The Oilseed Industry of India—Potential for Food Use of Proteins[1]

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ABSTRACT

India is one of the major oilseed-producing areas in the world with approximately 11% of its tillable land, 37 million acres, devoted to the various oilseed crops. Peanut is the principal oilseed, but enough sesame, rape and mustard, flax and castor are grown that they are classified as major oilseeds in Indian statistics. Cottonseed and rice bran are gaining in importance as vegetable oil sources and a host of native seeds such as neem, mohwa, kusum and sal are being promoted as sources of inedible fats for soap manufacture. There is a very real potential for soybeans in the Indian economy. Under AID contract, teams from the University of Illinois have been exploring the possibilities of growing soybeans at the Uttar Pradesh Agricultural University at Pantnager and the Jawaharal Nehru University at Jabalpur. Several United States varieties, particularly Bragg, grow well, and yields as high as the 60 to 70 bushels per acre range have been achieved in the *kharif* or rainy season (planting in late June, harvesting in October-November), and yields of approximately 60 bushels per acre have been obtained from early soybeans such as Ford planted as a second crop on irrigated land in the *rabi* or Spring season (planting in mid-February, harvesting in May-June). Oilseed processing ranges from the primitive ghani, a bullock-driven mortar and pestle, to relatively modern prepress-solvent extraction plants. Extraction plant size is small by American standards, ranging from 50 tons to about 100 or perhaps 150 tons per day. Limited quantities of the oilseed cakes and meals are used domestically for animal feeding, the bulk being shipped to European markets. With 550 million people there is urgent need for food protein in India, and oilseed proteins offer potential for supplementing traditional dishes. Corn soya milk (CSM) has had fair to excellent acceptance in various localities, and much ingenuity has been shown in adapting CSM to native cuisine. Now, an Indian counterpart, Balahar, is being formulated using peanut flour as the major protein source. This requires costly hand picking of peanuts to reduce the level of aflatoxin in the peanut flour to 120 ppb (equivalent to the FAO guideline of 30 ppb in the resultant Balahar). There is only limited potential for oilseed protein supplementation of bread and chapaties. A number of regional foods offer local opportunities for supplementation by oilseed flours and grits; and dal, which is used by both the rice-eating peoples of South and East India and the bread-eating people of North India could consume from one million to four million tons of oilseed meals per year (10% to 25% supplementation) with little or no change in consistency or flavor.

INTRODUCTION

With a population of 550 million, roughly one person out of six on the face of the earth, there is a very precarious relationship between availability of food in India and numbers of consumers. The Government of India has been keenly aware of the importance of agriculture, and improvement of farm productivity was the central theme in each of first three Five Year Plans. Now the much revised fourth Five Year Plan again concentrates on the farm economy and the need to increase the agricultural output in order to keep up with the burgeoning population.

Cereal grains are the mainstay of the Indian diet, rice being the most important followed by wheat, sorghum (jowar), corn, millet (bajra) and barley. During the decade from 1954 to 1964 the cereal crop averaged 61 million tons per year. Additive in the Indian diet is the pulse crop which ranges from 10 to 13 million tons. During 1965 and 1966 there were disastrous droughts as the monsoon failed, but during the next four years, 1967 through 1970, the cereal crops spurted ahead to an average of 83 million tons, approximately 20 million tons above the average of the preceding decade. With the abundant harvests of the past several years villagers were pulled back from the brink of starvation to the more normal state of undernourishment and malnutrition.

The predominantly cereal diet is short in protein, both quantitatively and qualitatively. The 80 million metric tons of cereal grains accounts for 6.4 million tons of protein based upon a reasonable composite average protein content of 8%, and the 12 million ton pulse crop at 23% protein adds another 2.8 million tons for a total of 9.2 million tons of protein, an average of only 46 g per person per day. Other sources, milk, meat, vegetables, add to the availability of protein, but the level still falls woefully short of need.

OILSEED PRODUCTION IN INDIA

Against this backdrop of food supplies short in both energy and quality it is worthwhile to evaluate the oilseed industry of India and its potential for providing much needed protein.

India is one of the major oilseed producing areas of the world, and approximately 11% of the tillable acreage is planted with one of the various oilseeds. An increase in oilseed production ranked high among the goals of the first three Five-Year Plans (Table I), but production consistently fell short of the targets (1).

The Major Oilseeds

For statistical purposes five oilseeds are grouped together as major oilseeds. These are peanuts, sesame, rape and mustard, flax and castor. Peanut is by far the most important oilseed in the Indian economy, the annual production usually running about twice that of the other four major oilseeds combined.

India accounts for approximately 50% of the world's peanut acreage but only 25% to 30% of the world's crop. Obviously, there is much room for yield improvement. For example the average Indian yield is 680 lb/acre compared with the United States and Nigerian yields of more than 1500 lb. In part, the low yield in India is accounted for by substantial planting of peanuts on marginal soils or in areas of scanty rainfall. By contrast

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TABLE I

Oilseed Production

Five year plan	Major oilseeds, target	Million metric tons production
First (1951-1955)	5.6	5.4
Second (1956-1960)	7.7	6.7
Third (1961-1965)	9.8	7.3
Fourth (1969-1974)	10.0	6.4 (1966)
		8.2 (1967)
		7.5 (1968)

yields of over 3000 lb/acre have been obtained on good land under conditions of adequate moisture.

Cottonseed

Cottonseed is a much neglected oilseed resource. Normally, more than 2 million tons are available yearly, but only 30% is processed for oil and meal. Cottonseed is widely used as a cattle feed, and farmers have a widespread but erroneous belief that the high fat content of the seed in the 18-20% range results in a higher butterfat content in the milk. Further, because cottonseed has been used historically as a cattle food there is prejudice against the oil for human edible purposes.

Coconuts and Copra

The coconut palm flourishes in South India and along the western coast of India from Goa southward with major production in the states of Kerala and Tamil Nadu (formerly Madras). Most of the coconut is used directly as a familiar component of much of the South Indian cooking, but small quantities are dried for copra and crushed for oil.

Rice Bran

Rice is the most important food grain of India and large tonnages of rice bran with an oil content in the 20% range are available as a byproduct of rice milling. Lipolytic enzymes are activated in the milling process and rapid development of acidity occurs on storage so that extracted oils may contain up to 50% free fatty acids. Consequently much of the rice bran oil is not suitable for refining and manufacture of edible products and is marketed instead for industrial uses. The defatted bran has a protein content of about 15%.

Minor Oilseeds

India possesses an extraordinary range of little known seeds and nuts which have potential as both edible and inedible oilseeds. The minor oilseeds are relatively insignificant in the overall oilseed picture, but when oil and protein are in short supply everything is important. Distinct effort is being exerted to promote village industry processing of such oilseeds as sal, neem, mahwa, kusam and many others. Hindu religious beliefs keep animal fats out of soap products, and as a consequence a considerable quantity of edible vegetable oil is used for manufacture of soaps and detergents. By channeling the minor oils into industrial markets, edible oils can be freed for human consumption.

Soybeans

Soybeans are not now a commercial crop in India, but there is growing optimism that soybeans will become established as a crop which will help to reduce India's huge deficits of edible oils and high quality protein foods.

In the mid-sixties the University of Illinois began a cooperative program under the Agency for International Development to explore the prospects for growing soybeans in India (2). Work was concentrated at two state universities modeled after our land grant colleges with the University of Illinois supplying teams with in depth experience in soybean culture.

The Uttar Pradesh Agricultural University is located at Pantnagar, about 150 miles east-northeast of Delhi. This station was carved out of the jungle in the Tarai region within the past ten years and is so new that tigers still roam around the sugar cane fields on the campus. (Earl Leng, a University of Illinois agronomist who initiated varietal trials on soybeans at the University achieved considerable notoriety when he shot a man-eating tiger on the campus grounds.) The tarai is a relatively wet belt raised slightly above the flatness of the Gangetic plain and located just below the foothills of the Himalayas. Monsoon winds strike the hills and drop their rain, and as a result the tarai is an area of rather high average rainfall. The latitude of 30° north is about the same as New Orleans.

The Jawaharlal Nehru Agricultural University at Jabalpur is the Madhya Pradesh State University and is located at approximately the geographical center of India. Here the land has been cultivated for centuries in contrast to the almost virgin fields at Pantnagar. Jabalpur is located on the Tropic of Cancer at 23° north, a latitude similar to Central Mexico.

Basically, India has a wet season, the Monsoon, extending from June to mid-October or early November, and a dry season. Crops grown in the rainy season are known as *kharif* crops; those grown as dry land crops on irrigated land following the *kharif* harvest are known as *rabi* crops. Finally, in southern India three crops per year are relatively common.

When soybeans were introduced in the United States the seed came from temperate regions of China, and the crop was considered to be suitable only for the northern tier of states in the "corn belt." Gradually varieties were developed which did well in such southern "cotton belt" states as Arkansas or Mississippi.

Soybeans from the cornbelt states were introduced into India during the time of Ghandi. Yields were relatively poor, either because the varieties were not well suited to the Indian climate or more probably because farm practices were not suited to high yields. Now southern U.S. varieties such as Bragg or Hampton have been grown in the *kharif* season with excellent results and northern U.S. varieties, Ford or Traverse for example, have given excellent yields when planted as a winter (*rabi*) crop in January or February.

At Pantnagar in the kharif season the top yields during the 1966-1968 seasons have varied from 55 to 70 bu/acre (2,3) and 1969 yields were of the same order (4). In the *rabi* season yield trial results for six varieties ranged from 57 to 62 bu/acre (5), and in a later trial covering 19 varieties yields varied from 43 to 61 bu/acre. Finally 30 local farmers near Pantnagar grew soybeans for the first time in 1968 and averaged 24 bu (6), and in 1969, 48 farmers had an average yield of 27 bu (4).

At Jabalpur top yields of 40 to 70 bu/acre have been reported. In a discussion of Indian soybean yields Carl Hittle of the University of Illinois, who has been stationed at Jabalpur, commented that "the soybean is much more of a tropical crop than we had ever thought" (C. Hittle, private communication).

Overall, the soybean yields have been as high or higher than experimental station yields in the United States. Agronomists closest to the Indian scene estimate that practical farm yields will be in the range of 1000 to 1500 lb, or 17 to 25 bu/acre in the *kharif* season (4,7). In theory with the potential for two crops per year the Indian farm could produce twice as much soybeans as we do. Practically the soybean will be grown as a wet season or *kharif* crop to be followed either by fallow or by wheat, sorghum or millet as winter crops.

PROCESSING OF OILSEEDS

Oilseeds have been processed in India from time immemorial, and present day processing ranges from the primitive *ghani* to modern continuous solvent extraction.

The Ghani

The ghani is a very inefficient method of oilseed processing in which a pestle rotated in a mortar by bullock or camel power is used to crush the seed. After several hours of grinding the oil is separated by dipping rags into the crushed seeds and then squeezing out the oil. Although the number is decreasing, several hundred thousand ghanis are still in use, primarily as village operations crushing mustard or rape seed and such minor oilseeds as kardi, mahwa or kusam. Perhaps 1/2 to 3/4 million tons of oilseed, about 10% of the total crush, is processed by the ghani.

The resultant meal is high in oil and the primitive conditions of processing virtually eliminates ghani meal from consideration as a source of protein for human consumption.

Mechanical Screw Presses

There are numerous small processors with anywhere from one to four or more mechanical screw presses. Currently it is estimated that there are more than 10,000 oil mills, most having one small press operated on a single shift during only a portion of the year. The meals will typically contain about 7% to 9% fat, and the poor sanitary conditions during processing and subsequent storage militate against use of these meals in human foods. Much of such expeller meal is marketed directly, but considerable quantities are forwarded to solvent plants for further extraction.

The crushing capacity of screw presses calculated on a 24 hr/day basis for 300 days a year is estimated to be in the range of 25 million tons, but the annual output is probably under 4 million tons.

Solvent Extraction

In India solvent extraction is described as secondary processing since virtually all solvent units are used for processing of oil cake. There are more than 100 solvent extraction plants in India varying from older batch extractors with capacities as low as 10 to 15 tons of oilseed cake per day to modern continuous units with capacities as high as 150 to 200 tons. The dominant type of continuous unit, and the only type manufactured in India, is the DeSmet horizontal traveling belt extractor.

Visits were made to several dozen representative Indian oilseed processors as part of an AID survey to assess their capabilities for processing of soybeans. These mills were reasonably typical of the Indian peanut-cottonseed processing plants, and with minor exceptions, the same comments are applicable to each.

Indian oilseed plants are quite small by U.S. standards. Typical solvent extraction plants have capacities in the 50 to 150 ton a day capacity range compared with the 1000 ton plus size of the most recent U.S. installations and the 1969 average capacity of 580 tons for the 132 mills which constitute the U.S. soybean industry (8). In 1951 there were 193 U.S. soybean mills with an average capacity of 160 tons. Presumably the Indian history will parallel that in this country with a gradual transition to fewer mills with larger individual capacities.

The processing plants are all multipurpose and process peanuts, cottonseed, sesame and, in some cases, copra, flax, rape or castor beans.

All processing involves a two-stage operation of mechanical pressing to oilseed cakes having about 7% to 10% residual oil followed by solvent extraction to recover additional oil and produce low fat meals containing typically about 0.5% to 0.75% fat.

Sanitary conditions in the mills would be considered poor by U.S. standards even for feed grade meals.

Equipment commonly used in the "preparation area" of U.S. plants was either inadequate or missing entirely. Bagged storage was the rule in all plants and high speed bulk handling procedures were found nowhere. None of the mills had cleaning equipment (other than magnetic separators) for removing sticks, stones, leaves, sand, weedseeds and other trash preparatory to processing. On the other hand, because of the extensive hand labor in harvesting and subsequent handling, all of the seeds and grains are remarkably clean compared with typical U.S. quality. There is (with a single exception) no dehulling equipment. None of the plants had conditioning equipment to adjust the moisture and temperature preparatory to flaking. Flaking rolls were either absent or inadequate for reduction of meats to the paper thin flakes needed for efficient extraction.

Desolventizing is performed in tubular horizontal driers (schneckens) and heat treatment would probably be inadequate or borderline for optimizing nutritional value.

None of the plants has the auxiliary grinders, sifters and bagging units needed to produce grits and flours of varying granulation and deliver them to the customer in a satisfactory condition.

The overall impression of the Indian oil processing plants was that they were well-operated and that management is eager to improve processing and to install missing equipment needed for soybean processing such as dehulling facilities, flaking rolls or desolventizer-toasters. Because continuous solvent extraction is quite new on the Indian scene the typical mills are about 20 years behind U.S. mills in design and general operating efficiency (and a culture apart in effective use of manpower).

Most of the Indian oilseed meals are marketed in Europe to gain needed foreign exchange. Worse yet, in a nation faced with chronic protein shortages a considerable portion of the meals which remain in the country are used as fertilizers.

OILSEED PROTEIN RAW MATERIALS

In the aggregate several million tons of high quality protein is available in India in the form of oilseed meals; and if soybean culture becomes an important part of the Indian agricultural economy, as many predict, still larger quantities of oilseed protein will be available in the future. Oilseed meals, flours and isolates have been considered as protein sources for modification of Indian foods:

Peanut Flour

Peanut meal is by far the largest oilseed protein resource. Nutritionally peanut protein is inferior to cottonseed and soybean proteins, but nonetheless, it is an excellent supplement for the predominantly cereal-based Indian diet.

If moisture levels at time of harvest or during storage are too high the ubiquitous mold, *Aspergillus flavus*, grows readily and may elaborate the highly toxic metabolite, aflatoxin. The government of India has established a maximum aflatoxin content of 120 ppb in peanut flour for human consumption. Then, if peanut flour is used at a level of 25% or less in the final foodstuff the aflatoxin level will not exceed the FAO guideline of 30 ppb (9).

The processing scheme at the Ravi Vegetable Oil Mill, Davengere, Mysore (about 150 miles northeast of Balgalore) is reasonably representative of the problems imposed by aflatoxin contamination. Peanuts are received in gunny sacks and are spread for drying on tarpaulins in a 4 in. deep layer on a field measuring about 150 x 300 ft. It had been raining consecutively for eight days at the time of the visit to the Ravi mill on October 17, 1969. In order to protect the peanuts from the rain they were concentrated under tarpaulins in 5 to 6 ft high piles, and the plant managers were anxiously scanning the leaden skies for a break in the rains so that drying could be resumed. Normally peanuts are dried to 4.5% moisture prior to storage.

Five stages are involved in the preparation of low aflatoxin content peanut flours for such uses as fortification of wheat flour or manufacture of Bal Ahar.

1. Peanut shells are mechanically cracked and separated from the nut meats.
2. Nuts are sorted mechanically retaining large, whole peanuts for further processing and eliminating small, malformed or low density nut meats.
3. The larger kernels (about 50% of the original input) are dropped from wicker baskets onto a steel ramp inclined at about 25° or 30° from the horizontal. Kernels reaching the bottom go to the hand sorting crew. Misshapen kernels and pieces of shell which do not roll to the bottom are swept aside. The rejection rate at this stage is about 30% of input.
4. Finally a crew of women (two shifts of 200 women per shift) sit on the floor and hand pick the mechanically sorted kernels to eliminate off color, shriveled, broken skinned, or underweight nuts. Rejection averages 30%.

By such cleaning about 20 to 25 tons of sound hand picked nuts are accumulated each day. Even though the payscale is very low, an effort of such magnitude does add materially to finished product cost.

5. Finally, sound nuts from hand picking are extracted in the usual way, and the resultant meal is ground to the established screen analysis.

Isolated Peanut Protein

A conventional protein isolation process of alkaline extraction of peanut meal followed by acid precipitation leads to a fairly complete recovery of protein from the meal and simultaneous chemical treatment, including hydrogen peroxide bleaching during the isolation sequence, leads to quite complete removal and destruction of aflatoxin. Tata, the vast Indian industrial complex, has produced isolated peanut protein on pilot scale for consideration as a food supplement.

Cottonseed Flour

Gossypol in cottonseed results in dark colors in both meals and flours. Furthermore during heat processing of meals gossypol combines with the epsilon amino group of lysine, the limiting amino acid of cottonseed protein, materially reducing the nutritive value of the finished meal or flours derived from it. The liquid cyclone process is a unique technique for separating gossypol from wet ground cottonseed flour based on differences in the specific gravity of the gossypol-containing pigment glands and other seed components (11,12). A Dorr-Oliver liquid cyclone pilot plant has been installed at Sundatta Foods and Fibres, Ltd. at Hubli, Mysore. If the process proves to be effective and economical, the annual two million ton cottonseed output can serve as a raw material for a quality oilseed protein flour.

Soyflour

To date, soybean plantings have been essentially experimental in nature although the acreage in 1970 reached 100,000 and covered most of the Indian states. There is enough optimism about the crop that UNICEF has authorized a soybean processing plant including flour and grit grinding facilities.

FOOD USE OF OILSEED PROTEINS

For successful introduction of oilseed proteins into the Indian diet it is almost mandatory that the protein resource be placed in familiar food without materially changing color, flavor or texture. People are essentially very conservative about the things they eat and incorporation of protein resources into new foods or food products which are not common to the geographical locality is likely to fail. Below are listed some of the foods in which successful introduction of oilseed protein could make a significant nutritional impact.

Fortified Atta

The people of northern India particularly are bread (chapati) eaters. Commonly the housewife buys enough wheat (or sometimes sorghum, millet or corn) for several days supply of her family's bread. She grinds the wheat into a coarse flour called atta, prepares a dough, molds it into discs with a diameter of about 6 to 8 in. and bakes the unleavened dough against a hot metal surface (12). There is no opportunity to introduce oilseed flours into the home processed chapaties.

Alternatively, the housewife will take her wheat to the chuckey, the village gristmill, for grinding. Again there is little opportunity to introduce oilseed flours.

Increasingly, large flour mills are producing atta as a packaged flour. A volume potential of 1.25 million tons has been estimated as a reasonable early goal for such packaged atta. Incorporation of oilseed flour at a 5% level offers a potential of 60,000 tons and at a 10% level the potential is 125,000 tons of oilseed flour. The fussy housewife maintains that chapaties from freshly ground wheat are better than those from atta ground and packaged at a flour mill. However, the added convenience is winning more customers. At a 5% level of soyflour the nutritive value of the chapati will roughly double and it is unlikely that flavor changes will be objectionable or even noticeable.

A start has been made in such a fortification program and according to Mr. Ramiswami, chairman of the Protein Foods Association of India, atta can now be purchased in Bombay which is fortified with peanut flour, minerals and vitamins (13).

Modern Bread

Modern Bread which is now produced in new government owned bakeries is a wheat bread fortified with vitamins, minerals and lysine (14,15). It has been widely heralded, and justly so, as a major achievement. Store bread sales in India have increased by 250% in the last decade, and the Modern Bread Program which was initiated in mid-1967 attained a volume of 25 million loaves in 1968. When the program is fully implemented with bakeries in the ten largest cities, the capacity will be only 100 million loaves of bread (400 g each). This quantity will require about 60 million lb of wheat flour and, at a 5% fortification level, only 3 million lb, 1500 tons of oilseed flour, would be required. Such a level of added oilseed protein would significantly improve the nutritional value of the bread, but because of the limited distribution of less than 1/5 lb of bread per person per year, the nutritional effects would be miniscule.

As a showcase of what can be accomplished and as a forerunner of a changing economy in which purchased bread will be an important component of the Indian diet, the Modern Bread Program is a resounding success. For now and for the immediate future the program has virtually no nutritional impact on the populace of the Indian subcontinent.

Protein Beverages

Somehow the misconception has become firmly fixed in the minds of many concerned Indians that milk can be produced by simply stirring soyflour into water. Calling a dispersion of soy flour in water, milk, does not make it milk; it remains a suspension of flour and water. It does not have the texture or the functional characteristics of either cow or buffalo milk, and furthermore, the flavor is relatively poor. Research, such as that being conducted at Cornell University (16), may pave the way to acceptable soymilks, but it is questionable whether any of the products developed to date would be acceptable to the palates of any but the Chinese who become accustomed to the characteristic soybean flavor at weaning age.

Buffalo milk has twice the fat content of cow's milk. By addition of nonfat dry milk solids and water to adjust the fat content to the normal cow's milk level, 2 qt of "toned" milk will be produced for every quart of starting material. Alternatively, an oilseed flour could be added to extend or tone the rich buffalo milk. The probability of success of this approach is much greater than for the straight soy milk approach since half of the product will be an acceptable and palatable natural milk.

The Central Food Technological Research Institute at Mysore developed a unique milk-like product based on isolated peanut protein (17). This "Lactone" is now being produced on a small scale in the ultra-modern Bangalore Dairy. Lactone has the advantage that curds can be prepared for use in the numerous curd-based Indian dishes, but flavor appears to be borderline for customer acceptance.

Bal Ahar

Several hundred million pounds of the vegetable-protein mixture CSM have been distributed in India. CSM (originally corn-soya-milk) is basically a 20% protein content product containing 65% gelatinized corn flour, 25% soy flour and 5% nonfat dry skim milk fortified with 5% soybean oil and needed vitamins and minerals. As part of the Food for Freedom program, over a billion pounds of CSM has been manufactured in the United States and shipped to underdeveloped nations. Great ingenuity has been shown in adapting this cereal blend to the native cuisine of India, and acceptability of CSM has been very good in most parts of the nation.

Now India is seeking to develop a related domestic product, Bal Ahar (children's food), as a blend of wheat with 25% peanut flour as the protein concentrate. The immediate goal is distribution of 60,000 tons of Bal Ahar, an amount which will require 15,000 tons of oilseed flour.

Textured Protein Foods

About 70% of the people of India eat meat, or would eat meat if they could afford it. Eating meat may mean having one serving of chicken during the year, but at least meat is an acceptable part of the diet of the majority of the people. Recently several methods have been developed in the United States for fabricating oilseed protein flours or isolates into food products having a meat-like texture. Such products could have an enormous appeal in India, for they would cut across the lines of both historical bias and religious prohibitions to introduce meat-like vegetable products to the "vegetarians" and to the "nonvegetarians" alike. Obviously this more sophisticated approach to protein foods is much farther down the road than fortification of wheat flour or development of a blended cereal food such as Bal Ahar. Such foods could have real impact over a long range and already Indian manufacturers are tooling up to produce pilot lots of textured foods.

Dal

The common Indian food, dal, offers by far the most exciting opportunity to introduce oilseed protein into the Indian diet. As was pointed out earlier, the pulse crop in India averages about 12 million tons per year. These pulses, known as red gram, black gram, tur, and other names, are members of the pea and bean family and are cleaned, dehulled and sold as the split pulses in much the same way as split peas are marketed in the United States. Dal is a soup-like product prepared by cooking pulses in water and forms an essential component of the Indian diet. Most important, dal has no regional bias; the people of South and East India eat dal with rice, and those in the northern states eat dal with chapaties.

Dal would seem to be an ideal food for modification by soybeans, since soybean, a pulse, would probably have reasonable flavor acceptance in a populace which has eaten cooked pulses in the form of dal for many centuries and probably for several millenia. With this prospect in mind samples of 50% protein flake or grit products were obtained from the United States representing four different levels of heat treatment during commercial processing. The products are the following: 90+ PDI, flakes; 70 PDI, flakes; 40 PDI, -14 + 35 grits, and 20 PDI, -20 + 40 grits.

The protein dispersibility index (PDI) is the percentage of the total protein extracted by water in an arbitrary wet grinding procedure (18). The 90+ PDI product has minimum heat treatment and the 20 PDI product is highly heat treated or "toasted." Grits are lightly ground flakes classified between screens to provide material with rather uniform particle size, thus a -14 + 35 grit is material which passes through a 14 mesh screen, but is retained on a 35 mesh screen.

Mrs. Arora of the Catering Institute in Delhi checked the various products in dal. None of the products produced dal of satisfactory consistency and flavor when used alone or when used in 90:10, 75:25, or 50:50 blends with red gram. However, a combination of 25 parts soy and 75 parts red gram produced a dal which was virtually indistinguishable from the red gram control in flavor and consistency. The "flake" products appeared to cook more rapidly to a more dal-like consistency than grits. The flake products are a blend ranging from rather coarse materials to flour-like fines. The flour-type material hydrates faster and produces a thicker consistency than grits. Addition of calcium chloride at a 1% level appeared to improve flavor of dal somewhat, but such addition was not explored more than superficially. Both sambar, a popular South Indian dish, and upma, a cereal preparation used widely in school feeding programs, were considered wholly acceptable when 25% soy flakes were incorporated in the preparations.

Incorporation of extracted soybean flakes at a 10% level in dal would offer a potential market of 1.3 million tons and at a 75:25 pulse-soy ratio, the potential rises to a huge four million tons.

Obviously there are problems. An extracted soybean flake does not look like a split pulse, and there would be consumer resistance to combining the two. The most attractive approach is to package the two components together in family size units. Further, a massive promotional campaign would be required to "sell" the concept. The nutritional rewards justify serious consideration, for this is the only type of program with the potential for introducing several million tons of high quality protein into the Indian diet; it is the only program which can reach people in all geographical areas of the subcontinent; it is the only program which can reach all population groups, city and village alike.

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