Food for Tomorrow

S. R. SHURPALEKAR*

THE rapid increase in human population with relatively a lesser increase in food productivity may force man to tap newer and unknown resources of food to feed his hungry mouth. The most reasonable prediction of world population in 1980, by United Nations assumes a maximum of 50% or a minimum of 25% increase in population which in figures will be 3,636 millions and 2,972 millions respectively. During 1939-49 the population has increased by 200 millions whereas food produce remained the same. Hence, it has been imperative that man, with all his knowledge today, aided by newer techniques, should go all out for increasing the food production.

Yearly, 400 billion tons of sugar are produced by land and sea plants as primary products of photosynthesis; of this 90% is produced by marine and fresh water algæ and the rest by plants on land. Anyway, all this sugar is rapidly converted into indigestible plant products of no nutritive value and of this a mere 0.2% is utilised by human race for its primary needs. Here, human ingenuity and resourcefulness are sought for the increased utility of photosynthetic, agricultural, marine and industrial products, by-products and wastes to feed the future population with a diet better in quality and quantity.

I. *Food from plant origin:*

Marine vegetations like sea-weeds and algæ have been used by man and coastal animals as food. One-fourth of the Japanese diet consists of brown sea-weeds incorporated in wheat flour. Micro-algæ are a valuable source of proteins containing all essential amino-acids except methionine, in sufficient quantities. Some species of algæ and sea-weeds are consumed on a large scale mainly in Hawaii, China and Scotland as vegetables as well as ingredients of special dishes. These are also rich in vitamins A and C and in mineral nutrients. In general, algæ and sea-weeds are low in protein, high in minerals and contain mild laxatives. Hence, they are fed as feed supplements to animals. Also, sea-weeds and algæ are excellent natural soil conditioners. With the aid of modern techniques, high photosynthetic activity of micro-algæ can be harnessed in increasing food production per unit area tremendously. German experiments have succeeded in growing fat—or protein—rich algæ under controlled conditions of strong illuminations and carbon dioxide supply. Also a number of species contain appreciable amount of B vitamins.

Incidentally, the antibiotic properties of algæ (e.g. *Chlorella pyrenoidosa*) are being utilised in preserving fish and other products from bacterial decomposition. This may ultimately result in larger availability of fish and other products for human consumption. Also, the colloidal action of algal tissues serves to retain texture and improves taste and appeal, of canned products.

Principal products of industrial application are polysaccharides-algin, mannitol, carageenin from brown sea-weeds and agar-agar from red species. Laminarin—a starch consisting of 20 glucose units obtained from sea-weeds can be considered as a source of glucose and blood plasma substitute. Other products have also contributed to food industry. Following figures will speak for the manifold utility of sea-weeds in food industries. 200,000 tons of brown sea-weeds can give 30,000 tons of alginic

---

*Second Year student, Food Technology section.

acid and more mannitol, 40,000 tons of laminarin with some fat, sterols, amino-acids etc.

Surprisingly, even sewage can be utilised for increased algæ production. 500 tons of sewage-grown algæ can be produced as compared to the best yield of 30 tons of soyabean from the same area. Nutrients of sewage increase productivity of algæ abnormally, while algæ in return oxidise sewage 25 times faster. 1,000-1,500 tons of dry algæ can be obtained from a daily flow of one million gallons of sewage. Dry algæ contains 50% proteins. Though acceptability of sewage grown algæ is doubted, drying and final pasteurisation can assure of complete safety.

Protein deficiency is very commonly experienced in most of the tropical countries. Well fertilised lfafy crops in areas with regular rain fall give the biggest returns of dry matter per acre with high protein content. With prototype machine, 30% of protein in good quality leaves from several crops can be extracted. Protein, separated by heat coagulation, is used directly to feed animals and the residue with some protein goes to feed the ruminants. Some refinement of protein can make it fit for human consumption and compensate partially the protein deficiency.

In tropics, little milk is economically available for the poor class. The great advance in the knowledge of food and nutrition should enable production of milk substitute-foods from cereals, pulses etc. These cereals and pulses are cheaper to grow in tropics and have sufficient nutritive value to be adequate substitutes for milk. Also, the substitutes can be fortified with ingredients, mainly vitamin C and iron, lacking in milk. In China, soyabean emulsions have proved good milk substitutes. A spray-dried soyabean emulsion "Soyalac", sold in Western markets, is claimed to approach the ideal infant food lacking only in vitamin C. Also, war-time needs led to another substitute "Maltvena" in Italy. This consisted of an emulsion prepared from malted cereal.

In India and some parts of Africa, most of the rich peanut crop goes to feed the cattle. Many highly nutritive protein-rich products such as peanut, butter and milk, predigested protein foods can be obtained economically. Peanut flour obtained from cakes can be used in protein fortification of foods commonly used and in the preparation of nutritive synthetic grains (mainly rice substitutes) from maize and tapioca flours. Oilcakes from cotton-seed, coconut, sesame etc., are the other sources that can be utilised in a similar manner. These are rich in good quality proteins, minerals and B vitamins and can be processed to obtain acceptable foods as meat substitute.

II. *Food from microbial origin:*

In Germany, the dearth of protein and fat during the second world war, brought the manufacture of food yeast from molasses into lime light. Predominently protein deficient human diets can be efficiently supplemented with food yeast because of its good quality protein, vitamins (mainly of B group) and minerals. On an average, pure dried food yeast contains 35-40% proteins, 6% fat with all essential amino-acids except cysteine and methionine, minerals like magnesium, calcium, potassium and phosphates, in sufficient amounts. Also, the digestibility is good.

Food yeast is mainly used as meat substitute and pound per pound its cost is one-eighth of that of meat. One kgm. of yeast is equivalent to 4.16 kgm. of fresh eggs, 2.77 kgm. of beef fat, 2.38 kgm. of herring or pea flours or 4,500-4, 700 calories. Though not fully exploited, raw material used in the manufacture of this well integrated food are molosses, sulphite wash liquor, wood sugar prehydrolysates, whey and potatoes.

In view of the present food situation in India manufacture of food yeast will help to increase the nutritional level to a great extent. Even ¼ ounce of food yeast a day will keep the doctor away. Moreover, nearly 0.5 million tons of molasses from sugar industry is wasted every year.

By ærated cultivation of the type employed in the manufacture of Baker's yeast or *Torulopsis utilis* and employing a special fat producing micro-organism, '*Rhodotorula gracilis*' (fat yearst), it is possible to produce a cell substance containing 64% fat on dry basis. Cheap raw material is cane-sugar molasses and the total cost estimation is between 6.5 d 1 s. 2.75 d per pound of fat yeast on dry basis. This product is tasty and contains 40% fat, 24% protein and appreciable amount of B group vitamins.

III. *Food from animal origin :*

Rapid advances in marine chemistry and preservation techniques only will make more of sea-food available for low income groups. Surprisingly, fishing is still limited to shallow waters mainly and unknown depths providing 26 million metric tons of fish per year remain unexploited. Thus, though human race is in dire need of proteins only 2% of world's total food consumption is accounted for by fish which essentially are protein reservoirs. It has been estimated that present fish production can be quadrupled by culturing brakish water and fresh water fish in natural water or special ponds. Yields obtained per acre are 8,000 pounds as compared to natural yield of 445-1,780 pounds per acre. Also only 3,000 tons of whale meat from present catch of 1.3 million tons is utilised as food. It is also estimated that by doubling whale meat output for human consumption and fish farming development, 15 million tons of food can be obtained every year.

Crustaceans, because of their enormous bulk, larger size and tendency to massive accumulation, seem to have good food prospects. 3,000 species of sponges constitute an entirely unexploited potential source of food-stuffs and fertilisers. Only 13 of these are utilised commercially. The decayed protoplasm of the killed sponge quarry is rich in protein, vitamins and minerals. But 2 million pounds of such organic matter is wasted every year. From crabs, lobsters, large clams and quahogs, tasty and nutritive foods e.g. clam broth, chowder etc. are being produced through highly mechanised processing. Even then, the quantity used in processing as compared to availability is very low. Sea mussels, mainly harvested on North Atlantic and Pacific coasts, form an excellent article of European diet. In France, because of the shortage of supply, artificial cultivation carried on French coast gave 10,000 pounds mussels per acre as compared to 190 pounds per acre of beef from best pasture land. However, the future of mussel production depends upon efficient preservation techniques as mussels are liable to rapid spoilage. Mussel meal, prepared by drying in sheels and grinding, contain 71% calcium salt, 11.6% protein, 13% carbohydrates and 2% fat.

In tropics, the protein and fat deficiencies were found to be compensated for by eating termites, locusts, caterpillars, etc. Insects such as cicadas, lice, grass-hoppers have been used by man, Anyway, in the West, aversion to insect food of some nutritive virtues is not based on instinct but is established by custom and prejudice.

One of the major resources of obtaining more food is the utility of wastes. Only 30-50% of edible fish is actually consumed by man. The waste still contains proteins, vitamins and often its food value is greater than that of utilised fish. In America total reduction of fish unsuitable for human consumption is being attempted. Fish offals and matter unsaleable for human food can be utilised for production of protein supplements and oil.

For example, condensed fish solubles which in the semi-liquid form with 50% solids, contain 32% protein, 4% fat and large amounts of B group vitamins. The product is obtained by wet reduction of whole fish or wastes. The aqueous fraction remaining after removal of oil, fish meal and other insoluble solids by steaming and centrifugation has a high nutritive value.

Fish flour, another product from fish waste, is odourless, tasteless and free flowing. Consumption of this flour solves partially the problem of protein deficiency in tropical and sub-tropical areas. Whole fish or fish wastes can be ground after drying to obtain flour, high in protein and vitamin (mainly B_{12}) content. This can be used in soups and other dishes and also can be mixed with wheat flour.

In India, the rejected shark fish, a by-product of fish dehydration industry, needs consideration as an article of human food after dehydration. Large amounts of fish offals from fish dehydration industry forms a good source of fish meal by drying. Dehydrated minced precooked fish can be preserved for 90 days without losing edibility.

Slaughter waste by-products, accounting for 11-24% of total sales of meat products, are mainly lard, edible and inedible tallow, animal protein feeds etc. Lard and edible beef-fats are the most important commercial by-products of meat packing industry. Also bone and meat offals of dehydration industry form a rich source of protein and B vitamins. Hence, full utilisation of these wastes and by-products is essential.

IV. *Synthetic food ingredients :*

Nature produces carbohydrates in greatest abundance from most inexpensive raw materials—water and air Hence, chemically or biochemically the synthetic production of carbohydrates is no doubt impracticable and insignificant. Also the amount of fat from seeds, nuts, beans of flowery plants, marine and land animals, surpasses all the demand for industrial and food purposes. Hence, the synthetic "Kunstbutter" obtained from hydrocarbon residues in Germany attracts little attention. The only type of food, with the production of which the synthetic approach is quite likely to yield favourable results is the protein food, the main requirement of expanding population. The scope for such an approach is limited primarily to improving the nutritive quality of natural proteins by addition of the limiting essential amino-acids. This is an utter necessity in the case of single protein diet of inadequate quality. Also if because of economic, hygienic and religious reasons, insufficient animals protein is consumed ; for good nutrition, the diet can be most favourably reinforced by synthetic amino-acids. Supplementation of animal and poultry feed with a little methionine increases feed efficiency appreciably, which will ultimately result in larger availability of protein food for human consumption. Lysine deficiency in diet dominated by cereal and vegetable foods (except legumes) can be lessened by enriching bread and flour with synthetic lysine hydrochloride.

In the field of synthetic vitamins, chemists have succeeded appreciably. Vitamin A and C, thiamine, riboflavin, and choline are manufactured industrially and economically. Enrichment of rice, bread and flour with thiamine is well known today.

V. *Animal Feeds:*

Animal feed today may form a significant means of increasing food production. Nutritive animal feed will result in increased yields of better quality animal foods such as milk, eggs, meat etc. Also proper processing of some of the animal feeds may lead to newer foods suitable for human consumption. Thus, increasing the quantity and improving the quality of animal feed has great possibilities as an indirect source of human food.

Planktons, the primary marine vegetation, can be utilised directly, as for mammals their food value is high. Dry zoo plankton (mainly micro-crustacea and copepods) contains 59% protein, 7% fat, 20% carbohydrates and 4.7% chitin. Hardy has revealed that on Scotland coast two men collected 588 pounds a day of planktons which can feed 357 people. Today they are only suitable for animal feed as they contain metabolic products, poisonous for human beings. Removal of this poison may lead to a food suitable for human consumption.

Fish-meal, an acid—peptised product, obtained from fish wastes, is unsuitable for human food. It contains proteins, mostly in soluble form and is used in animal feeds as protein supplements.

Inedible fats from grease and tallow, the slaughterhouse wastes, when stabilised against rancidity changes, go to form 200-250 million pounds of animal feed every year in U.S.A. alone. Also residual products such as meat scrap and tankage with bone obtained from rendering of inedible animal fats, form a protein supplement for animal feed. They contain a good amount of essential amino-acids.

The ability of micro-organisms to produce protein from glucose in a salt-glucose medium with ammonia as nitrogen source and the ability to elaborate proteins and B vitamins in rumens of cattle are utilised by Dr. R. S. Robert for the production of high grade milk liquid. This serves as a cattle feed supplement.

The food value of growing plant matter decreases rapidly with increasing lignin content in a few weeks time. Hence, lignified plant matter cannot be utilized as food for cellulose digesting ruminants as lignin protects cellulose against bacterial and enzymatic attack and reduces digestibility. However, wood—(white ones) rotting fungii utilise lignin through action of lignase, thereby making delignified cellulose available for ruminant feed. Also, corncobs and cornstalks, abundantly available in tropics, and oathulls, wheat straw etc., can be efficiently directed to preferentially degrade lignin under proper conditions or æration, with urea as non-protein nitrogen source.

Fine wood residues—sawdust, shavings etc., near the saw mills and processing plants, would prove best and economical substrate for delignification by white rot fungii. In U.S.A., only 40% of the total wood waste i.e., 44 million tons was inefficiently utilised as fuel during the year 1944. Even if 10% of the unused waste is utilised in conversion, 4.25 million tons of carbohydrate fodder can be obtained.

Recently, it has been demonstrated that wood exposed to 100 million roentgen can be readily fermented by rumen micro-organisms to low fatty acids yielding 79% of pure cellulose. On a large-scale, irradiated wood can economically serve as cattle fodder when mixed with other nitrogenous food-stuff.

Yearly, only 1% of 250 million tons of agricultural residues mostly consisting of herbaceous matter is used in industry in U.S.A. Even if 5% of the residue is available economically, more than 10 million tons of farm residue with 2% urea as non-protein nitrogen source is potentially convertible to 15 million tons of animal feed, whereas annual animal feed production is 19 million tons.

Residual gains after mashing, and soluble and insoluble solids in spent wash, which form distillery by-products can be recovered for enriching animal feeds. Insoluble solids are removed by fermentation or centrifugation and the total solids in spent wash are dried. The dried solids with substantial proteins, B vitamins and growth factors resemble skim milk. Grains screened from spent wash have composition similar to palm kernel.

War-time shortage in animal feeds led to the use of ammoniated wood pulp. Sugar beet pulp, molasses and other industrial and agricultural wastes can be converted into nutrient and palatable ruminant food by treating with ammonia as nitrogen source. The protein equivalents of citrus pulp and ammoniated citrus pulp are 6% and 40% respectively.

Citrus meal can be manufactured from factory wastes of citrus fruit industry. Press liquor, produced at a rate of 800-1,000 pounds per ton of pulp, contains 7-9% soluble sugars and is a valuable by-product usable for the production of citrus molasses and food yeast. Also, citrus meal is a palatable feed supplement with mild laxative properties and when fed to dairy cattle, it enhances milk yield. Dry orange meal contains 64% carbohydrates, 5.3% proteins and total digestible nutrients are 80%. This is fed in combination with high protein feeds, such as bean-meal, lucerne-meal etc. Moreover, orange peels are a rich source of pectin.

Some of the foods discussed above e.g. algæ from sewage insects, etc., in spite of their food and nutritive values are not utilised by man today. Foods meant for animal feed can be further processed to make them fit for human consumption. Also lack of knowledge of nutrition, customs and prejudices result in non-consumption of certain foods. For all these foods to come in modern dietaries, man must experience some starvation or war-times when he will be the slave of the situation.

Today every new invention means increased productivity and newer utility of wastes; every new chemical promotes plant growth or protects plants and animals against diseases and ultimately resulting in more food for man. Thus, wastes of today will be food for tomorrow.; feeds for animals today will be human food tomorrow. Man's genius will bring round known and unknown, available and unavailable foods to calm down his hunger. Thus, with the knowledge we already possess and technical facilities at our command, an even larger population of the world could be fed a better diet than the present one which in many countries is nutritionally inadequate.

REFERENCES:

1. Feiss, J. Food and Agri., 1955, 3, 388.
2. Weiss, **Ibid.**, 1953, **1**, 822.
3. " Food and Population ; Development of Food Industries in India ", C.F.T.R. I. Publication, p. 210 and 299.
4. Food Manufacture, 1954, **29**, 434.
5. Ibid., 1952, **27**, 491, 473, 345.
6. Nicholls, **Ibid.**, 1950, 25, 57, 95.
7. Tresslor and Lemon, " Marine Products of Commerce ", Reinhold Publishing Corp., New York, 1951.