were 101·2, 94·7 and 94·0% of the controls (van der Wal & Shacklady, 1968).

Both the F1a and F1b litters were taken up to slaughter weight—approximately 100 kg live—with the results shown in Tables. The existence of a 20% yeast group in the F1b litters was because we had enough pigs to make up a third treatment group and were anxious to see what would be the effect of such a high level (Shacklady & van der Wal, 1968).

Commercial grading of the carcasses failed to differentiate between any of the treatments.

Liver, kidney, muscle and fat from these pigs and eggs from the laying birds have been fed to rats for periods varying from 2 to 12 weeks with no indication of the presence of toxic materials.

Regarding palatability, we have fed a ration with 65% of gas oil grown yeast to a pig for 11 weeks without any trouble. After slaughter we submitted hams from this pig and those from a control pig to tasting by 250 people. Both were equally acceptable.

We have now farrowed gilts from this F1 generation and the F2a litters will soon be weaned. So far the performance of the control gilts in farrowing 10·35 pigs weighing 1398 g seems better than the experimental ones with 9·0 pigs weighing 1296 g but beyond merely quoting these figures there are no observations that can be made at present. We intend to go up to the F3a generation which we would expect late in 1969.

No doubt this exposition suffers from trying to present some years of work in 30 min and from describing experiments which are, as yet, incomplete. All that can be claimed for the results so far is that they give us reasonable grounds for expecting that our object of producing a safe and useful ingredient of animal feeds will be achieved in the relatively near future.

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Economic and production problems in the development of new protein sources

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While it is true that there is an overall world shortage of protein, it is equally true that there is protein available now which is not used in improving the nutrition of those in desperate need. Previous papers have described the problems and potential of fish protein, leaf protein, and single-cell proteins derived from yeasts

grown on hydrocarbon residues. In addition to these there is of course the substantial amount of 63 million tons of oilseeds (corresponding to 30–40 million tons of proteinaceous food) which could be used for direct human nutrition, but which is at present used either as fertilizers for crops or as feed for animals. The problem then is not so much one of seeking further sources of protein as of producing products that people want, and at a price that they can afford. The two points of product acceptability, and an economic selling price are the two themes of this paper, and it is failure to fulfil both these conditions that has caused many praiseworthy ventures to founder in the past. As these views of the need for strict observance of consumer requirements and a sensible price structure are by no means generally accepted, I feel it necessary to elaborate.

Since purified protein is odourless, tasteless and without apparent attraction to the consumer, it is not surprising that people do not readily accept it as an addition to their diet. In order to induce populations to increase the utilization of protein foods one must teach them the nature, source, and value of protein, and ensure that protein foods are sufficiently acceptable that they will be actively sought, demanded, and consumed. Thus education is necessary, and education is only another way of saying 'advertising', and this is inevitably expensive. It takes a lot of hard work to get people to change their purchasing and feeding habits, and so new products should fit in as closely as possible with present customs and dietary patterns. Changes of colour, taste or texture are frequently resented. To be successful in developing countries I am convinced that one must apply our sophisticated techniques of consumer research, product development, and marketing suitably adapted to the country in question.

Free or uneconomic distribution can only be a short-term emergency procedure, or used to encourage and develop the use and acceptability of the product. Even this has dangers in that undesirable associations have developed when a product is issued free, and these have prejudiced subsequent commercial distribution.

I wish to quote a 1968 United Nations report (United Nations, 1968) which admirably summarizes my views:

'The greatest obstacle to the commercial use of new protein foods . . . is not so much in their production in a safe, nutritious, palatable and sufficiently inexpensive form, but the requirements for effective marketing and promotion. Excellent products have remained laboratory curiosities because they were not presented to the public in a culturally acceptable manner or were not properly distributed in association with a well-designed educational and promotional campaign.'

I would like to consider now a number of commercial ventures which have set out to sell protein foods, and examine the reasons for their success or failure. The examples under consideration are listed in Table 1.

Multi-purpose Food in Brazil (Item 2 in Table 1) is a fortified defatted soya flour primarily intended for infants and small children. About 95% of the product is distributed through institutions and only 5% through the retail trade. The profitability is very unsatisfactory owing principally to the need for greater volume. The firm has not attempted to develop the retail market because it considers the

Table 1. *Some commercial protein food ventures (Values from Orr & Adair 1967)*

Country	Company	Product	% Protein	Price	Profitability
1. Mexico	Proteinas S.A. (General Mills)	Protea	50	3s. 3d./lb retail	Not known
2. Brazil	MPF Products	Multi-purpose Food	50	1s. 9d./lb F.O.B.	Very unsatisfactory
3. Brazil	Nestle subsidary	Fortifex	30	3s. 3d./lb retail	Unsatisfactory
4. India	Chandra Corporation	Multi-purpose Food	42	2s. 5d./lb retail	Does not justify expansion
5. Africa	Nigerian Creameries Ltd (50% Government and 50% Cow & Gate)	Arlac	42	2s. 3d./lb retail	Non-profit making venture to date
6. Africa	Glaxo Research Ltd	Amama	*c.* 50	3s./lb retail	Discontinued. Poor estimated profitability
7. Nicaragua	Alimentos Infantiles	Incaparina	*c.* 25	—	Discontinued
8. El Salvador	Productos Alimenticios	Incaparina	25	—	Discontinued
9. Guatemala	Cerveceria Centro Americana SA	Incaparina	*c.* 25	—	—
10. Colombia	Productos Quaker SA	Incaparina	27	8d./lb retail	Poor
11. Peru	Penilac (Nestle subsidiary)	Peruvita	35	—	New venture
12. South Africa	Hind Bros. Co., Ltd	Pronutro	22	2s./lb retail	Presumed satisfactory
13. Indonesia	P.N. Sarihusada	Saridele	19	—	Satisfactory
14. Hong Kong	Hong Kong Soya Bean Products Co., Ltd	Vitasoy	3	2½d./8 oz bottle	Satisfactory

promotion of the product through general advertising would be too expensive and speculative 'at this stage'.

Fortifex in Brazil (Item 3) is a fortified mixture of defatted soya flour and maize meal intended mainly for small children as a supplement. The product is distributed entirely through the retail trade supported by radio advertising at an initial promotion cost of 15% of the selling price. The profitability is unsatisfactory because of the inflationary situation in Brazil.

Multi-purpose Food in India (Item 4) is a fortified mixture of groundnut flour and Bengal gram intended for children and adults. Most of the production is purchased by the Government and thus has an assured market. Virtually no money has been spent on advertising, and the lack of profitability is mainly ascribed to the high cost of packaging material.

Arlac in Africa (Item 5) comprises groundnut flour and skim-milk powder, and is largely distributed free by the Northern Nigerian Government. The small amount of retail trade is not prospering because the company cannot afford a satisfactory packaging material and because the price is too high.

Amama was a blend of groundnut flour, casein, and dried yeast, and was distributed retail. Although the product was withdrawn at the time of the first aflatoxin scare, it is thought that it would not in any event have survived because of poor acceptability, and because it was promoted as a medicine, rather than a food.

None of the South American attempts (Items 7, 8, 9 and 10) to sell Incaparina seems to have been successful. The Nicaraguan company was largely a humanitarian operation established by a group of local physicians, and it failed because they underestimated the amount of market development required. Productos Alimenticios of El Salvador is a major food processing company, but although they launched Incaparina with a full-scale publicity campaign, the project failed because of the poor acceptability of the product, unattractive packaging, and the fact that it was promoted as a medicine rather than a food. In Colombia Productos Quaker have launched Incaparina with a wide initial publicity programme through radio and cinema but the profitability is poor because of unstable raw material supplies and loss of profit margins from inflation and Government price controls.

One of the successful ventures is Pronutro sold by Hind Bros. (Item 12) in South Africa. The product is comparatively complex and is made from groundnut and soya flour, fish protein concentrate, yeast, wheat germ, sugar and maize meal, with mineral and vitamin additives. It is sold in the form of a pre-cooked flour to be used as a breakfast food or as a baby food. In early work Hinds directed the product particularly towards the African market, and after satisfactory early selling, sales later declined because the African population believed that a product sold only to them must be inferior to products which were intended for the white population also. A feature of the present Pronutro campaign is that it is being sold in both European and African markets in South Africa. The product was carefully designed and a substantial amount of money spent on promotion.

Saridele in Indonesia (Item 13) is a spray-dried soya milk, sold both flavoured and unflavoured. After reconstituting with water it is used as a beverage in com-

petition with conventional soft drinks. Considerable effort has been put into promotion at an estimated cost of 3% of sales value.

Vitasoy in Hong Kong (Item 14) is a well-established commercially successful product. It is a liquid soya milk (malted or plain) sold sterile in glass beverage bottles sealed with a metal crown. Distribution is mainly to retail outlets, the product is promoted heavily at dealer and consumer level, and carries 5% of selling price on advertising.

I think that the successes and failures in the examples which I have cited illustrate the fact that the following points need to be observed in order to develop a successful venture in developing as in developed countries:

(1) Develop products which are acceptable to the local population and which fit well into existing or already changing eating habits.

(2) Ensure raw materials supply.

(3) Establish sound production methods and quality control.

(4) Establish a sensible price structure which results in a selling price which the consumer can afford and which offers a fair profit to the producer.

(5) Bring the virtues of the product to the attention of the consumer, i.e. promote and advertise.

Economics of the product

The economics of the product vary according to the country, its complexity, the competition, raw material and availability—to mention but a few. Whatever the product however, the following factors are always relevant:

(1) Cost of market, economic, sociological and consumer surveys and product development.

(2) Price of the raw material. For oilseeds this is unlikely to be less than £50–60/ton, which is equivalent to £120–140/ton of protein.

(3) The processing cost can vary from very little for simple products to something near the order of the raw material cost for sophisticated products.

(4) Packaging. The packaging of certain types of protein products was considered at an FAO/Unicef Conference (FAO, 1964) in 1964 and they concluded that for consumer-size containers the packaging cost would be of the order of £7/ton of product.

(5) Transport.

(6) Promotion and advertising. In the fourteen commercial protein food ventures which I have quoted, the expenditure on promotion and advertising varied from nil to 5% of sales value.

(7) Wholesalers' and retailers' margins. In Western Europe and the USA the combined wholesalers' and retailers' margin is said to vary between 20% and 40%. Very little information is available on distributive margins in developing countries. One could surmise on the one hand that distributive costs will be higher because of the less highly organized and efficient systems prevailing in developing countries. On the other hand, simpler facilities could mean lower costs.

Thus the best estimate we can make is that distribution costs will vary between

wider limits than in developed countries. This view is borne out from the information available in that the difference between ex-works bulk-packed product and retail consumer-pack (i.e. % margin) varies from 17% for Incaparina in Columbia to 85% for Pronutro in South Africa and 90% for Multi-Purpose Food in India.

Production problems

One of the major problems in the production of protein-rich foods is obtaining a reliable supply of raw material of the correct quality. Variations in cost, quality, and regularity of supply all disrupt economic running of the process. Taking oilseeds as an example, the difficulty starts with the fact that removal of the vegetable oil is usually necessary for the economic use of the crop, and the protein-rich residue has been really regarded as a by-product. Traditional methods of oil-milling are usually unsuitable for producing food-grade oilseed meals because the hygiene conditions are too low for food products and the processing conditions have an adverse effect on the protein nutritive value and on its physical properties such as colour, flavour and solubility. Thus in most instances we have to start with a new process and a new plant which has due regard for the condition of the protein-rich residue after removal of the oil. This example highlights the need for careful specification of raw material and the probable need for capital investment in new plant—with the consequent implication for raw material prices.

There are no special problems in the further processing stages which are not already standard practise in the food industry—mixing, separating, heating, cooling, drying, sterilizing, etc. The difficulties likely to be encountered will be consequent upon the fact that the operations may have to be carried out in places where they have never been done before, with no production experience, with unskilled labour, and with a shortage of necessary services.

These points underline the desirability of good pilot experiments to determine consumer acceptance and the potential size of the market, thereby defining plant size and capacity.

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