XO-PAV-233-A 91
ISN 49194

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WORKING PAPER[1]

UTILIZATION OF LEGUMES AS FOOD

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Paper presented at ACIAR[2] Workshop
"Food Legume Improvement for Asian Farming Systems"

Khon Kaen
Thailand.

1-5 September, 1986

1. Working Paper Only. Not to be cited without permission of author.
2. Australian Centre for International Agricultural Research.

ABSTRACT

Legumes have been a part of the human diet for centuries. They are particularly important as a protein source for developing countries where animal protein is in short supply. Cereal and legume proteins compliment each other and result in enhanced nutritional value when they are consumed in combination.

Increased production of legumes must go hand-in-hand with optimum utilization of available supplies in order to maximize their nutritional benefits. While there are well-established patterns for the consumption of traditional pulses, the food potential of oilseed protein is largely unexploited. The food use of such non-traditional materials could be approached by the adaptation of established technologies for the utilization of pulses, as well as by new appropriate technologies of general interest. Sound technological inputs geared to promote processing and utilization at the home, village, and commercial levels can have a great impact on the food use of legumes. Acceptance of foods is largely determined by aesthetic considerations rather than by their nutritional value. The challenge before us is to combine the high nutritional value of legumes with the aesthetic properties demanded by the consumer.

USE OF LEGUMES AS FOOD

W. B. Wijeratne and A. I. Nelson

INTRODUCTION

Leguminous plants that produce edible parts are generally referred to as food legumes. The term grain-legume is commonly used to denote legumes that produce edible seeds, and to distinguish them from numerous others that produce edible vegetative parts. Grain legumes is the subject of this paper and they will be subsequently referred to as legumes for the sake of simplicity. Two other terms, namely, pulses and oilseeds are also in common use, particularly in the eastern world. The word "pulse" has been used from biblical times to describe legumes that bear edible dry seeds that are directly consumed by man. In contrast, there are other legumes which have been traditionally used as sources of edible oil rather than for direct consumption. These are called oilseeds.

Legumes of economic importance are produced both in the tropical and temperate zones. A partial list of the more important species, along with the main geographical areas of production, is presented in Table 1. The areas of production are also usually the areas of wide consumption. However, in the case of oilseeds, such as soybean and groundnut, a large proportion of the production enters international trade in raw and processed forms.

Examination of the world production of legumes (Table 2) shows interesting trends. Approximately 75 percent of the total world output of pulses and 90 percent of the peanut crop are produced in the developing countries. Asia, alone, produces 51 percent of the world pulse crop and 68 percent of the world peanut crop respectively. In contrast, the developing countries' share of the world soybean crop is only 42 percent, of which, more than half comes from South America alone. The soybean continues to be a commercial crop produced largely in the United States. It is exploited primarily for oil and for export to the Orient, where it is traditionally consumed. In recent years, many countries in Asia and Africa have focused on the soybean as a potential food crop. More will be said later about this aspect.

The Significance of Legumes as a Food Source

In the present context of protein-calorie malnutrition and under-nutrition which is so prevalent in the developing world, the potential contribution of legumes to human nutrition cannot be overemphasized. Commonly consumed legumes contain 17-34 percent protein (Table 3). The potential for protein production from a unit land area is greater for legumes, compared to animal sources. Soybeans and groundnut (peanuts) are unique in that they are rich in both protein and high-quality edible oil. The desire of man for animal foods is universal, irrespective of the economic conditions. However, plant foods continue to be the major source of both calories and protein for people in developing countries. Approximately 90 percent of the calories and over 80 percent of the protein in the diets of many Asian countries are derived from plant sources (Table 4). In comparison, the developed countries derive only 70 percent of the calories and 43 percent of the dietary protein from plant sources.

A wealth of scientific knowledge has accumulated over the years, concerning the nutritional complimentarity between cereals and legumes.

The deficiency of the essential amino acid, lysine, in cereal protein is complemented by legume proteins which are richer in lysine content. Likewise, the sulfur bearing amino acids which are relatively rich in cereals make up for their deficiency in legume proteins. There is general consensus that the protein quality of cereal/legume combinations providing 50 percent of total protein in the blend from each ingredient, approaches the quality of milk protein (Bressani and Elias 1974). Legumes such as peas, chick peas, lentils, green gram, black gram, pigeonpea, horse gram, black beans, bengal gram, peanuts and soybean have been used in the experimental production of blended foods and their nutritional evaluation (Bressani and Elias 1974). The total protein content of dry cereal staples varies from 8-11 percent depending on the source. In prepared cereal foods, such as cooked rice and gruels, the protein content is further diluted by hydration. Consequently, weaning and weaned children are unable to consume sufficient quantity of cereal foods to derive their daily protein needs. Blending of legumes with cereals results in increased protein density so that relatively lower volumes are required to derive the protein requirements

TRADITIONAL METHODS OF LEGUME UTILIZATION

A very large number of traditional food preparations are made from various species of legumes. These vary with countries and regions, and also with the species which predominate in the respective geographic locations. However, most of these traditional foods can be classified under several simple techniques used in their preparation. These techniques can be summarized as decortication, boiling, grinding, roasting, frying, puffing, germination, fermentation, curdling, and pasta making.

Decortication

Decortication refers to the removal of the seed coat (hull) which results in the separation of the cotyledons. In the rural sector, the decortication process is still a part of the housewife's work in food preparation. In the case of black gram, green gram and cowpeas, where the hull is firmly attached to the cotyledons, water soaking is used to facilitate hull removal. The hulls absorb moisture and swell, thereby facilitating dehulling by gentle rubbing of the seed by hand. The hulls are easily separated from cotyledons by floatation. At this stage, the cotyledons are wet and must be used immediately.

Pounding by mortar and pestel is a common operation in the kitchen in many countries. Pounding of legumes followed by winnowing is also a common method of hull removal. In India and the neighboring countries, dry dehulled pulses are commonly called dhal. Many types of dhal are centrally processed in mills and sold as a ready-to-cook commodity. Much work has been done in India on the commercial milling of pulses, particularly concentrating on efficiency of decortication and minimizing milling losses (Kurien et al. 1972).

Application of dry heat to legumes at various moisture levels for different periods of time improves dehulling efficiency. Dry heating without hydration results in drying of the hull which becomes brittle. Mechanical means of hull removal are more efficient after such dry heating. On the other hand, when dry heat is applied to partially hydrated legumes, the cotyledons shrink more than the hull. As a result, the hull is loosened from the cotyledon (Kurien and Parpia 1968). Dry heating in the open pan or in a sand bed is commonly adopted in the home.

Boiling

Boiling or cooking of dhal and whole legumes in water is the most common method of preparation. On the Indian sub-continent, dhal cooked to a soft consistency, is seasoned with spices and condiments and consumed with the cereal staples. Cooked and mashed legume purees are popular in Africa and the Middle East (Siegel 1976). Boiled whole beans such as mung bean, chickpeas and faba bean are also directly consumed with grated coconut or oil sauce. In all these cases, the cooking time required to attain a soft consistency is an important consideration. While certain pulses, such as lentils and mung bean require short cooking time, others such as cowpeas, dry beans, and soybeans require prolonged cooking time.

Roasting

Dry roasted pulses are eaten as snacks in many countries of the semi-arid tropics. Whole chickpeas and cowpeas are popularly consumed this way in Africa, while in India and neighboring countries, various pulses are directly consumed after roasting. In India, chickpeas are sprinkled with water containing salt to taste and roasted in a hot sand bed in a dry pan. Roasting achieves a high temperature short time heat treatment during which the seed attains a pleasing nutty flavor which is well liked by both children and adults. In addition, the heating process improves the nutritional value of pulses due to the inactivation of certain heat labile anti-nutrients naturally occurring in them (Acharya *et al*. 1942).

Frying

Frying in hot oil is carried out with pre-processed legumes to produce a variety of food products. Combinations of fully or partially ground legumes and cereals are made into dough and oil fried, to produce popular Indian foods such as waddai and murukku. Oil cakes from dry bean paste made in Brazil, ready-to-eat fried snacks made from ground legume pastes in Nigeria, and filafi made from chickpea paste, are other examples of oil fried legume foods (Siegel 1976). The constraint against this type of food is the shortage of frying oil in many countries.

Puffing

Puffing of cereals and legumes is a traditional home process in many countries. The process consists of partial hydration of the seed, followed by dry heating at high temperature. The sand bed is commonly used for puffing in the Indian household. Rapid heating causes partial gelatinization of starch and the vaporization of internal moisture, causing pressure which eventually results in explosive puffing. The puffing process renders a light and porous texture to the product. Small and medium scale puffing equipment is used for the commercial scale manufacture of these products.

Germination

Germinated legumes (bean sprouts) are a popular food item in the Orient as well as in India to some extent. The production of bean sprouts is done usually at the home or on a small scale. Sprouted soybean and mung beans are year-round vegetables in Southeast Asia. Sprouting brings about certain desirable chemical changes of nutritional significance. Ascorbic acid, which is absent in dry soybeans, appeared in the first 24 hours during germination and reached a value of 290 mg/100g at the end of three days (McKinney *et al*. 1958). There was also a rapid disappearance of oligosaccharides, raffinose and stachyose, which are implicated in flatus (Lee *et al*. 1959). Increases in levels of thiamine, riboflavin, niacin, pyridoxine, biotin, and tocopherol during germination of various Indian pulses has also been reported (Siegel 1976).

Fermentation

Fermented food products made from various food raw materials form a significant portion of the diets of mongolian populations. Such products are specific to countries or regions on account of the characteristic flavors associated with the respective fermentations. Among the food legumes, soybean is the single most important raw material used in fermented food preparation. Some of the important fermented soybean products are shoyu (soy sauce), miso, tempeh, natto, hammanatto, and sufu. With the exception of shoyu, all the other fermented products are produced in the home or as small-scale industries.

Shoyu or soy sauce is typically a commercial product made from cooked whole soybean (or extracted meal) and wheat. The fungus *Aspergillus oryzae* is the organism which produces proteases and amylases which breakdown the protein and carbohydrate substrates during fermentation. Fermentation, followed by aging, produces the rich flavored peptides present in shoyu. As a flavoring and seasoning, shoyu finds wide acceptance in the West as well. In 1980, Japan alone produced approximately 135 million gallons of shoyu and per capita consumption was 27 grams/day.

Miso is a fermented soybean paste made from soybeans and cereals, mostly rice. The product undergoes two stages in the fermentation. The first stage which is koji preparation, is an aerobic process involving the fungi Aspergillus oryzae and Aspergillus sojae. This process yields the enzymes and nutrients required for the second stage of fermentation which is anaerobic, and involves yeasts and bacteria. Japan alone produces approximately 750,000 tons of miso annually and per capita consumption has been estimated at 21 gram/day (Shurtleff and Aoyagi 1983).

Tempeh is a traditional Indonesian food prepared from cooked soybeans by a fermentation using the mold Rhizopus oligosporus. The mold binds the soybeans into a cake which is then cut into pieces, fried in oil and used in many preparations. The product is not shelf stable and is therefore, made on a small scale or in the home. Large-scale production involves refrigerated storage. Tempeh does not contain salt which is used as a preservative in both miso and shoyu. Tempeh production in East Asia was estimated at 169,000 metric tons per year.

Natto is produced by a bacterial fermentation involving Bacillus natto Sawamura, identified as Bacillus subtilis. The product has a musty odor and sticky consistency due to polymers produced during fermentation. Natto has a short shelf life and is used in specific regions of Japan.

Sufu is a popular fermented food in China. Sufu making involves the production of soybean protein curd (tofu) and its subsequent fermentation using species of Mucor and Actinomucor. The mold forms a mycelial mat on the tofu which is then preserved in salt brine containing rice wine. Sufu is consumed directly as a relish or is cooked with vegetables and meats.

Besides the Oriental fermented soybean foods, there are few fermented legume foods traditionally consumed in other parts of Asia. In India, wet ground black gram and rice batter is naturally fermented and the resulting dough is used for preparing idli and dosai. Likewise, in Africa, ewa and soumbara are food preparations made from fermented legume pastes (Aykroid and Daughty 1964).

Fermented legume foods are of great significance from several considerations. Many of the products are shelf stable on account of both the products of fermentation and preservatives used in preparation. This is an important aspect in regions where household refrigeration is unavailable. Much evidence has been accumulated to demonstrate that the fermentation processes cause partial breakdown of proteins, resulting in increased digestibility. Furthermore, fermentation has been found to partially inactivate natural anti-nutrients that are contained in legumes (Liener 1962; Ebine 1972).

<u>Beverage, Protein Curd, and Pasta</u>

The milk-like suspension prepared by wet grinding and filtration of soaked soybean has been a popular beverage of the Chinese people for centuries. The product commonly called soymilk is prepared by a number of methods. The traditional Oriental method uses the cold grinding technique which results in a characteristic beany flavor which is liked by the Chinese people. However, this flavor is not acceptable to many other populations. As a result, other methods have been developed to minimize the beany flavor (Hand et al. 1964; Mustakes et al. 1971). In all of the above processes, the filtration step results in a residual wet cake (okara) which carries roughly half the protein originally present in the bean. Nelson et al. (1975, 1977) have developed a new process which incorporates all of the soybean solids into the milk and also eliminates the beany flavor. The bland beverage which can be flavored according to preference, has become a well-established commercial product in Japan, Taiwan, Hong Kong, Singapore, Korea, Thailand, and in recent time, even in the United States (Aocs 1984). The world soymilk production has been estimated at one million metric tons per year, utilizing approximately 130,000 metric tons of dry soybeans.

Soybean curd (tofu) is an equally popular product prepared by precipitation of protein from soymilk, followed by pressing out of whey. Like in the case of soymilk, tofu production technology has now advanced from the traditional home scale to the semi-continuous commercial scale. A very versatile product, tofu has gained wide acceptance in many countries where it is not a traditional food.

Pasta products such as noodles are also typical Oriental foods. From the point of view of legume utilization, mung bean noodles are of particular importance. Mung beans contain about 25 percent protein and also considerable amounts of starch. Traditionally, mung bean flour is mixed with wheat or rice flour in the preparation of noodles. Among common food legumes, mung beans had the lowest concentrations of the olgosaccharides raffinose and stachyose. Therefore, the flatulence problem was minimal in child feeding (Payumo 1978). Concentrated and isolated mung bean protein has been used in weaning foods such as "Kaset Protein" prepared in Thailand (Bhumiratana 1978).

Non-Traditional Approaches to Legume Utilization

Composite Flours

The descriptive term "composite flour" refers to mixtures of wheat flour with other starch and protein sources derived from cereals, roots, legumes, and oilseeds. Flour-based products, both leavened and unleavened, are either traditional or rapidly gaining popularity in developing countries. Bread, for example, has attained universal acceptance. The introduction of protein-rich legumes into cereal flour has great potential for increasing the consumption level of protein in all segments of a population. This concept has been researched from the turn of the century. Unfortunately, the concept has developed in the context of new technologies in baking, rather than for improved protein nutrition as such. Much of the research in composite flour is centered around the application of new baking technologies and their effect on the baked bread quality as it is perceived by the consumer in the developed countries. In developing countries, bread is made by traditional batch fermentation, often on a small scale, using manual methods. Therefore, much of the new technology on composite flours is not directly relevant to the needs of developing countries. Furthermore, the consumer preference for physical characteristics of bread, such as loaf volume, texture, crumb and crust are not universal.

In fact, great variation in such characteristics may be seen in bread sold in a given country in the developing regions. Therefore, the need exists for adaptive research in application of the composite flour concept under traditional baking conditions. On the other hand, there are many unleavened products made in developing countries from both wheat flour and other cereal flours. In such cases, the question of loaf volume is not an important consideration. Therein lies great potential for the incorporation of legume protein in larger proportion than is possible in bread making.

The greatest constraint against practical application of the composite flour concept seems to lie in the logistics of its production. Cereal flours are made by a process of dry milling, using conventional milling equipment. The milling of legumes cannot be done in the same process flow and calls for different methods of dehulling, pre-treating, and grinding. Once ground, the two types of flours have to be blended in the desired proportion. The overall process involves, among other things, additional capital expenditure for legume milling and blending, transport and storage of legume on-site, and harmonizing the two production lines. On account of these and other constraints, composite flour production remains to be a potential process yet to be commercially exploited. The alternative to centralized production is the small-scale manufacture of the legume flour and making it available for blending at the point of utilization. Some degree of success has been achieved by this approach in Sri Lanka, under the Sri Lanka Soybean Development Program.

Weaning Foods

Mal-distribution of the available food supply among different income groups, and even within the family unit, results in the so-called nutritionally vulnerable groups in populations. The weaning children and pregnant or lactating mothers have been the focus of many nutrition intervention program designed to alleviate malnutrition in developing countries. Many countries have received cereal/legume blended weaning foods such as corn-soy-blend (CSB), corn-soy-milk (CSM), and instant-corn-soy-milk (ICSM) under the PL480 Food for Peace Program from the United States. For a number of economic reasons, in the mid-1970s, both the donor and recipients of these products recognized that it was desirable to explore ways of processing these products in the recipient countries (Harper and Jansen 1985). As a result, several countries such as Sri Lanka, Costa Rica, Tanzania, Guyana, and Mexico have established local production facilities manufacturing weaning foods from locally grown cereals and legumes. In addition, Guatemala, Korea, India, Philippines, Thailand, and Ecuador have ongoing research and production level programs for weaning foods under government, private and/or non-profit organization sponsorship.

In most of the above cases, the product has been utilized for the specific nutrition intervention programs. While the value of such programs cannot be underestimated, the availability of these products to the general consumer could greatly enhance its positive impact on the overall population.

Textured Vegetable Proteins

The conversion of vegetable protein materials into food products with meat-like texture has been described as one of the great food inventions of all time (Horan 1974). Soybean is by far the major raw material used in the production of textured protein products. Textured soy protein products are produced by a thermoplastic extrusion process using defatted soy flour or soy protein concentrate as raw material. The extrusion process imparts a molecularly aligned and expanded structure to the product. Upon rehydration, it takes up over twice its weight of water and possesses a chewiness similar to that of cooked muscle tissue. Textured products are usually used as meat extenders in soups, stews, hamburger patties, curries, sausages, etc. However, they can also be directly cooked and consumed with proper spicing and seasoning. In 1971, the United States approved the use of 30 percent (wet basis) textured soybean protein as meat extender in the school lunch programs. The major constraints against application of this technology in developing countries is that it is subject to the availability of high quality defatted meal (or concentrate) and the high capital investment involved.

Constraints Against Extensive Utilization of Legumes

Insufficiency

The overall efforts to increase consumption of legumes in a population must be viewed in the context of the production and availability of these legumes. The production aspect of legumes is beyond the scope of this paper. While the green revolution of the 1960s resulted in pheaonmenal improvements in rice and wheat production in developing countries, its impact on other crops is being felt only in more recent times (Anderson and Hazell 1985). Many countries in Asia and Africa are exploring the potential of highly cost-efficient, but non-traditional legumes such as soybeans for direct human consumption. The success of the attempts to increase consumption of legumes depends, to a great extent, on the development of utilization strategies hand-in-hand with increasing production.

Socio-Cultural Factors

Irrespective of the economic status, animal products are the preferred protein foods of any population (with the exception of the strict vegetarian). Where certain legumes are traditionally consumed, they have been built into the diet pattern on their own merits as food items, rather than as sources of protein. For example, curried dhal is consumed in India as a gravy, along with the cereal staple which forms the bulk of the meal. The acceptance of more concentrated legume products depend primarily upon aesthetic properties (flavor, texture, appearance) and their ability to fit into the traditional diet pattern. Their merit as inexpensive protein foods could enhance product acceptance only if the primary criterion is satisfied. Misplaced emphasis on high nutrition at low cost could even be counterproductive. In certain societies, legumes are regarded as "the meat of the poor." In such cases, the challenge before the food technologist in product development is even greater.

Antinutrients

A number of biologically active principles which can have adverse nutritional and physiological effects are present in legumes. These have been collectively called antinutritional factors. The more important ones are the trypsin inhibitors, urease, hemagglutinins, goitrogens, saponins, phytic acid and flatulents. These factors have been studied extensively as to their effects and methods of removal (NAS 1973). Fortunately, the more nutritionally significant factors are heat labile, and as such, can be reduced to safe levels by proper processing. Soybean trypsin inhibitors which have been shown to inhibit bovine, porcine, ovine, and human trypsin are the most widely studied. In fact, the degree of their inactivation in a given process can be used as an index for process control.

Among the heat stable factors, flatulents and phytic acid are of some significance. Soybeans, in particular, contain the monosaccharides raffinose and stachyose which are not assimilated by man. They, therefore, move to the large intestine where they are fermented by intestinal microflora. The fermentation results in gas formation causing flatulence. Phytic acid, which has great potential for chelating metal ions can affect the bioavailability of trace elements.

Cooking Time

When legumes are directly consumed, they are cooked until desired tenderness is achieved. Some legumes, such as pulses, are easily tenderized. However, beans are more difficult to cook. Long cooking times of 120 minutes for dry beans (Bressani and Elias 1974), 90-150 minutes for cowpeas (Siegel and Fawcett 1975), and 138 minutes for soybeans (Spata _et al_. 1974) have been reported. Tenderization of a given bean during cooking depends on the combined effect of hydration and heating. Increasing the surface area by cracking of beans hastens hydration and heating, thereby resulting in reduced cooking time. In addition, the use of sodium bicarbonate (baking soda) at low concentrations in the cooking water further reduces the cooking time (Nelson et al. 1978). Another approach to the problem of tenderization is the concept of pre-cooking the bean so that only a short final cook is required at the point of consumption.

OUTLOOK FOR THE FUTURE

In the foregoing discussion, several aspects of the total picture on legume utilization have been analyzed. There exists a traditional, country specific and/or region specific pattern for utilization of legumes. The nutritional benefit of legumes in the diet has been widely recognized. Substantial research and development has been carried out in many countries for pre-processing of traditional legumes in order to facilitate wide consumption. Non-traditional concepts of utilization such as composite flour, weaning foods, TVP, etc., have been advanced. Yet, we are still far removed from the point where the available legume sources are completely exploited for their human food value. The reasons for this existing dilemma are many and complex. But some general observations can be made that are true of the overall situation.

The pulses, as a group, find wide acceptance due to the traditional eating habits. The constraint in the case of pulses seems to be one of supply rather than demand. However, it is not implied that the total output of these crops is available and consumed. In fact, the common pulses are highly susceptible to attack by storage pests, and therefore, post-harvest handling and storage is of great importance to narrow the gap between total output and availability. On the other hand, the oilseeds are primarily utilized as sources of edible oil and the protein-rich cake is used for feed purposes. The world production of soybean and peanut together is more than twice the total production of major pulses. The developing countries in 1983, produced as much soybeans as pulses combined (Table 2). In terms of protein yield per unit land area, soybeans surpass all other conventional food sources. It also carries about 20 percent of high quality oil. Therefore,the direct food use of soybeans and other oilseeds need serious attention for complete utilization of the available legume resources.

New Foods

The question is often asked, will the people accept new legume foods which are foreign to their diet? Before we consider approaches to answer the question, it is pertinent to point out some historical facts. Products such as bread, canned fish, powdered whole milk, powdered infant milk, and oleomargarine, which are now popular in many developing countries, were once in the category of new or foreign foods. Their successful introduction was conditioned by the fact that complex motivational factors of consumer acceptance were met, both by the intrinsic characteristics of the products and the strategy of presentation. Factors such as compatibilitv with local eating habits, convenience, ease of preparation, conformation to acceptable concepts of taste, texture and color, price structure, and good market promotion, played their own roles in gaining consumer acceptance for these products. Therefore, one can be optimistic about the acceptance of new legume foods, provided adequate consideration is given to the factors that influence it. Using soybean as a model, we would like to present the following considerations for the expanded use of legumes.

The Total Approach to Utilization

Although it may appear ambitious, the target market for soybean foods should ideally include all strata of society. This dictates that a variety of products to suit every economic class should be available. A number of technologies must be developed to meet this need. The most economical approach is to educate the housewife in the poorest segment of the population to prepare foods starting with raw soybeans. This process which involves development of home recipes, training of personnel and extension, we call the home level activity. A second scale of operation is at the village or community level. Small-scale operations which are labor intensive and require modest capital investment are an integral part of the industry in developing countries. Small privately owned enterprises, institutional feeding programs and cooperative ventures can be identified for the village level production of soybean foods. Low-level technologies for small-scale production must be developed and transferred to such venture. Split soybeans (and pulses), dry formulated cereal/soy mixtures, soymilk, tempeh, snacks, and tofu are some of the possible products that can be identified for this level of operation. A third scale of operation is at the commercial level. This involves centralized processing for wider markets using higher levels of technology. The possibility of diversifying existing food industries into the area of soybean foods is worthy of serious consideration. Wilson and Henkes (1986) reported that a number of reconstituted cows' milk plants in Thailand are considering diversification into soymilk. The establishment of large-scale industries are, of course, contingent upon prior work on product development, scale up and clear demonstration of economic feasibility. Previous experience of viable village-level operations can stimulate and encourage large-scale investments in more promising products. Although the exact course of product development should be geared to suit a given country, the multifaceted approach at the home, village, and commercial level can contribute greatly to the establishment of a viable soybean food industry.

PROMISING TECHNOLOGIES

In spite of the diverse food habits of different countries, several technologies of general relevance and high potential can be identified.

Extrusion Cooking

Extrusion cooking is perhaps the most important. Beginning in the 1960s, extrusion technology has developed to a high degree of sophistication. However, we refer to the so called low-cost extrusion cooking (LEC), also called dry extrusion. This is a continuous process of simultaneously mixing and cooking relatively low moisture dry ingredients using a high temperature short-time step. The process is energy efficient and little or no drying is involved after the process. The product can be in the form of expanded pellets and chips or milled into flour. The heating process in the LEC combines the beneficial effect on nutriutional value while minimizing heating cost. A number of commercial LEC systems are being used in connection with nutrition intervention programs in Asia, Africa, and Latin America (Harper and Jansen 1985). The LEC system can be adapted to process a variety of products other than the weaning type foods made for nutrition invention.

This involves research and development on ingredient formulations based on preference of target populations. Full-fat soy flour, composite flours, soup bases, snacks, and other products with wide application can be produced by low-cost extrusion. This technology is particularly suited to developing countries on account of the relatively low capital costs and high throughput. Present trends indicate that low cost extrusion cooking will gain increasing significance in the processing of food and feeds.

Weaning Foods

Legume/cereal mixtures of high nutrient densities have become an integral part of the supplementary feeding programs. These products have wide potential for production at different levels of technology. The housewife, in many instances, has access to the raw materials that go into weaning type foods. However, she lacks the knowledge regarding the optimum combination of ingredients and the possible home approach to converting these ingredients into wholesome foods for weaning children. The development of these techniques and their dissemination to the housewife is a function of a home-level program, as we have outlined before. Weaning foods can also be made at the village level by pre-cooking individual ingredients, followed by drying, grinding and blending in desirable proportions. It would be interesting to explore the possibilities of using existing small and medium scale food processing operations for the production of such foods. For example, rice milling in some countries involves parboiling, drying and milling. These unit operations are highly compatible with the procedures required for medium-scale production of dry formulated weaning foods. Mutual cooperation between research and industry can open the doors to such avenues of production. Dry extrusion, as mentioned before, has become established as a commercial level technology for weaning foods. Extensive use of such technology could make these foods generally available to wider segments of the population and not just for the nutritionally vulnerable.

Utilization of Oilseed Press Cake

In many countries, mechanical expelling of oil from oilseeds is centered around the production of edible oil and feed grade press cake. We see the potential for re-orienting the existing process for the production of edible grade press cake from food legumes. From the purely technological standpoint, several criteria are important. The level of hygiene in the existing plants will need upgrading if the cake is to be used for edible purposes. A close look into the expeller performance becomes necessary as regards the heat inactivation of antinutrients in the cake as well as its nutritional value. The process may have to be re-optimized, based on both oil yield and cake quality, rather than on maximum oil recovery alone. Properly processed press cake containing some residual oil is indeed ideal for the formulation of cereal/legume products of high nutrient density.

Upgrading of the press cake from feed grade to food grade adds commercial value to the cake. This in itself, may or may not be adequate to induce re-thinking on the part of the expelling industry. Other economic considerations such as assurance of markets for the food grade cake, the impact on the feed industry, and initial expenditure involved, may present themselves as constraints.

Soybean Beverage and Derived Products

Soybean beverage (soymilk) which was a traditional Chinese product, has in recent years, gained wide popularity in the Far East and in the Western world. Great progress has been made in improving the flavor characteristics of the traditional product and development of production technology. As a result, turn-key operations for the large scale production and aseptic packaging of soymilk have been established in a number of countries. Outside East and Southeast Asia, the potential of soymilk and derived products is largely unexploited. There is no real basis for comparing soymilk with cows milk or considering it as a substitute for cows milk. Nevertheless, it is a nutritious product that can supplement the shortage of cows milk in many situations. It is evident that the characteristic beany flavor of traditional soymilk is unacceptable to many populations. Also, soymilk is as perishable as cows milk. The newly developed commercial processes and automated manufacturing systems are highly capital intensive. Therefore, there is, what might be called a technology gap between the traditional soymilk process and the commercial processes. Some sound techniques that can yield a high quality product at low capital investment is an urgent need for introducing soymilk to new situations. Once again, research in the home and village level technology comes into focus. Of particular significance is the question of shelf life. The traditional method of sterilizing or pasteurising liquid milk in glass bottles is rapidly being replaced by plastic containers and more sophisticated sterilizable cartons. Can soymilk be pasteurized in flexible pouches for local sale on a small scale? Is it feasible to produce soymilk for mass feeding in institutions on a daily basis? These are pertinent questions to address and positive solutions to them can contribute to the success of soymilk in developing countries.

Soymilk can be processed further into derived products such as tofu, yoghurt, curd, and ice cream (toffuti). These products are versatile and can be adapted through research into acceptable preparations in a given situation. The concept of a "soy dairy" has been evolved around the multiplicity of products that can be made from the bean in the same processing facility. Such concepts are worthy of serious consideration.

In conclusion, it must be pointed out that there can be no single master plan for the expansion of legume utilization in all situations. The appropriate strategies must be developed for each country's situation. Nor can legume utilization be considered independent of the overall food and nutrition policy of a given country. The overall success of a program will depend upon the coordinated efforts of policy makers, scientists, nutritionists, and the food industry.

TABLE 1
LIST OF IMPORTANT FOOD LEGUMES

Systamatic Name	Common Name(s)	Areas of Production
Cajanus cajan	Pigeon pea, Red gram, Congo bean	India, Pakistan, Middle East, Africa
Cicer arietinum	Chickpea Bengal gram	India, Pakistan
Lens esculenta	Lentil Split pea Red dhal	Near East, India, Africa, Central and South America
Vigna radiata	Mung bean, Green gram	Asia, Africa
Phaseolus lunatus	Lima bean Butter bean	Tropical America, West Indies, Madagascar
Phaseolus mungo	Black gram Urid dhal	India, Iran, Africa, West Indies
Phaseolus vulgaris	Kidney bean, Navy bean, Pinto bean, Haricot bean	North, Central and South American,
Pisum sativum	Pea, Green pea, Garden pea	Temperate zones, India, Africa
Vigna unguiculata	Cowpea, Blackeye pea, Kaffir bean	Asia, Africa, China, West Indies
Glycine max	Soybean Soja	North America, Brazil, China
Arachis hypogea	Peanut Groundnut	Asia, Africa, North and Central America
Vicia faba	Faba bean Broad bean Horse bean	Temperate zones, Near East, Africa, South America

SOURCE: Siegel and Fawcett (1976); Purseglove (1968)

Table 2
Legume Production Statistics-1983, 1000 MT

	PULSES			OILSEEDS	
	Total	Lentils	Chickpea	Soybean	Peanut
World	43,662	1,496	6,827	78,566	19,792
Developing Countries	32,599	1,323	6,737	32,718	18,092
Asia (excluding USSR)	22,337	1,189	6,243	12,352	13,410

SOURCE: FAO 1983

Table 3
Composition of Food Legumes

Legume	Moisture	Protein	Ash	Fiber	Fat	Carbohydrate
Cajanus cajan (Pigeon pea)	10.1	19.2	3.8	8.1	1.5	57.3
Cicer arietinum (Chickpea)	9.8	17.1	2.7	3.9	5.3	61.2
Lens esculenta (Lentil)	11.2	25.0	3.3	3.7	1.0	55.8
Vigna radiata (Mung bean)	9.7	23.6	4.0	3.3	1.2	58.2
Phaseolus lunatus (Lima bean)	12.6	20.7	3.7	4.3	1.3	57.3
Phaseolus mungo (Black gram)	9.7	23.4	4.8	3.8	1.0	57.3
Phaseolus vulgaris (Kidney bean)	11.0	22.0	3.6	4.0	1.6	57.8
Pisum sativum (Pea)	10.6	22.5	3.0	4.4	1.0	58.5
Vicia faba (Faba bean)	14.3	25.4	3.2	7.1	1.5	48.5
Vigna unguiculata (Cowpea)	11.0	23.4	3.6	3.9	1.3	56.8
Arachis hypogea (Peanut)	5.6	26.0	2.3	2.4	47.5	16.2
Glycine max (Soybean)	8.0	36.7	4.6	2.4	20.3	28.0

SOURCE: Purseglove 1968; USDA 1968

Table 4
Per Capita Availability of Calories and Protein
in Some Asian Countries - 1978-1981

Country	CALORIES From Plant Sources	CALORIES From Animal Sources	CALORIES From % Plant Sources	PROTEIN, GRAMS From Plant Sources	PROTEIN, GRAMS From Animal Sources	PROTEIN, GRAMS From % Plant Sources
India	1952	104	97.7	44.2	5.5	88.8
Bangladesh	1771	66	86.1	34.4	5.3	86.6
Pakistan	1949	231	89.4	43.0	13.4	76.2
Nepal	1801	132	93.2	39.3	6.7	85.4
China	2180	246	89.9	47.6	11.1	81.2
Sri Lanka	2160	95	95.8	36.3	8.5	81.0
Thailand	2177	152	93.4	34.7	12.2	73.9
Malaysia	2165	353	85.9	31.1	24.9	55.4
Singapore	2477	689	78.3	43.4	38.7	52.9
Indonesia	2320	53	97.8	43.1	5.8	88.3
Burma	2326	94	96.1	53.6	8.0	87.0
Philippines	2176	228	90.5	34.9	19.0	64.7
Developed Countries	2355	1030	69.6	42.7	56.2	43.2

SOURCE: FAO 1983

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APPENDIX II

WORKSHOP PROGRAM
"FOOD LEGUME IMPROVEMENT IN ASIAN FARMING SYSTEMS"

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PROGRAM

FOOD LEGUME IMPROVEMENT FOR ASIAN FARMING SYSTEMS
Khon Kaen, Thailand, 1 - 5 September 1986
ACIAR, DOA, KKU

Monday 1st September, 1986

0830-0915: Welcome and Opening of Workshop

0915-0930: Organizational Matters

0930-1000: Morning Tea

FOOD LEGUMES IN FARMING SYSTEMS

Chairman: D.E. Byth

1000-1030: Invited Paper: Food Legume Crop Improvement - Progress and Constraints
J.L. Dillon and J.R. McWilliam

1030-1100: Invited Paper: The Role of Food Legumes in Farming Systems in the Tropics and Subtropics
I.M. Wood and R.J.K. Myers

1100-1130: Invited Paper: The Role of Food Legumes in the Nitrogen Cycle of Farming Systems
R.J.K. Myers and I.M. Wood

1130-1150: Discussion

1150-1300: Lunch

LIMITS TO PRODUCTIVITY AND ADAPTATION OF FOOD LEGUMES IN ASIAN FARMING SYSTEMS

Chairman: Kavi Chutikul

(a) Socioeconomic Factors

1300-1340: Invited Paper: Socioeconomic Factors and Policy Issues Affecting Food Legume Production
P. Parthasarathy Rao and M. Von Oppen

1340-1400: Discussion

33'

(b) Limits Imposed by Management Factors

1400-1440: Invited Paper: Limits Imposed by Management in Irrigated Farming Systems
V.R. Carangal, B.H. Siwi and M.V. Rao

1440-1500: Discussion

1500-1530: Afternoon Tea

Chairman: Ampol Senanarong

1530-1610: Invited Paper: Limits Imposed by Management in Rainfed Farming Systems
C.T. Ong and A. Patanothai

1610-1630: Discussion

1630-1930: Poster Session of National and International Research, Training and Publication.

Welcome Reception

Chairman: Sorasith Waichrothayan

(c) Limits Imposed by Climatological Factors

0830-0910: Invited Paper: Limits Imposed by Climatological Factors
R.J. Lawn and J.H. Williams

0910-0930: Discussion

(d) Limits Imposed by Edaphic Factors

0930-1000: Invited Paper: Mineral Constraints to Food Legume Crop Production in Asia
E.T. Craswell, J.F. Loneragan and P. Keerati-Kasikorn

1000-1030: Invited Paper: Alleviation of Soil Physical Limits to Productivity of Legumes for Asian Farming Systems
H. Bing So and T. Woodhead

1030-1100: Morning Tea

1100-1130: Invited Paper: Nitrogen Fixation
D. P. Beck and R. Roughley

1130-1200: Discussion

1200-1300: Lunch

(e) Limits Imposed by Biological Factors

Chairman: Arwooth Na Lampang

1300-1330: Invited Paper: Limits Imposed by Biological Factors: Pests
W.V. Campbell and W. Reed

1330-1345: Discussion

1345-1415: Invited Paper: Limits Imposed by Biological Factors: Diseases
I.W. Buddenhagen, S. Wongkaew, A.J. Gibbs, D.V.R. Reddy and G. J. Persley

1415-1430: Discussion

1430-1500: Afternoon Tea

(f) Limits Imposed by Genetic Factors

1500-1540: Invited Paper: Genetic Limits to Improvement of Food Legumes
D.E. Byth, R. Shorter and Sumarno

1540-1600: Discussion

Tuesday 2nd September, 1986 (Continued)

Chairman: Dely Gapasin

(g) Processing and Utilization of Food Legumes

1600-1630: Invited Paper: Limits Imposed by Pre and Post Harvest Factors of Food Legumes
J.S. Butler, M.R. Heslehurst and B.C. Imrie

1630-1700: Invited Paper: Utilization of Food Legumes as Food
W.B. Wijeratne and I.A. Nelson

1700-1730: Invited Paper: Utilization of Food Legumes as Feed
E.S. Batterham and A.R. Egan

1730-1800 Discussion

Evening Poster Display of Contributed Papers

2000-2030 Field Tour Briefing

Wednesday 3rd September, 1986

0830-1700: Field Tour

1900: Workshop Dinner - Khon Kaen Hotel
Speaker - J.R. McWilliam

Thursday 4th September, 1986

		Concurrent Sessions	Chairman	Reviewer
0830-1000	(a)	Management - Irrigated	Montein Somabhi	B.S. Dahiya
	(b)	Socioeconomics	J.L.Dillon	T. Walker
	(c)	Nitrogen Fixation	Yenchai Vasuvat	R.J.Roughley
1000-1030		Morning Tea		
1030-1200	(a)	Protection	C.Yang	G.J.Persley
	(b)	Management - Rainfed	D.G. Faris	A.Patanothai
	(c)	Nutrition	J.F.Loneragan	P.Keerati-Kasikorn
1200-1330		Lunch		
1330-1500	(a)	Environmental Factors	R.K.Pandey	A.Pookpakdi
	(b)	Utilization & Post Harvest	Metha Wanapat	B. Champ
1500-1530		Afternoon Tea		
1530-1700		Plant Improvement	R.B.Singh	S.Shorter
1700-1730		Break		

1730-1900: 1st Forum Session

(a) Rainfed Farming Systems
Chairman: D.E. Byth
Rapporteur: V.E. Mungomery

(b) Irrigated Farming Systems
Chairman: V.R. Carangal
Rapporteur: G.J. Persley

Friday 5th September 1986

0830-1100 2nd Forum Session

(a) Rainfed Farming Systems
(b) Irrigated Farming Systems

1100-1400: Lunch

Chairman: E.F. Henzell
Rapporteur: E.S. Wallis

1400-1500: Synopses by Forum Chairmen

1500-1545: Afternoon Tea

1545-1630: Close
J.R. McWilliam, Director, ACIAR.