A HAND BOOK ON LEGUMES IN INDIAN AGRICULTURE AND HEALTH BENEFITS

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FOREWORD

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.

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.

The book can be used as a handbook and a ready guide by the Students of Food Science and Nutrition, Agriculture, Horticulture and Forestry Sciences. This book is dedicated to the friends, Students of Food Science and Nutrition, Agriculture, Horticulture and Forestry Sciences and has been composed exclusively for providing first-hand knowledge on the related issues for the development of science and education.

Anil Bukya

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A HAND BOOK ON LEGUMES IN INDIAN AGRICULTURE AND HEALTH BENEFITS

Introduction

Legumes are useful as human and animal food, as wood, and as soil-improving components of agricultural and agroforestry systems. Legumes are among the three largest families of flowering plants and have a long history of use in agriculture. The seeds of many legumes are an important food staple worldwide because they are rich in both oil and protein. They are higher in protein than any other food plant and are close to animal meat in quality. In fact, they are often called “poor man’s meat” because they are an inexpensive source of high quality protein. The high protein content of legumes is correlated with the presence of root nodules which contain nitrogen-fixing bacteria. These bacteria, which are species of the genus *Rhizobium,* are able to convert free atmospheric nitrogen into a form that can be used by plants in the making of protein and other nitrogen-containing compounds. Because of the presence of nitrogen-fixing bacteria, the cultivation of legumes enriches the soil. For this reason farmers often rotate legumes with crops that deplete soil nitrogen.

Legumes belong to the family Leguminosae, (Fabaceae) which consists of four subfamilies, the Papilionoideae, Caesalpinoideae, Mimosoideae, and Swartzioideae.

Leguminosae family

Legumes are among the three largest families of flowering plants. The Leguminosae consist of about 750 genera and 19,000 species of herbs, shrubs, trees, and climbers. This large family is divided into four subfamilies—the Mimosoideae, Caesalpinoideae, Swartzioideae, and Papilionoideae. The Swartzioideae is a small subfamily of about 80 species and relatively unimportant economically.

History of legumes

People have been growing legumes as crops for 6000 years. In Switzerland, the lake dwellers who lived between 5000 and 4000 B.C. cultivated peas (Pisum sp.) and a dwarf field bean, both legumes. In China, farmers began cultivating soybeans between 3000 and 2000 B.C.

The Papilionoideae, with a worldwide distribution, are the largest subfamily. They are mostly herbs and include the most important species for human food.

Most common legumes include peanuts (groundnuts), soybeans, peas, lentils, pigeon peas, chickpeas, mung beans, kidney beans (also known as common or dry beans), cowpeas, alfalfa (lucerne), clovers (Trifolium spp.), and vetches. Legume trees like the Locust trees (*Gleditsia*, *Robinia*) or the Kentucky coffeetree (*Gymnocladus dioicus*) can be used in permaculture food forests.

Important Legume Food Crops

Legumes have been cultivated for thousands of years in both the Old and New Worlds. A possible reason for their long history as food crops may be that their seeds, which are easily harvested, have low water content and, when dry, are easily stored for long periods of time. These features, plus their high protein content and ease in growing, make legumes ideal crops.

Figure 1: Different types of legumes

Production of legumes world wide

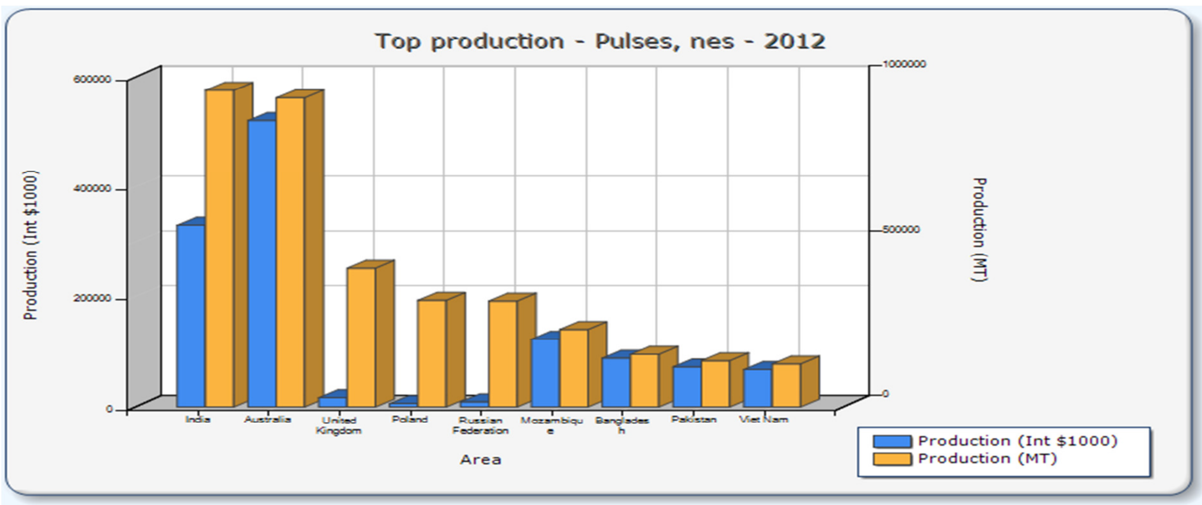

Figure 2: Production of Pulses by FAO 2012 Statistics

Beans and Peas

To most people the word *legume* brings to mind beans and peas; these are, in fact, some of the oldest and most common food crops. Beans come in all shapes, sizes, and colors., kidney beans, lima beans, pinto beans, navy beans, green beans, wax beans, and butter beans are just a few of the many types familiar to us. Beans are a good source of protein, with values ranging from 17% to 31% and the average about 25%. Although the dry seeds were considered the only edible part for thousands of years, some of the most popular varieties today, such as green beans and wax beans, have edible pods. Beans are warm-season annuals requiring a modest amount of rainfall. Like all legumes, they can tolerate most types of soil and can be grown worldwide.

Dry beans are a good source of proteins of reasonable quality and they contain up to 60 % carbohydrates (mainly starch). Dry beans are consumed in different ways; whole- fried, soaked and fried, soaked and cooked and germinated and cooked. They are also canned with meats and a variety of vegetables. Such preparations require different degrees of heating, which affect the nutritional quality and digestibility of the proteins, as well as the carbohydrates.

Vicia faba or Windsor bean which is an Old World species. It has been cultivated and eaten for several thousand years in the Mediterranean region; however, a disease called favism is associated with its consumption. In susceptible individuals, eating broad beans or even inhaling the pollen can produce favism—technically, hemolytic anemia (the lysis of red blood cells). The disease is actually caused by Nitrogen, one of the essential elements for all living organisms, is a major component of amino acids, proteins, nucleic acids, and other organic compounds. Nitrogen gas (N_2) makes up approximately 79% of the air we breathe, but unfortunately, most living organisms cannot use this form of nitrogen to make these cellular components. Certain bacteria and cyanobacteria have the enzymatic ability to reduce nitrogen gas to ammonium (NH_4), which cells can convert to other nitrogen- containing compounds. This process is called nitrogen fixation, and the organisms are called nitrogen fixing. Some species of nitrogen-fixing organisms can live freely in the soil while others are found in symbiotic associations with higher plants, as in the root nodules of legumes. The small water fern *Azolla* is known to have a symbiotic association with a nitrogen-fixing cyanobacterium Plants lacking a symbiotic nitrogen-fixing partner must rely on the nitrogen compounds present in the soil. During the decomposition of dead plants and animals and their waste products, microorganisms break down the proteins and other complex nitrogen-containing organic molecules into ammonium. Although some plants can uptake ammonium directly, nitrifying bacteria present in the soil quickly convert ammonium to nitrite (N_2^-) and then to nitrate (NO_3^-). Nitrate is the form of nitrogen usually absorbed by plants. Most commercial fertilizers contain a mixture of both ammonium and nitrate. World agricultural systems have become increasingly dependent on nitrogen fertilizer. The use of chemical fertilizers has been one of the reasons for the success of modern agriculture, including the Green Revolution, and possibly one of the factors contributing to recent world population increases. One-third of the proteins that sustain the human population are dependent on factory-fixed nitrogen. Although a significant amount of the chemically fixed nitrogen is absorbed by crops, much is washed away as run-off and contributes to the dangerous over fertilization of our waterways. Unfortunately, there are no means available to grow crops without nitrogen. Scientists hope to find more efficient ways to fertilize crops: by monitoring the amount of nitrogen in the soil to minimize fertilizer use, by increasing crop rotation, by increasing the use of organic fertilizers, and by additional legume cultivation. Meanwhile, in coming decades, world dependence on chemical fertilizers will increase even more to feed two billion people who will be added to the world population over the next 25 years. Humans have also impacted the nitrogen cycle through the burning of fossil fuels. During their combustion, nitrogen in the air is combined with oxygen to form nitric oxide (NO), which contributes to both photochemical smog and acid rain. Also, some fixed nitrogen from the fuel itself is released into the atmosphere. Nitrous oxide (N_2O) is also added to the atmosphere by the actions of soil bacteria on the nitrates and an inherited enzyme deficiency common in Mediterranean people but is aggravated by the type of alkaloids found in broad beans.

Those most familiar to us include green peas, split peas, black-eyed peas, lentils, chick-peas (garbanzos), and snow peas. Again the varieties, like snow peas with edible pods and green peas with fresh (not dry) seeds, are of more recent origin. Nutritionally, peas are also a good source of protein, with averages about 21%. Unlike beans, peas are grown during the cooler seasons of the year in temperate zones. Biologically, the most famous pea is the garden pea, *Pisum sativum,* which Gregor Mendel used for his famous genetics experiments.

Native to India, the pigeon pea *(Cajanus cajan)* is an important crop in India, east Africa, and the Caribbean. It is a nitrogen-fixing legume that can tolerate drought conditions and has probably been cultivated for over three thousand years. Large pods hold sweet-tasting seeds which can be eaten fresh or dry. The pigeon pea is one of several legumes used to makes dal, a thick paste made by boiling the split peas and flavoured by a variety of spices.

Nutritionally, the protein content at 22% compares favorably to other peas. In 1974, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India selected pigeon pea as one of five crops (sorghum, pearl millet, chickpea, and groundnut) for a breeding program to create improved varieties. Success was soon met in producing varieties of pigeon pea that matured quicker, three months rather than nine, and that were more disease resistant than traditional ones. But it has taken nearly 30 years to produce hybrid seed in the pigeon pea. Recall that the development of hybrid seed in maize led to improved productivity. In producing hybrid seeds, inbred lines are crossed to yield varieties which are hardier because of hybrid vigor. As with maize, it is desirable to create male sterile lines to control pollination. A breakthrough came when researchers found varieties of pigeon pea with a type of male sterility encoded by genes located in the chloroplasts. (This is an example of cytoplasmic inheritance in which genes outside the nucleus code for traits. Since it is the egg, not the sperm, which passes on its cytoplasm and organelles to the zygote, genes are passed down through the maternal parent.) Breeding for the male sterile trait finally produced pigeon peas with flowers lacking all pollen.

It was then possible to produce hybrid seed and by 2004, the new hybrid variety was ready for distribution. This was the first time hybrid seed had been created in a legume and the information for the development of pigeon pea hybrids will be useful in developing other legume seed hybrids. Already, the productivity of hybrid pigeon peas in the field has nearly doubled.

The chickpea (*Cicer arietinum*) is a legume of the family Fabaceae, subfamily Faboideae. Its seeds are high in protein. It is one of the earliest cultivated legumes: 7,500-year-old remains have been found in the Middle East. Other common names for the species include garbanzo bean, ceci bean, channa and Bengal gram. Chickpea distinguished by their seed size, shape and colour. Desi chickpeas, the smaller variety are wrinkled in appearance and may be brown, yellow, orange, black or green. These are usually sold dehulled or split. Kabuli chickpeas, known for their nutty flavour are round and white to cream in colour. There are three main kinds of chickpeas Desi, Bombay and kabuli.

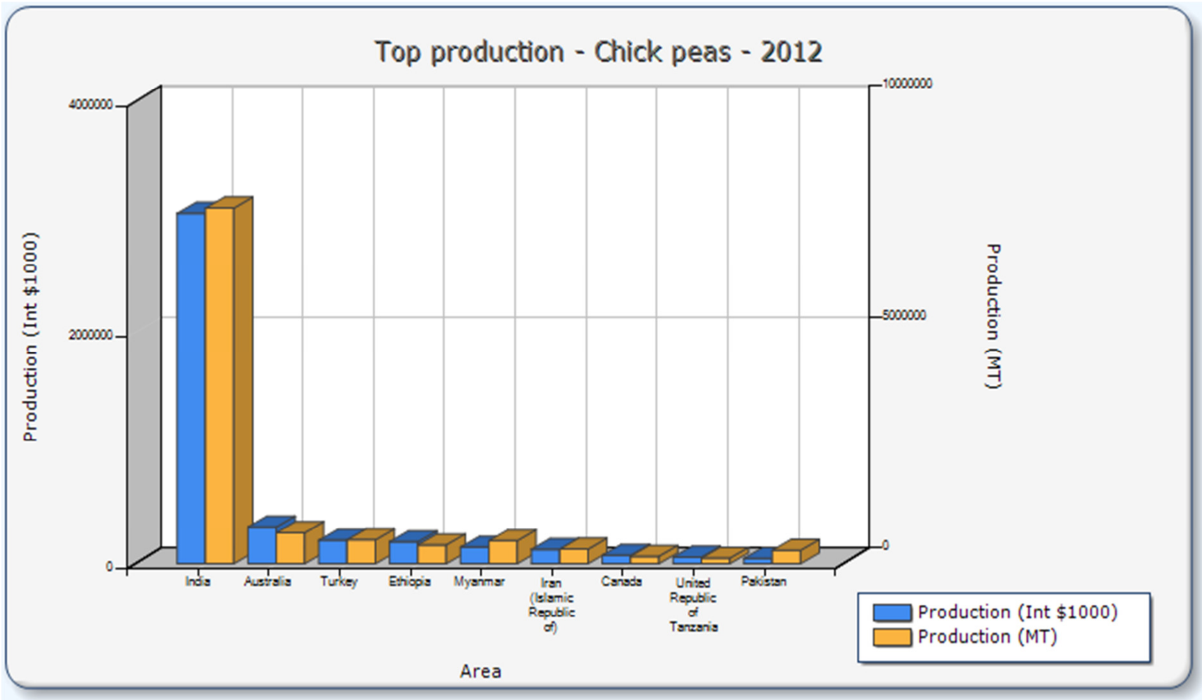

Figure 3: Chick Peas production in year 2012 by FAO statistic.

Desi, which has small, darker seeds and a rough coat, cultivated mostly in the India and much of the Indian Subcontinent, as well as Ethiopia, Mexico, and Iran.

Bombay (*Bambai*), which is also dark in colour but slightly larger in size than the Desi variety. They too are popular in the Indian Subcontinent.

Kabuli, associated with Kabul in Afghanistan. These are lighter coloured, with larger seeds and a smoother coat, mainly grown in Southern Europe, Northern Africa, South America and Indian Subcontinent, having been introduced during the 18th century to India.

Figure 4: Chick pea pod and pigeon pea seed dal.

Peanuts

Peanuts, also known as goobers and groundnuts, are originally native to South America but are grown more extensively today in other parts of the world. Although the exact date of domestication is unknown, finely crafted gold and silver peanut-shaped jewelry was recently unearthed in Peru in the tomb of a Moche warrior priest. Carbon dating indicates that the tomb was from A.D. 290. This archeological discovery shows that the peanut played a prominent role in the ancient Moche civilization. In the sixteenth century, Spanish explorers discovered peanuts growing in South America and brought them back to Europe. From there, trading introduced the peanut to Africa, where it soon became widely cultivated. The slave trade returned the peanut to the New World, but this time to North America. In the United States, the peanut is a staple crop of the South, growing best in light sandy soils and mainly cultivated in Georgia, North Carolina, Texas, Alabama, Virginia, and Oklahoma.

Figure 5: An uprooted peanut plant shows how peanut pods develop underground.

The peanut, *Arachis hypogea,* is one of nature's more unusual plants. After pollination, the flower stalk elongates downward, pushing the developing fruit into the soil. It is here, underground, that the fruit matures into a pod, characteristically with two seeds (peanuts) in a shell. The whole growing cycle takes about 5 months. Two varieties commonly grown in the United States are the larger-seeded Virginia peanut and the smaller-seeded Spanish peanut, which has slightly higher oil content. With 45% to 50% oil and 25% to 30% protein, the peanut is a highly nutritious seed that is used in many ways. It is a favorite in the United States, with over 1 billion pounds consumed annually, mainly as a snack food, in candy, and in peanut butter. In fact, half of the U.S. peanut crop is used to make peanut butter.

Today, peanut oil is found in margarine, shortening, salad dressing, cooking oil, certain soaps, and a variety of cosmetic and industrial products such as shaving cream, plastics, and paints. (Unfortunately for some, the widespread use of the peanut and its oil in a variety of foods can be deadly. Even after the extraction of oil, the pressed cake that remains is used as a livestock feed that is rich in protein. Hogs in particular have such a fondness for peanuts that they will uproot them in fields if given the opportunity. The versatility of the peanut is due in large part to the work of George Washington Carver (1864–1943), who developed more than 300 food and industrial uses and encouraged its cultivation in the South.

Faba beans

Faba beans also known as the broad bean, fava bean, vicia faba, field bean, bell bean, or tic bean, is a species of bean (Fabaceae) native to North Africa, southwest and south Asia, and extensively cultivated elsewhere. Faba Beans are round to oval in shape and usually flattened. There are two types which differ in size, V. Faba major (broad bean) and the V. faba minor (horse bean, tick bean).

Figure 6: Faba beans pod and soya bean seeds

Soybeans

The soybean, *Glycine max,* is relatively new to the West but has been esteemed in the Orient for centuries. It was considered one of the sacred crops of the ancient Chinese, and evidence suggests that it was domesticated in northern China at least 3,000 years ago. Soybeans were first brought to Europe in the seventeenth century by the German botanist Engelbert Kaempfer Although the soybean was introduced into North America in 1765, there was very little interest in growing the crop until the 1920s. During World War II, soybean oil substituted for imported fats and oils, and the nutrient meal was used to boost livestock production. Soybean production has continued to rise dramatically, making the United States a leading producer. Because of this spectacular rise from a second-rate crop, it has often been referred to as the Cinderella crop. Reasons for the success story are the versatility of the soybean and its suitability for growing in the cornbelt region of the Midwest; it does best in warm, temperate climates with moderate amounts of rainfall. Since ancient times in Asia, soybeans have been consumed in hundreds of ways. Soybeans cannot be consumed raw because of the presence of a trypsin inhibitor. Trypsin is a digestive enzyme, and the presence of this inhibitor interferes with normal protein digestion in humans. When cooked, soybeans can be eaten whole because the inhibitor is inactivated by heat. Most often, however, soybeans are modified into a paste, curd, or "milk." One familiar soybean product is soy sauce; although many American brands are made synthetically, soy sauce traditionally is made by fermenting soybeans in brine. In the preparation of soy milk, beans are soaked in water and puréed. The mixture is then heated, and the liquid soy milk is poured off. Soy milk provides a nondairy substitute for both milk and baby formula for lactose-intolerant individuals who are unable to digest the lactose that naturally occurs in cows' milk or for those allergic to the milk proteins. Tofu, or bean curd, is prepared from curds of soy milk and is extremely versatile, being used in main dishes in both Japanese and Chinese cuisine. Tofu on its own is bland tasting, but it acts like a sponge, soaking up flavours from other ingredients. It also serves as the basis for a large variety of soy cheeses, yogurt, sour cream, and other dairy spreads. Imitation cream cheese, cheddar cheese, Swiss cheese, and a host of other varieties are now available in health food stores. An ice cream–like desert called tofutti is another well-known tofu product. These are especially welcome products for lactose-intolerant individuals as well as for those wishing to avoid the saturated fat in dairy products.

The use of tofu, soy milk, and other soy foods has recently received a great deal of attention because they contain isoflavones, which are phytoestrogens. Although these plant estrogens are much weaker than human estrogen, they may have effects on the body. Some research indicates that these compounds lower cholesterol levels, especially LDL levels, which could lower the risk of cardiovascular disease. Some studies have also found that isoflavones may reduce symptoms of menopause and reduce risks of osteoporosis by preventing bone loss in older women. Other studies have shown that isoflavones may inhibit the formation and growth of tumors. Some researchers believe that low rates of both breast cancer and prostate cancer among Japanese are due to the consumption of a soy-rich diet. Further research is needed because other studies have shown only modest or insignificant beneficial effects of soy phytoestrogens on health.

Other common soybean foods in the Orient are miso and tempeh. Miso is a fermented food of Japan prepared from soybeans, salt, and rice; the mixture is fermented by fungi for several months and then ground into a paste and used as a spread. Tempeh, fermented soybean cake that originated in Indonesia, is prepared by inoculating parboiled soybeans with mold and allowing them to ferment for a few days. The fungal mycelium binds the soybeans together into a cake, which can be sliced and cooked in various ways. Soybeans are among the richest foods known, with 13% to 25% oil and 30% to 50% protein, depending on the variety.

Overall, they have higher protein content than lean beef. Although still used largely as animal feed, the soy protein is used more and more in the human diet. After the extraction of oil, the soy meal that remains is made into flour and can be included with wheat flour in a variety of breads, pasta, baked goods, and breakfast foods. Replacing a small fraction of the wheat flour with soy flour significantly improves the protein content. The soybean has also played a vital role in relief efforts as a protein-rich food supplement to famine victims in many developing nations.

Another product is textured vegetable protein (TVP), produced by spinning the soy protein into long slender fibers. TVP can pick up flavors from other substances and can therefore be used as a meat extender. With the addition of artificial flavorings and colors, TVP can be made into cholesterol-free imitation meats. Imitation bacon bits are made this way.

Soy oil is used extensively as cooking oil, as salad oil, and in the manufacture of margarine, shortening, and prepared salad dressings. It is such a widespread ingredient in so many foods that the average American consumes almost 6 gallons (23 liters) of soy oil a year. In fact, in 1996, 82% of the edible vegetable oil consumed in the United States was produced from soybeans. Today, many manufacturers are replacing unhealthy saturated fats with soybean oil in commercially prepared food.

Industrially, soy oil can be used in dozens of processes for the manufacturing of paints, inks, soaps, insecticides, and cosmetics.

Probably the most imaginative use of soy oil was the manufacture of a soybean-based "plastic" car by Henry Ford in 1940. Ford's commitment to the use of soybeans in car manufacturing was so great that at one point he stated that his goal was to "grow cars rather than mine them." Lecithin, a common food additive, is a lipid extracted from soybeans. Added to many packaged foods such as cake mixes, instant beverages, whipped toppings, and salad dressings, it stabilizes them and extends their shelf life. The use of soybeans should increase even more in the future. One possible market is developing countries. Attempts to improve the protein-deficient diets in these countries have included using soy products to enhance the nutritional value of the native foods.

Lentils

Lentil is an edible pulse. It is a bushy annual plant of the legume family, grown for its lens-shaped seeds. It is about 40 cm (16 in) tall and the seeds grow in pods, usually with two seeds in each Lentil colors range from yellow to red-orange to green, brown and black. Red lentils known as 'microsperma' are smaller and round whereas green lentils known as 'macrosperma' are larger and have a flattened seed. Lentils are a good source of protein and iron. Lentils are used in soups and casseroles


Figure 7: lentil plant and red lentils seeds.

Mung bean

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). In Thailand, mung bean is used to make mini sweet desserts of different shapes like vegetables and fruits. Mung bean noodles and breads are also common. Mung beans are prescribed for patients in the hospitals and served with bread. Green gram has good nutritive value and on germination, it is free of flatulence causing agents. Sprouting improves the protein digestibility by decreasing anti-nutritional factors. (Anil Bukya & T.P. vijayakumar 2014)

Figure 8: Green gram seeds and Black gram

Black gram

Black gram is called as Vigna mungo, Urad Dal, black lentil (not to be confused with the much smaller true black lentil *(Lens culinaris)*), it is a bean grown in the Indian subcontinent. Along with the mung bean, black gram was placed in *Phaseolus*, but has since been transferred to *Vigna.* Black gram originated in India, where it has been in cultivation from ancient times and is one of the most highly prized pulses of India and Pakistan. The coastal Andhra region in Andhra Pradesh is famous for black gram after paddy. The Guntur District ranks first in Andhra Pradesh for the production of black gram. Black gram has also been introduced to other tropical areas mainly by Indian immigrants 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

Human Food

Legume seeds (also called pulses or grain legumes) are second only to cereals as a source of human and animal food. 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. When legumes and cereals are eaten together, they provide complete protein nutrition. Nutritionally, legume seeds are two to three times richer in protein than cereal grains. Some legumes, such as soybeans and peanuts, are also rich in oil. Kidney beans and other legumes are a major source of food in Latin America, while lentils, pigeon peas, and chickpeas are important in South Asia. In the Middle East and North Africa, faba beans, lentils, and chickpeas are particularly important. Common food products made from legumes include tofu, peanut butter, and soymilk.

Nutritional facts

Legumes contain relatively low quantities of the essential amino acid methionine, as compared to whole eggs, dairy products, or meat. This means that a smaller proportion of the plant proteins, compared to proteins from eggs or meat, may be used for the synthesis of protein in humans, unless other higher methionine sources are consumed that are complementary in regard to their amino acid profile. The portion of plant proteins not suitable for the synthesis of human proteins is instead used as fuel in the human metabolism. However, lower methionine ingestion has been found to actually decrease oxidative stress and damage in rodent livers and increased longevity, which could possibly have implications for humans. These studies suggest that the reduced intake of dietary methionine can be responsible for the decrease in mitochondrial ROS generation and the ensuing oxidative damage that occurs during DR, as well as for part of the increase in maximum longevity induced by this dietary manipulation.

Table 1: Nutrient Composition of different Pulses

Nutrient / Pulses	Redgram	Blackgram	Greengram	Bengalgram	Soyabean
Moisture (%)	13.4	10.9	10.1	9.9	8.1
Protein (%)	22.3	24.0	24.5	20.8	43.2
Fat (%)	1.7	1.4	1.2	5.6	19.5
Carbohydrates (%)	57.6	59.6	59.9	59.8	20.9
Minerals (%)	3.5	3.2	3.5	2.7	4.6
Calcium (mg)	73.0	154.0	75.0	56.0	240.0
Phosphorus (mg)	304.0	385.0	45.0	331.0	690.0
Iron (mg)	5.8	9.1	8.5	1.1	11.5
Total N (%)	3.6	4.2	3.9	3.3	6.9
Calorie value	335.0	347.0	451.0	372.0	432.0
Vitamin 'A' (mg/100 g)	220.0	64.0	83.0	2160.0	710.0

(M.Subramanian 2000) Perspective of increasing Pulse Productivity in Tamil Nadu

Legumes are among the best protein sources in the plant kingdom. The low concentrations of the amino acid methionine in legumes may be compensated for simply by eating more of them. Since legumes are relatively cheap compared to meat, eating more legumes may be an alternative to meat for some.

Legumes provide a range of essential nutrients including protein, low glycemic (GI) carbohydrates, dietary fibre, minerals and vitamins. An economical dietary source of good quality protein and are higher in protein than most other plant foods. Legumes have about twice the protein content of cereal grains.

Generally low in fat, virtually free of saturated fats and contain no cholesterol. Soybeans and peanuts are the exception, with significant levels of mostly monounsaturated and polyunsaturated fatty acids, including alpha-linolenic acid.

Coming to vitamins rich in water soluble vitamins, legumes are good source of B-group vitamins (especially folate), iron, zinc, calcium and magnesium. Low in sodium – sodium content of canned legumes can be reduced by up to 41% if the product is drained and rinsed.

Table 2 : Nutrients in legumes and benefits to health

S.No	Nutrient	Benefits
1	Low saturated fat content	Replacing some animal protein in the diet with legumes reduces saturated fat intake without compromising overall protein intake.
2	Low glycemic index	Contributes to the satiating effect of a meal and may reduce insulin responses.
3	High resistant starch content	starch present in legumes is fermented by colonic bacteria to short chain fatty acids, which in turn imparts colonic health benefits
4	Phytochemical content	Non-nutritive bioactive compounds including antioxidants may play a role in the disease protection benefits of legumes. Legumes are also sources of phytosterols, isoflavones, saponins, and alkaloids, as well as some bioactive sugars, oligosaccharides and phytates.

(http://www.glnc.org.au/legumes/legumes-health/)

According to the protein combining theory, legumes should be combined with another protein source such as a grain in the same meal, to balance out the amino acid levels. A variety of protein sources is considered healthy, but they do not have to be consumed at the same meal. In any case, vegetarian cultures often serve legumes along with grains, which are low in the essential amino acid lysine, creating a more complete protein than either the beans or the grains on their own. Modification of protein to reduce the protein denaturation temperature through various method of processing will throw light on further value addition towards the preparation of high protein food supplement using defatted sesame flour like soy flour (Anil Bukya & Poongodi vijayakumar 2013).

Common examples of such combinations are the Indian Dal and rice, Mexican beans with corn tortillas, the Middle Eastern Hummus (Chickpea spread commonly served with Pita bread), tofu with rice in Asia and peanut butter with bread in the US and Australia and Mujaddara (A dish consisting mainly of rice and lentils).

Germination/ sprouting of legumes and nutrient changes

Sprouting from numerous disciplines provides a view of the role that germination Played in the evolution of physiological, biochemical, nutritional, and food functional properties legumes. Germination is the sprouting of legumes seeds that is induced by soaking in water. As soon as the seed is hydrated, chemical changes occur, which results in partial breakdown of storage components, such as starch and protein; transport of materials from one part of the seed to another; and synthesis of new substances such as vitamins. Simultaneously, amylases are synthesized in varying quantities, depending on the species and variety of seed and duration of soaking and germination. The steeping times ranges from two hours for pearl millet to 12 hours for maize and sorghum (gopaldas et al 1988). The optimum durations of germination is that which results in maximum amylolytic activity without undesirable changes, such as growth of moulds, development of unpleasant flavours, or excessive growth of roots and shoots. The range of optimum germination times is approximately 12 hours for quinoa, 48-72 hours for wheat, millet, sorghum, mung bean, cow pea and 72-96 hours for maize, rice, soya and ground nut (ashworth & Draper, 1992)

After germination malted grains are dried, the roots and shoots are removed and the grains are ground into flour. The shelf life of the resulting amylase rich flours (ARF) depends on their moisture and fat content.

Figure 9: Germination of legumes

Nitrogen fixing ability of legumes

Many legumes (alfalfa, clover, peas, beans, lentils, soybeans, peanuts and others) contain symbiotic bacteria called *Rhizobia* within root nodules of their root systems. (Plants belonging to the genus Styphnolobium is one exception to this rule). These bacteria have the special ability of fixing nitrogen from atmospheric, molecular nitrogen (N_2) in to ammonia (NH_3).

$N_2 + 8\,H^+ + 8\,e^- \rightarrow 2\,NH_3 + H_2$

Ammonia is then converted to another form, ammonium (NH_4^+), usable by (some) plants

$NH_3 + H^+ \rightarrow NH^+{}_4$

Root nodules are sources of nitrogen for legumes, making them relatively rich in plant proteins. All proteins contain nitrogenous amino acids. Nitrogen is therefore a necessary ingredient in the production of proteins. Hence, legumes are among the best sources of plant protein. When a legume plant dies in the field, for example following the harvest, all of its remaining nitrogen, incorporated into amino acids inside the remaining plant parts, is released back into the soil. In the soil, the amino acids are converted to nitrate (NO_3^-), making the nitrogen available to other plants, thereby serving as fertilizer for future crops.

In many traditional and organic farming practices, crop rotation involving legumes is common. By alternating between legumes and non legumes, sometimes planting non legumes two times in a row and then a legume, the field usually receives a sufficient amount of nitrogenous compounds to produce a good result, even when the crop is non leguminous. Legumes are sometimes referred to as "green manure".

Animal feed

As standards of human nutrition improve in all countries, there is a corresponding increase in demand for animal products such as milk, butter, eggs, and meat. This demand can only be met by using animal feeds with high protein content. Among the grain legumes, soybeans are the most extensively used in animal feed.

Forage legumes are commonly provided to animals in grass-legume mixtures. In the temperate regions, clovers, medics, trefoils, and vetches are important. In tropical and subtropical pastures, Stylosanthes, Pueraria, Lablab, Desmodium, and other tropical pasture crops are important sources of livestock fodder.

Other uses of legumes

Many species in the Mimosoideae and Caesalpinoideae subfamilies provide valuable timber, dyes, tannins, resins, gums, insecticides, medicines, and fibers. Many provide green manure for crops, such as Sesbania rostrata in rice cropping systems and Gliricidia sepium and Leucaena leucocephala in alley cropping. Many tree legumes have been identified as useful multipurpose species, and these are being introduced through agro forestry, soil restoration, and erosion control programs in many countries.

Table 3: Other Legumes and Use

Plant	**Scientific Name**	**Use**
Carob	*Ceratonia siliqua*	Chocolate substitute
Copaifera,	*Copaifera officinalis*	Resin for paints, lacquers
Fenugreek	*Trigonella foenum-graecum*	Spice
Indigo	*Indigofera tinctoria*	Dye
Licorice	*Glycyrrhiza glabra*	Extract
Mesquite	*Prosopis glandulosa*	Charcoal
Rosary pea	*Abrus precatorius*	Jewelry
Rosewood	*Dalbergia* spp.	Timber
Senna pods	*Cassia fistula*	Laxative
Tamarind	*Tamarindus indica*	Seasoning
Tuba-root	*Derris elliptica*	Insecticide

Forage Crops

Worldwide, many legumes are planted and grown exclusively as pasture or forage crops. Their high protein content, which makes them ideal as a source of food for humans, also makes them desirable as animal fodder. Combinations of carbohydrate- rich grasses and protein-rich legumes are grown in most pastures for direct consumption or for hay. Alfalfa *(Medicago sativa)* is probably the best known and most widely grown of these forage legumes The Romans recognized this crop as a superior feed for their horses; later the Spanish introduced alfalfa to the New World for the same purpose. One of the largest markets for alfalfa today is as a dehydrated feed for livestock (cattle, horses), pets, and laboratory animals (gerbils, rabbits, mice).

Figure 10: Alfalfa *(Medicago sativa)* has been used as a forage since the days of the ancient Greeks and Romans

Anti nutritional factors

Anti-nutritional factors and utilisation by ruminants

Many raw legumes (especially tropical varieties) and other high-protein grains contain anti-nutritional factors; toxic compounds such as proteinase inhibitors, alkaloids and tannins. Alkaloids and lectins (haemaglutinins) can cause scouring or death at high levels. These anti-nutritional factors have major effects on monogastrics, but have less effect on ruminants as microbial fermentation in the rumen can break down some toxic compounds such as the proteinase inhibitors.

If they can be detoxified either by the animal or by processing, legume grains and oil seeds are highly digestible, with energy content similar to cereal grain and protein contents of 20-28%. Whole cottonseed contains gossypol, but at moderate feeding levels this is detoxified by an effectively functioning rumen. Hence 2 to 3 kg/day can be fed to lactating cows, with proportionally lower levels for growing animals. It would be unwise, however, to use it for young calves or weaners. Some have high oil contents (soybean, cottonseed) and intake must be controlled to keep lipid content (fats and oils) of the diet below 5%, as fat coats the feed in the rumen, reducing microbial access to break down fibre. Depending on composition of the diet, up to 2 kg of oilseeds can usually be fed. Lupens (round) are widely used in southern states at up to 5 kg/head a day in dairy concentrates, but flat-Albus varieties contain alkaloids and are not suitable for feeding.

Legume grains have been examined much more closely for use for monogastrics - pigs, poultry and humans. If a legume grain is suitable for pigs, it can be assumed to be safe for ruminants. These have been tested at levels of 20-30% of the pig's diet. For lactating cows, a feeding level of 2 kg/day is less than 15% of the diet. Degradation in the rumen provides greater tolerance to low levels of some toxins such as trypsin inhibitors, allowing soybean and peanuts to be fed raw, but unless known, it could be wise to accept similar recommendations to those used for pigs.

Anti-nutritional factors in legume grains may not be completely denatured by rumen microbial action (e.g. alkaloids, lectins). Cooking may still increase responses by cattle. For instance, whole soybeans are widely used in dairy rations in the US and contain trypsin-inhibiting compounds. It is heated (dry cooking) to detoxify it for pigs and improve its utilisation for cattle. Trypsin is a pancreatic enzyme (proteinase) necessary for protein digestion. In monogastrics, feeding soybeans raw results in an enlarged pancreas, poor feed digestion and lowered production.

Anti-nutritional factors & Toxins in legumes.

Trypsin inhibitor

Trypsin inhibitor is a type of serine protease inhibitor that reduces the biological activity of trypsin. Trypsin is an enzyme involved in the breakdown of many different proteins, including as part of digestion in humans and other animals. As a result, protease inhibitors that interfere with its activity can have a nutritional effect. Trypsin inhibitors are Inhibit pancreatic enzyme function, hinder protein digestion and absorption. Rumen degradation reduces toxicity.

Haemaglutinin (lectins)

Haemaglutunin are potent toxins causes' slow growth, nausea, diarrhoea, clot red blood cells, death. Lectins are not degraded in the rumen. Lectins are carbohydrate-binding proteins, macromolecules that are highly specific for sugar moieties. Lectins should neither be confused with glycoproteins (proteins containing sugar chains or residues), lecithins (fatty substances in animals and plants), nor leptin, (the regulator of appetite and hunger, metabolism, and behavior). The large concentration of lectins in plant seeds decreases with growth, and suggests a role in plant germination and perhaps in the seed's survival itself. The binding of glycoproteins on the surface of parasitic cells also is believed to be a function. Several plant lectins have been found to recognize non carbohydrate ligands that are primarily hydrophobic in nature, including adenine,auxins, cytokinin, and indole acetic acid, as well as water-soluble porphyrins. It has been suggested that these interactions may be physiologically relevant, since some of these molecules function as phytohormones.

Saponins

Saponins are a class of chemical compounds found in particular abundance in various plant species. One or more hydrophilic glycoside moieties combined with a lipophilic triterpene derivatives saponins cause persistent bloat, when saponins absorbed dissolve red blood cells.

Alkaloids

Alkaloids are large complex group of chemicals, are a group of naturally occurring chemical compounds (natural products) that contain mostly basic nitrogen atoms. This group also includes some related compounds with neutral and even weakly acidic properties effects range from reduced palatability to causing death.

Gums

In Gums, guar used for glue manufacture, reduce intake and digestibility of feed, gums can cause scouring. Raw seed is unsuitable as feed for monogastrics or ruminants.

Protease inhibitors

All seeds, and especially those of legumes, contain enzyme inhibitors. The most harmful are the protease inhibitors that block activity of pancreatic proteolytic enzymes, such as trypsin and chymotrypsin, resulting in pancreatic hyperplasia and hypersecretion in small experimental animals. The structures and action of these protease inhibitors have been described extensively (liener, 1980). Although there is limited information on their specific effect in humans, it is generally considered prudent to remove these protease inhibitors from foods prior to consumption. These inhibitors are denatured by heat and they can be removed by roasting and wet autoclaving. Boiling may be insufficient to deactivate these substances fully, so dry heat (roasting, toasting) is the preferred method for home processing.

Phytates

Phosphorus is stored in plant seeds linked to inositol to form different compounds of inositol phosphates, known as phytates. Phytates can make up as 1-5% of the dry weight of some grains. Depending on the number of phosphorus molecules they contain phytates may bind strongly to minerals and trace element in diet, rendering them unavailable for absorption. Phytates also form stable bonds with protein and may inhibit the activity of some enzymes, such as amylases and proteases.

Phytates are not hydrolysed in the small intestine of human, but phytate content of raw foods may be modified by action of endogenous (plant) or (microbial phytases). Endogenous phytases are activated during soaking and germination. Microbial phytases can be produced certain forms of food fermentation, such as lactic fermentation.

Lectins

Lectins, or agglutinins, are found throughout the plant kingdom and in all parts of plants. They are particularly abundant in legume seeds, where they may make up as much as 1-3 % of dry weight. Lectins are high molecular weight proteins that have a high affinity for the glycan fraction of glycoproteins and other complex glycol-conjugates. The anti-nutritional effects of lectins are due to their adherence to glycoproteins of the intestinal mucosal membrane surface, causing decreased digestive and adsorptive capacity, and symptoms of nausea and diarrhoea. Some lectins, such as kidney bean phytohemagglutinins and castor bean lectins, may also be cytotoxic. By contrast, lectins from peas, lentils, and broad beans do not appear to have adverse effects. The harmful effects of lectins can be removed by heat treatments, as described for protease inhibitors.

Tannins and other polyphenols

Tannins are especially found in red or black seed coats. Reduce protein and energy utilisation. Rumen degradation reduces toxicity.

Polyphenols are a diverse group of compounds that may be more or less polymerized or condensed. The condensed polyphenols, like tannins, consist of polymerized proanthocyanidins that are neither hydrolysed nor absorbable. They are abundant in some cereals, such as sorghum, and in legume seeds. Tannins interfere with protein digestibility and lysine availability, but may also have beneficial antioxidative effects. Tannins are not denatured by heat treatment, so avoidance requires elimination of those parts of the plant that have the highest tannin contents.

Alpha- galactosides

Alpha-galactosides, which are found in legume seeds, are galactose-containing oligosaccharides, whose glycoside bonds cannot be hydrolysed by digestive enzymes in the human intestine. When these oligosaccharides pass into the large intestine they are fermented by colonic microflora, causing gas, distension, flatulence, and possibly diarrhoea. Alpha-galactosides can be eliminated partially by solubilisation or enzymatic hydrolysis during germination, or fermentation.

Processing of legumes

Processing can be used to destroy some anti-nutrient factors or toxins but is not practical for the individual farmer. Fortunately, rumen digestion reduces problems for cattle. Effective treatment to detoxify legume seeds depends on heat and moisture. Dry heat (roasting) is suitable for seeds such as soybean with high oil content, which aids heat transfer through the grain. With other legumes, adding 10% water or vegetable oil helps transfer heat through the crushed seed to destroy heat-sensitive toxins. Heat-resistant toxins such as tannins and gums, can't be effectively processed. Tannins, however, are of less concern for ruminants, though they can reduce palatability and intake. Moderate tannin levels may lessen bloat risk of high-protein legume pastures. Equipment required for processing is capital intensive and better suited to feed millers. Heating is not a satisfactory method for detoxifying fungal mycotoxins of weather-damaged or poorly stored grain.

Extracted meals derived from legumes and oilseeds are generally useful cattle feeds. Extracted guar meal has been used overseas for cattle. Suitability depends on efficacy of gum removal. Guar is bitter and its palatability low. Autoclaving and enzyme treatment help break down indigestible gums.

Milling of pulses involves 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. De-husking of some pulses poses a problem so there is 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 is then separated by sieving.

Pre-treatment 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-labour).

Post-Harvest Technology of Legumes (Jarnail Singh 2000)

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 purpose.

Controlled Atmosphere Storage

Different atmospheric conditions viz. CO2 level of 60 percent, 70 percent and 80 percent, O2 level of 4 percent, 7 percent and 10 percent and N2 level of 16 percent, 23 percent and 30 percent were evaluated at 0.4 kg, 0.6 kg and 0.8 kg/cm2 pressure level and air flow rate of 58 ml/min. The exposure time was 24 hours, 36 hours and 48 hours. The relative humidity (RH) and temperature were 71 percent and 30 ± 2ºC, respectively.

Thermal Treatment

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

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 process

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.

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.

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% oil and spread for sun drying in thin layer for 2-3 days. At the end of drying 2.5 % water is sprayed and mixed thoroughly. For tempering grains are heaped overnight. Then grains are milled with roller machine.

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

Thermal Treatment

The cleaned grain legumes are conditioned in two passes in a dryer 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.

Chemical Treatment

The use of chemicals has 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 % sodium bicarbonate solution for 0.5-1.0 hour and dried at 65ºC to 10-15 % moisture content gave 95 % hulling efficiency and dhal yield was 80 %. 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.

Milling Processes

There is no common processing method for all types of pulses. Some common methods are given below.

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.

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.

Pre-treatment

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 pre-treatment as recommended are applied in order to have better milling yield.

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 % moisture content.

De-husking and Splitting

Emery rollers known as gota machines are used for de-husking of conditioned grains. About 50 % 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 whole process is repeated two to three times until the remaining grains are dehusked and split.

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.

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 dehusking operation.

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 increases the de-husking rate as grains move forward.

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.

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 %), grits (5-20 %), husk (10-25 %) and powder (7-20 %) 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.

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.

Health benefits of legumes

The scientific literature on legumes and health is not as extensive as that for cereal grains, and it has been limited by the generally low intake of legumes in most free-living populations. 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). However, there is consistent evidence from epidemiological studies showing that eating legumes can play a role in preventing chronic disease, including cardiovascular disease, diabetes and overweight, as well as improving gut health. Dietary pattern that includes legumes, along with cereals, fish, vegetables and fruits was independently associated with reduced levels of clinical and biological markers linked to the metabolic syndrome.

Fiber Booster

Nutrition experts recommend that adults consume 25 to 38 grams (g) of dietary fiber per day (14 g per 1,000 calories); Dietary fiber intake contributes to feelings of fullness or satiety and helps maintain functioning of the digestive system. Beans are a rich source of soluble and insoluble fiber. On average, beans provide 7 or more grams of total dietary fiber per ½-cup serving. The consumption of fiber also has been associated with decreasing total and low-density lipoprotein (LDL) cholesterol, as well decreasing the risk for developing coronary heart disease, metabolic syndrome, stroke, hypertension, diabetes, obesity and some gastrointestinal diseases.

Heart Disease

Elevated blood levels of triglycerides and cholesterol, especially LDL cholesterol, are significant contributing factors to heart disease. High plasma levels of homocysteine have been associated with increased risk for cardiovascular disease. Although some studies have shown that folate may lower homocysteine levels, therefore, heart disease risk, the topic remains controversial and more research is needed. A varied diet low in saturated fat with ample fiber (especially soluble) and B vitamins are among the recommendations for reducing cardiovascular disease risk factors. Several studies have shown that regular consumption of beans can help lower total and LDL cholesterol and other risk factors for heart disease. One study showed a 38 percent lower risk of nonfatal heart attack when a cup of cooked beans was consumed daily. Other researchers reported significant reductions in blood cholesterol levels when canned beans were consumed on a daily basis.

Cancer

The role of bean-containing diets related to cancer risk has been the subject of ongoing studies. Eating beans may reduce the risk for developing certain types of cancers due to their contribution of bioactive compounds to the diet, including flavonoids, tannins, phenolic compounds and other antioxidants. These compounds act to decrease the risk of cancer, as well as other chronic diseases. Other researchers have shown that beans may have a synergistic effect when consumed in a diet containing other antioxidant-rich foods (such as fruits and vegetables) by decreasing oxidation in the body and reducing the overall cancer risk. Bean intake has been associated with a decreased risk of breast, stomach, colorectal, kidney and prostate cancers in human and animal studies. In particular, the dietary fiber content of beans may play a role in reducing the risk of colorectal cancers. For example, a study that examined the impact of dietary fiber intake on the development of colon polyps in a cancer survivor cohort found that people, who consumed more fiber, specifically fiber from legumes and cooked green vegetables, including green beans and peas, were less likely to show a recurrence of polyps than others.

Diabetes

Diabetes is becoming more prevalent throughout the world as the global obesity epidemic continues. Eating a variety of legumes, including beans, may be valuable not only in the prevention of diabetes but also in the management of blood sugar levels. Beans are rich in complex carbohydrates (such as dietary fiber), which are digested more slowly. As a result, bean consumption has been shown to increase feelings of fullness and help regulate plasma glucose and insulin levels after meals. Legume fiber was among the fiber types associated with reducing risk for metabolic syndrome, which includes glucose disturbances and increased risk of diabetes.

According to a recent study, regularly consuming beans as part of a low-glycemic-index diet improved blood glucose management, reduced systolic blood pressure and decreased risk of coronary heart disease. Participants with Type 2 diabetes mellitus were placed randomly on a high-legume diet (consuming 1 cup per day) or on a high-insoluble-fiber diet with whole-wheat foods. Hemoglobin A1c (HbA1c), a measure of long-term glycemic control, was measured after three months. The group consuming the high-legume diet experienced a significant decrease in HbA1c and reduced their calculated heart disease risk scores.

Obesity and Overweight

Even though beans are not often promoted as a weight loss food, regularly consuming nutrient-rich legumes may impact weight loss or management, although more research is needed. According to results from the National Health Nutrition Examination Survey 1999 to 2002, people who consumed beans regularly had a lower body weight, lower waist circumference and lower systolic blood pressure, in addition to a greater intake of dietary fiber, potassium, magnesium, iron and copper. According to the results of studies conducted in Brazil, a traditional diet high in rice and beans was associated with a lower body mass index (BMI), compared with a typical Western diet containing more fat, snacks and soda. Consuming beans may contribute to feelings of short-term satiety as a result of the beans fiber and protein content. In a study of 35 obese men fed four different protein-rich diets, the diet providing the majority of protein from legumes (including beans) induced the greatest amount of weight loss in an eight-week period. The group instructed to eat legumes at least four days a week also experienced significant reductions in waist circumference, body fat mass, blood pressure and total cholesterol when compared with the other groups. Researchers have studied the role of hormones, including leptin and ghrelin, in regulating appetite and weight. Researchers determined the leptin and ghrelin levels in 36 insulin-sensitive and 28 insulin resistant men. Leptin levels decreased among the group consuming a diet enriched with legumes. When leptin is present in smaller concentrations, it is more effective in regulating appetite and may aid in weight loss and weight maintenance.

Legume Cooking

Many people assume that dried legumes need to be soaked for hours and then cooked while recipe preparation.

Soaking Legumes

Dried legumes are almost always improved by soaking. Soaking of legumes helps to draw out lectins and phytates in legumes, as well as activating enzymes that break down indigestible starches and sugars. These starches and sugars are responsible for flatulence, as they ferment in the digestive system of gut to produce gas. Additionally, soaking improves the flavour and nutrition of dried legumes.

Soaking and simmering with repeated water changes is a good method for facilitating the enzyme activation and lectin and phytate extraction. Soak the beans overnight in the refrigerator and Change the water frequently in 1 to 2 hours. Alternatively, soaking at room temperature or above (*20-30°C / 68-86°F*) for at least eight hours, or 14 hours for soybeans and red kidney beans, will achieve most of the same results and allow for significantly reduced cooking time. Always discard the soak water, and cook in fresh water. The soak water is full of nutrients, however, making it valuable food for plants.

The problem of flatulence is much more objectionable when beans (causing gas volume) are combined with a sulphur source (causing a strong smell). Sulphur sources include egg yolks and pale dried fruit.

Peas (including black-eye peas and chickpeas) are also members of the legume family, but they do not contain the indigestible sugars and starches that cause flatulence. They still do benefit from soaking, however, as this activates enzymes and improves the flavour and available nutrition of all legumes.

- Dry beans, whole peas and chickpeas must be soaked before cooking.
- Dry lentils and split peas do NOT require soaking and only need to be rinsed before cooking.
- Before soaking or cooking rinse your legumes in water and look for any bits of dirt/stones or legumes that may be shrivelled

- Always discard the soaking water, place legumes in strainer and rinse well under cold running water. This will wash away any carbohydrates responsible for flatulence.

Cooking

- Combine pre-soaked Legumes with water (5 mL or 1 tsp of oil to prevent foaming) and seasonings in a heavy saucepan.
- Use a large enough saucepan, as legumes double or triple in volume during cooking.
- Bring to a boil, cover tightly, reduce heat and simmer until they are just tender and not mushy.
- Simmer legumes slowly as cooking too fast can break the seed coats.
- Guidelines for cooking times are provided above but these will vary with the type and age of the legumes, as well as with altitude and the hardness of the water.
- Tasting is the best way to check if legumes are done.
- Cooked legumes are tender, have no “raw” taste, and crush easily in your mouth.
- 250 mL (1 cup) of dry legumes will yield approximately 500 to 750 ml (2 – 3 cups) or 2 – 3 times the original amount when cooked.

Converting between dried and canned legumes

- 425g canned beans is equal to 1/2 cup dried beans i.e. kidney beans, chick peas, borlotti beans or cannellini beans.
- 425g canned lentils is equal to approximately 3/4 cup dried lentils.

Freezing

Cooked legumes can be stored in the freezer for up to 6 months. To freeze, simple separate cooked legumes into portions and freeze in small containers or freezer bags (ensure sealed).

Storage

Store the dry legumes in an airtight container in a cool and dry place.

Famous recipes of Legumes

Dal

Dal preparations can be eaten with rice, as well as Indian breads. In India, it is eaten with rice and with a wheat flatbread called roti. The manner in which it is cooked and presented varies by region. In South India, dal is primarily used to make the dish called sambar.

Dal has an exceptional nutritional profile; it provides an excellent source of protein, particularly for those adopting vegetarian diets or diets which do not contain much meat. It is typically around 25% protein by weight, giving it comparable protein content to meats. It is also high in carbohydrates whilst being virtually fat-free. It is also rich in the B vitamins thiamine and folic acid, as well as several minerals, notably iron and zinc.

Table 4: Indian Dal recipes

S.No	Types of Dal	Recipes
1	Toor dal (yellow pigeon peas)	It is the main ingredient for the Tamil Nadu (a south Indian State) recipe called sambar. In Karnataka it is called togari bele. It is also known as Arhar dal.
2	Chana dal (kabuli da)	It is produced by removing the outer layer of kala chana (black chickpea) and then splitting the kernel. Although machines can do this, it can also be done at home by soaking the whole chickpeas and removing the loose skins by rubbing. Other varieties of chickpea may also be used.
3	Yellow split peas	It is very prevalent in the Indian communities of Fiji Islands, Guyana and Trinidad, and is popular amongst Indians in the United States. There, it is referred to generically as dal and is the most popular dal, although masoor dal and toor dal are also used. It is prepared similarly to dals found in India, but also may be used in a variety of other recipes
4	mung beans dal	It is by far the most popular in Bangladesh
5	Urad dal	It is called as "black gram", is the main ingredient of the Tamil Nadu (South Indian state) dishes idli and dosa. It is also one of the main ingredients of East Indian (oriya and Bengali or Assamese) pitha. The Punjabi version is dal makhai. In Karnataka, it is called uddina bele. It is rich in protein
6	Masoor dal	It is split red lentils. In Karnataka, it is called kempu (red) togari bele.
7	Mussyang	It is from dals of various colours found in various hilly regions of Nepal.
8	Panchratna dal	Five jewels is a mixture of five varieties of dal, which produces a dish with unique flavour.

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Burrito

A burrito is a type of Mexican-American food. It consists of a wheat flour tortilla wrapped or folded into a cylindrical shape to completely enclose the filling. The flour tortilla is usually lightly grilled or steamed, to soften it and make it more pliable. In Mexico, meat and refried beans are sometimes the only fillings. Burrito is to be called as traditional food of northern Mexican state of Chihuahua, it has different varieties such as breakfast burrito a variety of American breakfast is composed of breakfast items wrapped inside a flour tortilla and a smothered burrito is smothered with a red chili sauce similar to enchilada sauce with melted shredded cheese on top.

Chili (Vegan)

Many vegetarian chili recipes use a variety of beans instead of meat. fresh vegetables are blended with beans to make a pleasing combination. Vegan Chili is chili that uses no animal or meat products in its creation. Many variations of a vegetarian based chili have been created using meat substitutes, tofu and even vegetables. The most popular vegan chilis use beans as the main weight of the dish, but others use tofu, eggplant, butternut squash or zucchini. This is a kind of Chili that needs no meat (and uses no ersatz meat). Many variations are possible; the recipe is very flexible. The molasses gives this chili a somewhat Louisiana flavor.

Field Bean pate

Soak the beans in water overnight. Boil them in plenty of unsalted water for 1 hour, until they are soft. Mash them with a fork, pound them in a pestle and mortar or press them through a sieve or mouli legumes. Add the olive oil, the finely chopped herbs and garlic and the seasoning. If the puree is too stiff add some lemon juice, water or more oil Chill and serve with toast.

How to add beans menu in a Diet

- Main dishes: Add beans to chili, burgers and rice for a satisfying entree. Or try replacing the meat in recipes with beans, such as a bean enchilada or black bean and cheese quesadilla.
- Side dishes: Baked beans or a bean salad would make a great addition to any meal.
- Salads: Add beans to salads for added nutrition, color and texture.

- Pasta: Adding beans to pasta dishes will provide another dimension of flavor and boost the appearance of the dish.
- Soup: Pureed beans can be used to replace cream or higher-fat ingredients.
- Dips and spreads: Bean dips and spreads make a great snack or appetizer.
- Baked goods: Replace all or part of the fat ingredients with mashed or pureed beans in foods such as brownies and cookies. Beans will give the baked items additional protein and fiber and reduce fat, cholesterol and calories.

Conclusion

Legumes 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.

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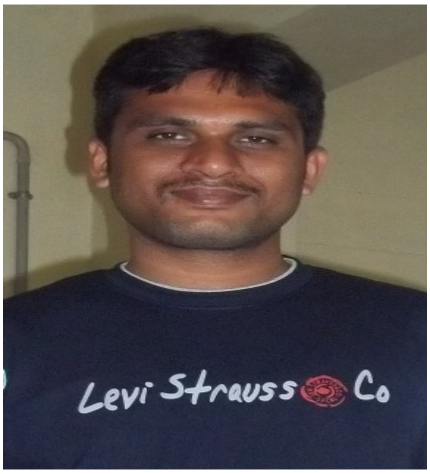

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