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India's food problems

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India, one of the four major regions in which enormous populations are crowded into confined areas, shares with adjoining China the unenviable reputation of enduring the world's worst famines and widespread malnutrition. North-western Europe and North America contain the other two major regions whose help India seeks.

Religions in India, China and other parts of the Far East advocate the principle of *ahimsa* (non-violence). It forbids the killing of animals, hence influences diets and is an important factor in India's food problems (Russell, 1954). *Ahimsa* originated 2500 years ago in the teachings of Buddha and other Indian religious leaders. Their dietetic principles were brought to Europe by Pythagoras, and passed down through the ages by the Essenes, Albigenses, Trappists and other religious groups to present-day vegetarians who consume no animal food except eggs and dairy produce. The United States of America contain several million vegetarians, representing about 2% of the population (Gunther, 1947). The United Kingdom contains less than 100 000 vegetarians, about 0·2% of the population. These few British vegetarians hope to help with food problems in India where the population is largely vegetarian.

Many nutritional surveys and studies have been made by the outstanding pioneer Sir Robert McCarrison and his successors at Coonoor Nutrition Research Laboratories and by workers at Bombay, Calcutta, Delhi, Mysore and elsewhere. At Buddh Gaya, Benares, Delhi and other places India also has centres of past and present religious activity that influence its dietary customs. In Delhi a new university is being established by Vishva Ahimsa Sangh (World Fellowship of Religions) to promulgate the principles of *ahimsa*. It is proposed that there will be there a vegetarian nutritional research centre that will apply these principles.

Nutritional studies in India reveal serious deficiencies not only of calories but also of vitamins and other nutrients, especially protein. The average daily intake of total protein in India is only about half that in the U.K. and U.S.A. The animal-protein intake in India is only about a seventh of the U.K. intake and only about a tenth of

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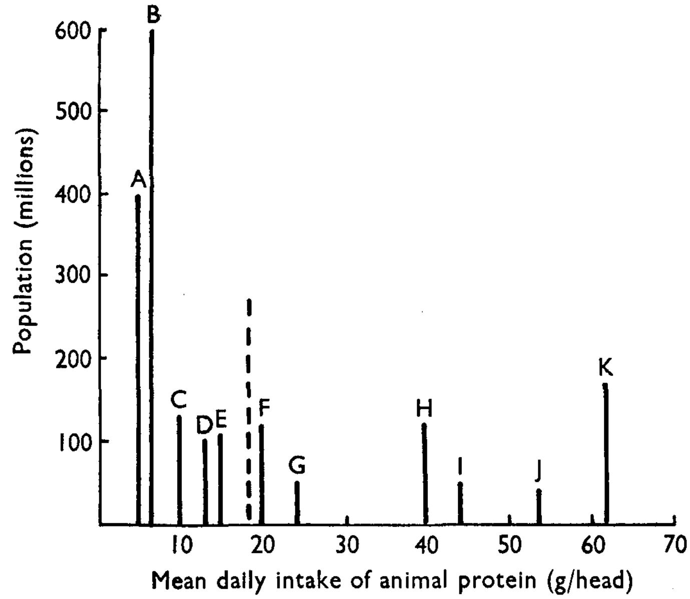

Fig. 1. World distribution of animal protein in human diets. A, India; B, China; C, Ceylon, Egypt, Pakistan, Philippines; D, Guatemala, Japan, Peru; E, Brazil, Mexico, Turkey; F, Italy, Portugal, Spain, Yugoslavia; G, Burma, Chile, Colombia, Israel, Union of S. Africa; H, Austria, Belgium, France, Germany, Holland; I, United Kingdom; J, Argentina, Scandinavia, Switzerland; K, Australia, New Zealand, N. America. – – –, weighted mean.

that in Canada and U.S.A. (Fig. 1). The average daily animal-protein intake throughout the world is only about 18 g/head. Hence India's shortage of animal protein cannot be overcome by importing supplies from other countries. Grateful as the Indians are for the generous gifts of dried milk sent to them from Western countries, they realize that their nutritional salvation depends on their own efforts, and that vegetable protein must always predominate in their diet.

In the present-day average Indian diet nearly half the protein comes from cereals, mainly rice. This cereal is low in protein and needs supplementation with protein-rich foods. The recommendations of the Indian Nutrition Advisory Committee in 1944 (Indian Council of Medical Research: Nutrition Advisory Committee, 1951) would if achieved have resulted in cutting down the intake of cereal protein from 3·05 to 2·44 million tons annually but in increasing that of pulse and nut protein from 2·53 to 3·68 million tons. An increase of 0·4 million tons of leaf and vegetable protein would have brought the intake of plant protein up to 6·56 million tons annually compared with 5·62 million tons in 1954. The most notable recommendation was a great increase in the intake of animal protein, equivalent to raising it from 0·86 to over 3 million tons annually or from 6 to 21 g/head daily (Table 1). This recommendation depended on a great expansion of the production and consumption of milk, meat, eggs and fish.

Improvement of milk supplies and especially of the very poor milk yields is highly desirable. However, *ahimsa* retards the weeding out of scrub cows for beef, and any

Table 1. *Protein in Indian diets* (*tons* × 10^{-6}/*year*)

Source of protein	1954*	Targets in 1944†	Targets in 1961‡
Rice	1·6		
Wheat	0·85		
Other cereals (e.g. barley, maize, millet)	0·60		
Total cereals	3·05	2·44	3·30
Pulses and nuts	2·53	3·68	3·65
Leaves and other vegetables	0·04	0·44	0·99
Total plant	5·62	6·56	7·94
Animal	0·86	3·05	0·96
Total	6·48	9·61	8·90
Total daily intake (g/head)	47	66	60
Animal-protein intake (g/head)	6	21	7
Plant-protein intake (g/head)	41	45	53

*Calculated (for 1954 population) from FAO data (Altschul, 1958) and data quoted by Russell (1954).
†Calculated (for 1960 population) from standards recommended by the Nutrition Advisory Committee in 1944 (Indian Council of Medical Research: Nutrition Advisory Committee (1951).
‡Suggested targets based on proposed addition of vitamin B_{12} to plant protein.

substantial increase in dairy herds seems unlikely because it involves feeding animals with foods needed for, and more efficiently utilized as, human food (Russell, 1954). This problem does not arise with eggs and fish; nevertheless, even if their consumption were doubled it would provide only 100 000 extra tons of protein annually when 2 million tons would be needed to increase the total daily protein intake to 60 g/head, a level that would still be below the total protein intake in most Western countries. The extra protein must, therefore, be obtained from the plant kingdom, from pulses, nuts or leaves.

Some years after the Nutrition Advisory Committee made its recommendations, vitamin B_{12} was discovered and used in steadily increasing amounts, with or without antibiotics, to improve the biological value of plant proteins for different animal species. Whether this effect will also apply to plant proteins in human diets has still to be decided. India seems a most suitable place to study this question. On this basis, let us consider possible modifications of the recommendations made in 1944.

First, every effort should be made to increase the production and consumption of pulses and nuts as recommended by the Nutrition Advisory Committee, in order to provide about 3·65 million tons of protein annually compared with 2·53 million tons in 1954. The potential supplies of nuts from India's 50 million acres of forest and the possibility of afforestation with nut-bearing trees require investigation. About 0·85 million tons of protein is available annually from groundnuts, but most of it is defatted and given to cattle. Direct human consumption of this protein would be much more efficient if large-scale processes could economically separate the protein from fibre and other unwanted constituents. The impulse process devised by Chayen & Ashworth (1953) yields palatable protein isolates or concentrates from groundnuts or other seeds or leaves and some of the products are being tested here and in India. Gram (chick-peas) with other pulses already provide over 2 million tons of plant protein annually; an increase of 0·4–0·5 million tons might be achieved with improved cultivation. Soya beans, so successful in China, might be a substantial protein source in India. Earlier clinical trials gave poor results, but the trials might be repeated with soya beans from which the trypsin inhibitor had been removed and to which vitamin B_{12} had been added. Cottonseed provides about 0·2 million tons of crude protein annually; it is now almost all used for cattle feeding, but is a potential human food.

Cultivation of pulses adds badly needed nitrogen to Indian soils but these soils also lack phosphates and especially water, which is the limiting factor. Russell (1954) suggests the sinking of thousands of tube wells for irrigation and the development of drought-resistant, early-maturing varieties of crops to overcome this difficulty. He also points out that deep-rooted plants flourish in dry soils, and such plants with weeds that are now used only occasionally for grazing, could provide leaf protein extracted by Pirie's (1947) methods. Certain prolific deep-rooted herbs such as Russian comfrey might give protein yields of several cwt/acre. Leaf protein extracted by Pirie proved acceptable to British palates (Pirie, 1959; Wokes, 1959); these extracts also provide provitamin A and other essential factors.

An increase in the intake of leaf and other vegetable protein from 0·44 to 0·99 million tons a year would raise the intake of plant protein to 7·94 million tons and the total protein intake to 8·9 million tons a year. This would provide the recommended average daily intake of 60 g/head of which 53 g would be plant protein compared with about 45 g suggested by the Committee. Much of this extra plant protein should be consumed in villages close to where it is produced. In cities and larger towns there should be scope for large-scale production and use of plant protein. In the extraction of plant proteins by the impulse process fibre and other unwanted constituents can be completely removed only if the cost warrants it. Defatting by pressing or solvent extraction eliminates bitter principles. Steaming removes these substances from soya and destroys the trypsin inhibitor, but the concurrent losses of lysine and thiamine must be avoided. Germination increases the content of some B vitamins, notably riboflavin, and can eliminate from certain beans and peas the trypsin inhibitor and the bitter or toxic substances such as those causing favism or lathyrism.

Lysine deficiency in Indian cereal proteins can only partly be made good by increased intakes of other plant proteins less poor in lysine (e.g. leaf protein, soya and other pulses). The deficiency can be better overcome by lysine-rich proteins in milk, beans or yeast. Pulse and nut proteins, from dhal, lentils, groundnuts and soya are poor sources of methionine. Rice, millet and maize are marginal. It is, in fact, difficult to construct a diet lacking animal foods, either in this country or in India, in which the methionine content is equal to that in milk. Hughes (1959) found the methionine content of a typical vegan diet which he and I calculated from dietary data on over 100 British vegans to be only 58% of Rose's (1957) 'definitely safe' level, but its cystine content was higher than that in meat-eaters' diets. It would be useful to know whether the methionine-sparing effect of cystine is affected by vitamin B_{12}, since this vitamin was absent from the vegan diet which caused certain signs and symptoms considered characteristic of human dietary deficiency of vitamin B_{12}

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(Wokes, Badenoch & Sinclair, 1955, 1957; A. D. M. Smith, 1961, private communication). Indian diets very low in animal protein may, like British vegan diets, cause neurological manifestations, but perhaps more gradually because of lower folic-acid intakes in India. Low serum vitamin B_{12} levels in British vegans have recently been paralleled by low levels in Indian vegetarians, especially those with nutritional macrocytic anaemia (Banerjee & Chatterjea, 1960). Continued observations on the Indian subjects may reveal the neurological effects observed in British vegans. These effects take several years to develop and may escape detection in short-term trials. Vegan children now in their 'teens who have received no animal food or dietary vitamin B_{12} since weaning are, on average, only slightly below normal body-weight (Wokes, 1957, unpublished). As their serum vitamin B_{12} levels are low it seems that growth rates of children may not provide reliable indication of vitamin B_{12} status, which may explain failures to improve the growth of children by giving them vitamin B_{12}. The Middlesex Hospital Institute of Clinical Research has begun an investigation, with which I am helping, into nervous and other changes in children and adults, including vegans and vegetarians, who have different vitamin B_{12} intakes. Preliminary findings indicate that these changes are often present with low serum vitamin B_{12} levels even though growth appears normal.

Indian infants after weaning suffer from protein malnutrition resembling kwashiorkor which in other countries is successfully treated with milk. In India milk production often lags far behind milk requirements and vegetable milks are being tried to extend the limited supplies of cow's milk. These vegetable milks, so far based mainly on groundnut or soya protein, might also include some nut protein as in America where almonds were used with success (Lane, 1931). The possibility of by-passing the cow and making vegetable milks directly from leaf protein is being explored, but many difficulties have still to be overcome.

After weaning, Indian diets can be supplemented with plant proteins. Groundnut protein freed from unwanted constituents might provide Indian products resembling 'Amama' now supplementing diets of Nigerian infants over 6 months old (Cuthbertson, 1961). The American soya-based 'multipurpose' food has proved successful in India and other countries. At the Central Food Technological Research Institute, Mysore, and the Indian Institute of Science, Bangalore, an Indian 'multipurpose' food has been developed in which defatted soya is replaced by a mixture of low-fat groundnut flour and Bengal gram flour. These products are fortified with vitamins and minerals but not always with vitamin B_{12}.

Plant proteins are basically much cheaper than animal proteins but processing increases their cost. American and British vegetable milks based on soya now sell at prices similar to those of full-cream milk powder but when made in larger quantities should cost much less than the cow's milk they replace. They are now used mainly for babies not given milk either for ethical reasons, as with vegans, or for medical reasons, as in milk allergies and galactosaemia (Payne, Prankard & Wokes, 1959). In the Far East liquid vegetable milks are being made quite cheaply in relatively simple equipment that costs less than £1000 and which may be used in India (Miller, 1960).

These liquid vegetable milks like most other plant-protein products will need fortifying with vitamins and minerals. This fortification should be a fairly simple and inexpensive task, especially in view of the recent dramatic fall in the price of vitamin B_{12}. The efficient distribution of vitamins and minerals throughout the different foods will present problems. They should, in my opinion, be added to types of food that might be expected to contain them, for example vitamin D to ghee. Vitamin B_{12} should be added to plant-protein preparations. On the large scale, as in the impulse process, it should be relatively easy. With leaf-protein preparations made in small units by Pirie's methods and with pulses and nuts prepared in the home difficulties will arise and it may be helpful to add vitamin B_{12} to curry powder or other condiments. Recent findings suggest that if sufficient manure is available the traces of vitamin B_{12} in some leaves may be increased so that they will provide the vitamin B_{12} needed for the leaf-protein preparations (Wokes, 1961, unpublished).

In conclusion, my brief examination of India's food problems shows that, even if efforts are concentrated on obtaining an extra 2 million tons of protein annually, there will be many serious difficulties to overcome. Clinical and nutritional research, food technology and control, agriculture, transport, education and economic factors will all have to play a part. Much as we can learn from experience in other countries, India will still confront us with her own special problems, of which *ahimsa* is not the least important. Nevertheless, we have faith that by facing the challenge firmly we shall find that our efforts have not been wasted.

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The commercial development of a protein-rich food supplement in Nigeria

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Nigeria is a large country, which includes several distinct climatic and geological areas and within which live many different peoples, so that it is rarely possible to

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