21. PROCESSING AND UTILIZATION OF GRAIN LEGUMES IN INDIA

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Introduction

Foodgrains constitute nearly 80% of the diet of a large majority of the population in India. Of this, grain legumes account for nearly 15%. Quantitatively, their importance is next only to cereals, but their qualitative importance is much greater because they contain as much as 25% protein and supply the essential amino acids lysine and threonine which are needed to supplement the cereal diets[1]. While cereal production has been increasing, attention paid to develop high yielding, disease resistant and nutritionally improved varieties of grain legumes is only of recent origin. Simultaneously with this effort, equal attenion needs to be paid for effecting improvements in processing and milling technology in order to derive optimum benefit from the efforts. Post-harvest technology has therefore a vital role to paly in increasing the legume supplies for raising dietary standards of low income population in India and other parts of the world.

India is the largest producer of grain legumes (except soya bean) in the world[2]. The present annual production of grain legumes is 11.58 million tonnes[3] equivalent to about 58 g of grain legumes providing 13.4 g of protein per capita per day. The number and variety of the edible legumes with the production figures are given in Table 1. Chick pea (*Cicer arietinum*) is produced in the largest quantity, red gram (*Cajanus cajan*) and green gram (*Phaseolus radiatus*) coming next in importance. Guar bean (*Cyamopsis psoraloides*) is also produced in certain areas for gum manufacture. Soya bean (*Glycine max*) is a comparatively recent introduction

Table 1. Production of Some Major Legumes in India
(in thousand tonnes)

Pulse	1960～61	1965～66	1968～69	1969～70	1970～71
Bengal gram (*Cicer arietinum*)	6, 306. 6	4, 441. 6	2, 528. 9	5, 545. 6	5, 247. 6
Red gram (*Cajanus cajan*)	2, 076. 8	1, 688. 3	1, 815. 8	1, 842. 2	1, 841. 0
Black gram (*Phaseolus mungo*)	467. 7	537. 6	513. 0	559. 6	513. 7
Green gram (*Phaseolus radiatus*)	304. 9	526. 1	509. 9	546. 0	577. 7
Horse gram (*Dalichos biflorus*)	384. 2	335. 1	418. 7	485. 3	454. 4
Other pulses*	3, 128. 0	2, 488. 2	2, 856. 5	2, 700. 9	2, 941. 8
All India Total	12, 668. 2	10, 016. 9	8, 642. 8	11, 679. 6	11, 575. 7

* Lentil (*Lens esculanta*), Lathyrus (*Lathyrus sativus*), Peas (*Pisum sativum*), Field beans (*Dalichos lablab*), etc.

Ref: Directorate of Economics and Statistics. Ministry of Food and Agriculture, New Delhi (1971)

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in India and is produced in small quantities in certain areas (70,000 tonnes in 1970-71).

Production and consumption of grain legumes vary from one part of the country to another. State-wide production and consumption are given in Table 2. The maximum production is in Uttar Pradesh (3.1 million tonnes) while in Kerala it is the least with only 14 thousand tonnes[3]. The consumption also varies according to food habits, availability and local traditions. The maximum consumption is in the States of Uttar Pradesh and Madhya Pradesh (55 g) and the minimum in the State of Jammu and Kashmir (8 g)[4].

Milling of Grain Legumes

More than 75% of the grain legumes produced in India are milled to produce dehusked splits (*dhals*) in which form it is consumed[5]. Legume milling industry is therefore one of the major food processing industries in India ranking next only to rice milling with a large capital investment employing several millions of people. There are about 10,000 mills of varying capacities (1 to 50 tonnes per day) processing different legumes at different seasons of the year. Legume milling is also carried out as a cottage industry, throughout the country, particularly in South India.

The traditional milling process is carried out generally in two steps. The first pre-milling treatment to loosen the husk is carried out by sundrying the cleaned grains after oil and water application. This step is completely dependent on climatic conditions. The second step of dehusking and splitting (milling) is done in hand or power operated abrasion type mills. The latter are generally mechanised versions of the age old hand operated units. The traditional milling process is laborious and time-consuming and entails avoidable losses as brokens and powder due to scouring. The yield and quality of *dhal* are sub-optimal. The average yield of *dhal* obtained from different grain legumes is given in Table 3.

Table 2. Production (1970～71) and Consumption of Pulses in Different States in India (in 1000 tonnes)

	Bengal gram	Tur	Black gram	Green gram	Other pulses	Total	Average* consumption g/caput/day
Andhra Pradesh	21.6	63.1	12.6	53.0	70.6	243.5	29
Bihar	163.8	145.0	53.4	5.4	497.0	926.0	42
Gujarat	43.9	40.8	5.1	25.1	50.2	165.2	43
Jammu & Kashmir	0.5	0.2	7.0	8.8	20.9	38.2	8
Kearla	—	0.9	1.5	1.2	4.0	14.0	24
Madhya Pradesh	844.4	377.0	146.7	65.6	400.6	1,889.5	55
Maharashtra	98.5	304.5	114.2	97.4	102.0	775.9	33
Mysore	62.1	152.6	13.6	18.9	43.3	403.6	26
Punjab	285.0	1.0	11.9	4.3	8.8	311.0	35
Rajasthan	1,184.2	13.3	27.5	82.2	441.9	1,749.1	43
Tamil Nadu	1.5	19.5	13.0	10.5	13.9	109.5	14
Uttar Pradesh	1,605.3	663.0	50.4	3.8	780.2	3,102.7	55
West Bengal	133.7	23.4	25.1	1.9	313.7	497.8	30
All India	5,247.1	1,841.0	513.7	577.7	2,028.9	11,575.7	34

* Diet Atlas of India. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India, 1971

Table 3. Average Yield of Dhal from Different Legumes

Legume	Maximum theortical yield	Home scale methods	Traditional commercial methods	Improved CFTRI* Process
	%	%	%	%
Bengal gram	88	75	75	84
Red gram	88	68	75	85
Black gram	87	63	71	82
Green gram	89	62	65	83
Lentil	88	80	78	83
Peas	87	—	75	84
Khesari	88	—	76	—

* Average yields on ½ tonne batches

Ref: P.P. Kurien. Central Food Technological Research Institute, Mysore, India (1969). (Unpublished).

The Central Food Technological Research Institute, Mysore has developed improved methods and machinery for the economic milling of grain legumes. The premilling treatment to loosen the husk is carried out by a conditioning technique of moisture adjustment to a critical level. The grain is exposed to heated air at specific temperatures for a predetermined time in specially designed units and equalibrated with gradual aeration to a critical moisture level in bins designed for that purpose. The husk becomes loosened and brittle. The removal of husk itself is carried out in an improved abrasion type machine. The abrasion pressure, speed, clearance, and other operating conditions can be adjusted to suit different varieties of grain legumes. An almost complete removal of the husk (99.5%) can be achieved in a single pass with the least scouring of the peripheral layers of the kernel if the grains are properly conditioned. The new technique is independent of climatic conditions and gives a higher outturn and better quality end product (*dhal*). The cost and time of processing also are considerably reduced. The average yields of *dhal* by the traditional and improved techniques from different grain legumes are given in Table 3. This method which can give about 10-15% higher yield of *dhal* when adopted on a national level can increase the legume availability by 1.0 to 1.2 million tonnes equivalent to 300,000 tonnes of protein.

Variations in milling characteristics and yield of *dhal* exist due to variations in variety and agro-climatic factors.[6]. Yield of *dhal* from five commercial strains of

Table 4. Yield of Dhal from Different Commercial Strains of Red Gram Grown in Different Agro-Climatic Tracts of India

Strain	Average yield %	
	Traditional method	Improved method
1. Lathur white	75	84
2. Hyderabad red-white mix	72	81
3. Bihar red-white mix	70	81
4. U.P. Grey	68	80
5. Mysore Red	64	79

Ref: Kurien, P.P., Ramakrishnaiah, N. and Manohar Kumar, B. Central Food Technological Research Institute, Mysore, India, (1970), (Unpublished data).

red gram is given in Table 4. Varieties with better yield of *dhal* have superior milling qualities. The gums present between the husk and endosperm may influence the adherance of husk and its amount and properties may determine the duration and severity of the premilling treatment[5]. It is generally observed that bold grain varieties grown in certain tracts, particularly harvested in summer months are easier to mill than the small and medium grains and require less drastic premilling treatments. Breeding of loose-jacketed bold-grain legumes would help to improve the milling outturn and reduce processing cost.

Puffed Grain Legumes

Toasting of grain legumes is practised in the household for improving the flavour, modifying the texture and to help in dry or wet grinding. Parched or toasted grain legumes are used in many food preparations. Puffing of grain legumes is also practised to bring about a light and porous texture in the *dhal.* Such products are traditionally used along with parched cereals as snack by children and adults all over India. They find their place in a variety of food formulations containing malt, oilseed meals and other vegetable products. For puffing, the grains soaked in water are mixed with sand heated to 250°C and toasted for short duration (15-25 sec.) After sieving off the sand the grains are dehusked between a hot plate and rough roller. Bengal gram and Peas are best suited for puffing treatment. Apart from hand-operated home-scale puffing units mechanised and automatic puffing machines have been developed in recent years[7]. Exploratory studies with Bengal gram have shown that moisture conditioning or moisture addition prior to heating helps in good puffing as also certain hardening agents[8]. Steaming, parboiling, or incipient fermentation of the grain does not help in giving good puffing[8]. However, the optimal processing conditions for effecting the best puffing await to be standardized further. The pressure explosion technique, used for cereals and soya bean needs to be applied for puffing of grain legume.

Legume Flours

Legume flours particularly from Bengal gram (*Besan*) are used in a variety of food preparations. Dehusked Bengal gram splits are finely powdered in plate mills, mostly as a cottage industry in villages. There is however need for systematic and scientific studies on the proper methods for production, handling and storage of legume flours.

Small quantities of soya bean produced in certain regions are dehusked by traditional methods and used in special food products as flour after extracting oil.

Industrial Uses

As already indicated the Guar bean (*Cyamopsis psoreloides*) is produced and processed for extraction of gums. About 400,000 tonnes of Guar seeds are produced mostly in the western India and processed by a dry milling technique which yields 22-28% good quality gum both for domestic use as well as export. The by-product meal containing the kernel is used in cattle feed after heat inactivation of toxic principles.

Grain Legumes in Daily Food

Legumes are chiefly consumed in the form of cooked products. A number of sweet and savoury dishes containing legumes are traditionally prepared all over India. Unlike soya bean, grain legumes are easily cooked in 30-60 min. in homes under rural conditions, and are accepted and relished by people in all parts of

India.

Germinated legumes: Germinated grain legumes are common popular products over many parts particularly in the western India. Germination is carried out both in the home as well as on a cottage scale. The germinated legumes have a special taste appeal. Germination does not reduce cooking time or improve texture. This is probably due to decrease in pH during germination as a result of acid production and the release of ascorbic acid.

Cooked grain legumes and *dhal*: Whole grain legumes or dehusked splits (*dhals*) are soaked in water for varying periods and cooked in boiling water or in pressure cookers and consumed after adding salt and spices. Dishes like *Dhal, Sambar, Rasam* and pastes are made and consumed along with cereals. It is known that the cooking quality of grain legumes depends on the variety and takes 30 minutes to 1 hr. The calcium and magnesium content as also the phytic acid and pectin contents have been implicated as factors influencing the cooking quality. Addition of alkaline salts like sodium bicarbonate, trisodium phosphate, sodium citrate or hexametaphosphate helps in reducing the cooking time. pH of the cooking water is of major importance in determining the flavour and taste[9]. Flaking also has been found to reduce the cooking time, but increase the packaging cost due to increased valume and there is some loss of flavour on prolonged storage[10]. Cooking under high pressures as in a pressure cooker is however the most effective method in reducing cooking time[8]. Immature legumes in green state cook faster than mature ones. Presoaking reduces cooking time in some legumes while reverse is the case in others.

Precooked dehydrated legumes and splits have been recommended for the Defence forces in high altitudes for quick and easy cooking as well as easy acceptance[11]. Methods of cooking and dehydration have been standardized. Rehydration of such products is facilitated by the use of proteolytic enzymes like papain. 'Ready mix' flours for certain South Indian dishes like *Rasam* and *Sambar* have been standardized for use as convenient foods, specially for the urban population[12].

Deep fried legume products : A variety of sweet and savoury dishes are known and prepared from grain legumes alone or in combination with cereals[13]. Either dry ground flours or wet ground doughs or batters are used. The eating quality of the deep fried products depends on the proportion of legumes to cereals, degree of fineness of grinding, proportion of particles of different mesh size, amount of water used in the dough, and the frying conditions. Bengal gram, black gram and peas are used extensively, possibly due to their relatively higher content of ether extractives and lecithin. Black gram gives the required adhesiveness due to its mucilagenous principles[14]. Instant mixes for several of the deep fried crispy products like *Chakli, Muchorai, Vadai, Jangere, Jelebi,* etc. have been developed and are marketed in recent years[12]. *Papads* are important traditional paste products made from black gram on a cottage level. Standardization of conditions for the mechanised production of the product is receiving attention[15].

Fermented products: *Idli* and *Dosai* are the most popular fermented products based on cereal and grain legume. Rice, jowar and wheat are used as the cereal component while black gram with its high mucilaginous principles for holding the fermentation gases and giving a spongy texture to the product is used as the legume component. For *Idli* the batter is steamed while for *Dosai* the batter is panfried. It is observed that a proportion of 3 parts of rice to 1 part of black gram *dhal* made into a thick batter (2.2 parts of water) gives a fine texture for *Idli* while one part of black gram *dhal* and 4 parts of cereal made into a more dilute batter (3 parts water) makes good *Dosai*. Ready mixes both of the fermentable type and chemically leavened type have been developed and are popular commercial products[16].

Toxic Principles in Grain Legumes

Many grain legumes contain toxic and biologically active principles such as trypsin inhibitors, hemagglutinins, saponins, cyanogenic glucosides, goitrogenic factors, diuretic principles, anti-coagulants, toxic histones, factors causing lathyrism and favism, deleterious alkaloids and astringent principles[17]. Even the edible grain legumes like red gram, Bengal gram, black gram, lentil, horse gram, field bean, etc., contain trypsin inhibitors and hemagglutinins[18,19] in varying amount which are usually destroyed or inactivated by heat treatment or autoclaving[20]. Lathyrus is known to contain an oesteo toxin (β-amino propio nitrile) and a neurotoxic amino acid (β-N-oxalyl amino alanine) which cause human lathyrism[17]. These toxins can be leached by soaking the grains in warm water[21]. Peas, double beans, etc., contain goiterogenic factors while cow pea, sword bean, etc., are reported to contain cyanogenic glucosides. Most of these toxic principles are eliminated by soaking and leaching in cold or warm water followed by cooking or other heat treatment[20].

Recently some work has been done in India to develop a lathyrus strain which contains only traces of the toxin and hence safe for human consumption[22]. Similar breeding programmes are to be undertaken for the development of toxinless legume strains.

Nutritive Value of Grain Legume

The nutritive value of grain legumes has been evaluated in detail during the last many decades since they form essential constituents in Indian diets. The protein content varies from 17 to 25%—about double that of cereals. The nutritive value of most raw grain legume proteins is low due to presence of toxic factors and deficiencies of sulphur amino acids and tryptophan especially when used as the sole source of protein in a diet. If the toxins are destroyed by optimal heat treatment, the growth promoting value and protein efficiency ratio are generally enhanced although conflicting results have been reported (Table 5)[20]. Surveys indicate that

Table 5. Effect of Heat Processing on the Growth Promoting Value and PER of Legumes

	Raw		Heat treated	
	Gain body weight (g)	P E R	Gain body weight (g)	P E R
1. Bengal gram	5.6	1.3	14.7	2.4
2. Red gram	19.3	0.78	33.3	1.76
3. Black gram	6.7	—	7.0	—
4. Green gram	9.4	1.4	9.9	1.3
5. Horse gram	4.4	0.7	10.7	1.7
6. Lentil	2.0	—	5.0	—
7. Khesari	2.0	—	2.4	—

Note: Average protein contents of the diets 12% Duration of Experiment 4 weeks

Ref: 1. Venkata Rao, S. *et al. J. Nutr. & Dietet.*, 1, 304 (1964).

2. Venkata Rao, S. *et al.* Central Fooo Technological Research Institute, Mysore, (1971). (Unpublished data).

there is no protein deficiency in diets based on cereals when legume content is 50-80 g and the calorie intake is adequate. Table 6 shows the beneficial effect of supplementing Indian rice and wheat diets with legumes. Average weekly increase

Table 6. Supplementary Value of Legumes to Rice and Wheat Diets

Diet	Protein content* (%)		Wt. gain/week (g)	
	(a)	(b)	(a)	(b)
I. **Rice Diet**				
Rice diet (RD)	8.5	8.5	5.7	13.7
RD+Bengal gram (2.3% extra proteins)	11.0	11.0	8.0	19.1
RD+Red gram (2.5% extra proteins)	11.0	11.0	7.9	19.3
RD+Soya bean (2.5% extra proteins)	11.1	11.0	8.0	21.6
RD+Skim milk powder (2.5% extra proteins)	11.0	11.1	22.2	23.5
II. **Wheat Dict**				
Wheat diet (WD)	11.3	11.0	9.2	17.6
WD+Bengal gram (2.2% extra proteins)	13.4	13.3	13.7	21.7
WD+Soya bean (2.2% extra proteins)	13.6	13.5	16.3	22.5
WD+Red gram (2.2% extraproteins)	13.3	13.0	15.3	21.8
WD+Skim milk powder (2.2% extra proteins)	13.6	13.5	23.9	24.0

*(a) Without vitamins and minerls;
(b) With the addition of vitamins and minerals
Daniel *et al., J.Nutr. Dietet.*, 1965, 2, 128.

Table 7. Amino Acid Supplementation of Legume Proteins*

Foodstuff	Protein level (%)	Experiment duration (days)	Weight gain(g)
Lentil (*Lens esculenta*)	10	21	−2.1
above+0.3% methionine	10	21	10.5
Bengal gram (*Cicer arietinum*)	10	21	27.3
above+0.3% methionine	10	21	60.9
Red gram (*Cajanus cajan*)	10	21	4.2
above+0.3% methionine	10	21	63.0
Pea (*Pisum Sativum*)	10	10	3.0
above+0.1% methionine	10	10	23.0
Lathyrus pea (*Lathyrus sativus*)	12	21	6.1
above+0.6% methionine	12	21	30.0
Green gram (*Phaseolus radiatus*)	12	21	14.4
above+0.6% methionine	12	21	22.7
Black gram (*Phaseolus mungo*)	12	21	20.0
above+0.6% methionine	12	21	38.2

* Venkat Rao, S., *et al., J.Nutr. Dietet.* 1964, 1, 304. & 192.

in weight of rats when supplemented with grain legumes is comparable with that of milk powder[23]. Grain legumes have been shown to supplement maize-tapioca diets also. Thus by a judicious balancing of the proteins of cereals and grain legumes the protein content and quality can be substantially improved.

Considerable amount of work has been done more recently in supplementing grain legume proteins with the limiting amino acids[24]. When supplemented with methionine at levels varying from 0.3 to 0.6% Bengal gram, red gram, green gram, black gram, lentil, pea etc., showed marked improvement in their growth promoting values (Table 7). Addition of tryptophan further increased the nutritive value in most cases[20].

Investigations have however shown that consumption of large quantities of certain grain legumes can cause flatulence. Bengal gram is known to produce the maximum flatus while green gram the least[12]. Uncooked grain legumes cause more peristalisis and quicker passage of food in the intestines. It is reported that about 15% of the proteins and 33% of the carbohydrates of grain legumes are not digested in the iliocecal region and some of them may pass into the lower ilium and colon where it is subjected to bacterial fermentation in the presence of acids[52,26].

Legumes in Weaning and Supplementary Foods

Diseases due to inadequate consumption of protein and calorie is commonly observed in underdeveloped and developing countries. The worst affected are the vulnerable groups of the population consisting of expectant and nursing mothers and pre-school children in the low income groups. Absence or meagre availability of protective animal proteins aggravates this situation. In India as in similar regions of the world, therefore, grain legumes and other sources of vegetable proteins assume significant importance to help to fight protein-calorie malnutrition. Considerable amount of work has been done to produce weaning and supplementary protein foods based on grain legumes, oilseeds and cereals[27]. The Indian Multipurpose Food (a mixture of 2 parts low-fat peanut meal and 1 part Bengal gram fortified with vitamins and minerals) is an important supplementary food of this category. This product can be incorporated in traditional recipes without any change in food habits and has been proved to supplement Indian diets to the same extent as milk powder or animal proteins[28]. There are five commercial units in different parts of India producing this product.

Many vegetable mixtures based on grain legumes, cereals and peanut flour have been developed, several of them fortified with essential amino acids, vitamins and minerals and used extensively in famine and distress affected areas to prevent protein and other dietary deficiencies among vulnerable groups of population. Nutritive value and protein efficiency ratios of these blends have been studied by animal and human feeding trials. The results indicate that a blend of 80 parts cereals and 20 parts grain legumes containing about 14% protein would be adequate to meet the protein needs of growing children when such blends are fortified with vitamins and minerals. For treatment of several protein malnutrition and for use as food supplements, the protein content of such blends should be 20–22%. The more well-known of such blends which is extensively produced and used is "Bal Amul" a cooked roller dried blend of Bengal gram, green gram, wheat flour and soya flour fortified with vitamins and minerals or sesame flour. Similar blends based on peanut flour, grain legume flour, cereal flour and sesame flour have been developed containing 22–25% protein and protein efficiency ratios ranging from 2.3 to 2.5[20].

Storage and Handling

The post-harvest technology of the grains particularly relating to storage, handling and processing is of great importance in the food economy of the country. Grain legumes, like other grains, undergo qualitative and quantitative losses due to infestation by rodents and insects as also by microbial infestation. This aspect is particularly glaring in India where more than 70% of the foodgrains are stored and consumed in the rural areas under inadequate storage conditions[29]. The legume beatle (*Callosobruchus chinensis*) is the most common pest which lays its eggs on the pods at different stages of maturity[30]. In the subsequent stages of drying, the larvae feed on the seeds and remain as internal infestation, developing into the adult stage, which in turn lays more eggs. Thus several generations of insect infestation develops on grain legumes in storage. The progress of infestation depends on the grain size and the intergranular space; bigger the size, more the infestation. If the intergranular space can be reduced by filling with smaller grains, sand or fine clay, a protective barrier against deeper infestation can be created[31].

Infestation causes heavy destruction of grains and makes it nuhygienic for consumption due to insect excreta and other metabolites such as uric acid[29]. It also causes increased fat acidity, decreases the nutritive value (as shown by reduction in PER) and reduces milling yields. Insect damage also causes favourable conditions for further microbial spoilage.

Several techniques have been developed for controlling infestation. Fumigation with ethylene dibromide alone or in combination with methylene bromide destroys resident infestation as also fungal infestation[29]. By treating the jute bags with pesticidal emulsions, cross infestation by insects can be precented, and grains safely stored for periods upto 6 months.

Grain legumes when stored after improper drying or under humid conditions, are conducive to mould growth, leading to the development of fungal toxins. Aflatoxin and other toxic metabolites of *Aspergillus* sp. and *Penicillium citrinum* found in grains stored under humid conditions are known to be potent hepatotoxins that can cause serious health hazards[32]. Such mould growth on foodgrains can be effectively controlled by various methods like treatment with (a) mixture of ammonia and phosphide, (b) ethyl formate and (c) mixture of methyl bromide, ethylene bromide and chloropierine[33].

Summary and Conclusion

Grain legumes play a vital role in the Indian dietary which is often deficient in protein and calorie. Greater production and consumption of these grains is called for to improve the qualitative and quantitative deficiency of proteins. In view of the limited availability of meat and other animal proteins, greater consumption of food legumes is the best practical method for raising the nutritional status.

Dhal, the dehusked split grain legume is the major form in which they are mostly used although they are also consumed as whole, puffed or pulverized. Conversion of grain legumes to these products is a major food industry in India. This industry has largely remained traditional. There are considerable losses in the processing techniques which are laborious, time consuming, wasteful of resources and dependent on climatic conditions. There is a great need to minimise these losses by better techniques. Modernization of grain legume processing industry, particularly of milling technology is an effective method for stretching the supply of grain legumes by 1.0–1.5 million tonnes valued at Rs. 3000 million.

It is estimated that the country would require about 20 million tonnes of grain legumes during the next decade. Hence greater production through better agricultural practices, conservation by appropriate post-harvest technology and improvement in the nutritive value by proper processing and blending with other food items are urgently called for. A coordinated effort of the agricultural scientists, technologists and nutritionists is being made to achieve these objectives.

Discussion

K. Saio, Japan: The beany flavour of soybean is the most important problem to use soybean as new protein foods. What about the flavour? I'm asking general comment of Indian people. I like to ask your idea whether soybean milk is acceptable for Indian or not.

Answer: Yes, soybean flavour is one of the major factors that affect its easy acceptance. Its cookability is another factor as also the trypsin inhibitor. If these problems are solved the soybean may be acceptable to Indian people.

The soybean milk is slowly being introduced into the Indian dietary. It may take some more time before it becomes popular.

N. Yamada, Japan: I would like to have information on "*dhal*". What advantage and benefit does the *dhal* have, from the nutritional standpoint of view? Does this process simply aim to increase digestibility by removing husk and splitting grains into two parts?

Answer: Removal of husk reduces the fibre content and enhance the digestibility of proteins. The people of India are used to legumes in the form of *dhal* from many centuries ago. Therefore methods for converting legumes to *dhal* economically is a perpetual problem. It is more a question of habit.

T. Yamamoto, Japan: As you know, many kinds of soybean products are very popular in daily life of Japanese people nowadays. However these products were not favorite with Japanese people at the time of their first introduction from foreign countries. Japanese history shows us that the first introduction of "Tofu" from China by a monk was so early as Nara era, 8th century, but it did not show any widespread among Japanese people until Kamakura era, 12 or 13th century. Indeed, about 4–5 hundred years elapsed until it became one of the most popular foods among Japanese people. It is very delightful if this historical fact encourage the introduction of soybean products to some countries where there is no custom to use them, and I am more than happy if soybean products would play a role in overcoming the protein malnutritional condition. In this case the propaganda of nutritional knowledge about protein would be useful to get soybean products into popularity. What is your opinion about it?

Answer: The role of legumes, partiticularly soybean, in fighting against protein malnutrition in developing countries cannot be underestimated. It is a question of development of appropriate technology for the requirement of individual nations to meet the national needs and resources. The requirements of the region and the local sources will be the major factor in determining the (intermediate) appropriate technology.

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