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Commodities Into Food

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Commodities into food

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[Plates 1 and 2]

It is not surprising that past predictions of the extent of adoption of new technology by the food and agricultural industries have only been partly realized. This is a result of the difficulty of forecasting the take-up of technology that is capable of being transferred from other industries, for example, process control methods and the advent of new packaging materials. Most technology that is adopted is normally incremental over the existing technology and forecasting of this type is best done by specific experts within the industry.

Factors which influence uptake of technology in the food industry include not only the available technology, but also the supply of raw materials, economics and disposable income, food habits, health and nutrition and market requirements. In addition to these there is legislation, which imposes compositional, labelling and trade requirements on grower, processor and retailer. New products and processes are determined by all these factors, the overriding influence being the consumer's requirement for palatable and nutritious foods that provide value for money.

In the cereals-processing industry significant developments have taken place in the provision of U.K. wheat varieties for breadmaking. The U.K. is now in the position where the bulk of its breadmaking wheats are homegrown. Further advances can be made by investing in applied research into those characteristics of bread wheats which are determinants of good bread flours, that in turn will help in the provision of suitable bread wheat varieties. A less traditional area is that of flour fractionation. With the massive wheat surpluses now available to us there is potential for further uses, both food and non-food, for wheat starch and gluten. An example of the way in which biotechnology will play a role in the 1990s is the use of wheat starch, or other plant starch, as biomass for the conversion of carbohydrate into a protein-rich food – myco-Protein – by using a sophisticated fermentation process.

The effects of future requirements of the food industry on primary production will result in greater flexibility and in crops that are of consistently high quality to supply the new computer-controlled food processes under development. To the consumer there will often be little apparent qualitative change: unseen technology will enable the production and distribution of foods which have a much greater perceived freshness and lower real cost than at present.

The 1990s will bring new pressures on farmer and food manufacturer alike, in the form of increased competition both nationally and internationally. It is necessary to follow up government initiatives already made to ensure a collaborative effort by producers and food manufacturers to identify the optimal balance of primary production; also to support research to identify and apply new technology to the efficient and competitive conversion of commodities into food products.

1. Introduction

In reviewing and predicting the prospects for technology in the 1990s and how commodities will be turned into foods, we must rely on the extrapolation of what is happening now without any knowledge of the discontinuities which lie ahead. However, an indication of how accurate such predictions are likely to be may be obtained from the study of previous publications on the subject.

In 1975, the Royal Society discussed 'Food technology in the 1980s' (Royal Society of London 1975). While this did forecast some of the developments that have since been made in food processing and indicated the economies of large-scale production, it did not, for example, predict the widespread impact of computerization and process control, or the development of extrusion technology for the processing of foods, both of which have figured significantly in recent advances in the food industry. More generally, the chairman of Unilever, Kenneth Durham, has recently pointed out (Durham 1984) that *Britain 1984* (Brech 1963), which was published 22 years ago, made no reference to the development of stereo 'decks', video-cassette recorders, microcomputers or cable television, even though all were technically feasible in 1963.

A less general 20-year forecast was made by the Food Research Association in 1972 (Food Research Association 1972). Their Delphi Forecast was based on the opinions of a select panel of food experts. Now, three-quarters of the way through this period, the forecast is seen to be reasonably accurate in predicting the adoption of new technology which had a high probability of fitting into the then-existing technology and methods of manufacture. This approach to forecasting, that is, experts in the field making predictions based on probability and their knowledge of existing technology, is similar to that adopted by large organizations in their corporate planning. The conclusion is that new incremental technology must be compatible with and additional to existing forms of manufacture if it is to be adopted in the short term. What is more difficult to predict is any 'quantum-leap' technology that may arise and be applied, or more likely be transferred laterally, to the food industry from an unrelated discipline or industry.

Predicting or forecasting should not be based on technology alone, but should take into consideration the availability of raw materials, food habits, market requirements, economic factors (including disposable income) and, in the case of the food industry, nutritional and health requirements.

A further factor is government. Both in the U.K. and within the Common Market, the farmer and food manufacturer are faced with a multiplicity of regulations governing and influencing what is grown, where it is grown (within the E.E.C.), how it is processed, and how it is distributed and sold. Methods of interpreting the legislation vary widely and much effort is put into taking the best commercial advantage from them.

Superimposed on this trade legislation is the growing concern with the effect of too much food on the consumer, that is, over-nutrition. Over-nutrition can lead to obesity and is implicated in a range of human diseases. For instance, obesity, along with smoking, excess of alcohol, inactivity and stress are perceived to contribute to cardiovascular disorder (D.H.S.S. 1984). The current interest and concern in this aspect of food consumption will greatly influence farm production over the next two decades. The nutritional aspect of food cannot be dealt with fully here, other than to point out its relevance in determining what the consumer will wish to eat and therefore require from the farmer and food manufacturer in the 1990s.

Before considering future trends in technology, it is of value to study current and future markets and processing operations.

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2. The market: consumer choice

Success or failure in the food industry depends directly on what the consumer chooses to buy from the supermarket shelf. This freedom of choice on the part of the consumer is a spur to the manufacturer to produce what the consumer perceives as quality products from the best raw materials available within particular cost brackets. Competition is intense in a market which has a low or even negative growth rate. The market potential relates to population size, the spending power of the consumer and how much disposable income the consumer wishes to spend on food.

Table 1. U.K. age distribution of total population[a]

age range	percentage of population 1901	1981
0–5	11	6
5–14	21	15
15–45	48	42
45–65	15	22
65–75	3	9
75-plus	1	6
total population	38.2M	55.1M

[a] Source: Central Statistical Office (1984).

The population of the U.K. is largely static and is predicted to level out at around 58M by the year 2000 (Central Statistical Office 1984). This contrasts with estimates of 70M made in 1973 and has caused revision of market expectations. The population is also changing in age distribution where, for example, the 65–75-year age bracket now represent 9% of the population, compared to 3% in 1901 (table 1). The working population has remained proportionately steady but has changed its lifestyle, with a larger population living alone or in much smaller family units. Market researchers study the food habits of the various age categories and their likes and dislikes with a view to developing new products. Current significant influences are the trends towards more meals eaten outside the home and the rapidly growing awareness that eating too much food, or having a nutritionally unbalanced diet, can be injurious to health.

There are various solutions which are open to the consumer in meeting the problem of over-nutrition. One is to substitute high-calorie foods in the diet by low-calorie equivalents. Examples of such products are low-fat cheeses and spreads, drinks and desserts sweetened with non-calorific sweeteners and starch-reduced baked goods. Another approach is to avoid the so-called 'convenience' foods (which tend to be calorie dense) and eat a 'natural' diet which consists of 'wholefoods' or 'farm-gate' foods, which have been subjected to a minimum of processing. The latter contain more fibre and water, but are consequently considered less attractive and palatable by many consumers.

In attempting to predict the outcome of these swings of food fashion the middle road emerges: given a food intake that is appropriate to maintain correct body mass, the consumer can choose from a range of palatable and satisfying foods which come from both of the categories mentioned above and which will maintain adequate health and nutrition in the individual. In making his or her choice, the consumer has always required ready availability, cheapness,

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convenience, safety and palatability; with the current interest in health and nutrition, one can add naturalness, freshness and nutritional soundness, although it is often difficult to know what is meant by these expressions in terms of products or processes.

Fifty years ago much effort was put into cleaning and refining farm produce to make it edible and attractive to the consumer. Vegetable and fruit crops were commonly diseased or mould-infected. It was necessary to select and peel off husks and skins to produce the edible portion and over a third of the product could be lost between the farm gate and the table. Modern husbandry has now reduced wastage dramatically, often to less than 5% of the harvested crop. The consequence is that fruit and vegetables can be better presented in their harvested state, clean and disease-free. This improvement in quality coincides with the growing demand for 'naturalness' and the renewed recognition that the husks and skins of the crop contain valuable nutrients and fibre. Such products are also less energy-dense and are therefore less likely to promote obesity. The preservation of 'naturalness' among a wide variety of products, often transported long distances for highly urban markets, requires a substantial technological input, which is growing rapidly in sophistication.

The term 'freshness' requires definition in the context of the supermarket shelf. Conventionally, it would refer to products straight off the farm or out of the kitchen oven. Nowadays it is perceived in many processed products, products in which an unseen technology has been used to present them as they were originally harvested or prepared. Consumer research has confirmed this new definition of freshness, which has been brought about by technological improvements in growing, processing and packaging.

3. Food-processing operations

In meeting the needs of the largely urban populations in the U.K., there are problems to be overcome in delivering food products, fresh or preserved, to the consumer. This is a centuries-old problem and the history of food processing, from simple cooking to the more sophisticated forms of dehydration (with subsequent rehydration), canning (meat and vegetables) and freezing, is well documented (Drummond *et al.* 1957).

It is estimated that almost 80% of the food we eat is processed in some form. The term 'processed' must not be misunderstood. It is basically a manufacturing technique to preserve products that, if left to the atmosphere, would become inedible for aesthetic reasons or microbiologically dangerous. The food technologists exercises his skill to achieve this stability with minimal loss of quality. Early attempts to achieve long-term stability were crude, producing over-cooked or over-dried products with poor eating qualities and with diminished nutritional content. Traditional methods have been vastly improved and new methods have emerged. Such developments were greatly accelerated by the two World Wars. The Great War of 1914–18 underlined the nutritional inadequacy of our fighting men ('pygmy battalions') and led to immediate nutritional remedies inspired by Lord Boyd-Orr and others (Boyd-Orr 1936). In World War II, methods of dehydration, and preservation by canning and freezing, received new impetus, as did adequate nutritional planning for optimal growth and health of both the military and civilian populations.

The extent to which farm produce is processed has advanced further since the last war. Much research has gone into minimizing loss of quality and increasing convenience in use by applying the various processes to preserve foodstuffs. Previously farm produce intended for sale 'as is'

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was bought for processing by the food industry, now farmer and processor collaborate to produce a crop that is 'tailor-made' for preservation.

Packaging developments figure largely in such advances and we have moved from an era in which most basic foodstuffs were sold 'loose' to one in which they are now available in long shelf-life, convenient packages of paper, film, tin-plate and foil. The invention of the ring-pull can is an example of how a new technology can create new convenience products and new methods of marketing them. Modern barrier materials are capable of preserving food for long periods at optimal moisture content and without undue microbiological deterioration. These have also enabled the food manufacturer to adopt gentler methods of processing as an aid to improved product quality.

The term 'unseen technology' may be used to paraphrase those unseen processes to which foods have been subjected before they are bought or eaten by the consumer. The term includes process control operations which ensure consistent quality and improved methods of processing. The recent growth in process control of food-processing operations is expected to expand rapidly over the next ten years (MacFarlane 1983). Robotics have already been adopted for some packaging operations. More and more quality aspects will be controlled by sensors responding to particle size, colour, moisture, humidity, bulk density, rheological properties, pressure, weight, conductivity and the presence and quantity of components such as fats, carbohydrates, proteins, vitamins and minerals. None of these improvements will be immediately apparent to the consumer; the measurements and subsequent corrective action will be performed remotely without any direct contact with the food. The result will be improved consistency and product quality, provided that the grower provides produce with the right characteristics and quality.

The current definition of fresh products includes commodities that have been gas or vacuum packed, or processed in some way to nullify the deleterious effects of time. The objective is to leave the foods physically the same as when harvested without any deterioration in taste or appearance. In aseptic packing, cooked foods can be subjected to gentle heat treatment before being sealed into an aseptic flexible container. This form of preservation has been limited so far to liquid foods, which are easily heat treated. The next decade will see this technique grow to include particulates such as large meat chunks in sauces. Pilot samples indicate a quality, maintained over long storage periods, which cannot be distinguished from the same dish fresh from the kitchen.

4. Scientific and technical development

For an industry which has a sales turnover of some £30G per year it is only possible to speak in generalities, because the compass of materials and products is so great. However, three examples from the cereals processing industry may serve to illustrate how science and technology can combine to meet a consumer need and also provide a pointer for developments in the 1990s.

Breadmaking

In the post-war era, wheat for breadmaking was largely imported; U.K. wheat was considered unsuitable. This stemmed from the wheat varieties used and the U.K. climate, and a flour which resulted in a 'sticky dough' and led to handling problems for the plant baker.

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The stickiness is caused by the action of the enzyme α-amylase on the flour starch. Research at such institutes as the Plant Breeding Institute and the Flour Milling and Baking Research Association has since resulted in the adoption of a new range of wheat varieties and associated breadmaking technology (Chamberlain *et al.* 1962), which makes it possible to use U.K.-grown wheats to a much greater extent than formerly.

TABLE 2. FACTORS IN BREADMAKING QUALITY

'hardness' of endosperm
protein (gluten) content
colour of flour or breadcrumb
degree of starch damage
enzyme activity: α-amylase
flour water-absorption

Despite the growth in knowledge of breadmaking and the attributes of flour required to make good bread (table 2), it is evident that there are other factors which remain undiscovered. Flours that meet all the known specifications can still give poor bread. We need a greater basic understanding of the components of wheat flour, in particular of gluten, and how they interact during dough mixing and baking. This work will not necessarily affect the nature of the 1990s product as perceived by the consumer, but will ensure that the cooperation of farmer, miller and baker adopt new unseen technology, which leads to a consistent product with maximum use of European raw materials.

Wheat flour fractionation

This industry has grown rapidly in Europe in recent years because of the particular circumstances of the Common Agricultural Policy relating to starch separation. The U.K. tonnage processed is small but increasing rapidly. In 1983, 200000 tonnes of wheat flour were processed.

The basic washing-out process for the separation of starch from flour is over 80 years old. Today there exist several automated processes, meeting a variety of end-uses for the starch and gluten produced (figure 1). The starch used in industry has traditionally been maize starch which is either imported or separated in the U.K. About two million tonnes of maize starch are still used each year within the E.E.C. The fact that wheat starch has characteristics that

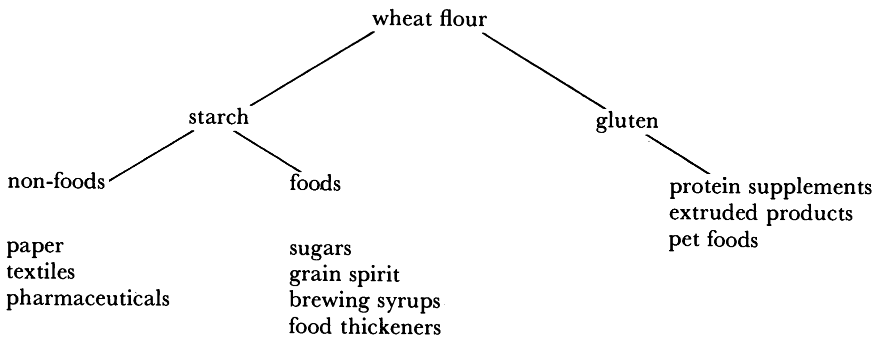

FIGURE 1. Present uses of wheat flour fractions.

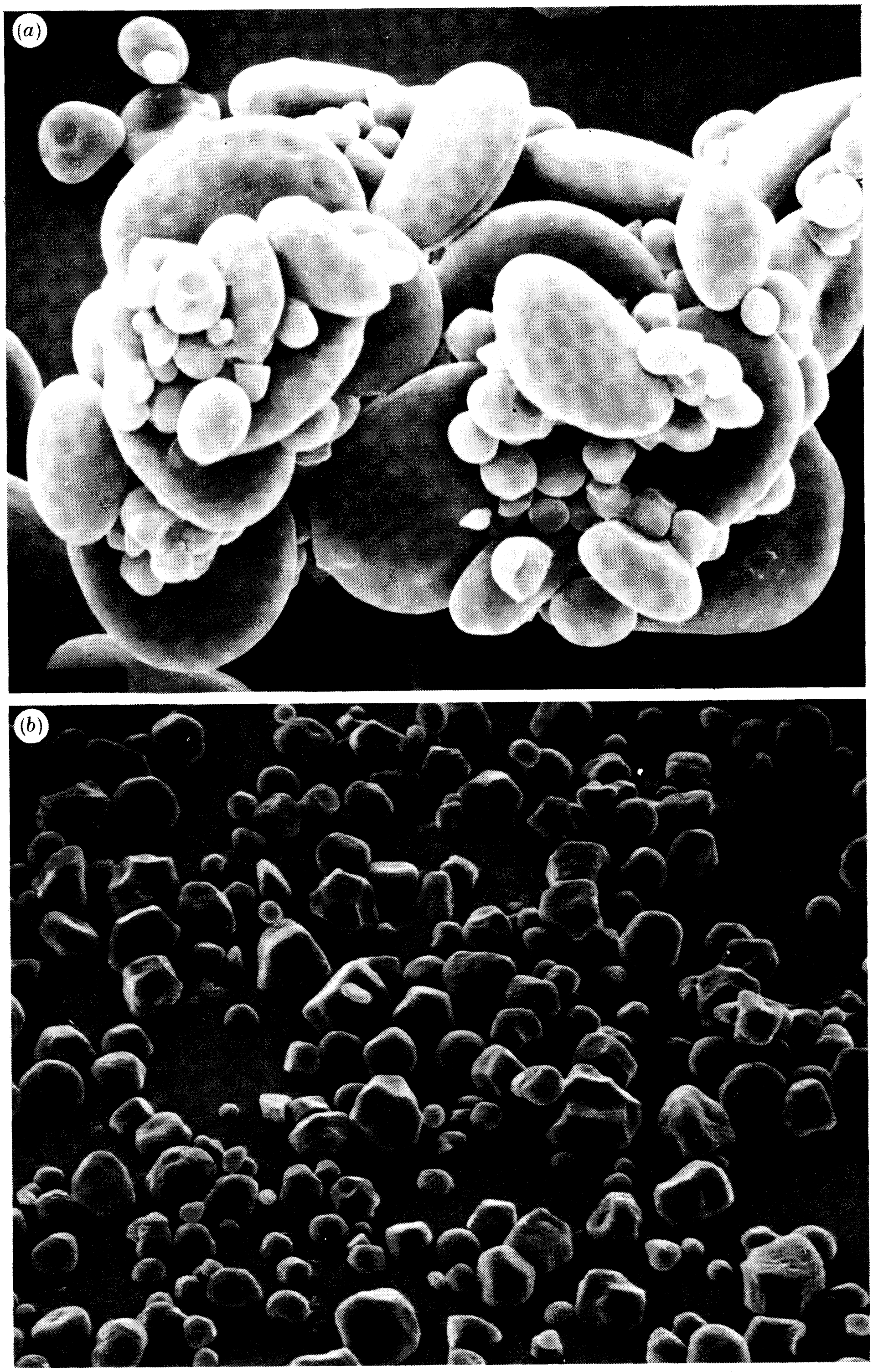

FIGURE 2. Electron micrographs of (*a*) wheat starch and (*b*) corn starch. Magnification ×650.

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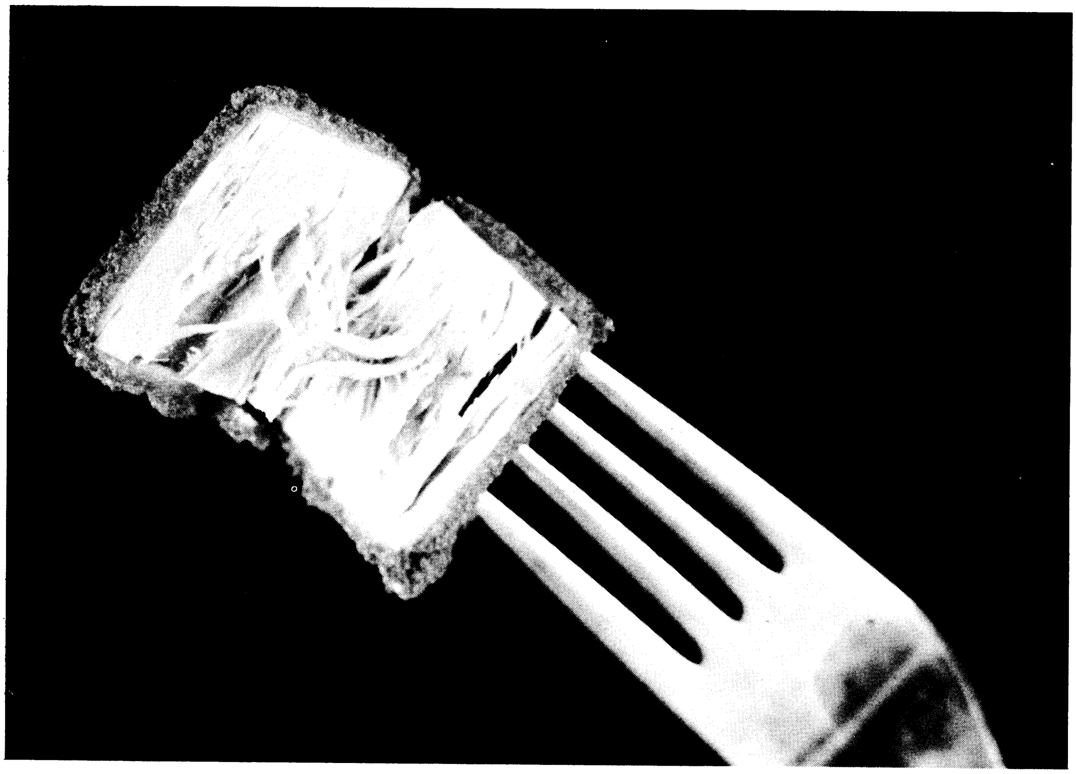

FIGURE 5. Myco-Protein simulated chicken product coated in breadcrumbs.

make it less suitable than maize starch for industrial applications has prompted research into the conversion of wheat starch by enzymic hydrolysis to produce sugar hydrolysates for industrial use.

One of the major differences between maize and wheat starch is that of granule size (figure 2, plate 1). Wheat starch contains two different sizes of granule, the large desirable granules and many much smaller granules. The latter are often associated with protein fragments and subsequently cause effluent problems in wheat starch processing. Maize starch granules are 'clean' and are more easily processed or hydrolysed. Wheat breeders could assist in developing varieties suitable for industrial processing. The recent U.K. production of wheat shows the potential for its further industrial use (figure 3): less than one-third of the 1984 harvest will be required for flour milling in the U.K. The remaining two-thirds will be exported, used as animal feed, or will be available for industrial purposes.

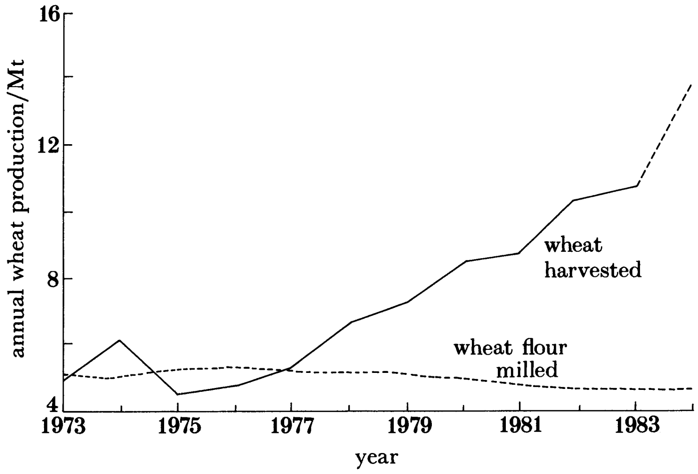

FIGURE 3. U.K. production of wheat. Central Statistical Office (1984).

Fermentation technology: myco-Protein

The above examples from breadmaking and flour separation are examples of how technology can develop with small incremental changes over a long time-scale. In contrast, the production of a protein-rich food from starch hydrolysate by using a sophisticated biotechnological process is an example of a more radical and consequently higher risk approach to innovatory technology.

Based on a need – in this case the need to use a starch by-product – work was started in the 1960s to add value to the starch by converting it to a protein-rich food, myco-Protein, by using a fungal micro-organism. The process used is continuous aseptic fermentation of starch hydrolysate (figure 4) to produce a mushroom-like product that can be textured to simulate meat and poultry products (figure 5, plate 2) and also a wide variety of other foods such as breakfast foods and snacks. Nutritionally, myco-Protein matches meat with the added advantages of little fat and much dietary fibre (Edelman *et al.* 1983).

The initial stages of research and development have been completed; test marketing of selected food products containing myco-Protein is in progress as a preliminary to large-scale production; as always with food and drink products, the consumer will have the casting vote on acceptability.

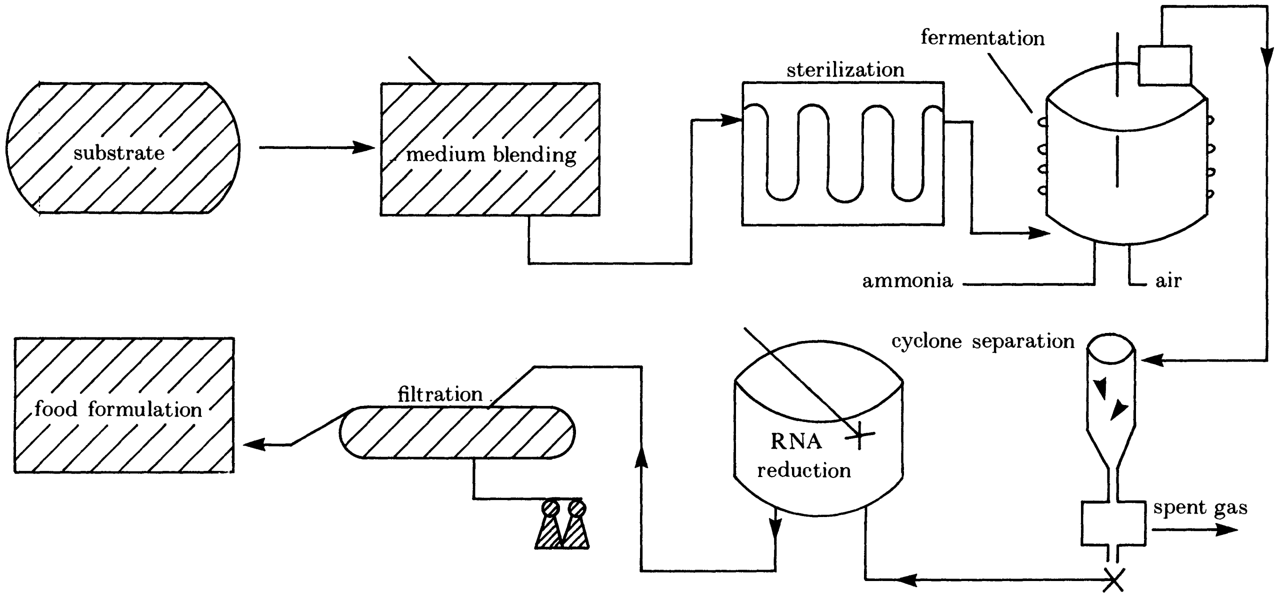

FIGURE 4. Myco-Protein process flow diagram. Hatched areas show hygienic operation, open areas show sterile operation.

5. The effects on primary production

What emerges clearly from the foregoing discussion is the need for close cooperation between the farmer and processor to meet the continuing demand for preserved foodstuffs by our large and largely urbanized population.

A significant development as we move towards the 1990s will be increasingly stringent specifications for raw materials set by the processor. Ultimately this means that quality, which can be defined as tightly specified characteristics of produce, will displace quantity as the principal production incentive for farmers. In certain categories there is the likelihood of more on-farm processing to shorten the time between harvest and preservation. Such demands will lead to greater flexibility by the farmer in reacting to market demands for premium crops.

Crop preference by the farmer has changed continuously over the generations and his choice is normally based on an economic appreciation. For instance, it would seem that the current over-production of cereals must lead inevitably to some change of crop choice. Diversity is likely to increase as consumers become more adventurous in their tastes and lifestyles.

In making a perspective the future activity outside the U.K. must not be discounted. World competition is growing as the market for finished food products becomes increasingly international and British producers and processors will find it increasingly difficult to market their products, even within the U.K. Increased action should be considered now to defend the agriculture and food industries against foreign domination by cheap imported food products, as it was previously against cheap imported food commodities.

6. Conclusion

In discussing the problems that face the industry an optimistic prospect is that new technologies being developed, or yet to be conceived, present an opportunity to maintain the

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U.K.'s position in world agriculture and food production. This means that we must have commonality of view by the farmer and the processor to enable the identification of areas requiring research, development and marketing. The Agricultural and Food Research Council has stated the intention of directing more research effort to underpin the technologies of the food industry. 'Food from Britain' has been set up by the Government at the marketing end of the chain to promote food exports (C.C.A.H.C. 1983). Additionally this should be supported by a unified action group led by the National Farmers' Union and the Food and Drink Federation. A main task should be to identify the ways of establishing the optimal balance of primary production in the light of changing consumer demand. Having established the policy, agricultural and food scientists and engineers can then apply existing and new technologies to convert commodities efficiently and competitively into the foods of the 1990s.

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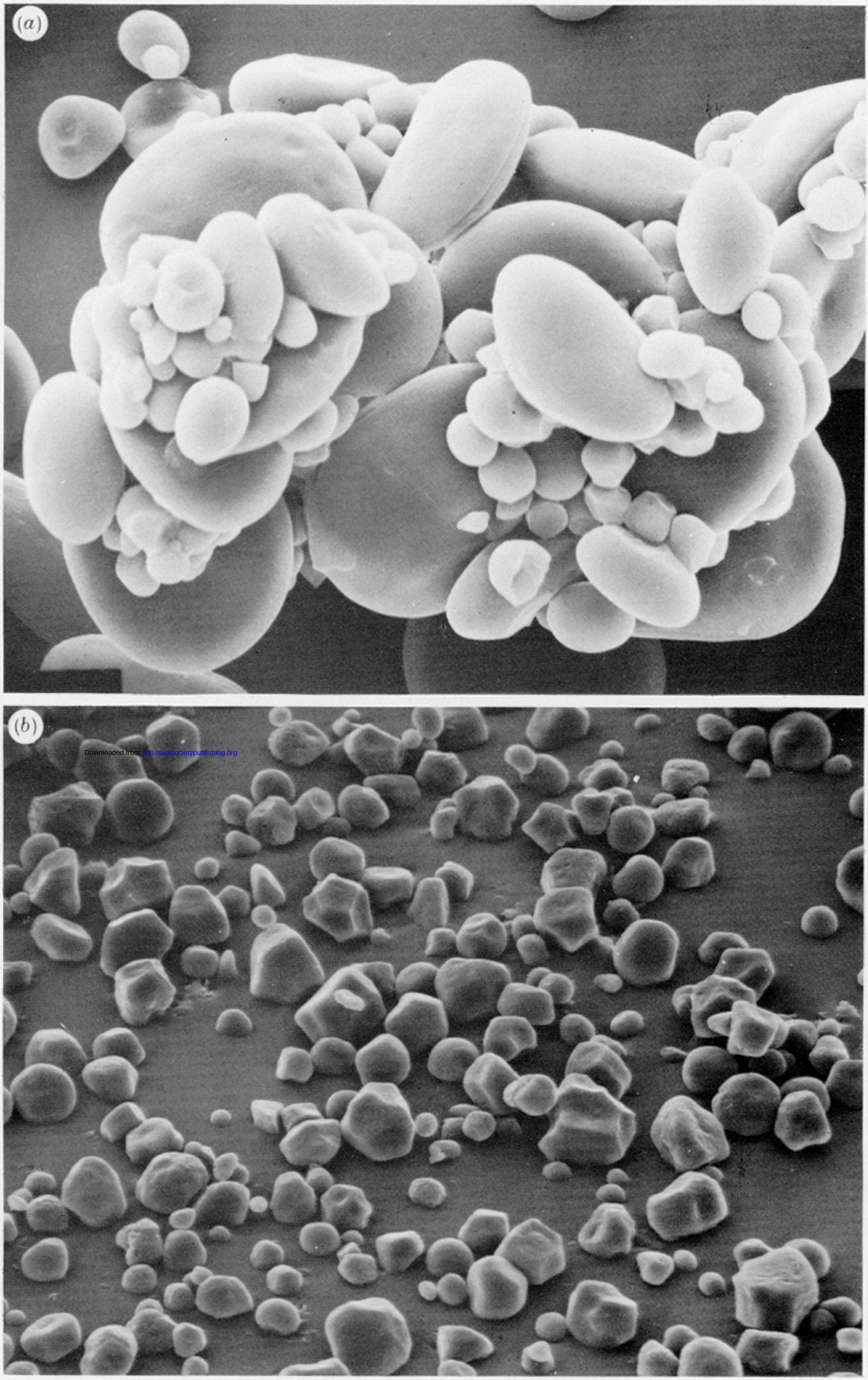

FIGURE 2. Electron micrographs of (a) wheat starch and (b) corn starch. Magnification ×650.

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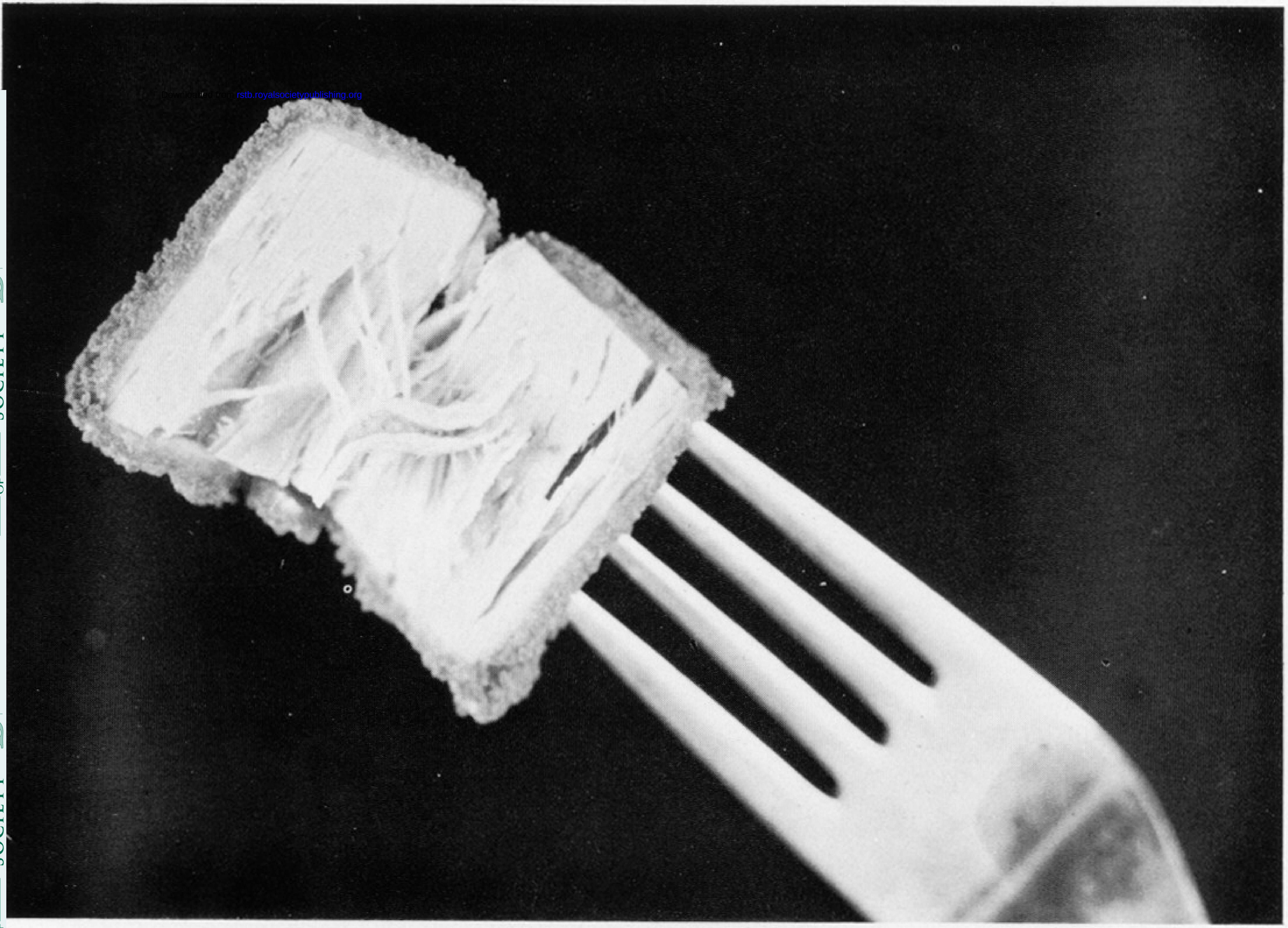

FIGURE 5. Myco-Protein simulated chicken product coated in breadcrumbs.