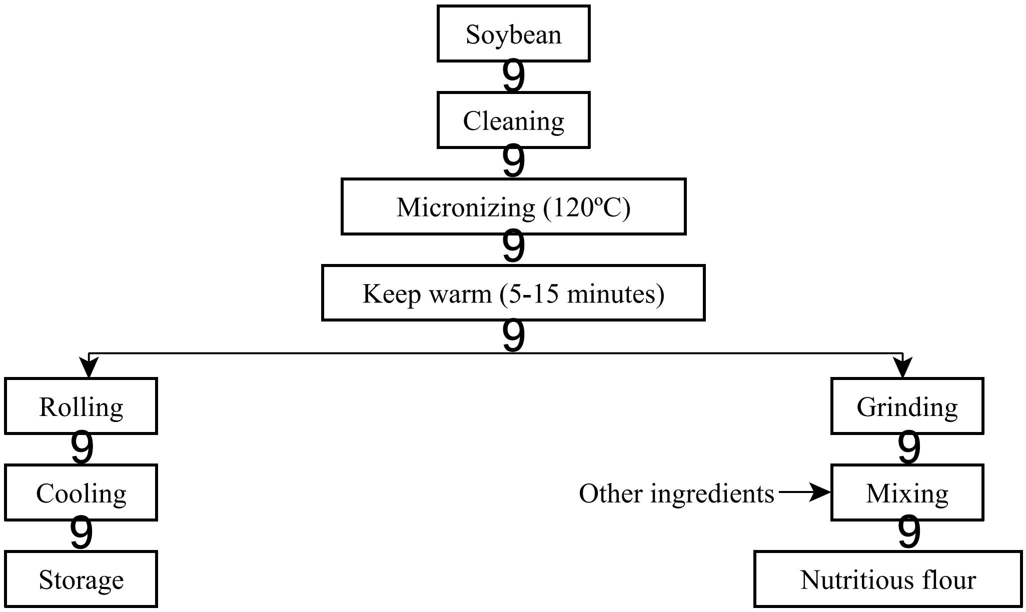
Research has produced vermicelli with the same quality but the cost of the product was reduced by half.

2. ***Treatment and Processing of Soybean by Micronizing*** (PHTI-HCMC, 1997)

The equipment used was micronizer model "Micro Red 10"; capacity, 750-1,000 kg/hour; manufactured by Micronizing Co. (U.K.)

The objective is to use the micronizing method to activate the harmful Trypsin inhibitors and hemagulitinins, to avoid the loss of lysine and thermal sensitive amino acids.

The procedure is as follows:



The quality of soybean before and after micronizing is (percent):

Quality Trait	Sample 1		Sample 2	
	Before Micronizing	After Micronizing	Before Micronizing	After Micronizing
Protein	33.21	33.21	33.21	33.13
Fiber	4.6	4.8	4.7	4.8
Moisture	11.0	8.6	10.12	8.8
Lipid	18.44	19.79	19.05	19.58
Urease activity (mg N/g/g min.)	3.3	0.16	3.0	0.16

Source: PHTI-HCMC's data, 1998.

After micronizing, moisture and especially urease activity decreased considerably (well-done product); lipid content increased; and protein remained unchanged (nutritive value was unchanged or was enhanced).

3. ***Removal of Mung Bean Hull by Micronizing*** (PHTI-HCMC, 1997)

Mung bean is very popular raw material for food processing for Vietnamese people. The removal of hull in traditional way (soaking then manually panning-off) consumes a lot of time and it is difficult to store the de-hulled beans (because of high moisture content).

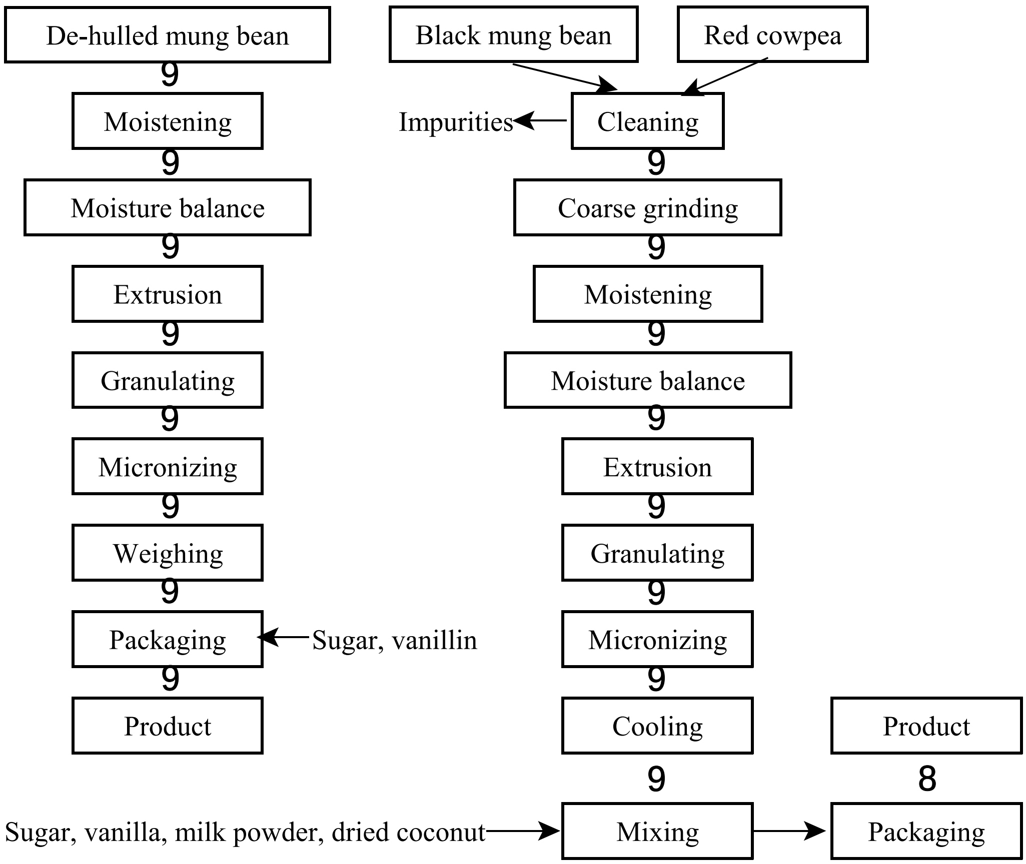
PHTI-HCMC conducted research to remove mung bean hull by micronizing to limit the above inconveniences.

The procedure is: Mung bean ÿ removal of impurities (by fanning, sieving) ÿ micronizing (60 seconds) ÿ removal of hull (by fanning, sieving, separating) ÿ cooling ÿ storage.

Beans absorb infra-red radiation and become dry quickly. The cracks appear on their surface and then the hulls burst out. Bacteria and mold are also killed by high temperature of micronizing process.

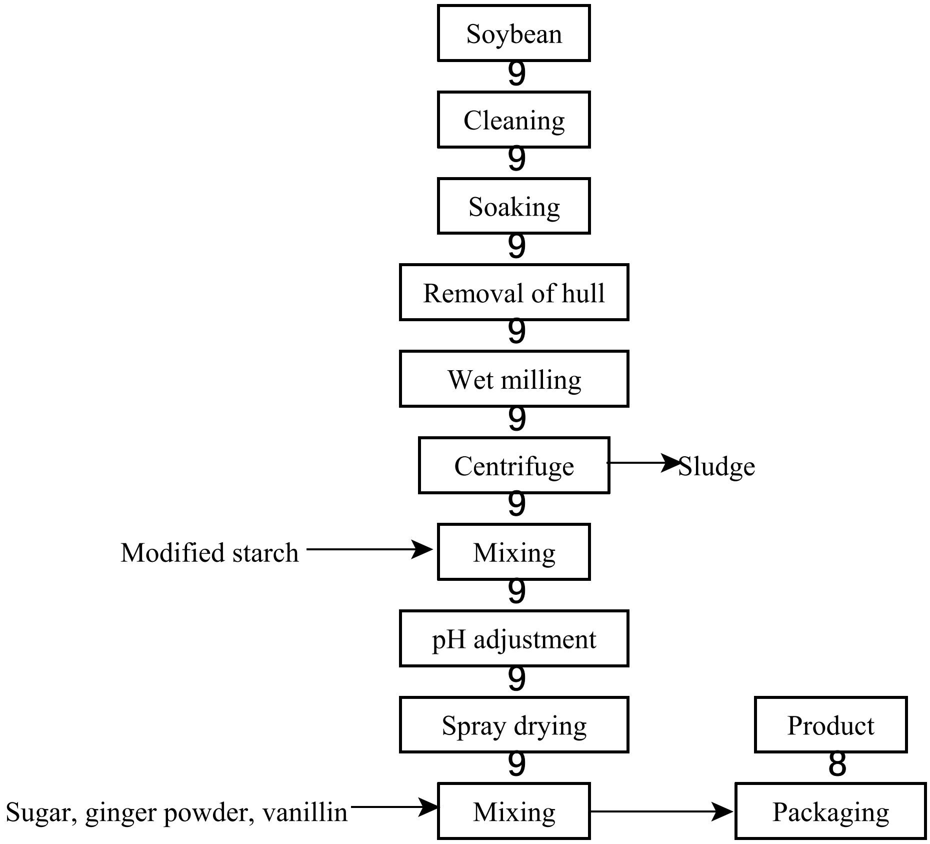
4. ***Combination of Extrusion and Micronizing Technology to Produce Instant Mung Bean Sweet Soup, Instant Black Mung Bean and Red Cowpea Sweet Soup***
   (PHTI-HCMC, 1997)

The procedure is:



5. ***Research on Production of Instant Soybean Curd***

The procedure is:



6. ***Reducing Mycotoxin Content in Agricultural Products*** (Le, 1994)

Studies from PHTI-HCMC on mycotoxins in grain, food, and feed showed that the principal mycotoxin in South Vietnam is aflatoxin. The aflatoxin content in groundnut cake is always high (500-2,000 ppb). Aflatoxin in feed is also very variable.

PHTI-HCMC used two methods to lessen the aflatoxin content in agricultural products.

7. ***Detoxification of Groundnut Cake by Ammonia***

Ammonia (NH_3) was used at high temperature, high pressure and at atmospheric pressure, room temperature to detoxify groundnut contaminated by high level of aflatoxin (up to 2,000 ppb).

Aflatoxin content (ppb) in groundnut cake before and after treatment are shown below:

Sample	Quantity (kg)	Before Detoxification	After Detoxification
1	20	400	<100
2	20	3,000	<100
3	30	1,500	<100
4	10	1,000	<100

(a) *Using an aflatoxin binding substance to mix with contaminated feed before feeding*

The bound aflatoxin cannot pass through the digestive tract to the blood so it is not harmful to livestock. Polyplasdone (DSP Co.) was used to mix with feed containing 300 ppb aflatoxin B1. The dosage of polyplasdone is 200-400 ppm.

(b) *Information program using the mass media*

A number of programs on radio and TV as well as articles in magazines and at seminars, and exhibitions focus on aflatoxicosis and preventive measures. Ten years ago, very few people were aware of aflatoxin. Nowadays almost all feed mills, livestock farm managers and technicians understand the danger of aflatoxicosis and how to prevent it.

8. ***Rapid Detection of Aflatoxin in Groundnut, Crude Groundnut Oil, Peanut Paste, Soybean Extract Meal Using the Methods of BGYF (Bright Green Yellow Fluorescence), Minicolumn, TLC (Thin Layer Chromatography), Immuno-affinity Column*** (Tran, *et al., 1996).*

Since 1994, PHTI-HCMC promoted the use of BGYF test by feed mills and livestock farms in South Vietnam. Though it has some limitations, the BGYF test has the potential to monitor aflatoxin through out Vietnam more effectively.

Since 1989, with the aid of Department of Agriculture in Thailand, PHTI-HCMC has started to use the minicolumn test to analyze aflatoxin semi-quantitatively. Use of aflatoxin minicolumn standards (50, 100, 200 ppb) enhanced the accuracy of the analysis. These minicolumn standards are calibrated by TLC. PHTI-HCMC has also promoted the minicolumn test for 20 feed mills, livestock, poultry farms in South Vietnam. This test is simple, cheap, needs few equipment and therefore all feed mills and farms throughout the country welcomed it for rapidly detecting on the site the raw material, products, feed which were contaminated with aflatoxin to have suitable treatments. Since 1993, Sigma Co. used the TLC method (based on AOAC-1990 method) as standard, the limit of detection is 5 ppb. At present, the research is focusing on the use of ELISA (enzyme-linked immunosorbent assay) test to detect aflatoxin in agricultural products. An immuno-affinity gel had been realized to quantitatively test for aflatoxin B1.

9. ***Pesticide Residue Monitoring in Vegetables; Study and Application of Rapid Biological Pesticide Residue (RBPR) Test in Vietnam***

PHTI-HCMC has successfully applied the Taiwanese RBPR – acetyl cholinesterase (AchE) inhibition test (with some modifications) to monitor the organophosphate and carbamate pesticides residue in fresh vegetables. Seven most widely used pesticides in HCMC (*Methamidophos, Monocrotophos, Diazinon, Dimethoate, Dichlorvos, Fenobucarb, Isoprocarb*) have been shown to have strong inhibition action on AchE at the MRL (maximum residue limit) authorized by Vietnamese regulation (e.g about 1 ppm). This very fast, simple, economical, sensitive and accurate test has efficiently served the extension work for establishing HCMC "Safe Vegetables Production Zones" to screen clean vegetables before they are sold on the market.

The principle of the method is: insect nervous system has AchE which plays an important role in the transmission of nervous influx (nervous impulsion). Organophosphates and carbamates can inhibit this enzyme and kill insects by damaging their nervous system.

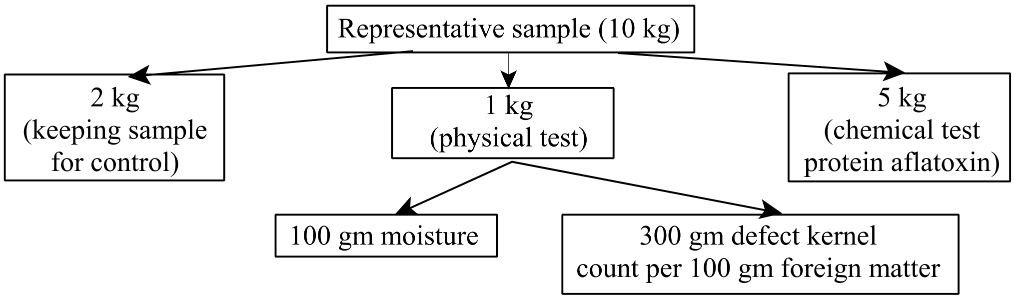
The comparison between the classical method (GC, HPLC) and RBPR method is shown below:

	GC, HPLC	RBPR
Duration	One week	About two hours
Cost/unit	US$11-50/sample	US$7/sample

Results of pesticide residue analysis in some samples of leguminous vegetables using RBPR's method is: (PHTI's data, 1999 and 2000)

Date	Sample	Result
30/08/1999	String bean	Negative (<1 ppm)
17/11/1999	Snap bean	Positive (>1 ppm)
23/11/1999	Snap bean	Negative (<1 ppm)
01/12/1999	Snap bean	Negative (<1 ppm)
06/07/2000	String bean	Positive (>1 ppm)

10. ***Establishment of the Procedure for Analyzing the Quality of Exported Legumes (mung bean, soybean, peanut, red cowpea)*** (PHTI, 1999)



THE PROBLEMS OF PROCESSING AND UTILIZATION OF VIETNAMESE LEGUMES

Mycotoxin Problem (Le, 1994)

Unlike Northern Vietnam, the southern plain has two distinct seasons: dry and rainy. The rainy season begins in mid-May and runs to the middle of November, but is wettest in June-October when there are more than 15 days a month when the rainfall is 200-270 mm. It does not rain continuously everyday but intermittently.

The humidity of air is highest (>84 percent) from June to October. Temperatures are lowest between midnight and dawn.

The cropping system and seasons are given in Figure 15. For example, 50 percent of annual groundnut production is harvested in July, when the rains are heaviest. Due to tropical climate, shortage of warehouses and non-availability of appropriate means for drying, the post-harvest losses are high especially in the rainy season in Vietnam. Fungal infection is responsible for a relatively high proportion of these losses. The problem of molds and their toxin (mycotoxin) is rather serious. It was shown that *Aspergilli* were one of the main source of aflatoxin in groundnut. The contamination by aflatoxin in some leguminous crops, especially groundnut and their products considerably affect the export (Table 14). There have been many incidences of poisoning of domestic livestock in recent years as a result of consumption of feeds contaminated with aflatoxin. HCMC Agricultural Department has prohibited inclusion of groundnut cake in animal feeds. A lot of shipments of groundnut, crude groundnut oil, and peanut paste could not be exported or were returned due to aflatoxin content over the allowable limit (>10 ppb). The export of instant processed peanut or refined processed peanut products are quite low.

Table 14. Aflatoxin Contamination in Food and Feed in South Vietnam

Product	No. of Samples	No. of Samples Contaminated	Average Aflatoxin Level (ppb)	Range (ppb)
Groundnut cake	11	11 (100)	292	7 – 1,602
Groundnut	10	8 (80)	77.2	0 – 480
Crude groundnut oil	5	5 (100)	38	10.2 – 64.6
Refined groundnut oil	5	0	5	
Soybean			25	
Soy oil cake	4	2 (50)	23	0 – 91
Mixed animal feed	24	21 (88)	55	0 – 398
Yellow maize	15	15 (100)	121	1.9 – 625
Rice	10	0	5	

Source: Le, 1994.
Note: Figures in parentheses are percent.

High levels of aflatoxin (>100-125 ppb, even 500 ppb) were found in some samples of groundnut in the market; aflatoxin in contaminated groundnut in North Vietnam is higher than the ones from South Vietnam. Crude groundnut oil collected from factories has high level of aflatoxin (>100 ppb, in which: 50-60 percent is aflatoxin B1; 30-33 percent is aflatoxin G1 and B2; and G2 occupy 10 percent). After refining, aflatoxin content in groundnut oil decreased considerably and nearly became negative. For soybean, the contamination is very weak. In soy cake, the contamination is significant and variable.

The aflatoxin content in agricultural products varies with the season. The rainy season is conducive to the development of mold, and aflatoxin increases markedly (Table 15).

Table 15. Effects of Climate on Aflatoxin Contamination in Food and Feed
(Unit: Aflatoxin average, ppb)

Commodity	Dry Season	Rainy Season
Groundnut	68	86
Groundnut cake	525	1,520
Animal feed	28	80

Source: Chu, *et al*., 1999.

Practical ways to prevent aflatoxicosis include monitoring fodder moisture and aflatoxin levels and timely drying of newly harvested products. Driers are valuable in this regard in rainy season.

Pesticides Residue in Vegetables (Tran, *et al*., 1999)

Intensive vegetable farming relies heavily on new technology, mostly the use of fertilizers and pesticides. Though some new, less toxic pesticides, such as pyrethroids have been used, about 30 percent pesticides used in HCMC suburbs belong to two neurotoxic groups such as organophosphates and carbamates. Survey conducted by Department of Plant Protection showed that pesticide residues in many vegetable samples exceed the maximum residue limit of FAO-WHO (1994) (Tables 16 and 17).

Table 16. Pesticide Residue in Some Domestic Leguminous Vegetables

Crop	Pesticide	Times Exceed MRL	Year of Analysis
Snap bean	Methamidophos	70.6	1996
	Cypermethrin	55.0	1995
Stick bean	Methamidophos	6.2	1996
Red cowpea	DDT	1.3	1994

Source: Plant Protection Department of HCMC, 1997.

Table 17. Pesticide Residue in Some Shipments of Vietnamese Mung Bean and Red Cowpeas Exported to Japan

Crop	No. of Samples	Aldrin			Endrin			Dieldrin		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Red cowpea	17	14	2	1	17	0	0	16	0	1
Mung bean	1	1	0	0	1	0	0	-	-	-

Source: PHTI's data, 1996.
Notes: (1) = 0 ppm; (2) = <0.0002 ppm; and (3) = >0.002 ppm..

So it not surprising that in Vietnam, there are many cases of food poisoning and it is a great concern for the government and public consumers. Therefore monitoring pesticide residue in vegetables is necessary to protect the health of farmers and consumers.

For exported legumes, due to small quantity and due to strict regulations of imported countries, the pesticide residue problem is not significant.

The Unstable Quality of Some Exported Vietnamese Legumes (in the form of raw material)

The Vietnamese legumes (soybean, mung bean, red cowpea etc.) cannot be exported in large quantities and cannot attract good price due to unstable quality and non-uniform appearance (color, dimension, count per size, etc.), and grain characteristics (moisture, defects, foreign matter, etc.) A number of factors are responsible for the poor quality.

Mass Production of Legumes in Vietnam

In general, except some areas specializing in soybean and groundnut cultivation throughout the country, most legumes are still considered as a secondary crop. As a result, the investment for leguminous crops research is inadequate for breeding, cultivation, watering, plant protection, post-harvest preservation, and storage, etc. When investment is increased 2.6-2.7 times, value will increase 3.0-3.2 times correspondingly (Pham, 1999).

Most of the legumes are processed for use as human food. Industrial use of legumes is limited. Very little quantity is exported. Aflatoxin problem is a constraint for export.

By-products from the processing of legumes (groundnut cake, soy cake, etc.) is utilized chiefly as raw material for the production of animal feed; the research on utilization of them for other industrial uses has not been seriously considered. Unfortunately, the quantity of the by-products is not so large, therefore every year Vietnam has to import a large quantity of soybean meal (300,000 mt) for use in producing animal feed.

Although Vietnamese legumes have numerous species, only a few of them (soybean, groundnut, mung bean and to a lesser degree, red cowpeas, black mung bean, white pea, and other leguminous vegetables) are processed and utilized. The other leguminous crops are neglected although some of them have very high nutritive value and can become valuable crops.

The modern legumes processing techniques have not been introduced and applied in Vietnam: techniques of processing of soybean; production of soy protein (full-fat soy flours and grits, defatted or lecithinated, soy concentrates, soy protein isolates); production of texturized products (spun and fiber-type products, extruder-texturized products); production of dried soy milk and tofu; production of nut-like soy bean products (roasted, dessert topping, soy bean buffet); the production technology of peanut butter with international quality; the technology of processing of mung bean in industry scale. All the products processed from these techniques are imported from overseas.

Until now, all kinds of food for vegetarians (based mostly on legumes such as soybean, mung bean, groundnut, etc.) are imported from Taiwan, Hong Kong, and Singapore.

Although some research has been conducted on processing of legumes, rural people have not adapted them. The processing in Vietnam is small scale and they are scattered all over the country.

PROPOSED PROSPECTS AND TRENDS OF DEVELOPMENT OF LEGUMES IN VIETNAM

Increasing the area for Leguminous Crops to Increase the Total Production

Soybean area will be increased to 300,000 ha to increase production to 360,000 mt. For groundnut, the area will be increased to 400,000-500,000 ha in 2005-10 from the present level of 250,000 ha. New cultivation techniques will be used to stabilize and enhance the yield. Breeding will focus on developing new varieties with high-yield, good quality, good resistance to the insects and good adaptation.

One ha of soybean can provide a quantity of protein enough for six persons per year. Therefore the increase in soybean area to 300,000 ha will provide protein source enough for two million persons and lipid source enough for five million persons every year. The main role of soybean is to solve the protein needs for human and domestic animal (to replace part of fishmeal) and to meet part of the demand for lipid in Vietnamese diet. Therefore, priority will be given for selecting soybean varieties with high protein. In addition, varieties suitable for export (big size, uniform dimension, light yellow husk, etc.) should be selected and planted in some areas specifically for export. Groundnut is also a promising crop because it has high economic value. It is an important food crop and an important source of protein and lipid for most Vietnamese people, especially farmers. It can be planted easily and is suitable for the tropical climate. The forecast for production and export of soybean and groundnut is given in Table 18.

Consumption of the plant-based food is the current trend. The numbers of vegetarians are increasing rapidly. People understand the value of plant-based food. People are consuming more leguminous food instead of meat, seafood and other products. In this connection, processed soy foods and soy proteins will be very valuable.

Diversification of legume products will enable effective utilization. For example, protein content of various soy products differs tremendously (Figure 17). Strict quality control should be enforced through monitoring specifically aflatoxin level.

Table 18. Forecast of Production and Exportation of Groundnut and Soybean up to 2010

Crop	Unit	Quantity		Rate of Increment	
		2000	2010	1996-2000	2001-10
Production					
*Groundnut					
– Area	000 ha	260	320	2.48	2.10
– Production	000 mt	300	380	4.6	2.7
*Soybean					
– Area	000 ha	110	120	1.92	0.87
Export					
*Groundnut	000 mt	160	280	7.7	5.7

Source: University of Agronomy, 1996.

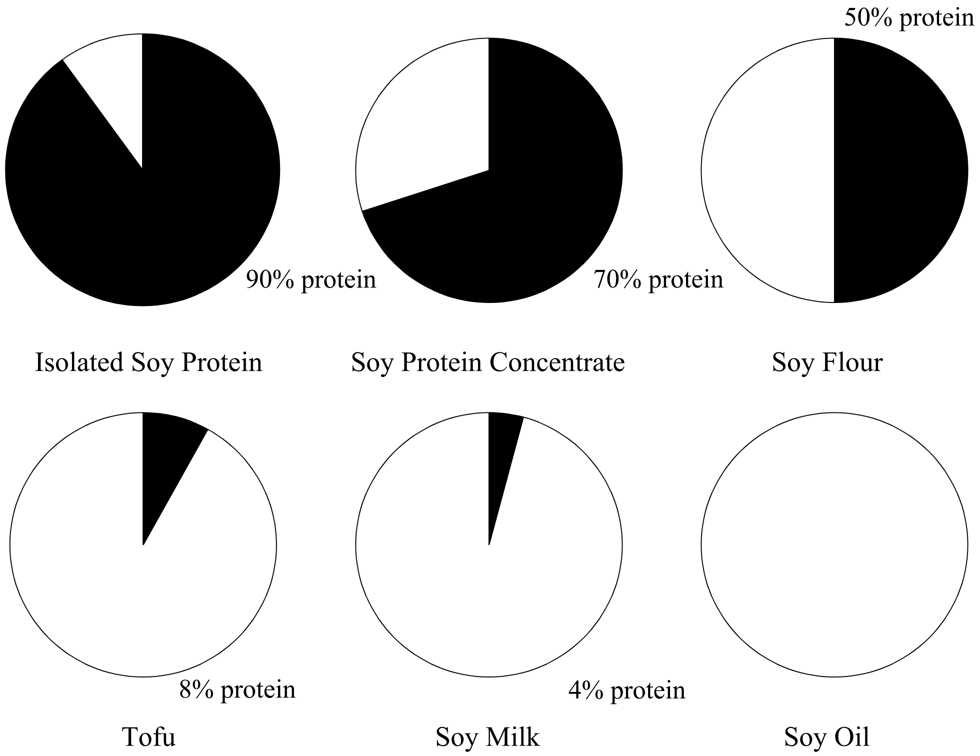


Figure 17. Protein Content of Soy Sources

Source: Hoogenkamp, 1998.

Through domestic and cooperative research with international centers production, aspects should be improved. Such improvement will result in more export, more profit for farmers, and the country.

To limit the post-harvest losses, proper post-harvest technologies (storage, preservation, preliminary processing, processing, etc.) must be selected and applied. Integrated Pest Management IPM), drying, and micronizing technologies need to be selected based on the following:

- Low investment, low energy requirement, effectiveness and simplicity.
- Suitable for different ecological areas and localities.
- Effectively link traditional with modern techniques.

Finally, a national program on research, production and processing of legumes should be set up to organize, to monitor, and to coordinate effectively the development of Vietnamese legumes so that they can contribute to the industrialization and modernization of Vietnam agriculture in the new century.

REFERENCES

Bich Chi's Factory. Dry Extrusion Cooking in Processing of Soybean and Nutritious Powder in Bich Chi's Factory, Dong Thap Province (Vietnamese).

Chu, Pham Ngoc Son, *et al*., 1999. "Aflatoxin Contamination in Food and Feed in South Vietnam", *CASE*; Ho Chi Minh City.

Dong Thap Province, 1985. "Soybean – Local Standard 61 TCV-2-85" (Vietnamese).

Erickson, David R., 1989. *Practical Handbook of Soybean*, AOCS Press and United Soybean Board, U.S.A.

FAO, 1993. "Use of Tropical Food and Oilseeds in agriculture and Food Industry", Ha Noi (Vietnamese).

General Statistical Office, 1998. *Statistical Yearbook 1997*, Ha Noi (Vietnamese).

Hoang, Duc Nhu, 2000. "Production and Processing of Vegetable Oil", Ho Chi Minh City (Vietnamese).

Hoang, Phuong. "Tofu", An Giang Province (Vietnamese).

Hoogenkamp, Henk W., 1998. *Vegetable Protein*, Protein Technologies International, Inc.

Lan, Bui thi, 1999. *Vietnam's Agriculture in the Context of Regionalization and Globalization: Opportunities and Challenges*.

Le, van To, 1994. "The Mycotoxin Problem and Its Management in Grain in Vietnam", ACIAR (Australian Council for International Agricultural Research) Proceedings No.60, 1995 (Post-harvest Technologies for Agricultural Products in Vietnam), Australia.

----------. *Small-scale Processing of Agriculture Commodities to Reduce the Post-harvest Losses and Improve Live Condition of People in Vietnam*, Ho Chi Minh City.

MARD. Vietnam Agriculture Before Its Opportunity of Investment and Development, Ha Noi.

Ngac, van Dau, 1983. "Processing of Soybean and Groundnut into High Protein Food", Ha Noi (Vietnamese).

Ngo, The Dan, *et al*., 1999. "Soybean", Ha Noi (Vietnamese).

Nguyen, Cong Huan, 1985. "Food Small Industry", Ho Chi Minh City (Vietnamese).

Nguyen, Duc Tam, 1984. "Do It Yourself", Tay Ninh Province (Vietnamese).

Nguyen, Huu Phuc, 1998. "The Traditional Food Fermentation Methods in Vietnam and Asian Countries", Ho Chi Minh City (Vietnamese).

Nguyen, Khoa Chi, 1989. "Groundnut", Ho Chi Minh City (Vietnamese).

Nguyen, van Thuong, *et al*., 1992. "Handbook of Nutritive Ingredients of Vietnamese Animal Feed", Ha Noi (Vietnamese).

Nguyen, Van Tiep, *et al*., 1973. "Production Techniques of Canned Fruit and Vegetables", Ha Noi (Vietnamese).

Pham, van Thieu, 1996. "Soybean – Planting and Processing Techniques", Ha Noi (Vietnamese).

----------, 1999. "Mung Bean – Planting and Processing Techniques", Ha Noi (Vietnamese).

Phan, Huu Trinh, *et al*., 1986. "Export Subsidiary Crop", Ha Noi (Vietnamese).

Phan, Lieu, 2000. "Groundnut Production – The Main Trends in Processing and Enhancement of the Value of Groundnut in Vietnam", Ho Chi Minh City (Vietnamese).

PHTI, Ha Noi, 1999. "Research on Manufacture of Full-fat Soybean Meal for Animal Husbandry by Extrusion Technology", *Science Research Report*, Ha Noi (Vietnamese).

PHTI-HCMC, 1997. "Food Processing Technology by Infra-Red Radiation", *Science Research Report*, Ho Chi Minh City (Vietnamese).

----------, 1999. "Management of Post-harvest Grain Quality", *Training Documents*, Ho Chi Minh City (Vietnamese).

----------, 2000. "Research and Application of Advanced Technologies, Suitable Machines to Process Agricultural Products with High Quality for Domestic Uses and Export", *Science Research Report*, Ho Chi Minh City (Vietnamese).

Pro Soya Inc. *Advanced Soy Milk Technology*, Canada

Quach, Dinh, *et al*., 1996. "Post-harvest Technology and Processing of Fruit and Vegetables", Ha Noi (Vietnamese).

Quang, Nam, 1988. "The Popular Home-made Techniques", Da Nang Province (Vietnamese).

Tan Binh Oil Factory. "Processing Line of Refined Vegetable Oil Production", Ho Chi Minh City (Vietnamese).

Thio, Goan Loo, 1971. *Small-scale Processing of Soybeans and Some Applications*, Bulletin 294 of the Department of Agricultural Research, Koninklijk Institute, Voor De Tropen, Amsterdam.

Tran, Khac Thi, *et al*., 1995. "The Techniques of Planting and Exporting of Export Vegetables", Ha Noi (Vietnamese).

Tran, van An and Duong Thanh Liem, 1996. *The Aflatoxcosis Problem and Management of Aflatoxin in Feed in Vietnam*, ACIAR Technical Report 3, Australia.

Tran, van An, *et al*., 1997. "Realization of An Immunoaffinity Gel for Aflatoxin B1 Quantitative Determination", *Science Research Report*, Ho Chi Minh City.

----------, 1999. "Pesticides Residue Monitoring in Vegetables – Study and Application of Rapid Biological Pesticides Residue Test (RBPR) in Vietnam", *Science Research Report*, Ho Chi Minh City (Vietnamese).

Truong, thi Hoa, 1994. "Development and Improvement of Baby Food in Vietnam", *Science Research Report*, FIRI, Ha Noi.

University of Agronomy No. I., 1996. "Industrial Crops", Ha Noi (Vietnamese).

Vo, Cong Hau, *et al*., 1995. "Groundnut", Ho Chi Minh City (Vietnamese).

Watanabe, Tokuji, *et al*., 1984. *The Book of Soybean*, Japan Publications, Inc., Japan.

1. LIST OF PARTICIPANTS, RESOURCE SPEAKERS AND SECRETARIAT

A. PARTICIPANTS

Country	*Name/Official Address*
Bangladesh	Dr. Md. Amiruzzaman Principal Scientific Officer Postharvest Technology Division Bangladesh Agricultural Research Institute Bari, Joydebpur Gazipur 1701
Republic of China	Mr. Wen-Lian Chen Senior Food Scientist Food Industry Research and Development Institute (FIRDI) 331 Food Rd., Hsin-chu Taiwan 300
India	Dr. Jarnail Singh Professor Department of Processing and Agricultural Structures College of Agricultural Engineering Punjab Agricultural University Ludhiana
	Dr. Nawab Ali Project Director Soybean Processing and Utilization Centre Central Institute of Agricultural Engineering Nabi Bagh, Berasia Road Bhopal 462038
Indonesia	Dr. Ignatius Suharto Dean Faculty of Industrial Technology Catholic University of Parahyangan Jl. Ciumbuleuit 94-96 Bandung 40141, West Java

Islamic Republic of Iran	Dr. Mohammad Reza Jahansooz Staff Member and Secretary of Pulses Research Faculty of Agriculture The University of Tehran Karaj
Republic of Korea	Dr. Suk-Ha Lee Assistant Professor Division of Plant Science Seoul National University 103 Seoudun-Dong Kwonsun-Gu, Suwon 441-744
Malaysia	Ms. Norijah Mohd Nor Assistant Agriculture Officer Department of Agriculture Kompeks Pertanian Bukit Temiang 02400 Beseri Perus
Mongolia	Ms. Enkhtaivan Gombosuren Head Department of Food Processing and Services Institute of Food Technology Mongolian Technical University Ulaanbaatar 210646/520
Nepal	Dr. Hari D. Lekhak Associate Professor Central Department of Botany Tribhuvan University Kirtipur, Kathmandu
Pakistan	Ms. Saeeda Raza Senior Scientific Officer and Programme Leader Food Technology and Research Labs National Agriculture Research Centre Pakistan Agricultural Research Council Park Road, Chak Shehzad P. O. Box N1H Islamabad
Philippines	Dr. Olivia M. Del Rosario University Researcher Institute of Food Science and Technology University of the Philippines at Los Baños (UPLB) College Laguna

Sri Lanka	Dr. Nandanie Daya Ediriweera Head, Agro and Food Technology Division Industrial Technology Institute (ITI) 363 Bauddhaloka Mawatha Colombo 7
Vietnam	Mr. Le Thanh Hiep Laboratory Manager Post Harvest Technology Institute 45 Dinh Tien Hoang St., District 1 Ho Chi Minh City

B. RESOURCE SPEAKERS (alphabetical)

Dr. Saipin Maneepun
Director
Institute of Food Research and Product Development
Kasetsart University
P. O. Box 1043, Kasetsart
Bangkok 10903
Thailand

Dr. Akinori Noguchi
Director
Crop Production and Post Harvest Technology Division
(Research Planning and Coordination Division at present)
Japan International Research Center for
Agricultural Sciences (JIRCAS)
Ministry of Agriculture, Forestry and Fisheries (MAFF)
1-2 Owashi, Tsukuba City
Ibaraki Pref., 305-8686
Japan

Dr. Sundar Shanmugasundaram
Plant Breeder and Director
Program I – Vegetables in Cereal-based System
Asian Vegetable Research and Development Center
P. O. Box 42, Shanhua
Tainan 741, Taiwan
Republic of China

C. SECRETARIAT

AICAF	Mr. M. Nakajima Manager International Cooperation Division

Association for International Cooperation of
Agriculture and Forestry (AICAF)
19, Ichibancho, Chiyoda-ku
Tokyo 102-0082
Japan

Tel: (813)3263-5208
Fax: (813)3234-5137

APO

Mr. Teruo Miyake
Director
Agriculture Department

Dr. Muhammad Saeed
Program Officer (Agriculture)
Agriculture Department

Asian Productivity Organization
Hirakawa-cho Dai-ichi Seimei Building 2F
1-2-10, Hirakawacho
Chiyodaku, Tokyo 102-0093, Japan

Tel: (81-3)5226-3920
Fax: (81-3)5226-3950
e-mail: apo@apo-tokyo.org
URL: www.apo-tokyo.org

2. PROGRAM OF ACTIVITIES
(9 - 14 October 2000)

Date/Time	Activity
Mon., 9 Oct.	
Forenoon	Opening Ceremony
	Presentation and Discussion on Topic I: *Present Situation and Economic Importance of Legumes in Asia and Pacific Region*
	by Dr. Sundar Shanmugasundaram
Afternoon	Presentation and Discussion on Topic II: *Traditional Processing and Utilization of Legumes*
	by Dr. Saipin Maneepun
	Presentation and Discussion on Topic III: *Modern Processing and Utilization of Legumes – Recent Research and Industrial Achievements in Soybean Foods in Japan –*
	by Dr. Akinori Noguchi
Tues., 10 Oct.	
Forenoon	Presentation of Country Papers by Participants
Afternoon	Continuation of Presentation of Country Papers by Participants
Wed., 11 Oct.	
Forenoon	Presentation of Country Papers by Participants
Afternoon	Continuation of Presentation of Country Papers by Participants
Thurs., 12 Oct.	
Forenoon	Visit National Food Research Institute
Afternoon	Visit Fuji Oil Co., Ltd.
Fri., 13 Oct.	
Forenoon	Visit Taishi Food Inc.
Afternoon	Leave Utsunomiya for Tokyo
Sat., 14 Oct.	
Forenoon	Summing-up Session
	Closing Session

ASIAN PRODUCTIVITY ORGANIZATION

Bangladesh
Republic of China
Fiji
Hong Kong
India
Indonesia
Islamic Republic of Iran
Japan
Republic of Korea
Laos
Malaysia
Mongolia
Nepal
Pakistan
Philippines
Singapore
Sri Lanka
Thailand
Vietnam

570.3.2003
ISBN 92-833-2343-2