The problem of assessing the safety of novel protein-rich foods

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At the outset, it is worth asking: 'Why novel protein-rich foods?' In Britain we eat, on the average, more than twice as much protein as we need for nitrogen balance and, throughout most of the world, where cereals with pulses and mixed vegetables are staples, it is unusual to find a diet adequate in energy which fails to achieve nitrogen balance. In fact, this only happens where there is an excessive dependence on cassava, sago, bananas or other plant products with comparably low protein content. Admittedly, newly-weaned babies and very young children require diets richer in protein, but their share of the food consumed by a whole population is so minute that securing suitable food for them is not a question of agronomy, but much rather a social and political problem. McLaren (1974) has exposed, in part, the mixture of naïveté and monomania that ensnared the United Nations and its subsidiary organizations into the idea of 'the protein gap'. Perhaps the etymology of the word 'protein' itself took a hand in it (Vickery & Osborne, 1928; Tracey, 1948). These organizations would have been far better occupied in encouraging people up and down the world simply to grow more food of various kinds, balanced to suit their local conditions. Rather than this, UN and other governmental 'Aid' money was handed out to various scientific band-waggoners, as well as to straightforward commercial undertakings, to develop techniques for preparing 'protein isolates' from plants, fish, algae, yeasts and other micro-organisms. Scarcely any of these products has gained acceptance by the intended beneficiaries, partly because of their extreme conservatism in food habits, partly because of the absence of wholesale and retail food distribution in rural communities engaged in subsistence agriculture, but mainly because the products are inherently too expensive for them to afford.

Here in Britain, particularly during the last three years, we have experienced, over and above the general inflation, a disproportionate rise in food prices. This is attributable to an evil conjunction of increased prices of imported livestock feeds, bad harvests at home, overfishing and loss of access to fishing grounds; the whole has been compounded by our entry into the European Economic Community and by our failure during the same period to increase the proportion of our food produced within Britain. For the first time in 25 years, most British people are being forced to take a serious attitude to how they budget their outgoings on food.

We are probably about as conservative in our food habits as the 'natives' who have resisted the salesmen of protein isolates. But we do have highly efficient

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wholesaling and retailing of food. And we are also in the habit of eating a variety of factory-processed meat and fish products, into which a proportion of protein-rich non-animal material can be introduced without being much noticed by the eater. Examples are sausages, luncheon meat, hamburgers, fishcakes, rissoles and so on. The materials and the technical expertise are becoming available for such introductions, and the commercial incentive is there, as the substitution will make it possible to sell the new article at a slightly lower price than that of the meat or fish product which it replaces and should, at the same time, give a comfortable profit to the manufacturer of the protein-rich additive.

Of course, there is another approach to cutting food expenditure, and that is to increase the proportion of unprocessed vegetable materials in one's diet, using meat sparingly, like the Chinese, and thriftily, as the French peasants manage their stockpots. Such a movement exists, and is gaining strength, particularly in the better-educated strata of the community. 'Natural food' or 'whole food' freaks are viewed with apprehensive interest by the food industry as a whole (Marshall, 1974), since the 'value added' on the contents of their shopping baskets is tiny, compared with that on the average basket coming out of a supermarket. I learn that there has recently been started in Edinburgh a shop selling 'real food', perhaps even more dangerous.

Well, there are the two tendencies, and it is silly to try to predict the outcome. Both are likely to be with us for a long while yet, so I will just apologize for the length of my preamble, and get down to dealing with 'safety of novel protein-rich foods'.

The Food Standards Committee's report on novel protein foods

This document (MAFF, 1974) represents a notable effort of collective thought on the whole subject. The Society will doubtless be wanting to discuss, on some other occasion, their recommendations on nutritive value (which seem to have been mostly slanted by their doubts as to the education and ethics of those in control of publicly financed catering establishments). But their recommendations in the matter of safety will, I think, shape developments in this and other countries for many years to come.

Their first distinction is between familiar and unfamiliar starting materials. (For useful and up-to-date general reviews of most possible sources of dietary protein, see Pirie, 1975; University of Nottingham, 1976.) The question of starting materials deserves a little quantitative thought. Even if the food industry were to succeed in selling 10 g processed protein/d to every inhabitant of this country, that would only amount to a total of 180 ktonne protein/year, which is less than one-fifth of the protein in oilseed cakes, fish and meat meals, etc. at present fed in one year to livestock on British farms (JCO, 1975). Supply of raw materials is thus not a serious problem for the processed-protein manufacturers for the next several stages of development, and one can predict with confidence that they will feel free to use soya and conventional food-legume seeds, conventional cereals, buckwheat, sunflower and sesame seeds, as well as slaughterhouse and fishery byproducts.

Potato-protein concentrate, a byproduct of the potato-starch industry, might be added if it could be given desirable 'functional' characteristics (Kinsella, 1976). Lupin seed and cotton seed seem likely to be the first 'unfamiliar' protein sources to be considered, since substantial progress has been made in using them as animal feeds, after freeing them from alkaloids and gossypol respectively. In general, 'unfamiliar' protein sources are only likely to enter the field after long years of use as animal feedingstuffs.

The second distinction made by the Food Standards Committee is between processing procedures. Those involving mainly mechanical or physical treatments will require little or no surveillance, whereas those involving chemical treatments (including the use of solvents) will need to get some kind of official approval.

Toxicity of familiar food-protein sources

Of course toxic materials can and do occur in familiar foodstuffs. Morton (1977) has already dealt with this, so I can be brief. Extraneously arising mycotoxins, etc. need surveillance. Some low-molecular toxic substances (e.g. the substances of *Vicia faba*, responsible for favism in susceptible subjects, and the potato glycoalkaloids) may be largely eliminated in the course of processing. Toxic proteins, in particular the lectins or phytohaemagglutinins, which represent a substantial fraction of the proteins of many food-legume seeds, lose their toxicity on suitable heating; the optimum heating, to destroy toxicity without too much damage to biological value, is a topic that merits further detailed study. Contrariwise, heat does not destroy the toxicity of that wheat protein to which coeliac-disease patients react adversely, so it would be hard on those people to allow wheat gluten to get into a wide range of processed-protein foods. In general, though, we have the measure of the inherent toxicity of familiar dietary staples.

Toxicity arising during processing and storage

I have recently tried to collect together and to document the chemical reactions known to occur in proteins during processing and storage (Synge, 1976); many of these probably do no more than lower digestibility or biological value, without introducing toxicity. To have done this releases me from the need to catalogue reagents and reactions in the present paper, and I would like to single out just two topics for special consideration.

Alkali treatment. Judging from the volume of papers and patents, solubilization with alkali is often a step of major importance in the industrial preparation of 'protein isolates' etc. We should remember that treatment of open-air-dried cod (*stockfisk*) with caustic alkali is a traditional step in preparing *lutfisk*, the nauseating centrepiece of the Scandinavian Christmas dinner. More importantly, maize commonly receives alkali treatment in Latin America, and this has been shown to be nutritionally valuable, by making bound nicotinic acid available (Mason, Gibson & Kodicek, 1973). Severe alkali treatment of soya-bean protein gave toxic symptoms in rats (De Groot & Slump, 1969). Milder alkali treatment did not produce these (Van Beek, Feron & De Groot, 1974). The chemical reactions effected by alkali in proteins are multifarious. A suspected mediator of toxic effects is lysinoalanine, which is certainly toxic as the free amino acid. On the other hand, in bound form, it may do no more than lower digestibility. And, once you start looking for lysinoalanine, you find substantial amounts of it in the white of hard-boiled eggs (Anon, 1976). Nevertheless, caution is certain to be urged on those wishing to use alkali as a step in processing. Their discomfiture will be the greater because, at least with soya bean, and presumably with other seed globulins, solubilization can be achieved with high concentrations of common salt at neutral to weakly acid pH values. This process was patented in 1972 (Tombs, 1972, 1976) and promises a rich harvest for the Unilever concern during the coming decade.

Sulphite. This is a chemical reagent used in nearly all branches of the food industry, and its known valuable effects are greater in number than its known adverse effects. Thus, sulphite can prevent 'enzymic' and 'non-enzymic' browning (reactions of quinonoids and reducing sugars respectively with amino acids, proteins, etc., usually damaging to nutritive value as well as to aesthetics); sulphite can regenerate methionine residues from their sulphoxide forms; sulphite can stabilize ascorbic acid. About the only known adverse effect of sulphite is that it can destroy thiamine. However, it forms a wide variety of coupling products with reducing carbohydrates (McWeeny, Knowles & Hearne, 1974), some of which might eventually prove to be toxic. With proteins, its availability to promote rupture of cystine -SS- bonds may have valuable effects on 'functionality' during processing (Kinsella, 1976). The only abnormal chemical constituent known to be produced in proteins by sulphite is cysteine-*S*-sulphonic acid. This was shown to accumulate in the tissues of a baby congenitally deficient in sulphite oxidase, and may have been responsible for its death at 18 months (for references see Olney, Misra & de Goubareff, 1975). As this is the only known case of sulphite oxidase deficiency in man or animals to date, it is of doubtful relevance, and further studies on the feeding of sulphite-treated protein foods to normal animals seem to be called for (cf. BIBRA, 1970). The toxicity of free sulphite is scarcely relevant, as very little of it remains in foods so treated; moreover, it is actively unpalatable before reaching a level dangerous to health. Certainly, the benefits derived from the use of sulphite in the food industry are so great that it would be wrong to throw them away without contraindications of much greater weight than those at present in existence.

Conclusion

'Safety' is one of the mass neuroses of the present age, promoted to the profit of the Sunday press, and promoting 'jobs for the boys' in the scientific and administrative professions. The events consequent on the discovery of Kwok's (or Chinese-restaurant) syndrome perhaps point a moral. Glutamic acid is present in nearly every food we eat. It is a palatable comestible with many dishes. But would it not have been better if manufacturers had refrained from adding it to canned baby foods? It would then not have seemed necessary to conduct laborious and

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expensive neuroembryological studies on the effects of overdoses of glutamic acid on baby animals.

So my conclusion is to urge on food processors conservatism in their choice of protein sources and conservatism in their choice of processes. Within this conservative approach, there is ample scope for palatable and nutritious innovations. For example, in processing oilseeds for human food, both extraction with organic solvents and the use of high temperatures for their subsequent removal may in future be replaced by low-temperature mechanical treatments, that will leave a moderate residue of much-propagandized 'polyunsaturated' fat in the protein-rich product (Weber, 1974; Mieth, Kroll, Pohl & Brückner, 1975). (There are contraindications to the careless storage of proteins in the presence of unsaturated fats (West & Redgrave, 1974), but conditions for suppressing such reactions are becoming much better understood.)

I urge this conservatism because we must remember, in dealing with human beings, that the effects of a new dietary constituent may not be manifested as disease until fifty years or more after beginning to eat it. The danger may also completely elude detection in the course of animal experiments or in the practical feeding of our relatively short-lived farm livestock.

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