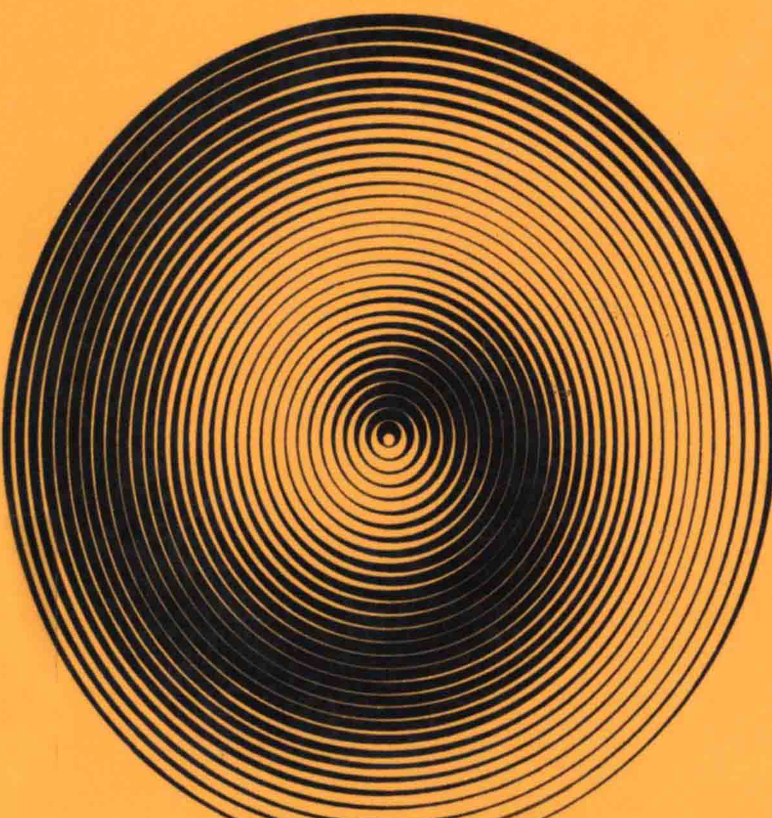
International Biological Programme **4**

Food protein sources

Edited by N. W. Pirie



INTERNATIONAL BIOLOGICAL PROGRAMME 4

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THE INTERNATIONAL BIOLOGICAL PROGRAMME

The International Biological Programme was established by the International Council of Scientific Unions in 1964 as a counterpart of the International Geophysical Year. The subject of the IBP was defined as 'The Biological Basis of Productivity and Human Welfare', and the reason for its establishment was recognition that the rapidly increasing human population called for a better understanding of the environment as a basis for the rational management of natural resources. This could be achieved only on the basis of scientific knowledge, which in many fields of biology and in many parts of the world was felt to be inadequate. At the same time it was recognized that human activities were creating rapid and comprehensive changes in the environment. Thus, in terms of human welfare, the reason for the IBP lay in its promotion of basic knowledge relevant to the needs of man.

The IBP provided the first occasion on which biologists throughout the world were challenged to work together for a common cause. It involved an integrated and concerted examination of a wide range of problems. The Programme was co-ordinated through a series of seven sections representing the major subject areas of research. Four of these sections were concerned with the study of biological productivity on land, in fresh water, and in the seas, together with the processes of photosynthesis and nitrogen fixation. Three sections were concerned with adaptability of human populations, conservation of ecosystems and the use of biological resources.

After a decade of work, the Programme terminated in June 1974 and this series of volumes brings together, in the form of syntheses, the results of national and international activities.

Preface

The inclusion of the words 'For Human Welfare' in the full title of IBP led many early enthusiasts for the Programme to assume that the practical application of research would be so widely recognised that there would be no need to deal with it specifically. However, as research proposals began to come in, it became clear that most participants had an academic approach. There was at first some opposition to the idea of having a Section UM (Use and Management): it was set up later than the other sections and several countries did not form national UM committees. Those countries that had UM committees usually attached more importance to the themes 'Plant Gene Pools' and 'Biological Control' than to the other five themes included in the section. Consequently, a synthesis volume on Theme 3, 'Development of Biological Resources', is more a record of the type of work it was hoped would be included in IBP than of work that actually was included.

The nature and mode of operation of IBP were at first widely misunderstood. Some thought it was a sinister conspiracy out to dictate the world's biological research policy, others thought it was a source of funds. Both were wrong. It was a piece of machinery that was often helpful in getting research funds. But the machinery had to be set in motion by whoever wanted the funds. Differences in the time taken by different people to realise that they had a new ally in fund-getting largely explain the uneven distribution of research effort within IBP. Sometimes an existing national or international research structure helped IBP by providing an organisation within or alongside which it would work. Sometimes a pre-existing organisation inhibited IBP activity because nothing more seemed to be needed. This distinction is clear in national programs: some are mainly new work that might not have started without IBP while others list many projects on which active research had been financed for years.

National UM programs demonstrated widespread interest in protein sources. This limitation of the meaning to be given to 'Biological Resources' was congenial to the co-ordinators of Theme 3 because it seemed that more research would be needed to meet the world's present and impending protein need, than to meet the equally important need for dietary components such as energy and vitamins. Methods for meeting the latter needs are known though not fully applied.

The IBP organised a Working Group meeting in Warsaw in 1966 on

'Novel Protein Sources', a symposium in Varna in 1968 which included a section on 'Subsidiary Sources of Protein Food', and a symposium in Stockholm in 1968 on 'Evaluation of Novel Protein Products'. Summaries of the first two were published in *IBP News*, 7 and 12; the complete text of the third was published (Bender *et al.*, 1970). A Technical Group meeting in Coimbatore in 1970 was limited to leaf protein and IBP Handbook 20 (Pirie, 1971) resulted from it.

The published programs contain many projects connected with protein supplies. Unfortunately, some did not get fully organised. A book limited to those that actually started would have covered the subject inadequately. A meeting convened at the time of the International Nutrition Congress in Mexico in 1972 decided to put no such limit on either subject or authorship. It should, however, be recognised that IBP was actively involved in research on protein in algae, coconuts, deer and other wild herbivores, groundnuts, leaves, and seed legumes.

The book is divided into four sections. The divisions between the first three depend on the extent to which the original products of photosynthesis, on which all the foods eaten at present depend, have been altered in the course of making the ultimate food. The last section deals with restraints on the introduction of new foods and the methods that can be used to popularise them.

Many plants, or parts of plants, can be eaten with no more treatment than can be managed in the kitchen. Obviously, some of these protein-rich foods, e.g., cereal seeds, usually get this pre-treatment in a factory. But it could be managed in the kitchen, and it could be dispensed with. Because a palatable diet usually contains some fat and sugar, if it is finally to contain 8 to 12 % of protein in the dry matter, much of it must consist of material containing significantly more protein than this. Arbitrarily, the lower limit for a 'protein source' was set at 15 % protein. That limitation excludes all the underground parts of plants. It also excludes the cereals that supply more than half the protein that is now eaten, but not some of the newer cereals; there is therefore a chapter on them. Some minor seeds are included, because they are interesting and liable to be overlooked, although they contain less than 15 % protein. Blue-green algae are eaten now in parts of Africa, and were at one time eaten in Mexico, having been collected by hand from natural growth in lakes. They are, therefore, properly included in this section even though industrial production is now proposed. By contrast, a chapter in this book argues that green algae, after a phase of popularity in research institutes, are not to be taken seriously as a bulk human food. They are included for historical reasons, because of their role as condiments and pharmaceutical agents, and because a mixture of algae and bacteria, grown on sewage, is used as an animal feed.

Most of the protein sources that are grouped together in the section on concentrates made by mechanical extraction, are regularly eaten in small quantities in some places without extraction. However, it would be unwise to rely on them for a large fraction of the daily protein supply because of the presence of fibre or of components of varying degrees of toxicity. During the extraction, these deleterious components are removed. This section is intended to be illustrative rather than comprehensive. Work on coconut, groundnut, and leaf protein is included because these were the subjects of IBP projects. Work on leaf protein was indeed undertaken on a more international scale than work on any other topic in Theme 3: useful contributions came from India, New Zealand, Nigeria, Sweden and the UK. Choice among the other sources that might have been considered was more arbitrary. Soybeans are included because of the interesting contrast between the sophisticated methods used in industrialised countries, and the traditional methods in which the extracted protein is coagulated with gypsum, or in which deleterious components are destroyed by fermentation. This chapter is designed to stress the idea that each approach has its merits, and that more attention in research institutes could with advantage be given to improving the traditional methods. Rape is included because of its growing importance. It could be argued that cottonseed should be included for the same reason, and it has the added merit of being a by-product. But the gossypol, which makes cottonseed unsuitable as human food in its unprocessed form, is so conveniently concentrated in glands that can be separated from the meal, that no principle not covered by the other examples of seed-fractionation seems to be involved.

Nothing need be lost during mechanical fractionation. A protein source that could not be eaten in its original state is separated into a concentrate that can be eaten, and a remainder that can still be used as animal feed or in other ways. Biological conversion inevitably involves loss because of the metabolism and energy requirement of the converter. Domestic ruminants are the most obvious and important source of protein made by conversion. A chapter on them is not included because the subject is so vast that it would need a whole book to itself – and there are many such books. There are, however, four chapters on mammals that are now widely eaten, and one on mammalian products that could be eaten though they are not eaten at present. Wild animals are of special interest to IBP; it has been criticised for paying too much attention to conservation for its own sake. The choice of species that could have been considered is enormous. Many will regret that there is nothing here on the capybara, kangaroo, or manatee. The last omission is particularly sad because of the role it could play as a source of meat and as a controller of unwanted aquatic vegetation. Instead, the chapter on wild animals is limited to some species that are already being exploited commercially – there had to be omissions to ensure that the book would be of manageable size.

The decision to limit Theme 3, and this book, to protein sources was not taken because proteins have a unique position in human and animal nutrition that is not shared with vitamins and energy sources, it was taken because more problems can be foreseen in meeting human and animal protein needs than in meeting other nutritional needs. It has been known since 1891 that ruminants, by virtue of the synthetic capacities of the rumen flora, can use nitrogen (N) in forms other than the amino acids. This observation has remained curiously underexploited as a means of diminishing the demand for protein in animal feeds but, as one chapter shows, it is now getting purposeful attention. Mammals without a rumen, presumably because of their different, and smaller, microbial population, are less able to use non-protein N. Nevertheless, the ability of non-ruminants to use simple N compounds is the subject of one chapter. The food requirements of non-ruminants are so similar to our own that much of what they usually eat could have been used as human food. So long as the domestic non-ruminants in a country can be maintained on scraps and by foraging, they are admirable; in a country with a food shortage the advantage of keeping so many that they compete with people must be considered carefully. The case for them would be strengthened if their needs could be partly met by simple N compounds. Non-ruminants are more fecund than ruminants and can therefore respond more quickly to changes in the food supply. The case against both types of animal, when kept on potentially arable land or on fodder grown on arable land, is that they return only 10 to 30 % of the protein they eat in forms usually considered edible by people. It may be that we are too prejudiced. One chapter suggests that such animal products as hair and feathers could be made acceptable. If this were done, the effective efficiency of some animal converters would be greatly increased.

Fish and mussels are the concern of other sections of IBP and are the subjects of other books in this series. During the past decade a widespread impression has been fostered that the future of fish lies in its conversion to the tasteless impalpable powders that will not be noticed when added to conventional foods. Many of the protein sources discussed in this book have that form; silence could have suggested agreement with the popular view. There is, therefore, a chapter arguing that there is an unsatisfied market for fish eaten as fish. Without any increase in the amount caught, much would be gained if more of the catch were eaten instead of being turned into animal fodder.

The enzymes produced by the digestive systems of vertebrates are, to a large extent similar. Consequently, no vertebrate is able, unaided, to use a large group of naturally occurring carbon compounds. It is important to remember that, since the development of methods for the industrial fixation of N, protein production is as often restricted by the supply of precursors containing carbon in the reduced form as it is by the supply of compounds containing N. Plants that photosynthesise can use fully oxidised carbon (CO_2): other organisms, living in the atmosphere made by photosynthesis, have perforce to depend upon carbon in a partly reduced state. A more extensive group of such compounds can be exploited by micro-organisms than by animals because the former are equipped with a more varied set of hydrolytic enzymes. Micro-organisms, even when cultivated on substances that vertebrates can metabolise, have a useful role because of their ability to depend entirely on simple compounds for the N needed in protein synthesis.

Most research is either done in the industrialised countries, or is influenced by their needs and academic interests. This is clearly shown by the dominant direction of research on the production of yeast for use as feed or fodder. The favoured substrate is petroleum although that is an exhaustable asset, and although the techniques needed when it is the substrate are more complex than those needed with molasses and other by-products of agriculture. Those who think that protein sources become more interesting and important in proportion to the likelihood that they could be produced from local products for local use, will study the three articles on microbial protein critically. There is much in them that is of universal applicability; some of the techniques could be used by highly skilled people only.

Pessimists, looking superficially at the history of many attempts to introduce new types of food devised by scientists during the past twenty-five years, are apt to conclude that the outlook is gloomy and that people, even, or perhaps especially, when malnourished, are very conservative in their eating habits. Optimists observe that during the same period there have been great changes in the types of commercially promoted food eaten, and increased substitution of processed for traditional foods. A change that is particularly relevant in the context of protein supplies is the catastrophic replacement of breast-feeding by the bottle. Scientists agree with the old dictum: 'A food has no nutritional value if it is not eaten'. Some of them conclude that the poor acceptance of their new foods may be the fault of their techniques of presentation and advocacy, rather than of intrinsic defects in the foods themselves. Two chapters deal with this point. One is on the safety and quality standards that have to be met to satisfy local and international regulations; the other is on the more subtle question of how to interest consumers in a new product, and how to retain interest once it has been aroused. Within a community, just as within a family, no factor is more important than example.

The letter inviting contributions said that the book would cover every major type of protein source and that it was '...intended primarily as a source of information either on the weight of edible protein that can be produced from a hectare within a year, or on the amount that can be made by extraction or conversion from some inedible material. An indication of the nutritive value of the end product should therefore be given'. The subjects treated have the scope envisaged in the original plan, but authors have not always followed the other suggestions. However, the information given should be sufficient to enable the applicability of each method in any country to be assessed shrewdly. No attempt has been made to get uniformity in the period covered by the different chapters. April 1973 was the original date agreed for the receipt of typescripts; a few were received by that date or soon after. As other editors of collective works have found, plans were then seriously upset by a few dilatory authors.

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April, 1974 N. W. PIRIE

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