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RAW MATERIALS TO BE CONSIDERED WITH SPECIAL REGARD TO PRODUCTION OF PROTEIN CONCENTRATES OF ANIMAL OR VEGETABLE ORIGIN

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Protein malnutrition problems exist in most countries and particularly in those in the development stage. In the latter the problem is especially acute in two population groups: the rural population which cannot be reached with industrially processed feeds and the low income population in urban areas.

The bulk of the population affected by malnutrition is made up of children. The children of today are the young adult generations of the 1980's and 1990's, upon whose health and performance the future depends. Adequate protein is essential for normal physical and normal mental developments, resistance to infection and disease and maintenance of health.

Most important is the provision of adequate protein for the feeding of infants, young children and pregnant and nursing mothers, because protein deficiency can cause irreversible damage to the foetus, the infant and the young child.

Infant foods, in order to cover the daily necessary protein supply in a reasonable volume of prepared food are recommended to contain no less than 20 to 25 percent of protein of good quality.

Because the largest volume of protein and calories for the foreseeable future must come from cereals with a protein content between 8 and 15 percent it is necessary to improve the protein content by the addition of a protein concentrate usually containing about 50 percent of protein. The term "protein concentrate" is to keep separate from the term "protein food" which is employed to describe any food which may provide a significant proportion of the dietary protein and so includes the cereal as well as the protein-rich animal and vegetable sources of protein.

All cereals and cereal flours are deficient in one essential amino acid, lysine. In addition, some cereals, like maize and wheat, contain too small amount of a second and third essential amino acid as tryptophan, methionine or threonine in order to be classified as a well balanced protein source.

A well balanced protein like the hen's egg or milk proteins contain all essential amino acids in right proportions to cover the daily needs for growth and maintenance. Most of the protein concentrates of vegetable source are not well balanced with regard to at least one essential amino acid or another. This defect might be corrected by addition of necessary amounts of synthetic amino acids which are now produced in necessary amounts to reasonable prices.

In the following a short review will be given of the most important raw materials to be considered with special regard to the production of protein concentrates of animal or vegetable origin. At the same time comments will be given of protein quality and if possible of prices and present production sites and volumes. Special emphasis will be given to the situation in African countries. Likewise some examples will be given of commercialized protein foods containing protein concentrates which could be used as weaning foods for infant feeding.

ANIMAL PROTEIN CONCENTRATES

Livestock

It is recognized at the outset that from the standpoint of pure economics we can supply protein foods that will sustain life more economically by direct use of vegetable protein material than by converting it to animal protein. However, it has been pointed out that many animals do not compete with the human for the type of food they eat. The ruminants, particularly, convert grass and grass products and other forages into more readily and certainly more desirable forms of proteins.

Even where the animals may be competing with the human for certain types of food, as may be the case with the pig and the hen, these animals are producing a product desired by man. The 1965 estimated total production of such meats for the 44 major producing countries has been estimated to about 50 million tons.

Ten countries low in supplies of animal protein, meat, poultry, egg, available for human consumption, provide from 5 to 14 grams per person per day, in contrast to 51 to 74 grams in ten countries where animal protein is more plentiful. The African countries belong to the first group. In these countries there is at present time an insufficient base for establishing plants for process meat or egg meals as valuable animal protein concentrates in infant foods. At present only limited amount of first grade meat is produced in the African countries at high prices which limits consumption conditions and favors export. The following measures have found to be both possible and feasible to improve this situation in the developing countries: improvement of genetic selection of efficient feed converters of all classes of livestock; b) increase the productivity by use of appropriate feed additives as oil cakes; c) adopte modern feeding practices using balanced rations for livestock and poultry feeding; d) use protective measures against livestock diseases and parasites by improvements of vaccines, many of which are not at present oriented to the diseases relevant in developing countries; e) improved veterinary education and services.

According to FAO data the consumption of animal protein in 1965 was about 11 grams per capita per day and will in 1985 hopefully increase to an average of 18 grams in the developing countries. Improved livestock production and increase in per capita income will in the future be important factors which will decide when a part of animal protein production can be used as meat powder in weaning foods.

Milk proteins

At present time the population of the Far East obtain only 6 % of their caloric intake from animal products. Those living in Africa average 7 % while those inhabiting the Near East get 8 % of their calories from this source. When these are compared with the diet of the North American, who derives 35 % of his calories from animal products, the problem begins to come into focus. This disparity exists in spite of the fact that most of the countries in the low animal-calorie regions are basically agricultural and frequently possess large livestock holdings. In Kenya, East Africa, for example, a country of 8.6 millions inhabitants, there are a cattle population of nearly 7 million, about a quarter of a million camels, and 13 million sheep and goats. In Ethiopia with a population of 22 million the relationship between number of inhabitants and animals are very much the same.

Most of the cattle are kept for reasons of prestige in the community and with disregard for quality and economic considerations. As veterinary services have gradually improved and disease controls practices have been adopted, the number of improductive cattle has increased, bringing further deterioration of pastures and soil. It has been reported that at least 20 milking cows are required to supply the milk needed by one nomadic farm family. The calf takes precendence over the needs of man, so a yield of 200 ml to 2 liters of milk per day is about all that can be expected from these native cattle during their short lactation periods.

In the United States well managed herds now average 20 liters per cow. In consequence North Americans consume about 0.9 liters of milk (in all its forms) per capita per day, while the average Asian is limited to 0.9 liter equivalent every 14 days.

The Dairy Branch of FAO contends, through experience in many countries that milk production is possible in any country of the world, but that production alone without a system of processing and distribution is futile. FAO also contends that the need in the world is not for butterfat, but for the milk protein in skim milk.

Through FAO and UNICEF cooperation and help some cooperative milk processing centers have been developed in Kenya. A few of these process as much as 100.000 liters per day, which is considered to be a minimum quantity for commercial production of skim milk powder as a by-product.

Contrary to common belief, it has been demonstrated that the climates of the tropics and subtropics are not serious obstacles to milk production by highly productive dairy cattle. Israel and other hot countries have introduced environmental modifications which make it possible for European and American breeds to produce milk at levels comparable to that in their home countries.

Assuming that the present 1 billion underfed were to receive only 0.25 liter of milk equivalents per day, there would be an immediate need for 2.500 new processing plants, each with a capacity of 100.000 liters per day. To provide milk at the same rate for the anticipated increase in population over the next ten years would require 125 more new plants of the same size each year. Put together, this means that in 1979, 3.650 new plants of 100.000-liter capacity would have to be built, equipped and opened each day of the year for the next ten years even to catch up. Then at the end of 1979, we would have processing capacity to provide 0.25 liter of milk and milk products for the underfed and the increased population at a consumption rate only one fourth that of the current per capita utilization on the North American continent.

For the present, we have to be reconciled to the fact that those nations that "have" will need to continue to help provide the milk protein for those that "have not".

This help, both by donation and through normal trade channels, will of necessity be confined largely to nonfat dry milk, which normally contains about 36 % milk protein. This protein concentrate is considered the most valuable source of complementary protein for the malnourished and lends itself to distribution and storage conditions throughout the world.

In 1964 the United States produced 1 million tons of food grade nonfat dry milk. A similar amount was processed in the rest of the world. A considerable part of this product is used for livestock feeding. Due to this and other factors UNICEF has recommended a "stretching" of dry milk. This has resulted in proposals to restrict the content of nonfat dry milk in weaning- and infant supplementary foods to 10

Nonfat lactosfree skim milk products are available as suitable ingredients in weaning foods for children with severe protein calorie malnutrition.

<u>Fish and fish protein concentrates</u>

In many quarters it is being said that man must turn increasingly to the oceans for extra food needed by the world's growing population. It has been questioned how far present fish and other seafood supplies can be increased using the traditional approach in which the fish stocks are exploited by hunting but are not husbanded like farm animals. It may be that fish farming on a major scale will one day be accepted practice.

It has been calculated that 20 million tons of animal protein would be needed to cover the yearly world demand. The potential world harvest of fish using the traditional hunting type methods of exploitation has been estimated at approximately 200-250 million tons of fish corresponding to about 40 million tons of protein.

The world catch of fish in 1963 was 46 million metric tons or one fifth of the available resources. More than a quarter of this was not caught for human market but for conversion into animal feedstuffs. This is a measure of the extent to which current supplies could yield additional food for direct human consumption.

It is worthwhile to consider briefly the pattern of the world fish meal production. In 1963 meal made from oily-fleshed species amounted to 2.5 million tons, whereas meal made from nonoily species, the so-called "white" fish meal, amounted to only 0.5 million tons. By far the greater part of the oily meal was made from fish caught primarily for animal feeding whereas the white fish meal was mainly a by-product of fish caught for the human market. On the whole, it is the oily pelagic species of fish that can be caught most cheaply and in the greatest quantities, so favoring their direct use for manufacturing "fish meal" for animal feeding.

It is ironic that some of the world's most protein-deficient populations are engaged in large scale exportation of protein in the form of fish meal. Outstanding is Peru, which in 1963 produced well over a million tons of meal from one species of oily fish and exported practically all of it. Other examples are Chile, South Africa, and Morocco. In all these countries schemes have been iniated to divert part of this fish supply for direct local human use, in the form of a fish protein concentrate (FPC), but to date none has gone beyond the pilot plant level of production.

The term "fish protein concentrate" is generally accepted as including any stable (defatted) preparation from fish, intended for human consumption, in which the protein is more concentrated than in the original fish. The word "stable" is imprecise but in respect of FPC has been tentatively defined as implying no significant deterioration in 6 to 12 months at room temperature when packed in hermetically sealed containers. Fish meal with a fat content from 3 to 11 percent is much cheaper but less stable than FPC. Anchovy meal f.o.b. Lima costs about 10 U.S. cents per kg., with a protein content of 65 percent, compared with a deodorized, defatted Moroccan FPC with 80 percent protein at 40 cents per kg. For infants and young children only FPC can be used.

There is considerable experience showing that the processing of FPC is facilitated by using very fresh raw material, preferably from white fish. It is also realized that the safety and wholesomeness of FPC may depend on the nature of the fish species and the treatment of the fish before and during processing. Thus it may be necessary to test any concentrate of this type which may be developed before they are recommended for use in human food.

In principle the fresh fish is minced, cooked and pressed. The fresh cakes are extracted preferably with isopropanol. The tentative specifications include zero levels of "harmful" solvent residues. The deodorized and deflavoured FPC has a high nutritional value and is suitable in weaning foods for infants and young children. The amount of FPC suggested for inclusion in human diets should supply 15 grams of protein. At about 80 percent protein content this means about 18 to 20 grams of FPC.

At present a pharmaceutical company in Sweden, Astra, plans to start manufacturing a FPC of good quality on a large scale, 10.000 tons or more, starting during 1970. The problems of its manufacture are not less recalcitrant than those of its widespread introduction in the areas where the need is greatest. In part the problems are rooted in conservative food habits and dietary patterns.

Particular attention must be paid to the acceptability in consumer tests of products containing FPC. It may be found that the addition of FPC to a food, particularly a staple food, may convey no obvious benefits to the consumer and may indeed, as in other instances, increase the difficulties of producing food products of normal quality. Work is required on the functional properties of FPC when used in a number of staple foods intended for the preparation of traditional food products by normal procedure.

Activities concerned with the production and consumption of FPC are recently reported from a few countries, while a few others are considering the matters. Supported by FAO and UNICEF the government of Chile in 1958 set up the first pilot plant in the world to produce FPC for human consumption. Technical and administrative difficulties hampered progress, but eventually

Chile now is producing a FPC which Chilean and foreign research workers have pronounced non-toxic, of high nutritive value, stable, easily digested and assimilated either directly or as a supplement to conventional foods.

As a result of surveys in Chile, protein-rich mixtures containing FPC have been developed and successfully tested on groups of very young and school-age children during the last two years, 1966-1968. Trials in rural communities are now being planned in cooperation with the food industries with a view to using the mixtures in the national feeding programmes of the National Health Service and the School Welfare Board.

In Uruguay there is laboratory production of a powder which is made by drying material produced by the fermentation of ground fish with yeast and sugar. The powder is said to be stable and nutritious. It has been tested successfully in feeding under-nourished children. There are plans for a pilot plant.

In Massava on the Red Sea Coast in northern Ethiopia a modern fish meal factory has been established for the production of fish meal for animal feeding. Studies are in progress about the possibility in using equipment and sources to produce FPC as part of a supplementary mixtures for children and in possible school feeding programs.

An experimental factory for the production of FPC has been established in the United Republic of Tanzania. Attempt will be made there to manufacture a product acceptable to the people of the country. It has been found that FPC made from fresh water fish appear to be more acceptable than those made from marine fish. It is proposed to establish a number of pilot plants on Lake Tanganyika and Victoria to manufacture about 10.000 FPC.

PROTEIN FROM UNCONVENTIONAL SOURCES

1. Oilseed Meals and Protein Concentrates

Approximately 8 million tons of fermented or cooked soy-bean products are consumed annually in the Far East and another 3 million tons of peanuts, coconuts and other oil-seeds are eaten in the world. Almost no use is being made for human feeding of the remaining nearly 90 million tons of oilseeds. The meals left after soybean, peanut, cotton seed, sesame, sunflower, safflower, and coconut processing for the extraction of oil can with proper processing contain 40 to 50 percent good quality protein suited to human consumption and particularly to combination with cereal grains. Because the extracted oil pays part of the cost, these meals are the world's cheapest sources of protein and likely to remain so.

They provide protein at a cost of 0.08 to 0.12 U.S. cents per pound compared with 0.22 to 0.27 for non-fat dry milk and $ 1 to 2 for most other proteins of animal origin. Although available in large quantities in most developing countries, these nutritious and low-cost protein materials are now largely exported, fed to ruminants or wasted as inefficient fertilizes.

The soybean, containing up to 40 % of protein, can be considered as a protein concentrate even without defatting. The protein nutritive value of soybean is among the highest of all proteins of vegetable origin. In comparison with other plant proteins it is unusually high in lysine and is therefore useful as a supplement to the cereals. Its limitation in terms of protein nutritive quality may be primarily a moderate deficiency of methionine.

Soybean milk, produced by aqueos extraction, can be a product of considerable merit in its own right. It has not achieved the popularity it deserves primarily due to the fact that home and village processing are unable to control the critical heat-processing step adequately, and also to the absence of refrigeration which is required to maintain this product safe. Processing on an industrial scale are already in operation, notably a flourishing one in Hongkong.

Defatted, toasted edible soybean meal containing 50 percent or more of protein has been shown to be an excellent source of economical protein in a form suitable as human food. The pre-eminent virtue of these nutritious soybean flours is their low cost, representing probably the greatest value in protein available on today's market. If the present U.S. soybean crop, representing 65 percent of world's crop of that oilseed, were to be processed entirely into such soybean protein concentrates, it could provide 750 million children with a 40-gram ration of high quality protein. Instead it is used in animal feeding, where 80 to 90 percent of protein and calories are lost.

As useful and cheap as defatted, heat-processed soybean concentrates are as protein supplements, they suffer certain limitations. In the first place the appearance, flavor and color remain a compromise among various processing factors. Efficient production of a solvent-processed product reqires capital investment and the installation of ancillary facilities as grain storage, rinsing and drying equipments. Market outlet for oil might again temporarily become a complicating factor.

The potential of protein isolates from soybean and other oilseeds and the slowness of a protein-hungry world to utilize such potential is a challenge to the food industry and the food technologist to prepare more palatable forms. A number of experimental foods have been prepared by filament-spinning techniques to imitate meat and fish products. These developments are pointing the way to entirely new and highly sophisticated foods which may open mass markets for this product.

Meanwhile the interest for soybean cultivation is increasing in the developing countries. A soybean protein concentrate is used in INCAPARINA, a supplementary food commercialized in the Latin American countries. The amount of milk supplied by urban milk schemes in India can be doubled through a process of mixing skimmed milk with a solution of an oilseed protein concentrate. The product is a milk of roughly the same protein and fat content as cow's milk.

The United Republic of Tanzania proposes to promote the production of soybean, peanuts and sunflower with a view to increase the sources of oil-seed protein and to set up a pilot plant to find out whether it is feasible to produce oilseed protein in that country. A local firm in Zambia is investigating the possibility of using peanut and soy flour to make a locally acceptable product. The Ethiopian Government states that because of the shortage of dried skim milk on the world market it is hoped to begin production of mixtures containing imported soybean protein concentrate. The ultimate aim is to replace this with a product made from indigenous cultivated oilseeds, sunflower and soybean. Improved varieties of sunflower seed are being imported into Botswana.

Cottonseed suffers from some drawbacks in spite of the fact that its protein biological quality, limited to some extent by methionine and lysine deficiency, is not markedly inferior to that of soybean. The most serious problem is the ubiquitous and toxic natural polyphenolic pigment of this species - gossypol - whose presence has until recently restricted even the animal feeding use of cottonseed meals almost entirely to ruminants. Wider understanding of the basic mechanism of binding the gossypol to proteins, particularly to the detriment of the lysine content, have resulted in market improvement of cottonseed protein concentrates, many of which are now acceptable for swine and poultry feeding.

Some of these heat-processed gossypol-bound materials are already in use in Latin America, Columbia and Peru for the production of protein-rich cereal food mixtures highly useful as infant weaning foods. A food-grade product of this type has been marketed in the United States for a number of years.

Surveys of possible cottonseed processing in Turkey, Iraq and Pakistan have shown that cottonseed protein concentrate could be produced in these countries. However, the general feeling in all three countries were that cottonseed flour could be hard to get the people to use, particularly hen they were spending their money on it. Production of flour for the armed services and other similar outlets seemed to offer the most practical way to build up a good sized production base which would give the oil industry incentive to produce the best quality material they can.

Cottonseed production is widely distributed in a number of developing countries. New varieties of raw materials and new processes will provide protein feeding components more suitable for human consumption. A remarkable advance in cottonseed protein quality has resulted from a recent breakthrough on the genetic front. Gossypol-free varieties of cottonseed have been developed, from which the characteristic pigment glands are absent. This breeding factor can apparently be introduced into virtually any strain of seed without impairing the fiber quality or desirable agronomic characteristics. These new varieties might be available to growers by 1970.

PEANUT

The third major oilseed resource, peanut, which suffers least of the three from indigenous or naturally occurring deleterious components, has nevertheless recently been exposed to this rather difficult and unsettling experience of aflatoxins. This might be a major reason why peanut meal has achieved little traditional food use. Peanut production, like that of cottonseed, is also more spread about than soybeans, India and several countries of West Africa being the major producers. India alone grows about one third of the world's total crop of 15 million tons.

With means to control the aflatoxin problem at hand, this major protein resource will doubtless achieve wider use for feeding as well as for industrial purpose. Careful selection of peanuts can provide flours of good nutritious quality, highly valuable in a variety of diets, and acceptable as components of low-cost protein-rich foods suitable in a number of developing countries.

In India blends of full-fat soya flour and peanut flour, fortified with lysine and methionine have been controlled in feeding trials over a period of 5½ months in a local boarding home. The effect of daily supplement of 40 g of this protein food on the growth and nutritional status of 40 school children of low-income group families were tested with good results. These blends have also been tried and are as effective as skim milk powder in initiating cure of kwashiorkor in children.

SESAME

Sesame, one of the few seed sources rich in the sulphur-containing amino acid, methionine, is the only oilseed which has decreased in production since the postwar period. Although synthetic methionine has been found a satisfactory solution in the case of a number of methionine-deficient feeds, the use of methionine-rich plant protein sources offers advantages, at least from the point of view that such protein sources will furnish bulk protein and a certain amount of other essential amino acids, as well as methionine. It may also be advantageous to use the protein instead of the free amino acid, so as to make an even release of amino acids in the foodstuffs upon digestion possible. Whatever the merits of introducing proper levels of methionine in the food through the use of methionine-rich products, consideration should be given as well to making use of available raw materials in given countries when this is the case, as a decision may in itself bear a positive economic significance.

In Mexico two methods have been developed to produce protein concentrates from sesame. In the "dry" method part of the oil is first removed by means of a conventional expeller type unit and the remaining high oil meal is then solvent extracted. The protein content is 65 to 70 percent and the protein quality is much higher than concentrates resulting from expression of the seed in regular expellers. The "wet" process with water extraction, iso-electric precipitation and drying is substantially more expensive and results in a protein concentrate with 90 percent protein.

Feeding experiments with chicks comparing the regular sesame meal at high levels, have shown that growth is lower than when using a standard diet, both at the same protein level. When the experimental diet was supplemented with lysine the results obtained were quite close to those of a commercial optimal diet. A considerable part of lysine could be found bound, as a result of heat treatments affecting the materials.

The protein concentrates from sesame have recently been tried out as ingredients of products fed to humans. The results obtained showed that these concentrates may be satisfactorily used for human feeding.

SUNFLOWER SEED

Many oilseeds contain toxic factors which complicate the use of such protein concentrates for human consumption. The sunflower is one of few species whose seeds seem to be comparatively free from antinutritional factors. Sunflower is one of the main oilseeds cultivated in Russia. In Africa, sunflower is cultivated on a small scale in Ethiopia, Tanzania and some other countries.

The amino acid composition of sunflower protein in the form of flour compares favorable with the amino acid requirement pattern for children although it is slightly low in lysine but rich in both methionine and tryptophan. The sunflower has mainly been cultivated due to the excellent quality of the oil. The press-cakes have been used for animal feeding.

An oil mill in Morocco using pre-press solvent (hexane) extraction has produced a substantial quantity of sunflower protein concentrate on a commercial scale. It has been used by FAO and UNICEF in the development of weaning foods so far with unknown results. A similar concentrate has been prepared on a laboratory scale and tested as a component of a vegetable mixture on children in Ethiopia with good results.

COCONUT

Coconut is among the most important oil bearing fruits in the world trade. Producing countries consume some of it as fresh nuts, but the chief products of commerce are copra and the oil of it. The production of copra is declining. In 1956 it was of the order of 3.4 million tons and in 1960 estimate was 3.1 million tons.

The average fat content of copra is 64 percent and of protein 9 percent. Good quantities of coconut are utilized as such in daily dietaries in growing regions. Protein concentrates and protein isolates have been prepared in India and in Philippines and tested in feeding trials on under-nourished children for periods of several months with good improvements in growth and well-being. On the other hand, experience of interference of fibre in coconut with digestibility and nitrogen retention in child feeding has also been reported.

Of economic necessity, all processes to prepare protein concentrates from coconut as well as from all kinds of oil seed are designed to produce oil as the main product and the protein bearing material as adjunct. None of the present proposed processes have been used in commercial preparation of coconut protein concentrates. The material is low in lysine, methionine and threonine compared with egg protein. Screw pressing yields a flour of lower quality than solvent extraction.

Feasibility analysis have been made and given favorable results. It would be possible to prepare edible coconut flour for a price of 10 U.S. cents per kg. A factor of importance is that coconut is available in large quantities in many countries where protein malnutrition is also widely prevalent. It is increasingly recognized that coconut protein concentrates, properly processed, could be used to supplement the diets of infants and children of these areas.

FUTURE SOURCES OF PROTEIN CONCENTRATES

SINGLE-CELL PROTEINS

No major differences exist between the quality of protein from single cells of yeast and bacteria and from other plants and animals. Sufficient information has accumulated to indicate that certain single cell proteins are readily utilized by animals and man. The advantages of microorganisms as sources of protein are their rapid growth and ability to convert cheap energy and nitrogen sources into high-quality protein.

The rate of microbial synthesis of protein far exceeds the rate at which animals synthetize protein. A cow weighing 500 kg when fed by grazing can synthesize 0.5 kg of protein per day whereas 500 kg of microorganisms growing on paraffinic hydrocarbons could synthesize 1.250 kg of protein per day.

Yeasts grown on carbohydrate sources have been used for many years as minor components of animal and human foods, but the strains so far tested have not proved attractive as a bulk component of the human diet. Protein from single-cell organism grown on petroleum products has a special merit of production without agricultural land or products of agriculture. If the microorganisms can be processed to products which will be safe, nutritious, acceptable and within the economic resources of the developing countries, then these could supply a large part of the human protein requirements in these areas because hydrocarbons from petroleum are cheaply and readily available in most parts of the world. Assuming a 50 percent efficiency of conversion, the petroleum products to produce single-cell protein for a million people would amount to a negible 1/10.000th, of the current crude oil production.

Alternatively, 2 million cubic feet of methane, available in enormous quantities in natural gas, is calculated to suffice for producing 10 tons of such protein. There is as yet no final assurance of a safe and acceptable product for human consumption. In France a plant is now being erected with paraffins as substrate and a yearly production of over 16.000 tons (CNRS-BP). The product will only be used for animal feeding. Another major effort utilize the combined research and development resources of the Nestlé company, Switzerland and the Esso Research and Engineering Company based in U.S.A. The pilot plants studies are nearly at the end and plans are finished for the construction of plant for commercial production of a product intended for human use as a protein concentrate.

The products which contain from 40 to 50 percent of protein have been tested for several years on animals with good results. There are borderline values for some essential amino acids but other characteristics such as digestibility and protein quality have shown good values and the product is flavour- and colorless and without toxicity. While final costs cannot be predicted at this time, they can be expected to be within the range of those for defatted soybean concentrate and non-fat dry milk, $ 0.08 to $0.20 per pound of protein concentrate.

Even when production problems are solved, however, these single cell products may encounter the same resistance to incorporation at high levels into human diets as has been observed for food yeast.

On the other hand the developing countries are quite familiar with fermentation processes for making bread, beer, ensete products, and fermented soya products. In Chad in Central Africa a blue algal has been consumed traditionally for a long time.

GREEN LEAVES

Considerable publicity has been given to the fact that green leaves contain protein of relatively good quality. From the pulped leaves a green juice can be expressed and heated quickly to 70°C to coagulate the protein, which, after washing and drying, can be stored as a green-colored meal, with a slight taste of hay and with poor palatability. Moreover, when consumed in larger amount the chlorophyll will color the faeces.

As a source of protein concentrate in child weaning leave protein has a limited interest.

AMINO ACID SUPPLEMENTATION OF FOODS

All proteins are formed from amino acids in varying proportions. Of the eight essential amino acids which are dietary essentials for human nutrition, only lysine, methionine, tryptophan and threonine are likely to be deficient in ordinary plant proteins.

By adding the limiting amino acids to plant proteins, the protein quality can be made comparable to the best animal proteins thus reducing the necessary intake of protein. All cereals are deficient in lysine and a considerable increase in utilization of cereal protein can be achieved by the addition of small amounts of synthetic lysine. The deficiency in most legume or legume-based diets is in methionine and a considerable increase of protein quality might be achieved by methionine supplementation.

At present only lysine and methionine are available at a reasonable price. When a market for tryptophan and threonine is created they might also become available at reasonable prices. If the cost of lysine could be reduced to $1.00 a pound with large scale manufacture, the lysine supplementation of the wheat would cost only 5 U.S. cents per kg protein that would be upgraded. With 10 percent protein in wheat the price would be 0.5 cent per kg wheat. A reduce in the world market price for lysine can be expected due to a new inexpensive way to synthetize lysine, recently developed at the Dutch State Mines. The present price of feed grade methionine might be slightly less than $1.00 a pound.

When the required materials are available at low cost in a developing country, a suitable enrichment of cereal flours would be the combination of methionine or lysine additions with small quantities of legume or oilseed. This will improve the quality of the protein in the cereal flour and will provide some additional protein. The nutritional result is similar to that when non-fat dry skim milk is added to a cereal flour.

COMMERCIAL HIGH PROTEIN FOODS

A number of commercial high protein foods with a protein content from 20 to 25 percent are available in the developing countries of the world. Many of these products have been processed for child feeding and many of them could also be used as weaning foods. A list of some of the more commonly used is attached.

NO. 1

SUPPLEMENTARY MIXTURE NO. 20, PRODUCED BY CNU, ADDIS ABABA, ETHIOPIA

Wheat flour	57%
Split chick pea flour	10%
Soya protein concentrate	18%
Non-fat dry milk	5%
Sugar	8%
Salt, iodized	2%

Protein content: 23%

Price: $ 0.32 per kg

NO. 2

SUPERAMINE, PRODUCED BY S.N. SEMPAL, ALGER, ALGERIA

Cereals	28%
Chick peas	57%
Non-fat dry milk	10%
Sugar	5%

Protein content: 20%

Calorie content: 387 per 100 g

Price: Unknown

NO. 3

SUPRO, PRODUCED BY SUPRO LABORATORIES LTD., UK, OXFAM OF UK., AND AFCOT OF NAIROBI, KENYA

Barley flour	50%
Torula yeast	25%
Non-fat dry milk	17.5%
Salt and flavor	7.5%

Protein content: 23.5%

PER: 1.77

Price: $ 0.32 per kg

US. FOOD FOR PEACE/UNICEF CSM-MIXTURE

Maize flour, precooked	68%
Defatted soy flour	25%
Non-fat dry milk	5%
Salts, vitamins	2%

Protein content: 20%
Calorie content: 360 per 100 g
PER: as casein
Price: Unknown

NO. 5

AFRICA BASIC FOOD COMPANY UGANDA, Dr. W. Harrison

1. PORRIDGE MIX FOR SALES TO SCHOOLS

Maize flour	60%
Full-fat soy flour	20%
Sugar	20%

Protein content: 13%
Price: $ 0.17 per kg

2. PORRIDGE MIX FOR SALE TO SHOPS

Maize flour	43%
Full-fat soy flour	42%
Sugar	15%

Protein content: 21%
Price: $ 0.33 per kg

NO. 6

VEGETABLE MIX, PRODUCED BY SENTENAC, DAKAR, SENEGAL

Flour on sorghum or millet	20%
Beans	50%
Non-fat dry milk	20%
Sugar	10%

Protein content: 22%
Price: $ 0.39 per kg

Table 1

AMINO ACID COMPOSITION OF SOME SELECTED ANIMAL PROTEIN SOURCES

mg/g of Total Nitrogen

Amino Acids	Hen's egg	Beef	Meat meal	Pork	Cow's milk	Non-fat milk concentrate	Fish all types	Fish protein concentrate
Isoleucine	393	301	179	356	295	330	299	293
Leucine	551	507	374	563	596	619	480	473
Lysine	436	556	328	625	487	453	569	602
Methionine	210	169	89	188	157	161	179	174
Cystine	152	80	49	88	51	59	73	-
Phenylalanine	353	275	213	288	336	303	245	261
Tyrosine	260	225	140	247	297	311	229	204
Threonine	320	287	193	319	278	263	286	265
Tryptophan	93	70	55	85	88	89	70	81
Valine	428	313	278	324	446	440	315	430
Protein Score	100	80	68	81	66	69	80	-
First limiting amino acid		Meth + Cys	Meth + Cys	Meth + Cys	Meth + Cys	Meth + Cys	Meth + Cys	

Table 2

Amino Acid Composition of Some Selected Vegetable Proteins.
Amino Acids as mg per grams of Total Nitrogen

Amino Acid	Whole egg	Peanut	Soy bean protein concentrate	Sun-flower protein concentrate	Nug protein concentrate	Cotton seed protein concentrate	Sesame meal	Peanut meal
Isoleucine	393	211	302	302	292	209	230	218
Leucine	551	400	474	434	408	357	403	413
Lysine	436	221	412	246	269	299	242	211
Methionine	210	71	97	161	126	95	145	74
Cystine	152	78	114	120	173	182	31	135
Phenylalanine	358	311	330	311	304	325	247	357
Tyrosine	260	244	250	179	174	198	201	264
Threonine	320	163	256	256	220	209	202	171
Tryptophan	93	65	75	90	63	58	57	68
Valine	428	261	325	377	351	272	284	243
Limiting Amino Acid		Meth	Meth	Lys	Lys	Meth	Meth +Cys	Meth
Protein[X] Score (A/E)		56	61	70	88	64	80	56

[X]Protein score according to FAO Nutr. Meet. Rep. Ser. No.37. Rome 1965.