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PRESENT STATUS AND RECENT DEVELOPMENTS RELATING TO SOME CLASSES OF PROTECTIVE FOODS WITH INDICATIONS FOR FUTURE LINES OF RESEARCH AND APPLICATION

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The present contribution deals with a class of products which deserve an important place in the national programmes bearing on the improvement of nutrition of the people and on which a large amount of scientific and technological work, along with nutritional evaluation, has been done. Some of these have already proved useful on a fairly large scale and offer scope for further expanded production and utilisation. There are others which are promising and deserve to be pursued. There are, at the same time, other lines which are also possible and on which more work should be done. Considering the widespread prevalence of malnutrition—especially in respect of proteins—programmes relating to such products should be viewed not only in terms of national needs but also in relation to the requirements of vast areas inhabited by more than half the population of the world. There is a place for every class of product and every line of approach; and all such efforts should be regarded as being complementary to each other rather than as rivals in programmes of future development.

Different approaches to the food problem

There are, at present, at least three main lines of approach to the food problem, especially for developing regions, like India, with rather restricted industrial potential, and large and fast growing population, and low *per capita* availability of land for agricultural production.

There is, firstly, the agricultural programme which is deservedly important and occupies a high place in any national planning. This includes all categories of products, including protective foods, but the largest amount of emphasis has been on the production of foodgrains. The reasons for this are well known. The need for a more selective approach in favour of more balanced and nutritious foods has been often emphasised and generally recognized. The producer is, however, largely influenced by economic considerations and given the choice, he would produce only such crops and products as would bring the largest monetary return. Even the producers of milk, meat, eggs and fish retain very little for their own consumption because of their need for food grains and various other types of commodites.

The second approach would be on the basis of nutritional requirement, and planning on that basis would be the ideal one in the long range interests of the people. The needs have been indicated, but in most areas, the production has not kept pace with it. The high prices of different classes of natural protective foods have taken them beyond the reach of the low-income groups who need them most. In certain parts of the world, with small populations and mechanised production over large areas, the cost has been reduced to a minimum, but in countries like India which have a different set of conditions, this has not, so far, been possible. Judging from the trends, and considering the present rate of increase in population, we should be happy if the availability of protective foods, on *per capita* basis, is maintained at least at the present level during the next decade.

The third approach is the technological one which has to start with a recognition of the availability of food materials under the existing conditions. The objects are to aim at better conservation of what is available and can be easily produced; at better processing to avoid waste and to conserve the essential nutrients; to produce different classes of concentrated and protective foods out of raw materials which are already available, including those which have not, so far, found adequate application for meeting human requirement. The object is to produce as far as possible, different classes of products

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which will come within reach of different sections of the people and which can be used with benefits, without seriously affecting the existing dietary patterns. In such a programme, nutritional evaluation and consumer acceptability are recognized as being very important.

Importance of food industries

All the three types of approach are really interdependent. Agricultural production and animal husbandry are the basic necessities and their orientation for production of more nutritious foods or their conservation, efficient utilisation and enrichment for better nutrition should all go side by side. In a country like India, with large population and limited resources, Government agencies, even with foreign aid and the help of U.N. and other International Organisations can only show the way. The ultimate development should come through the initiative and enterprise of the people of the country. Unfortunately, food industries occupy a very low place in regions like India, whereas in countries like U.S.A., which are also highly developed in other fields, food industries occupy the highest place and are highly influential even in orienting for the right agricultural production to meet their needs. In U.S.A., the food industries account for a turn over of about 60 thousand million dollars, whereas, the next important group of industries (the automobiles) accounts for only about 35 thousand million dollars. Lack of adequate emphasis on food industries in national planning and want of leadership from industrialists, with the necessary resources and vision, is a great handicap to most of the countries which need them badly. Consequent on this, utilization of scientific and technological research is extremely slow. While a few lines have already found some application, quite a number of others still remain unutilised. This is a matter of growing concern to leading thinkers in different parts of the world.

Changes in dietary pattern not easy

There have been several references, at national and international levels, to the need for changes in the dietary patterns so as to reduce the consumption of food grains, root crops and other low grade foods which is abnormally high and in many areas to replace them, at least partially, with more nutritious foods. This is a highly desirable change and every effort should be made to pursue it, both by educative work and organisation of larger production at less cost. At the same time, it has to be recognised that the present dietary patterns in most areas are based, to a large extent, on the availability of certain classes of foods and the feasibility of producing them to the largest possible extent in the areas where they are being consumed. Thus, a country like India can be divided into broad groups where rice, wheat, millets and root crops (especially tapioca) are predominantly consumed. It would not be easy to replace one major crop with another as each region is best suited for raising the type of crops which are now consumed. Thus, the areas under dry cultivation (which are the chief millet producers) cannot produce rice; rice growing areas cannot produce wheat. There are, of course, some changes which are being introduced through nutritional education and improvement in economic conditions, but this will apply to only a small section of the population. Even the richer classes do not always change over to more nutritious foods.

If one can picture the major changes that have taken place in a country like India during the past 50 years or more, it will be found to be chiefly in the consumption of beverages like coffee, tea and to a less extent of cocoa; aerated waters and other classes of soft drinks as also alcoholic beverages and liquors; more extended use of potato, onion etc., increased consumption of bread, biscuits, breakfast cereals and confectionery—many of which are linked with a more urbanised type of life. Such changes have not materially affected the nutritional status of the the people. The present generation cannot claim to be better nourished than its ancestors who led a predominantly rural life and were less exposed to various stresses and strains of modern life. The increased expectation of life in many of the developing countries is more due to better control over disease than to any distinct improvement in the nutritional status of the people.

The human being is no doubt adaptable and can easily develop new tastes with change of environments. Considering, however, that the

majority of people continue to live in the same environment, we have to recognise that the deficiencies arising from any dietary pattern will continue to exist; that over considerable areas in countries like India, the *per capita* deficiency of protein will be of the order of 25-30 gms; of vitamin A to the extent of 1,000-1,500 units; of B_1 to the extent of 1-2 mg.; of calcium to the extent of 150-200 mg. and so forth; that the adverse effects will be most seen in the case of vulnerable groups and especially the pre-school age children. It would also be generally agreed that if the extra quantity can be made available to meet the needs of at least a small section of the population, it will represent an useful beginning. That will also pave the way for further development, with benefit to increasingly larger sections of the people.

With such a background, we may now review some of the recent contributions based on food science and technology (combined with nutritional evaluation) with particular reference to the progress made and scope for extension and application for the betterment of the nutrition of the people.

Infant foods and other products based on buffalo milk

The valuable work that has been done by dairy scientists, combined with Government programmes supported by International organisations like the UNICEF and also from other national and other charitable bodies has been of great help both in India and in several other countries in improving the availability of clean and standard fluid milk especially in several urban areas. The baby food comes, however, in a somewhat different category and has to conform to a composition which will make a fair approach to human milk and reach all sections of people, including those in rural areas, in dry and well-packed condition. One of the major difficulties, in many parts of countries like India, has long been the lack of adequate and steady supply of good quality milk and processing facilities for the production of clean, hygienic and stable products, conforming to certain established standards and with consumer appeal. The only raw material that is available, in fair quantities in several of the areas, is buffalo milk which was till recently considered to be unsuitable for production of baby foods. The basic researches, as also the pilot plant studies, carried out by the Central Food Technological Research Institute (in association with the National Research Development Corporation) showed that if certain precautions are taken at the stage of collection and certain treatments and processing conditions are followed, the buffalo milk can be converted into a baby food with nearly as much facility as with cow's milk. The buffalo milk also possesses the added advantage that the surplus butter fat can be taken out and used for the production of butter or *ghee* and bring additional return. After some years of systematic work, involving comparative feeding trials in collaboration with child health institutions, the first production unit was set up by the Kaira District Milk Producers' Union at Anand. This paved the way for other manufacturing firms also to follow. At the present time, about half of India's requirement of baby food is being produced out of buffalo milk. This is an important development which can also be applied with benefit by several other countries like Egypt where the chief milch animal is the buffalo.

The possibility of setting up a number of small units, with capacities of even half to one ton per day, which could work on a common formulation and with a centralised Government control has already been repeatedly suggested for the consideration of the Government authorities. This type of procedure is well known and adopted in some of the western countries and would be an effective way in which better use can be made for the surplus milk available in several areas in India none of which can afford to start the manufacture of any new brand of baby food, with a different proprietary name, and market it on independent basis. On the other hand, if a start can be made in the proposed manner and if there is a steady guaranteed offtake, more of milk production from the same areas can be expected. Unfortunately, this step has not yet been taken, with the result that difficulties still continue to exist. There is need for a bolder policy and its execution on the basis of scientific advice. The present development of the industry was possible because of scientific research. Further

programme for development as now advocated by the Central Food Technological Research Institute, Mysore, and which has also been supported by other leading colleagues in the country, would deserve consideration and early implementation can not only help to meet the entire requirement but also lead to further production of milk which can be utilised with benefit to the people in a variety of other ways as well.

Taken as a whole, buffalo milk proteins have about the same nutritive value as those present in cow's milk, but their physical properties are somewhat different from those of the latter. The buffalo milk protein is more sensitive to heat and certain other treatments. It also forms a harder type of curd, the property of which affects certain types of processing and also preparation of products like cheese. All these properties are interlinked and more of scientific and technological work is needed to further improve on the properties of buffalo milk proteins so as to render them more adaptable for various other types of uses. In countries like India, there is a large potential demand for cheese which is a highly concentrated form of food, with consumer appeal. If buffalo milk can be suitably adapted for production of good cheddar cheese, it will make an important advance that will be of benefit not only to India but also to several other parts of the world. Use of the highly active vegetable rennet from fig latex has shown the way for producing a good cheese that will also help to overcome the objection from vegetarian section of the users. This work has also been done by the Central Food Technological Research Institute, Mysore in collaboration with the National Dairy Research Institute, Bangalore. Vegetable rennet has the added advantage in that it can be used for making products with similar compositions from vegetable milks and such other emulsions. This line of work, as also other methods of processing vegetable proteins for making products like animal milk cheese are now being actively pursued in India as also in other parts of the world.

Products based on edible groundnut flour

In this field the largest amount of work has been done in India which has also led to practical application on a fairly big scale. Besides, this offers scope for further quick development. Groundnut is the most important oilseed of India and it is not too much to expect that the country will soon reach a production level of about 8 million tons per annum, which can be still further increased if there is an assured offtake. Similar facilities also exist in many other parts of the world where groundnut is the most important oilseed.

The possibility of producing and utilising edible quality groundnut meal, which contains about 50 per cent protein of fair quality, was envisaged shortly after the second world war and a committee of nutritionists and biochemists in India was appointed to go into it. After the committee showed the possibilities, a large amount of scientific and technological work had to be done, during subsequent years, to standardise the conditions and to evolve methods for utilising the product. It can now be stated that production of edible quality groundnut flour, conforming to the prescribed specifications and with a fairly good keeping quality, is an accomplished success and that the production can be easily expanded, with simple equipment which can be easily fabricated in most countries. This was rendered possible not only through concerted efforts of a large number of workers but also through generous support from various national and international agencies which have appreciated the value of the work done in this country.

Aflatoxin and its elimination: During the past two years, there has been a large amount of interest and some apprehension in respect of the possible harmful effect of the toxin (*Aflatoxin*) produced by infection of groundnut with the fungus *Aspergillus flavus* under certain abnormal conditions. While further studies are still going on, it is fairly clear from the results so far obtained that (*i*) the infection by *Aspergillus flavus*, resulting in the production of the toxin at a harmful level, is only occasionally encountered; (*ii*) if the groundnut kernels are carefully selected so as to eliminate the infected kernels, as is already the practice followed in the preparation of edible groundnut flour, there is no risk of any hazard through the use of the product as now produced

in India. It may also be noted that, while the toxin is known to be harmful, especially to young poultry, there is yet no evidence of its being harmful to man or to the other farm animals. This is the conclusion reached by the British group of workers who have made an intensive study of the subject. While there may be need for periodical check to confirm the absence of the toxin, the procedure already followed for the production of edible quality groundnut flour, is along sound scientific lines and there is no need for any apprehension in respect of safety in the use of the product. This is also supported by the experience of the past ten years during which several tons of the product have been produced and consumed in various forms throughout the country. There has not so far been even a single complaint of any ill-effect through the use of edible quality groundnut flour, or any of the products prepared out of it, for human consumption.

Indian multipurpose food: Among the products based on the use of the edible quality groundnut flour, multipurpose food (MPF) has, so far, been the most successful in India. The product contains 75 per cent of groundnut flour while the remaining 25 per cent is made of roasted Bengal-gram flour, besides vitamins, minerals, and spices or other flavouring. It has a pleasing taste and flavour and has found acceptance wherever it has been tried. The extensive mass of scientific data which have been collected by different groups of workers would show that the product has useful supplementary value and can produce beneficial results even at levels of 25g. or less per day. This is a cheap product, now available at Rs 1.34 per kg. (for bulk purchase in large tin packs and inclusive of transport charges) and will come within easy reach of all sections of the population. The spiced formulation, which is most popular, has a very good keeping quality and does not develop any rancidity or other off-flavour, even after 18 months of storage in tin containers. Starting with small beginnings (in which the country received a substantial amount of assistance and support from the American Meals for Millions Organisation and also its national counterpart, the Indian Meals for Millions Association of India, under the Presidentship of Dr P. S. Deshmukh), the present annual production is about 1,500 tons. The demand for the product from all sections of people is steadily increasing, though till this date, it has not been advertised or marketed through trade channels. With adequate publicity and sales promotion drive, together with proper quality control, the production can be easily stepped up at least ten-fold in the course of the next few years. The UNICEF has donated equipment for two plants, each with a capacity of 10 tons per day, for the production of edible groundnut flour. The Indian Central Government, through the Department of Food, has also made a substantial provision for organising production and in the popularisation of the use of this product in different parts of the country.

At the present time, the largest single buyer of the product is the Government of Madras, who are purchasing the major part of the production from the Coimbatore plant for use in connection with the mid-day school-feeding programmes in that State. During the first year, the product was used as a supplement for the mid-day meals of about 250,000 children. During the second year, it was stepped up to meet the requirements of about 700,000 children. During the third year the demand has been increased to meet the requirements of over a million children. The pioneering effort of the Madras State has already attracted the attention of other States and when the present plans of the Central Food Department are implemented, it should not be difficult to have similar programmes in several other states in the country. The large number of enquiries that have been received from all sections of the people in different parts of India and also from several other countries, would show that there is a large potential offtake for the product through the usual trade channels. The rate of expansion in the production and consumption will depend, to a large extent, on the association of private enterprise, with suitable Government control for the maintenance of quality of the product.

There have been repeated suggestions that the name of the product should be changed. While the product used for Government distribution may continue for some time under the same name, it may be left open to the industry

to introduce proprietary brands with attractive names and some permissible modifications in the formulations. Whatever be the policy in this direction, there will be need for continued control over the quality of the product. There has not, so far, been a single complaint of any ill-effect produced through the use of this product and this tradition started through the efforts of the CFTRI should be maintained in the years to come.

Nutro-biscuits: The formulation which was first developed by the CFTRI contained about 30 per cent of the edible quality groundnut flour and was given the name of Nutro-biscuits. It had a very good start with an initial offtake of about 50 tons for use in distress-affected areas of India with the assistance from the Prime Minister's relief fund. The American Meals for Millions organisation and also the Indian affiliate have been taking keen interest in the promotion of the product and it is now being produced by one of the leading biscuit manufacturing firms in the country. The biscuit has generally found favour and, with suitable advertisement in respect of its nutritive value, it should find increasingly large demand. If so required, the formulation can be modified and different flavouring substances and other desirable components incorporated to meet different types of consumer demand. The production of such a class of enriched biscuits, which are both tasty and nutritious, can be stimulated not only by a steady offtake by the Defence Services but also through the introduction of legislation by the Government that certain class of biscuits should contain at least 15 per cent protein. This is a type of positive step which the Government, interested as it is, in the welfare of the people, can take and it will automatically lead to the increased use of groundnut flour or other similar protein-rich materials by the biscuit industry in the country. The material required for enrichment should, of course, be made easily available at reasonable price to the biscuit manufacturers by organising production in different parts of the country, instead of having to be transported over long distances as is now the case.

Enriched wheat atta: Residual *atta* as now produced by flour mills is a product of somewhat variable quality depending on the variety of wheat used for the milling. The average specimen produced out of low-grade wheats is not of high quality and is deficient in protein. It has been shown that the nutritive value of residual *atta* can be improved through incorporation of 5-10 per cent of edible quality groundnut flour without in any way affecting the keeping quality or consumer appeal. It is well known that wheat and groundnut proteins supplement each other. The Food Department in India is taking steps to pursue this programme. Admixture of a small percentage of wheat flour, along with residual *atta*, in addition to supplementation with groundnut flour will produce a still higher class of product which would be superior to the conventional *chakki* (hand-pounded) *atta* and would be readily acceptable to even the fastidious consumers. All the basic research in this field has already been done. What is now needed is an organised production, with adequate quality control.

Whole wheat flour is also being produced, on a fair scale, with motor driven units in certain areas. This class of product can be enriched with benefit to the consumer. In view of its better nutritive value, the Defence Ministry can make it a policy to use only enriched *atta* for its personnel.

Paushtik atta: Formulation was evolved by the CFTRI with the object of extending the available supply of wheat without affecting the nutritional value or consumer acceptability. Systematic trials carried out with several tons of the product in Uttar Pradesh have shown that the incorporation of 17 per cent of edible quality tapioca flour (for the production of which the conditions have been fully standardised) and 8 per cent of edible quality groundnut flour, to wheat *atta*, to maintain the desired protein level, would yield a product which a good section of consumers would readily accept and buy even in preference to the usual type of whole wheat *atta*. The consumer trials were carried out by the Planning, Action and Research Institute, Lucknow and was a careful and exhaustive study showing that the product had definite practical possibilities with considerable saving to the country.

The above programme, if pursued, with

adequate Government control, will have far-reaching possibilities in extending the available wheat supplies in the country. India is still importing large quantities of wheat and even if there is a slight reduction in the imports, through the introduction of such a product, it will be of considerable moral significance, and show the way for future extension. It should eventually be the object to progressively increase the protein content to an even higher level than is present in wheat *atta*. With adequate co-operation from the Agricultural Departments, tapioca can be produced in most parts of the country without encroaching on the production of other major crops. The tuber is a heavy yielder, can be processed into a clean, white attractive flour and incorporated in the blend. All the basic work in this field has already been done and what is now needed is a planned developmental programme. It may be started in at least one state in the country (Uttar Pradesh or Bihar) in the first instance. A large amount of organisation, hard work and distribution in an effective manner in the fair price shops and other agencies is needed. The scientists and technologists have shown the way, and it is for the concerned organizations to follow up the programme to a logical conclusion.

Tapioca macaroni: Tapioca which has a very low protein content (about 1 per cent) can be suitably enriched with groundnut flour and processed into a product with the shape and size of rice or any other product which would appeal to the consumer. Several hundred tons of a product with the name tapioca macaroni and containing higher percentage of protein and more of calcium than rice were made. The extensive trials carried out by the CFTRI, in Kerala during the late fifties, showed that the product was generally acceptable to a large section of the people. The trials carried out by the State Health authorities showed that the product promoted better growth than rice. Plans for setting up a 20-ton plant in Kerala had been approved by the Government of that State, but subsequently other difficulties including shortage of foreign exchange came in the way with the result that the large-scale production was deferred for some time.

Indian contribution in this field has attracted a large amount of attention in other parts of the world and there are already 3 or 4 fair-sized plants operating in some of the far eastern countries. The U.N. organisations and also some leading manufacturing concerns in Europe and America are interested in this development. The concept of enriching a low grade food with a cheap protein-rich material and then processing it to meet the requirements of the consumer is now recognized as being, not only fundamentally sound, but also realistic and feasible. Such products can also be supplemented with minerals and vitamins so as to further improve the quality. Consumption of such products, even as a part of the diet, will help to reduce some of the dietary deficiencies besides reducing the pressure on the requirements of staple foods *viz.*, rice and wheat.

Enriched wheat macaroni and weaning foods: There is already a ready market in India and many other countries of the region for different types of paste goods based on wheat semolina. This market can be easily expanded if some production units similar to those in the west can be set up. Macaroni products have the advantage of being easy to cook and to consume in a variety of ways. Even rice eaters have been using some paste goods and it should not be difficult to create an increased offtake. In addition to wheat semolina, other types of raw materials including millets can be used for similar processing. All such products have the facility of being easy to cook and to serve. They are also easily digested.

Among the new classes of products, special mention may be made of the enriched wheat macaroni with a protein content of 18-20 per cent through incorporation of edible quality groundnut flour. There are also other formulations with similar protein content in which protein-rich materials like the protein isolate, casein, milk powder etc., along with added minerals and vitamins have been used. Such products, which can be cooked in a variety of ways and which can be easily blended with other food preparations would make excellent weaning foods. This class of products can be produced on a large scale, in a clean, hygienic manner and therefore offer scope for quick industrial development. The immediate

potential demand may be placed at a few thousand tons with scope for further expansion.

Such products can also be used by other age groups even for regular consumption. They will be useful in hospitals and as invalid and convalescent foods. The Defence Services can also make use of such foods. Being partially pre-cooked products, they can be easily cooked in a few minutes even at high altitudes. They will be more nourishing than the usual cereal diets.

There are thus several classes of products with scope for substantial offtake, which can be produced through enrichment with edible groundnut flour. While research in such lines should continue, there is scope for the Government organizations and leaders of industry to make early use of the work that has already been done and of the possibilities that have been demonstrated. Once a beginning is made, improvements are always possible, and there will be ample scope for developing further new classes of products with appeal to different types of consumers. A major handicap at the present time is the lack of experience—rather than want of enterprise on the part of the industry in many of the countries. This can be overcome only by making some beginning with encouragement and assistance from the Government. A large amount of educative work is also needed and, in this programme, there is need for collaborative approach on the part of all the Government agencies—at the Centre and in the States—that are concerned with food and nutrition. If a country like India can produce and consume about 30,000 tons of this class of products per annum by the end of the Third Plan period, as now envisaged by some of the authorities, it will be a good start that may also gather further momentum in the years to come.

Products based on groundnut protein isolate

This group of products is representative of a class which is steadily gaining in importance and on which a large amount of work is now being done by research groups and industrial organizations in other parts of the world. Such products have the advantage of high concentration, freedom from interfering substances, facility of solubilisation and consequent ease of administration and assimilation and also several other features with consumer appeal. A large part of the work so far done in other parts of the world relates to the use of soya protein, whereas the Indian effort carried out at the CFTRI has been mainly directed towards the use of protein isolates from groundnut, which is the most important oilseed of India and many other countries of the world.

The Indian work on the production of protein isolates from vegetable materials was started, during the early thirties, at Bangalore and was largely directed towards industrial uses like production of plywood adhesives, plastics, etc. The programme did not, however, make much headway partly because of the ready availability of milk casein which makes a stronger adhesive and partly because of the introduction of synthetic resins which have still better binding properties and impart better resistance to penetration of water.

During the fifties, a large amount of work was done in India under the auspices of the Indian Council of Medical Research and also under other auspices to study the use of edible quality groundnut flour supplied by the CFTRI under the name of low cost protein food, both by itself and also with other combinations for the treatment of protein malnutrition. The results showed that while the product was generally useful, it was not so effective as some other formulations and especially as compared with skim milk powder. It was also reported that there was some difficulty in the administration and assimilation of the product which contained about 50 per cent of the weight in the form of non-essential constituents such as carbohydrates (including fibre) and also about 8 per cent of oil. Taken on the whole, it was felt that some of the other formulations were better for the treatment of *Kwashiorkor*.

In view of the above observations and with the background of the earlier experience in the preparation of the protein, it was felt that the isolated protein, which would be comparatively pure and highly concentrated, may be therapeutically more useful than the flour itself. Following this, a large amount of scientific and technological work was done at the CFTRI leading to the development of elegant methods for the production of the protein isolate, both from the edible quality meal and from the whole ground-

nut kernel. The latter process showed the possibility of obtaining a high yield of oil (about 95 per cent) of refined quality, together with a yield of 23 per cent protein (of about 95 per cent purity), besides starch and other fractions. These observations which showed the possibility of a new line of approach, without the use of hydrocarbon solvents, were extended to pilot-plant studies which also revealed the commercial possibilities of producing the protein isolate as a valuable by-product along with oil. The process has now been taken up by a leading industrial concern in the country which is setting up a plant for production, on a large scale, in association with the National Research Development Corporation.

A large amount of basic work was also done on the quality of the isolated protein. It was established that it is practically of the same order as that of the protein present in the whole kernel or the edible flour. Systematic trials carried out at Mysore, and also by other colleagues at Hyderabad and Vellore showed that the isolated protein is well tolerated and easily assimilated by young children and that its usefulness in the treatment of *Kwashiorkor* is enhanced by admixture with 33 per cent milk powder. The trials which were carried out, for fairly long periods at those centres, showed that the groundnut protein-skim milk powder formulation is, for practical purposes, as effective in the treatment of *Kwashiorkor* as skim milk powder alone; that it has also the advantage that diarrhoea is arrested in a shorter time than during experiments with skim milk powder alone. Other formulations based on the use of blends of isolated proteins (groundnut protein isolate as the major component) and with added essential amino acids, especially lysine and methionine, produced even better results. The results showed that, as contrasted with the much larger quantities required for the earlier treatments, only 30 g. of the concentrated product per day were sufficient for the treatment of even advanced cases of *Kwashiorkor*. Supplementation with potassium, calcium and vitamins (especially A and B_1) added to the value, covered associated deficiencies and helped in quicker recovery. The formulations based on protein isolates have also the added advantage that they keep well in spray-dried forms with some added starch and can find regular use in hospitals and by medical practitioners.

It is generally recognized that, for every case of *Kwashiorkor* that is diagnosed and taken up for treatment, there are very large numbers of border-line cases living in similar environments and subjected to similar dietary deficiencies which can also benefit through the regular use of such formulations as dietary supplements.

During the past few years, a large amount of further intensive work has been done by CFTRI, not only for standardizing the conditions for the large-scale production of the protein isolate, but also its solubilisation and subsequent processing with suitable combinations as roller- or spray-dried products for use in a variety of ways.

It may also be of interest to mention that the protein efficiency ratios (PER) of the products as determined by rat experiments, do not always bear quantitative relationship to the therapeutic efficiency in the case of human subjects. The different formulations based on groundnut protein isolate have a PER ranging from 2.0 to 2.6 depending on the nature of the added components, while milk protein has a PER of about 3.0. In spite of this difference, the therapeutic response has been almost the same in all the cases. This may be partly due to the somewhat lower requirement of the human subjects and partly also because of the quantity of protein administered, which, together with the other components of the diet, provided the required quantities of the different essential amino acids.

During recent years, researches in some of the western countries have been directed towards the use of protein isolate for the enrichment of different classes of foods for production of vegetable cheese, meat-like products, incorporation in sausage formulations, etc., which conform to the dietary patterns of those countries. In addition to dealing with some of these aspects, the Indian work has also been extended towards the production of formulations corresponding to that of skim milk and whole milk powder so as to facilitate use in the dietary of the vulnerable groups and especially the pre-school age children. The isolate has also been used for the production

of superior qualities of paste goods containing 20 or more per cent protein. These can be used either as such or in combination with other foods as desired by the users. A large amount of nutritional studies and other related researches have been carried out with such products by the CFTRI and have been reported to the Protein Advisory Group of the FAO/WHO/UNICEF and published in the form of several research papers both in India and abroad. The work done in India, in this field has attracted a large amount of attention in other countries and programmes are now under consideration for trials in collaboration with colleagues in different parts of the world. These should eventually lead to the establishment of production units in different countries through their national efforts and also with International collaboration.

The isolated protein has also other uses, such as in the enrichment of toffees and chocolates, ice-cream mixtures, biscuits and confectionery, etc. Protein enrichment of all such food products will help to increase protein intake and thus improve the nutritional status of the people. If the value of such products is made known, they can be successfully marketed on the basis of consumer appeal as is now being done in other countries. There are vast possibilities for commercial development in the above and other lines. It may also be stated that the isolate which will be clean, concentrated and practically free from oil can be sold at a price which would not be proportionally more than that for the edible flour on equivalent protein basis.

The following particulars relate to some of the products with which nutritional and other studies have already been carried out at the CFTRI:

Product I. This is a spray-dried product incorporating groundnut protein isolate, dextrimaltose and a small percentage of skim milk powder. It contains about 36 per cent protein, which is about the same as that of skim milk powder. The PER of this product is rated at a minimum of 2.3, though some batches have given higher values. This product is fairly easily dispersible in water. Although it requires no cooking, it can be heated with water and brought to boil, or dispersed in boiling water as desired. It can also be incorporated with a variety of other food products and used by all age groups. The object of making such a product is to economise on the use of milk powder. Similar or closely allied formulations have been used for the treatment of *Kwashiorkor* and the response has been practically the same as that with skim milk powder. The therapeutic response has been generally more favourable than that suggested by the PER, as determined by rat experiments.

Product II. This is similar to the above with the difference that it contains added fat (M.P. 37°C) to correspond to that in baby food formulations based on milk. The PER is the same as that of Product I.

Product III. Spray-dried formulations based on coconut honey (65-70°brix concentrate of coconut water from fresh coconut and obtained in the Krauss Maffei-process) groundnut protein and skim milk powder. This product contains 36 per cent protein. The PER as obtained for some of the earlier batches was fairly high, but to be on the safe side, it may be rated at a minimum value of 2.3.

Product IV. Roller-dried cereal preparations based on rice, coconut honey, groundnut protein and skim milk powder: This is a very tasty product in the form of flakes with good keeping quality and containing 26 per cent protein. The PER of the protein is 2.1. This product can be prepared very easily. It makes a very tasty porridge for weaned children. Other age groups can also benefit by the use of such a product.

The above products have already been made on a pilot-plant scale, and it should not be difficult to supply a few hundred kilograms of each for further field studies, consumer acceptability and other types of market research leading to large-scale production by national and international organizations and by industry in different parts of the world. They should also be regarded as being representative of a large class of such products with similar or modified formulations.

Protein hydrolysates of vegetable origin

While the protein hydrolysates based on animal proteins are well-known and some of those have

long been on the market, the hydrolysates by themselves are somewhat bitter but they can be made palatable by the addition of malt extract and other sweetening agents, and rendered more acceptable and nutritious through addition of flavouring substances, minerals and vitamins. More recently, preparations based on hydrolysed groundnut protein have also come on the market. Systematic work done in India has helped to standardize the conditions for the hydrolysis of blends of protein or protein-rich meals, (*e.g.*, groundnut and sesame) so as to obtain composite products with a better admixture of essential amino acids. Further quantities of essential amino acids can also be added to such formulations. These products have the facility of easy dispersion in water and quick absorption and utilization by the body. Because of the elaborate processing methods involved, these preparations are generally expensive and beyond the reach of the low-income groups. There is, however, a demand for such class of products and if the cost can be further reduced the offtake can be easily increased.

The processing methods adopted in practice, such as enzyme hydrolysis, followed by essential steps like extraction, concentration and drying even when carried out under the best possible conditions generally result in some destruction of certain essential amino acids and the consequent reduction in the over-all protein value. With the necessary precautions, this can be reduced to a minimum. It may be mentioned, at the same time, that in the majority of cases, the unhydrolysed protein isolate itself is well tolerated and adequately utilized. There are, however, certain conditions of highly impaired digestion in which the use of the hydrolysate would be of particular value. The hydrolysates have a definite place in nutrition and therapeutic practice and their production should, therefore, be encouraged.

Groundnut is only one of the protein-rich materials which can be used for such enrichment. If a beginning could be made with it, it may be expected that, in course of time, other raw materials like edible quality coconut, cottonseed and sesame flours etc., will also find application for the preparation of similar products. A large amount of basic work has already been done by the Central Food Technological Research Institute, Mysore, in this and allied lines.

Products based on coconut protein

Researches done in India and also in other parts of the world have shown that coconut meal obtained after expelling the oil contains about 25 per cent protein of high quality. The PER of coconut meal protein has been variously rated, depending on the method of processing employed. Under the best conditions, it may be as high as that of the milk protein, but the average PER may be rated at 2.0–2.5 as compared with 3.0 for milk protein.

As contrasted with groundnut meal, coconut meal, as obtained by mechanical crushing, usually contains a higher percentage of oil which may, sometimes, be as high as 12-15 per cent. This, combined with the high fibre content of coconut meal and the heavy microbial infection, usually carried by it, discourages the acceptability and use of the product in more than small proportions. Coconut meal is also rich in certain minerals. It contains a fair proportion of sugar which may tend to react with essential amino acids, particularly lysine, if the necessary precautions are not taken. In spite of the above handicaps, carefully prepared coconut meal incorporated to the extent of 20-25 per cent has been tried out in blended formulations with groundnut meal to produce a multi-purpose food. The product is relished by children and the growth response has been satisfactory. Shredded coconut along with steamed or baked tapioca is a popular dish. Similar products in the dry state can also be made preferably after reducing the oil content to a minimum. The presence of the starch helps to improve the keeping quality.

Integrated processing of fresh coconut for oil and protein: During recent years, several investigations have been carried out with the object of developing methods of processing fresh coconut kernel—instead of the copra or dried kernel—so as to obtain a high grade oil, protein and a tasty syrupy product which is popularly known as coconut honey. The last mentioned product contains sugars, some percentage of protein and

non-proteins, minerals and other soluble constituents and has a pleasing flavour reminiscent of coconut.

Most of these earlier studies had not proved successful because of the low yield of oil. The more recent work done in India has indicated the feasibility of a more quantitative separation. In addition to giving a good yield of high grade oil with consumer appeal, the method has yielded some valuable by-products. The honey has some attractive features, and food industries in different parts of the world have shown keen interest in the use of such a product. The syrupy product has also been blended with other products including groundnut protein to obtain attractive preparations with consumer appeal and good protein value. The effect of addition to cereal flours, particularly wheat and rice, has been rather striking. Fairly pure protein can be separated by heat coagulation and used either by itself or in combination with other proteins.

There are also other methods of obtaining the protein or protein-rich concentrates by extraction from freshly pressed cake or from the residue after solvent extraction of the oil. Azeotropic distillation of oil from the wet kernel as recently tried out at the CFTRI, has also shown promise. The residue can then be used for extraction of protein and other solubles.

At the present time, the major part of coconut produced in a country like India is consumed in the fresh condition as an article of food. At the same time, substantial quantities of dried coconut, either as produced in the country itself or imported from other countries, are used for extraction of oil. There appears to be scope for a modified approach which will also yield fairly pure protein or a protein-rich by-product.

The possibility of using the extractives including the proteins and the non-proteins for supplementing and enhancing the nutritive values of other proteins or food products has already been demonstrated. Further work is in progress and more useful developments can be expected. The flavour of coconut has universal appeal and that is a desirable feature.

Protein-rich foods based largely on coconut would be of considerable significance to many of the eastern and far-eastern countries and also the groups of pacific islands where protein malnutrition is known to be prevalent. These areas are large producers of coconut. Although other methods of processing coconut for human consumption and particularly that of the coconut cake are practised in some of these areas, they have not yet found extensive application because of certain inherent difficulties and also because of the occasional development of certain toxic products resulting in serious illness or death. The processing methods which have been recently developed are safe and offer scope for application on a large-scale, to produce a variety of nutritious products with consumer appeal.

Products based on cotton-seed flour

The value of cotton-seed protein as a good quality product with adequate distribution of essential amino acids has long been recognized. Until recently, the major difficulty in the use of cotton-seed flour has been through the difficulty in the separation of the fibrous hulls on the one hand and the presence of gossypol (free and combined) on the other. During the past few years, a large amount of work has been done, especially in U.S.A., on the production of edible quality cotton-seed flour. The Southern Regional Research Laboratory at New Orleans has developed a technique of azeotropic distillation with a mixture of solvents which helps to remove the oil and most of the gossypol at the same time. Work done in India has shown that cotton-seed oil, as also the associated gossypol, can be extracted with alcohol. Both methods of extraction deserve further study and application.

It has been recently reported that a gossypol-free strain of cotton-seed has been evolved. Further developments in this line will be of much practical value. Even as it is, some occasional specimens of cotton-seed meal have been found to contain only negligible amounts of free or combined gossypol. Pending fresh developments in this line and their large-scale application in field practice, some pre-treatment will be needed for obtaining edible quality cotton-seed flour. While there is yet no clear evidence to show that gossypol is toxic to man or other higher animals, it would, nevertheless, be desirable to adopt some precautions and to eliminate it as far as possible.

The development and use of protein enriched formulations based on cotton-seed flour along with locally available foodgrains by the Central American Institute (INCAP) at Guatemala are well known. The scope for developing similar products conforming to the taste of consumers in other parts of the world, as also incorporation with other protein-rich foods would deserve to be studied. Hexane extracted cotton-seed meal is now available in countries like India, but it is not free from hulls. Methods of mechanical separation are now being tried and if they are successful, they would deserve to be extended.

Cotton-seed is a valuable raw material for the production of protein-rich foods in India and also in many of the African and Central and South American countries all of which are large producers of cotton. Even if a small part of the present production is used for the manufacture of edible flour, it would be a valuable addition to the available supplies from other sources. The national organizations in several countries, as also the U.N. organizations are interested in further pursuit of this programme.

Products based on sesame meal

A fair amount of work has been done both in India and in other countries, where sesame figures as an important oilseed. The sesame protein is one of the few plant proteins which are naturally rich in methionine. The practical difficulty in the use of sesame arises through the presence of associated fibrous skin which is difficult to remove and which, though rich in calcium, renders the meal, as obtained after removal of oil, generally indigestible and otherwsie unacceptable. Simple methods for removing the skin prior to expelling the oil from the kernel have been worked out on a small scale, but they should be mechanised for application in commercial practice. Mechanical separation of the skin from the meal by air or other physical means has also been tried with fair success. The commoner varieties of sesame have a brown or black skin and the presence of even a small percentage of it in the flour renders the meal rather unattractive. There are also white or yellow coloured varieties of sesame, but their production is still not very extensive.

The earlier trials carried out in India with protein-rich mixtures containing sesame meal showed that though they were somewhat superior to those containing only groundnut meal, the difference was not considerable. There was also some consumer resistance to use of products containing sesame meal. The significance of this requires to be further studied. The work carried out with premature infants in U.S.A. showed that the response to sesame meal was not satisfactory. These observations may not have any direct relation to the quality of the protein. Some of the associated products including the bitter principle may have led to the undesirable results. With improvements in the methods of processing, it may not be difficult to remove or modify them so as to improve the acceptability.

The production of sesame—excepting in small areas—is not of the same order as that of groundnut. It is a popular animal feed and may be available only in small quantities for human consumption. It has, however, a good supplementary value to other protein-rich materials because of the associated methionine and this should be taken advantage of by incorporating small proportions in blended formulations. Reference has already been made to the use of sesame meal, along with that from groundnut, for the preparation of a protein hydrolysate with adequate balance in regard to essential amino acids.

Sesame has a definite future as a good class protein-rich material and further improvements in processing methods may soon be expected.

Products based on milk casein

In spite of its high nutritive value (which may, to some extent, be modified by the method of preparation), casein by itself does not find much application in human foods because of its physical properties and the characteristic flavour which makes it unacceptable to a large section of consumers.

Solubilised casein products, chiefly in the form of sodium or calcium caseinate along with other additives and flavouring substances are already on the market and have long been recommended by the physicians as tonic foods for invalids. They are, however, expensive preparations because they require rather costly

processing. More recently, a simple method of preparing calcium caseinate which is easily dispersible in water and other food products has been evolved at the CFTRI. This is based on the dispersion of casein in ammonia and addition of the calculated quantity of calcium in the form of calcium sucrate (which has about 50 times the solubility of calcium hydroxide) followed by roller-drying. The resulting product has an attractive physical appearance, a good keeping quality and very little of the original flavour of casein. It is a valuable protein-rich food which can be used with benefit by all age-groups. It can be incorporated with various types of foods but the popular vehicle would be the slightly soured lactic fermented curd or even butter milk with which the caseinate forms a very pleasing food supplement.

The product has been successfully used for treating not only protein malnutrition but also in the alleviation of diabetes. The caseinate has been shown to be helpful in improving glucose tolerance. In addition to reducing the required dosage of insulin in a fair number of diabetic cases, the regular intake of 30-40 g. of the caseinate also produces a general improvement in the physical condition of subjects, thus rendering them more fit for normal work.

In addition to incorporating some calcium, the sucrate in such a medium seems to have some relation to the removal of the natural odour of the product thus making it more bland and acceptable. The amount of calcium that can be incorporated varies with the nature of the protein, but the technique has shown possibilities in respect of the preparation of attractive flours from meat, fish and vegetable proteins.

Most of these countries where protein malnutrition is now extensive, are also deficient in regard to milk supply. At the same time, some quantities of casein are generally available and there is a strong case for utilizing as much as possible for the preparation of calcium caseinate which is a high class protein-rich material. In addition to the facility of being used by itself, the caseinate can also be blended with other proteins and thus improve their quality. Countries like India should concentrate on making use of available casein for the preparation of caseinate rather than divert it for use as an adhesive or for other purposes for which better materials like synthetic resins are now available. Other countries like Australia, New Zealand, Canada and U.S.A. which have large surpluses of milk and which are also big producers of casein, can convert part of their production into calcium caseinate to be made available to regions which need them for relief of protein malnutrition. Wherever possible, hospitals should stock the product for use as a protein-rich food with a variety of uses.

Products based on soyabean

Among the oilseed and protein-rich plant foods, soyabean now occupies the most important position in the world. Until recently, its use in human food was largely confined to the far-eastern countries. With the introduction of modern methods of processing, it is now steadily gaining in importance in the west. Its use has, however, presented problems in countries like India. Researches conducted during the late forties under the auspices of the then Indian Research Fund Association (IRFA) showed that, in spite of its high protein content, soyabean, cooked as a pulse, is neither well digested nor adequately utilized by experimental animals or human subjects; and that, in this respect, it is, in no way, superior to the other pulses (with lower protein content) which are already being produced and consumed in India. Other researches which had been started independently in the country, and subsequently sponsored by the IRFA showed that the protein present in the milk extracted from soyabean is well digested and utilized and when supplemented with calcium to the same level as in milk, can give a growth response corresponding to 80-90 per cent of that of milk protein. The apparent contradictory response observed from the two sets of studies proved to be of far more significance than was first realised. They showed that the whole soyabean contains certain factors which interfere with the digestion and utilization of the protein and that these are largely eliminated through the processing involved in the preparation of the milk. This feature seems also to have been generally recognised in practice in the far-eastern countries, which can be regarded

as the home of soyabean and where, even now, the bean is not consumed, as a whole, but generally only after extraction, pre-digestion with micro-organisms, or similar other processing. The more recent findings relating to the existence of the anti-trypsin and anti-growth factors in soyabean emphasise the need for processing to remove these undesirable factors by suitable heat treatment. It is possible that there are also other factors which do not affect utilization by the farm animals but which may have a bearing on human nutrition.

While the major part of the soyabean produced in countries like U.S.A. is utilized for the production of oil and animal feeds, a large amount of research has been carried out during recent years on the production of edible quality flour with or without the associated oil for human consumption. It is now well-established that the protein of soyabean is of high quality and that, in its make-up of essential amino acids, it is superior to many other vegetable proteins; that its main deficiency is only in respect of methionine. Recently, work done both in U.S.A., India and elsewhere, has shown that, when dl-methionine is added to soyabean in the required proportion, the over-all value of the protein is equal to that of milk protein. More recently, the methyl-hydroxy analogue (MHA) of methionine which is a cheaper product, has shown equally good supplementary effect in the case of experimental animals. Soya protein has also been isolated and is now being produced on a commercial scale for use in a variety of ways as an article of human food. The isolated protein has given divergent protein values and many of the figures, thus obtained, are lower than those found for the protein as present in the whole flour. This may be partly due to the effect of the processing employed and partly to the presence of the anti-growth factor which is still found to be present, to some extent, in the isolated protein. These defects can however be easily overcome. Recent studies carried out in U.S.A., South America and some other countries have shown that defatted soya flour is digested and fairly well utilized by growing children and premature infants. This work deserves to be followed up in relation to the earlier observations with cooked whole soyabean or whole soya suspension as obtained during the pasting for the preparation of milk. Some systematic work is also needed to determine whether the carbohydrates of soyabean, which correspond to those present in some of the insoluble gums, have any influence on the utilization of the protein in the human body.

In spite of the above features which are now being studied by several research groups, there is no doubt that soyabean is potentially, one of the most valuable materials for use in world programmes. Further work will soon reveal the best method of processing the bean so as to produce protein-rich foods suitable for all age groups. The cheapest would, of course, be the defatted flour, but the extractives processed as liquid preparations or stable solid products do also offer considerable scope. The protein isolate with its versatility of application will also come into greater prominence.

While further large-scale developments in the use of soyabean as human food may be expected in U.S.A. and other parts of the world, the future of the bean in countries like India is still somewhat obscure. This is largely due to the emphasis that is now being placed on the value of the oil rather than on that of the protein. If soya flour and products made out of it find more application as human food, the value of the oil will be of secondary importance. It is also possible that some new method of processing the whole soyabean so as to make it a nutritious article of human food can be found. The production of the bean as an inter-cultivated crop and as a soil conserver and enricher especially in plantation areas, where there is extensive erosion, may be a method of its introduction in many areas that may steadily find favour. These should, however, be regarded as long-range developments, and, until such time as they become possible, countries like India will have to depend largely on crops like groundnut and cotton-seed as cheap raw materials for the production of protein-rich foods.

Vegetable milks

Although this class of products is extensively produced and consumed in countries of the

far-east, they have not yet found favour in India where the consumers generally prefer animal milk. In the west, some manufacturing firms regularly produce such products in both liquid and solid forms for meeting the needs by children and adults who are allergic to or cannot digest animal milk. The total production is, however, comparatively small. In the far-eastern countries the milch animals are not reared to any great extent. The popular taste has long been established in favour of vegetable milks, with the result, that the consumers do not even like the taste or flavour of animal milk.

In India, the *per capita* consumption of cow or buffalo milk is at a fair level only in some of the states, like Punjab, Rajasthan, Gujarat and Uttar Pradesh whereas it is comparatively low in the others. In states like Assam and Kerala, it is as low as 40ml. In some others, it is only of the order of about 85ml. Judging from considerations of nutrition, there is a strong case for supplementing the dietary of the people at least in some of the areas with vegetable milks and also products made out of them. Apart from the large amount of scientific research done on the subject, considerable amount of extension work was also done in India to demonstrate the value of different vegetable milks and particularly those from soya and groundnut. In spite of all such effort, the milks by themselves have not found favour among adults because of their characteristic flavour, but young children, who have no such prejudices, generally like them. At the same time, there is a significant feature in that the milks were offered as supplements to the dietaries of the low-income groups, whereas the higher income groups who could afford to buy cow or buffalo milk did not participate and even discouraged such efforts. This was admittedly a very important factor in the failure of the programme. In the far-eastern countries, all classes of people—without distinction—use these vegetable milks and products made out of them. The product that has found a fair amount of general acceptance is the lactic fermented curds prepared out of such milks, but a great deal of publicity and educative work has to be done to popularise their use. The curd is now finding use, admixed with cow or buffalo milk products, for use in hotels and restaurants, but this has certain other implications to which objection can be taken. The prejudice may not, however, exist to the same extent if the extracted material, whether from soyabean or groundnut or both, can be dried and converted into attractively flavoured products suitable for the feeding of children. This is now being done in Indonesia. The processed products based on the isolated protein have also been designed with the same object. Such products will have a definite future and can be produced comparatively cheaply and in large quantities out of raw materials available in each country. This would be an area where there would be large scope for entrepreneur with experience in the promotion of new classes of food products as in some of the western countries. Collaborative efforts with mutual benefits may lead to quick development in such lines. In countries like India, such products have to compete with imported milk powder. The related problems have to be carefully considered when evolving future policies in regard to the development of this class of products.

What is most needed is the realisation of the long-range value of such products for the better nutrition of the vulnerable groups in the countries where animal milk is not available in sufficient quantities. More of educative work is badly needed. The cultured people should take the lead and help to remove the existing prejudices by their own example.

Fish flour

The importance of this class of products has been well recognized and a large amount of work on the subject has been done in several parts of the world. Valuable work has also been done in India. The object is primarily to use the surplus catches of fish (during certain seasons) which are not finding sufficient use as human food as also to use certain classes of fish which cannot be easily stored and do not find a ready market.

Although there are some variations in the nutritive values of proteins from different edible fishes, it is found that they generally have

a high protein value (some of them of the same order as milk protein) and are very rich in lysine (9 per cent or more) in which most of the cereal diets are generally deficient.

Recent work done by some industrial concerns and also under the U.N. auspices in countries like Chile and Morocco, have attracted a large amount of attention. According to the reports so far available, none of these is operating on a large scale or on continued basis throughout the year. Thus, the Morocco plant has a capacity of only 300 kg. per day. There is also need to work out the economics after continued working for at least some months.

If the fish flour plant is to operate beyond a limited season, there should be need to store the surplus catches of the season by some quick, cheap and efficient method. Quick freezing is, of course, well known. There may also be other methods, such as some safe chemical treatment either by itself or in combination with some method of silaging. These lines are already attracting much attention and some useful progress has been made especially in some Scandinavian countries.

Specifications have already been laid down for different types of fish flour. While a completely white and odourless, fat-free product would be the ideal for general use by all classes of people, it is now recognized that there is also considerable scope for products with a certain percentage of fat and residual odour, provided they have good keeping quality and are free from undesirable infection. In many of the eastern countries, the latter class of products will find favour with all age groups, provided they can be made available cheaply.

In addition to the production of fish flour made exclusively out of fish material, there seems to be a fair amount of scope for other classes of products—such as those incorporating starchy materials—in which fish material would form the main source of protein. Such formulations which will contain a high percentage (30-40 per cent) of protein are easy to dry and can be converted into attractive flours or paste goods which can find varied applications.

Fish flour is the name given to a class of products which would be based on different types of catches from fresh or sea water. Besides the fishes, there are several other edible forms of fauna such as crabs, lobsters, etc., which can also be processed in the same manner. Some of them have already been studied for their nutritive value. More of such work will be needed in respect of other forms to ensure that none of them contains any harmful component. Some of these seem to have the advantage that they have a very low fat content. A few forms do not have any pronounced odour. The use of fresh-water fish has so far been considered uneconomical, but there may be some areas where it may be feasible and even facilitate operation over longer periods than may be possible with some of the marine fishes.

On the basis of the knowledge and experience already available, there would be scope for making a beginning in certain lines, demonstrating the value of different classes of products and ensuring their consumer acceptance. In the meantime, further developments can follow leading to the standardization of conditions for large-scale operations. This line of study offers considerable scope for fresh thinking and development of new methods of processing which may be even more economical and efficient than those which have so far been tried.

Products based on fish hydrolysates

Under controlled conditions, fish material can be either autolysed or subjected to hydrolysis in presence of enzymes, acids or alkalis. According to the traditional methods, the autolysis is usually carried out in presence of salt and the resulting fish sauce is highly popular in many of the far-eastern countries. It will come in the same category as soya sauce. While the presence of salt confers protection against spoilage, such products have the disadvantage that they cannot be consumed in sufficiently large quantities to supplement the different regional diets. They are, nevertheless, of some value and render the diets more tasty and otherwise more acceptable.

Hydrolysis through the agency of added enzymes or chemicals has long been used for the production of fish peptones. Conditions of hydrolysis of materials from some of the indige-

nous varieties of fish have been worked out in India. It has also been recently reported that the Scandinavian investigators have evolved a procedure for liquefying the fish right from the stage of the catch. The advantage of such a method would be that addition of salt is not necessary and that the resulting product can be easily dried over rollers. At the same time, it may be expected that the resulting product would be hygroscopic and would require careful packing. Partial hydrolysis of fish may offer some advantages even in respect of the preparation of fish flour, because it will help to improve the extraction and render the product more dispersible in water. It may also help in the reduction of the fat content of the finished product if centrifugal or other method of fractionation is possible.

Meat powder

This class of products will have large consumer appeal and also find varied applications. Recent work done at Mysore has shown that it would be possible to prepare an attractive product by dispersing lean meat in ammonia, then adding calcium as sucrate followed by roller-drying. There has been a good deal of interest in the production of such a product from meat residues and even offals which do not now fetch a good price.

Meat powder made out of good raw material, preferably in an easily water-dispersible form has considerable consumer appeal and can be used in a variety of ways. It can also be combined with preparations based on vegetable protein isolates into attractive formulations. The protein value may vary to some extent with the nature of the starting material but the PER may be rarely less than 2.0. As in the case of fish flour, the preparation will require careful microbiological control. Meat powder will come in the rather expensive class, but in every part of the world, there are people who can afford to pay for it. Even low income groups can use it with benefit in small quantities. There will be an assured off-take if the industry can be started.

Egg powder

The egg protein, as that obtained from the hen, has been given the pride of place as being nutritionally the best and is generally looked upon as the standard for adjudicating the value of other proteins. During recent years, a number of investigations have been carried out for the standardization of conditions for the production of good grade egg powder which would be free from glucose and *Salmonella* infection. A standard product, conforming to the desired specifications, as made in Britain is now under systematic study under the auspices of the Protein Advisory Group. The various possible uses of such a powder, both by itself and in combination with other food materials, is now under investigation both in India and in some other parts of the world.

Some surveys have recently been made with the object of setting up an egg powder plant in Kerala State in India. It has been reported that large quantities of eggs would be available at very low price. Production of egg powder will not be difficult if the necessary precautions are taken. In addition to hen's eggs, duck's eggs can also be processed, though this may yield a somewhat inferior product. While egg powder will always come in the expensive class of products, its production may have commercial possibilities if the various uses can be fully standardized.

Both egg and meat powder would be of tremendous value as concentrated emergency foods with consumer appeal.

Leaf proteins

This class of proteins should be regarded as being of tremendous potential value for the whole world. In many parts of the world, there is large abundance of grasses and other edible leafy materials of high quality which are now being used for animal feeding. If even a part of the proteins contained in them can be extracted and processed in a satisfactory manner, they would make substantial additions to the world's available supplies of protein-rich foods. There is also scope for using leafy by-products from several agricultural crops.

Pioneering work in the subject was done in Calcutta in India, and at Rothamsted in U.K. Practical difficulties in the use of products such

as those so far developed are well known. There is consumer resistance to the associated colour, odour and bitter principles. The precipitated proteins also contain large amounts of glycerides, unsaturated fatty acids which though highly desirable by themselves, adversely affect the keeping quality. Unless all the undesirable components are removed, leaf proteins are not likely to find ready acceptance for human consumption.

Nutritional studies carried out, in different countries, have shown that leaf proteins from some of the well known varieties of grasses and fodder crops, have a high protein value, comparable with that of milk proteins. Starting with this background, there is need for more intensive research to develop methods of processing which would yield attractive products suitable for human consumption.

The problem of leaf protein should be looked upon as a challenge to science and technology rather than as a practical failure. Whatever be the present difficulties, they are not insuperable. A realistic approach will be to select some promising raw material, the various components of which are known to have uses. If the different fractions can bring some return, the cost of a bland product conforming to consumer requirement will come down considerably. If success with one raw material can be achieved, the uses of several others will automatically follow.

Protein-rich products from algae

During the past decade, a large amount of work has been done especially in U.S.A. and Japan on the standardization of conditions for the production of *Chlorella* and certain other types of algae which can be produced under controlled conditions in large quantities. The proteins from algae are also reported to be nutritionally of the same order as some leaf proteins. The main difficulty at the present time is the same as that with leaf proteins. Sooner or later, the problems are certain to be solved. The algae should be looked upon as a rich potential source which will one day be of value to the whole world.

Calcium fortified common salt

Work done at Mysore has already shown the practical possibilities of this line of fortification which will ensure the uniform distribution of calcium throughout the mass of food. The calcium content can be raised to a fairly high level without affecting the taste, solubility or use of the salt. The usefulness of the product as a supplement to diets, based on cereals like rice and wheat, has already been experimentally demonstrated.

Both the sea water and also some of the inland lake waters contain calcium salts along with sodium chloride. Some inland waters contain sodium carbonate along with calcium and sodium salts with the result that the calcium salt settles at the bottom. In the preparation of common salt from sea water, the calcium separates out first in the form of the sulphate and is largely eliminated during the preparation of salt of fairly high purity. The calcium can, however, be recovered and incorporated with sodium chloride without affecting the consumer acceptability or the keeping quality of the latter. Such a product has already been made in fair quantities and its usefulness adequately demonstrated.

The National Nutrition Advisory Committee of India has already recommended the production and the use of calcium fortified salt at a level which will add to the value of all diets without being excessive. The implementation should not be difficult if the necessary encouragement and assistance can be given to at least some of the manufacturers in the first instance. Based on this experience, others can then follow.

Considering the enormous production and consumption of salt and the large number of agencies involved in the production, it may be difficult to legislate for calcium fortification of edible salt on a nation-wide basis.

There is therefore a case for permitting the manufacturers to advertise the value of such product (conforming to prescribed specifications) and to market it at a slightly higher price than the usual type of salt. The price may be fixed in consultation with the Government with due consideration for the extra cost involved in the blending.

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