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Synthetic Meat - A Challenge To The New Zealand Meat Industry

by
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MASSEY UNIVERSITY
PALMERSTON NORTH
NEW ZEALAND.

COMMODITY REPORT No. 2

FEBRUARY 1972

28

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SYNTHETIC MEAT - A CHALLENGE TO THE NEW ZEALAND MEAT INDUSTRY

by

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Commodity Report No. 2

February 1972

PREFACE

The Market Research Centre was established in June 1970. A major objective of the Centre is to provide economic and market information to commercial and Government organisations. This publication - the second in the Centre's 'Commodity Report' series - deals with an issue that is particularly pertinent to organisations associated with the New Zealand meat industry.

The advent of synthetic meat has introduced a potentially direct threat to the continued profitability of the New Zealand meat industry. At the present time, the nature and magnitude of this threat remain uncertain. Nevertheless, the unhappy experiences of other producers of agricultural raw materials - particularly butter and wool - when confronted by competition from synthetic substitutes, suggest that the New Zealand meat industry should exercise extreme vigilance.

The information currently available concerning the production and marketing of synthetic meats is characterised chiefly by its scarcity and fragmentation. In the study reported here, Messrs. Gendall and Bull have attempted to assemble relevant information from a number of sources in order to provide an up-to-date summary.

The authors have found that although synthetic meats have not yet captured large shares of world meat markets, synthetic products offer potentially strong competition, particularly for natural meat of manufacturing grades. This report suggests that the New Zealand meat industry should devote urgent attention to developing a substantial research programme designed to (i) maintain close surveillance of developments in synthetic meat production and marketing, and (ii) evaluate competitive strategies for the production, slaughter, processing, packaging, and distribution of New Zealand meat.

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1. INTRODUCTION

In the last 20 years major advances have been made in the production of substitutes for traditional farm products. Among the more recent substitutes to appear on commercial markets are synthetic or artificial meats, produced from vegetable protein. Although present consumption of these products is relatively small, their development is of some concern to meat producers because of the experience of the impact of synthetics on the prices of other agricultural commodities, especially butter and wool.

Synthetic meats are produced from protein of non-meat origin. At the present time, vegetable protein - especially soya bean extract - is the dominant raw material. Wheat and various types of herbage also have potential as precursors of synthetic meats, while intensive research continues into the derivation of suitable protein extracts from fish, various industrial wastes, and micro-organisms cultured on petroleum-based materials.

A wide variety of synthetic meats is already available and substantial expansion of the product range is inevitable. Three distinct categories of synthetic meat are produced. In the first, the non-meat protein is incorporated as an ingredient in manufactured products such as sausage, hamburger, and the like. These products may or may not contain natural meat. The second category is textured chunks and meat-like pieces which are incorporated in meat loaves, soups, stews and goulashes or serve as savoury pieces. The developing use of non-meat protein in these two forms should not, however, be confused with the third category of synthetic meat products in which synthetic analogues, intended to simulate natural meat cuts in texture, taste, odour and appearance, are being introduced.

Although the more sophisticated meat imitations are still relatively expensive, the use of plant protein products in synthetic/natural meat blends can reduce the cost of the final product substantially [1/]. To a

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1. This point is discussed in more detail on page 10.

country like New Zealand, the world's largest meat exporter (in 1970/71 exports of meat and meat by-products earned $NZ507.1m.), any product that becomes an accepted substitute for meat poses a real threat, not only to meat producers, but to the whole economy.

The purpose of this paper is to review the available information on developments in the production and marketing of synthetic meat products. Some assessment is made of the factors likely to influence their competitiveness with natural meat, and emphasis is placed on a preliminary evaluation of the effect on the New Zealand meat industry of competition from synthetic meats in 'natural' meat markets.

No claim is made to originality and this paper draws heavily on similar review articles [2]. However, since much of the relevant information is not readily available in New Zealand, it was felt that a further paper of this type could serve a useful purpose by alerting the New Zealand meat industry to market developments that could pose a very real threat.

It is extremely difficult to obtain statistical and other pertinent data on production, prices and sales of simulated meat products, since most of this information is of a proprietary nature. This inhibits the scope and precision of this review; nevertheless, sufficient information is available to enable some tentative conclusions to be drawn.

2. PROTEIN SOURCES

Meat substitutes are produced from a protein base which may be extracted from a wide range of plant and non-plant sources. In practice, the most widely used of these has been soya beans. However, edible protein has also been extracted from other oilseeds, cereals, pasture herbage, and from fish and animal wastes. As well as these plant and animal sources,

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2. Articles drawn on include: Sault and Gale [11] and White [13]. A tongue-in-cheek review worth attention is [3, p.375].

petroleum and industrial by-products can yield edible protein by the action of various micro-organisms [3]. These sources are of particular interest because of their potential for substantial reductions in production costs as the scale of processing plants increases.

Besides soya beans, the only source used on a commercial scale to provide the protein base in simulated meats has been wheat, which has found use in Japan.

3. PRINCIPAL PRODUCTS [4]

Synthetic meats compete with a wide range of natural meats in one of three different forms. Synthetics are used as fillers, as textured chunks and meat-like pieces, and as simulated cuts. Brief descriptions of these products are given below. Further details of the production processes are given in the Appendix.

3.1 MEAT FILLERS

In this class of uses, non-meat protein may be included in manufactured products such as sausages, luncheon meats and gravies. In this role the fillers perform certain specialised functions - such as minimising shrinkage and retention of fat and natural juices - where they compete with other non-meat ingredients such as starch and milk powder. Additional amounts may also be included as 'meat extenders', in the place of some of the natural meat previously used, to lower the cost of the product.

In the United States, a major use of soy protein has been to replace meat in pet food formulations. However, its use in products intended for human consumption is restricted by law to an upper limit of between 3.5% and 12% (by weight).

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3. For a discussion on the development of new foods from yeast, algae, plankton and petroleum products see [6, p.26].

4. An account of some of the vegetable protein products available on the U.S. market is given in [2, p.85].

3.2 TEXTURED CHUNKS OR MEAT-LIKE PIECES

Fifteen United States and some nineteen Japanese manufacturers 5/ produce chunked or crumbled forms of textured protein for the institutional market; they are used in the preparation of meat loaves, hamburger meats and various savoury meats.

Synthetic items are also available in a variety of meat-like pieces which may serve as savouries or as ingredients in home-prepared soups, stews, casseroles, goulashes and similar dishes. The most popular among these synthetic meat pieces are simulations of chicken, turkey, beef, luncheon slices and bacon bits. These products cook with minimum shrinkage, without waste. Taste and tenderness are uniform. Protein content runs as high as 30%, which compares with the 12% to 20% found in most natural meats. The advantage of these products is that their composition, type of fat, and calorie content can be changed to suit different markets. For example, Bac*Os, a recent introduction, has the appearance of uniformly rectangular, fried, dry bacon pieces of very high quality. This product is used as a garnish for salads and other dishes, reportedly having the taste and other qualities of excellent bacon. Bac*Os also has the advantage of not requiring refrigeration.

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5. These figures are quoted by Sault and Gale [11, pp.213-214]. They say (referring to the United States) "The bulk of this input (of soya bean protein) has been manufactured by a small number of firms. In 1967, three soya bean processors accounted for over 90% of the total output of soy flours and grits, four manufacturers produced all of the soy protein isolate. There appears to have been less concentration in the manufacture of simulated meat products, in which at least fifteen firms were involved in 1969".

"The bulk of the simulated meat products marketed in Japan has been produced locally. In 1969, nineteen firms were engaged in the various manufacturing processes relating to simulated meats and a further four firms were involved in the small import trade".

3.3 SIMULATED CUTS OR MEAT ANALOGUES

Non-meat protein forms the basis of products designed to substitute directly for natural meat cuts. In this case the produce is processed to imitate the texture, flavour and form of natural meat and a wide range of these products is available to United States and Japanese consumers. They are usually pre-cooked and marketed either in a frozen form or as a shelf-stable, dehydrated product.

The bulk of these simulated meat cuts is bought, however, by certain consumer groups to whom natural meat is unacceptable for dietary or religious reasons. This specialised outlet for meat-like synthetic products does not compete with natural meat supplies. Examples of such products available in the United States include "Holiday Roast" a frozen, uncooked, 2 lb turkey-style entree which bakes in about two hours and serves six to eight people. A more recent product is "Stripples", a bacon analogue that is more convenient to prepare than the natural product as well as being cheaper when allowance is made for shrinkage of bacon during cooking [4, p.26].

4. THE IMPACT OF SYNTHETIC MEAT ON NEW ZEALAND'S EXPORT MEAT TRADE

The following paragraphs focus attention upon the impact on New Zealand's export meat trade of the advent of synthetic meats. At the present time, the paucity of data relating to both the supply of synthetic meats and the demand for them makes a quantitative evaluation impossible. Nevertheless, the information that is available permits some tentative conclusions concerning market trends to be made, and indicates potentially rewarding lines for future research by the New Zealand meat industry.

4.1 PRESENT MARKETS FOR SYNTHETIC MEAT

Present demand for synthetic meats is concentrated almost exclusively on meat fillers and textured chunks and pieces. Simulated cuts are available in some countries but have apparently made little headway against competition from natural cuts. Thus the synthetic products that have gained greatest initial consumer support are those competing directly with New Zealand's exports of manufacturing-grade beef and mutton. A more detailed regional review of markets follows [6].

4.11 The United States Market

In the United States, the quantity of soya bean protein used in food products has been rising in recent years. It is estimated that the consumption of soya bean protein products competing directly with natural meat rose from 30m. lbs. in 1967, to 50m. lbs. in 1969 [11, p.213]. However, even if synthetic meat production was five times the level of protein produced (allowing for the addition of water, and other additives), the figure of 250m. lbs. for 1969 would be small in relation to total United States meat consumption of 4,500m. lbs. Nevertheless, it would be quite significant by comparison with total imports of meat of 1,600m. lbs., and would be greater than the level of imports from New Zealand which amounted to 209m. lbs. in the same year.

At the same time it appears that most of the synthetic meat sold has taken the form of meat fillers and extenders, and textured chunks. Restaurants, hotels, hospitals, and vegetarians have been the chief buyers. As yet, simulated cuts of meat have had virtually no impact on the retail trade.

United States Federal and State regulations limit the percentage of non-meat ingredients that may be used in processed meat products; in most cases these meat extenders are not permitted to exceed 3.5% and are not permitted at all in products labelled as hamburgers.

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6. For a fuller account of production and marketing see Sault and Gale [11, pp.212-215].

4.12 The Japanese Market

In Japan, the production of simulated meat items is only a very recent development and consumption of these items is still very small although it appears to be rising. A feature of the Japanese industry has been the importance of wheat as a protein source.

Although a variety of simulated meat products has been available in retail outlets, most of the output has been marketed through the institutional trade, especially lower priced restaurants where it is reported to have been mixed with minced natural meat.

Research into the production of simulated cuts is being directed mainly towards products resembling beef, as the resources for increasing production of beef in Japan are more limited than they are for pork or poultry meats.

Japan is regarded as possibly the greatest potential market threatened by synthetic meats since most of the people have not acquired a taste for red meat. A large proportion of beef consumption is by relatively few people and the 100,000 tons or so of mutton imports are used in processed products. Thus a cheaper synthetic product could absorb a substantial proportion of what should be a rapidly growing market. Also soya beans are a traditional source of protein in Japan providing 12%–13% of protein intake.

In Japan, the maximum content of vegetable protein in processed meat products has only recently been limited to between 3%–5%, depending on the product.

4.13 The Western European Market

Synthetic meats have so far not proved popular in Europe. The products, marketed mainly in the Netherlands, the Federal Republic of Germany and Sweden, have been used primarily as sausage binders and food additives or sold in packets of small pieces with pork or beef flavouring suitable for use in stews, goulashes, and the like.

The initial demand for simulated cuts and meat pieces, arising from their novelty and intensive promotion, has dropped off rapidly despite decreases in retail prices.

However, there is currently a greal deal of experimental work in the synthetic protein field, mainly concerned with yeast protein. Most of this material is being included in livestock rations, but it seems certain that yeast protein will be developed for human consumption, and the U.S.S.R. is reported to have been producing yeast protein at a rate of 10,000 tons annually.

4.14 Markets in Other Countries

Simulated meats have been marketed in South Africa, Canada and Australia, but the volume of sales has been very small. Synthetic products have found little acceptance with the general public and have been consumed mainly by vegetarians.

4.2 OVERALL EFFECTS OF SYNTHETIC MEATS ON NATURAL MEAT SALES

From the previous section it is apparent that the effect of synthetic meats on the demand for natural meats has been small, although already there appears to be some depressing effect on demand for grinding beef in the United States.

The future effect of synthetic meats on natural meat sales will involve at least the following factors [7].

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7. A detailed discussion on the current situation, competitive effects and technological factors affecting synthetic meat development is given in U.S.D.A. [14, p.34]. See also Call [7, p.5]; [4, p.24]; American Soybean Association [1, p.44]; and van Musschenbroek [15].

4.21 The Properties of Synthetic Meats

Synthetic meats generally have a higher protein and lower fat content than natural meats. This would favour expansion in affluent countries where there is increasing emphasis on high protein, low calorie and low cholesterol foods [8]. Artificial meats are less palatable than natural meats and this explains in part why consumers still tend to prefer natural meats. Synthetic meats lack "chewability"; some items tend to be "mushy" while others have been inclined to shatter into granules or particles when eaten.

The fact that synthetic meats require chemical additives, both in extraction of the protein and in the preparation of the product, may also count against them. Consumers today are tending to become suspicious of synthetic food products, particularly those requiring chemical additives or treatment.

These problems are the subject of substantial current investments in technical research, and some recently introduced products show great improvements [9]. In addition, manufacturers can be expected to develop mixtures of synthetic and natural meat which combine the desirable properties of both products while masking the undesirable features of the former.

The great advantages of synthetic meats are:

(i) They are free of gristle, bones, skin, or excess fat and can easily be standardised at the point of manufacture, so the need for inspection by experts during subsequent marketing is reduced.

(ii) Their composition can be changed to suit the observed preferences of the consumer.

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8. In [12, p.61], it is suggested that the most important future development in the food industry will be foods that are balanced nutritionally with the emphasis on nutrition as a form of preventive medicine.

9. One of the major producers, General Mills Inc., is reported to have invested several million dollars and more than 300 man years of effort in developing simulated meat products [11, p.213].

(iii) They are convenient and quick to prepare. This makes them attractive to institutions since they allow a large volume of food to be prepared quickly with a minimum of equipment and with little waste.

(iv) In a dehydrated form they are stable at room temperature; they don't shrink or lose weight during storage and they have a long shelf life.

(v) The protein of the soya bean is highly nutritious, containing all eight amino acids essential for human nutrition. In addition, the basic soy protein products (soy flour and grits) are a source of the B- complex vitamins and choline, and provide calcium, iron, phosphorous, potassium, and traces of the other essential minerals [1, p.45].

4.22 Relative Prices

Prices of simulated meats which attempt to imitate natural meats are still relatively high. One study indicates that in the United States spun soy protein products sell at about $NZ1.30 - 1.35 per pound, wet weight basis, compared with the average retail price for choice grade beef of $NZ0.87c. per pound. Prices for other textured protein items are low enough, however, to make synthetic/natural meat mixes, in which palatability problems would be less apparent, a threatening prospect. A recent United States case study for example, suggested that if 40 lbs. of textured soy protein were added to 100 lbs. of manufacturing beef, the net cost of the 140 lbs. of product could be reduced by $NZ0.10c. per pound. In Japan, where meat prices are much higher than those in the United States, the price advantage of such mixes would be even greater [13, p.5].

Rising world demand for meat has not been met by a similar increase in supply, particularly of beef, which is limited by long gestation periods and the need to retain breeding stock. Consequently, the world price for beef has been rising significantly in the past decade.

Government intervention in some major consuming countries has also kept prices well above world market levels. These factors have stimulated research into the production of synthetic meats just as the wool boom of the early 1950's gave impetus to the development of synthetic fibres.

The relative price of meat substitutes is an important consideration, since it is clearly more difficult to promote a meat analogue that is very little cheaper than the product it imitates. This is particularly relevant to the United States market where meat imports are limited by a quota. Quota relaxations would increase supplies of natural meat and prevent prices rising to a level where simulated meat prices were competitive with those of natural cuts.

A further competitive advantage of many substitutes has been their relative price stability. Prices have tended to move downwards, being virtually constant for long periods between successive falls /11, p.218/. In contrast, prices for most traditional agricultural products, including meat, are characterised by wide short-term price fluctuations /9/.

Future price levels for synthetic meats will partly depend on cost-reducing developments in processing and improvements in palatability and appearance. High natural meat prices will encourage research into production and market development. If these products do gain wider acceptance among consumers, increased sales will allow manufacturers to reduce costs still further through achieving economies of scale.

4.23 Government Regulations

Government regulation of the sale of simulated meats has taken two forms:

(i) Limitations on the quantities that may be included in processed meat products, and

(ii) Truth and accuracy of labelling.

There is no evidence of legislation to curb or prevent the production of simulated meats in any country.

In the United States, Federal standards prohibit non-meat additives in hamburgers, apart from seasonings, but soy protein (and other additives) are permitted in the major processed meat products; ranging from 3½% in sausages to 12% of the meat used in meat balls. Greater quantities may be used provided the products are correctly labelled and not given pseudo meat titles similar to those of traditional meat products. For meat analogues, truth in labelling is the only requirement.

Regulations relating to the marketing of meat-type products containing vegetable protein in Japan, Western Europe and Canada are still under consideration. It appears that the main objective is to ensure that such products are adequately and truthfully labelled rather than to limit their manufacture. The general attitude to simulated meats and non-meat additives is summed up by the Australian Meat Board's policy towards them. In 1970, the Board said:

> "The consumer of meat and the meat industry are entitled to no more and no less protection than truthful and adequate labelling and/or description confer." /5/

4.24 Increases in Income, Changes in Taste, Promotion

Food consumption patterns tend to change rather slowly, but in high income countries where consumption is already high, further rises in income, changes in taste, and increased knowledge about nutrition have caused changes in diets, particularly towards high protein foods. These changes have been associated with the demand for more variety, greater convenience and more elaborate processing and packaging in food products.

In the United States, at least, broad sections of the public have become sufficiently affluent to willingly pay substantially higher prices for both convenience and variety. These trends have benefited meat and should continue to do so, but they may also help to promote consumer demand for

simulated meats as "different", easy-to-prepare foods. Manufacturers of substitutes may, in fact, be able to take greater advantage of changes in demand because of their ability to tailor their product to suit specific consumer requirements.

Synthetic meats face the problem of overcoming unfavourable images created by food products incorporating soy flour and grits in the Second World War, when meat was in particularly short supply. The quality of soy flour processed at that time was poor and products in which it was used were not very palatable. However, unfavourable images such as these have been overcome in the past by synthetic fibres and margarine.

Recent promotional campaigns have stressed the nutritional qualities of synthetic meats and have presented them as being highly palatable and "different". In Australia, for instance, they have been marketed under the slogan: "Break the monotony of Meat, Meat, Meat, Meat" and their manufacturers claim they "give you the same high protein in a delightfully new way" [11, p.219].

The success of promotion of synthetic meats will depend on whether or not manufacturers can produce products matching the texture and palatability of natural meat at competitive prices.

4.25 Forecasts

Estimates of the long-term effect of meat substitutes on the demand for fresh and frozen meat vary widely. One opinion is that, by the end of this decade, synthetic meats and closely related vegetable proteins will probably be selling at about equal volume with genuine meat products [4, p.24]. More conservative estimates put the total market share of synthetic meats by 1980 at 5-10% [4, p.24].

Some idea of the magnitude of factors such as price elasticity, income elasticity, and cross elasticities of demand of simulated meats are required before any serious attempt to predict the effect of synthetic meat on

natural meat sales can be made. However, very little quantitive analysis of the demand for meat substitutes has so far been published and the writers are aware of no studies that estimate the relevant elasticities of demand. Investment in such studies should have a high priority with agricultural producers, processors and marketers.

Priority should also be given to forecasting the rate of technological change in the synthetic meat industry. This is important for two reasons: First, cross elasticities of demand change over time in response to quality improvements resulting from technological change. Second, the price of synthetic meats, which is affected by technological change, tends to set a floor price for the natural meat market and so directly affects the price that suppliers of natural meat can expect.

4.3 IMPLICATIONS FOR THE NEW ZEALAND MEAT INDUSTRY

In 1971, the meat industry was again the main source of New Zealand's export earnings. Receipts for meat and meat by-products reached a record level of $507.1m; 42.5% of total exports. It is clear that any threat to this major export industry must be considered as a problem of national importance.

Available evidence suggests that sales of synthetic meats which are competitive with meat cuts have been negligible. It is reasonable to expect, however, that future improvements in palatability and texture, as well as lower prices, will increase the acceptability and sales of simulated cuts. Despite this trend, rising incomes and populations should continue to increase the demand for natural cuts and this should at least partly offset any substitution effect arising from the greater acceptance of synthetic analogues in the next few years.

In established markets for New Zealand meat, it appears that the greatest competition from synthetic meats will initially occur from the use of non-meat fillers and extenders in processed meat-type products - sausages, meat loaves, meat-like pieces for savouries and stews - where

their palatability problems are less obvious [10]. In particular, processors may make greater use of blends of synthetic and natural meats. At present, the composition of these mixes is subject to Government regulations in major meat consuming countries, but the controls are aimed at ensuring accurate labelling rather than limiting the use of synthetic meats. Under pressure from processors or consumers the regulations could no doubt be modified and, in any case, more synthetic protein can be used provided the package clearly indicates this.

Of total New Zealand meat exports in 1970/71, over 37% by value (worth $158m.) went to the United States and Japan [10, p.46]. The great bulk of this meat was boneless beef for the United States hamburger market and ewe mutton for the Japanese manufacturing trade. These two countries are also the major producers and consumers of synthetic meat and it is in these manufacturing markets that the most serious immediate threat to New Zealand meat exports lies. Both these countries have adopted legal maximum levels of non-meat proteins that may be used to replace meat in manufactured products. This is fortunate for New Zealand, since at these low levels non-meat protein replaces other fillers and its water and fat binding properties improve the final product. However, it has already been pointed out that the meat industry cannot hope to rely solely on legislation to protect its interests - in general, regulations only require truthful labelling.

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10. Sault and Gale [11, p.217] state that palatability problems appear particularly evident in the use of soy flours and grits which impart a bitter, beany taste to products containing more than 3-5% of them. Also the carbohydrates in them cause flatulence. These carbohydrates are washed out during the preparation of the more expensive soy protein concentrates and protein isolates, eliminating the flatulence problem. The bitter, beany taste is also removed, but there is still an undesirable flavour present which manufacturers attempt to mask by the addition of spices.

    Some progress has been made towards eliminating these problems. For example, it has been found that the flavour of soy protein concentrate and isolate products may be improved by treatment with sulphur dioxide and Sault and Gale report that some manufacturers have produced completely bland protein powders; but no details of the cost involved are available.

Another major threat to the New Zealand meat industry lies in competition from synthetic meats for potential markets in the protein-starved developing countries. In these countries, meat does not yet form a large part of established diets but, as incomes rise, demand for meat will grow. As the people will not have acquired a taste for natural meat, synthetic meats will be able to compete relatively more easily in these markets.

It is foreseeable that a stage might be reached where there are two distinct markets for meat products : a quality market for natural meat cuts and a bulk manufacturing market for meat or synthetic protein where the important criteria will be price. White emphasised the importance of the manufacturing market when he said:

> "At present the greater part of New Zealand's exports of beef and mutton go into this bulk market and it would not be going too far to say that the economics of the whole meat industry depend very largely on obtaining satisfactory prices for manufacturing meat." /13, p.7/.

A major factor in the effect of meat substitutes on natural meat sales will be the ability of meat producers and exporters to ensure that natural meat prices are competitive with those of their synthetic counterparts. This will, in turn, depend on success in keeping production, transport, and processing costs at the lowest possible level.

It is also in the interests of the New Zealand meat industry to convince meat importing countries, like the United States and Japan, that import restrictions which maintain artificially high meat prices may not be in the long-term interests of either domestic producers or consumers.

4.4 RESEARCH TO MEET THE THREAT

Available evidence suggests that the New Zealand meat industry has not yet suffered significant losses from synthetic meat competition. It is clear, however, that this situation provides no room for complacency; product and market development for synthetic meats is proceeding rapidly overseas, and the main thrust of this activity is aimed directly at the New Zealand meat industry's most lucrative markets. The industry must take urgent action to meet this potential threat. Work should proceed on two fronts: continual monitoring of overseas market and product developments, and technical research aimed at predicting the characteristics and presentation of New Zealand manufacturing meat that may be desired by overseas processors who will use non-meat protein ingredients. These suggestions for research are elaborated below.

4.41 Market Intelligence

In order to prepare marketing strategies designed to meet the challenge from synthetic meats - particularly fillers and extenders - the New Zealand meat industry urgently requires information relating to:

(i) The rate of technological progress in synthetic meat development. The technology of synthetic meat production is evolving rapidly. Thus it can be expected that reductions in costs and changes in product characteristics will be important determinants of the competitiveness of synthetic meats with natural products. It follows that the New Zealand meat industry will need to continually acquire up-to-date information regarding technical changes in synthetic production, so that plans concerning processing, distribution and promotion of natural meat exports can be revised to meet rapidly changing market conditions.

(ii) The demand relationships between synthetic and natural meats. The crucial issue here can be illustrated by the question: 'If the price of synthetic meats changes, what will be the affect on the demand for New Zealand manufacturing meat exports?' To answer this question, the

New Zealand meat industry must estimate the cross elasticities of demand that indicate the influence on the demand for manufacturing grade beef and mutton of changes in price of synthetic meats.

(iii) Response of other suppliers of natural meat to the threat of synthetics. A substantial expansion of market research is justified to maintain a close watch on developments such as:

(a) Changes in the type of natural meat product being offered by other suppliers. For example, product changes may result from the use of additives such as flavour-enhancers, from the introduction of new breeds, or by the adoption of different slaughter ages and improved processing, cutting, grinding and ageing techniques.

(b) Methods of promotion; with particular attention being given to whether natural meat is being differentiated as a 'quality' product or promoted as a complement to non-meat proteins.

(c) Changing methods of sale and distribution; particularly those relating to forward contracting and 'off-the-shelf' sales ex-store.

(d) Pricing strategies adopted to compete with synthetics.

It is clear that changes introduced by competing suppliers of natural meat may well indicate desirable changes in the production and presentation of New Zealand meat exports.

4.42 Technical Research and Product Development

In conjunction with research aimed at acquiring market intelligence, the New Zealand meat industry could well derive substantial benefits from technical research and product development specifically designed to meet competition from synthetic meats. This could include:

(i) Technical research into the possibility of establishing New Zealand meat as a premium grade material for blending with synthetics. A basic question would be whether or not the characteristics of New Zealand cattle and sheep carcasses would have to be changed. This line of enquiry

could lead to comparisons of different breeds, different farm management practices (such as those influencing age at slaughter) and different processing methods.

(ii) Technical and economic evaluation of alternative methods of grading, standardising, storing and packaging natural meats for the blending trade. It may be desirable to place emphasis on the 'off-the-shelf' approach implemented so successfully by the manufacturers of synthetic apparel fibres. The aim would be to produce a standardised product, available on demand at the point of manufacture into synthetic/natural meat blends. The development of such an approach to meat marketing would demand intensive technical and economic research into transportation, storage, grading, processing and packaging.

(iii) Research into the feasability and desirability of New Zealand developing a non-meat protein industry with the aim of producing for export a ready-mixed blend with natural meat. So little is known about the economics of protein extraction and processing that it is impossible at present to assess the feasability of this suggestion.

The production of synthetic protein overseas appears to be associated with chemical industries of a scale which does not exist in New Zealand. Any attempt to develop this type of industry would strike the problem of competing with large overseas firms, possibly protected by import restrictions as well. However, New Zealand can produce grass and lucerne cheaply, and urgent attention should be given to a thorough programme of technical and economic research into the extraction of protein from them, for export in pure form or blended with natural meat.

5. CONCLUSIONS

Synthetic meats compete with a wide range of natural meats either as meat fillers, as textured chunks and pieces or as simulated cuts.

While present world consumption of synthetic meats is small relative to total meat demand, estimates of their total market share by 1980 run as high as 50%. Already there appears to be some affect of the use of non-meat protein on the demand for manufacturing-grade natural meat and it seems that the greatest competition from synthetic meats will initially come in processing uses. This is of particular concern to the New Zealand meat export industry since, after lamb, its major exports are beef and mutton destined primarily for the manufacturing trade.

Although originally expensive, synthetic meats now offer significant savings in producing some ground meat products and frozen and canned foods which use meat chunks. The cost of refined soy protein added to ground meats is now as low as (NZ) 6-7c per pound. The upper limit is probably less than NZ$1.40 per lb for the most sophisticated and realistic analogues.

Other advantages of synthetic meat products include their convenience and variety, their excellent storage properties, the ease of standardising them and the fact that their composition can be changed to suit consumers' tastes. Considerable amounts of money are being devoted to cost reducing, quality improving research and a substantial expansion of the synthetic product range is inevitable.

There is little quantitative information on the production and supply of synthetic meats. However, the threat that they pose to the meat industry is such that this situation should not be allowed to continue. The New Zealand meat industry should be prepared to finance substantial programmes of research designed to monitor technical progress in the synthetic meat industry, to examine demand relationships between synthetic and natural meats, to evaluate marketing strategies adopted by other suppliers of natural meat, and to consider the establishment of a New Zealand non-meat protein extraction and blending industry.

6. APPENDIX

6.1 PROTEIN SOURCES

* Oilseeds - those other than soya beans include cotton seed, sunflower, rapeseed and coconut. Some of these seeds give rise to special processing problems, but these are being resolved.

e.g., Cottonseed has a toxic pigment which can, however, be rendered harmless, also glandless varieties are being developed which do not contain the toxin. Sunflower, rapeseed, and coconut have a fibre problem, but this is also being overcome.

* Greenleaf plants - certain quality problems have been encountered with green leaf derived proteins. However, when problems such as colour and toxins have been resolved, this promises to provide a protein source comparable to soya beans in cost.

* Fish Protein Concentrate - can be produced from fish or fish by-products not normally eaten [11].

* Micro-organism produced protein - yeast, fungi and bacteria can be grown on a wide variety of materials including industrial by-products, sewage, hydrocarbons and petroleum. The bodies of these micro-organisms can be harvested and processed to yield edible protein. The growth of the product is continuous and exponential. For example, a yeast colony doubles every two hours so that, in principle, a culture weighing 1 lb would grow to two tons (half protein, half growth medium and fats) in one day [12]. Hence these processes are of particular interest because of their large potential for economies of scale.

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11. See [8, p.60], which describes Fish Protein concentrate and its uses, recent developments and potential markets.

12. These figures quoted in [11, p.210].

6.2 PRODUCTION OF SYNTHETIC MEATS

The production of synthetic meats can be illustrated by describing the procedures involved when processing soya beans, the most common protein source [13].

6.21 The Extraction of Soy Protein

Three types of protein are extracted. The first is soy flours and grits which is the cheapest to produce, contains about 50% protein and is priced in the United States at between 5c and 11c per pound. It is used in sausages, baked goods such as pizza pies and pre-cooked patties, and dog food.

Soy concentrate is a more sophisticated product containing 60% to 70% protein and is priced at between 16c and 20c per pound. It is used in processed meats, some baby foods and health foods.

Soy isolate is the most refined product, containing over 90% protein and priced at 35c to 40c per pound. It is used in meatless ham, synthetic bacon, hot dogs and various other meat analogues.

Soy flours and grits are produced by removing the seed coat from the soya bean, extracting the oil and then grinding the oil free flakes (or meal) sufficiently to pass through fine mesh screens.

Soy protein concentrate is made by removing soluble carbohydrates in addition to the seed coat and oil. As well as yielding a product of higher protein concentration, this process also modifies some of the undesirable flavours present in soy flours and grits, and removes rattinose and stachyose which are a cause of flatulence.

Soy protein isolate is manufactured by a multi-step process involving solvent extraction, clarification of extract by various screening, filtering and centrifuging devices, and then precipitation of the protein by acidification. The isolate is 95% protein and is suitable for spinning

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13. This discussion draws on Sault and Gale [11, pp.210-212] and White [13, p.2]. A technical account is also given in [16, p.72].

into edible fibres. Its amino acid composition is not as satisfactory as that of soy protein concentrate because of the selective concentration of proteins during the isolation process, but this deficiency may be remedied by blending with other proteins during the formulation of final products.

All three types may be incorporated into manufactured meat goods without further processing. This may be done either to improve the technical characteristics of the product or to reduce production costs by substituting for some of the more costly natural meat. To the extent that these protein products are cheaper, and their use is permitted by law, they may replace some manufacturing meat. However, they are bland, flavourless substances and this limits their use as substitutes for natural meat. Considerable extra processing is needed to manufacture soy protein into meat analogues with the texture, taste, colour and odour of natural meat.

6.22 Production of Synthetic Texture[14/]

Texture is created by extrusion or spinning to produce thin fibres of protein, which are then bound together and further shaped to give a meat-textured product.

Thermoplastic extrusion - in this process, the less expensive soy flours and concentrates are compacted and textured by mixing them with water to produce a plastic mass. This mass is heated and subjected to pressure, then forced out through holes into a suitable coagulating medium. By this process a range of textures and 'chewiness' can be imparted to the product.

Spun fibre technique - only the expensive soy isolate is used in this process which requires protein of a high degree of purity - at least 80% and preferably 90% or more. The soy isolate is dispersed in an alkaline solution to produce a material resembling liquid honey in appearance,

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14. For a detailed account of spinning and extrusion and a review of products in commercial use in the U.K. see Wood /17, p.37/.

called the 'spinning dope'. This is forced through spinnerettes containing thousands of tiny holes into a coagulating bath where fibre formation occurs. The fibres are drawn away by a series of adjustable speed rollers and then bound together with a heat coagulable protein, e.g., egg albumen. The texture of the final product may be varied by changing the composition of and treatment given to the spinning dope, the configuration of the orifices in the spinnerettes, the conditions in the bath, the degree to which the fibres are stretched by the rollers and the patterns in which they are bound together.

During these processes, fat, flavouring, colouring and nutrients are added in order to simulate other desirable properties of natural meats. A new method of encapsulating liquid flavour inside microcapsules enables flavour to be sealed in until chewing ruptures the capsules and releases it.

The final textured protein product is cooked or smoked and may be ground, diced or sliced, and sold in a dehydrated, canned, or frozen state, or ready for direct consumption.

6.3 PROTEIN CONTENT OF MEAT ANALOGUES AND NATURAL MEATS

A comparison of the protein content of meat analogues and natural meat products shows that synthetic products generally contain considerably more protein than their natural counterparts.

Analogue	% protein of analogue	% protein of natural product
Sea food	70	16.7 (flounder)
Ham	60	17.5 (commercial cured med. fat)
Ground beef	55	17.5 (hamburger regular ground)
Bacon bits	45	8.4 (cured)
Chicken	70	18.6 (fryers ready to cook)
Beef	60	16.5 (total c/c U.S. good grade)

Source: Miscellaneous publication No. 1141, Economic Research Service, U.S. Department of Agriculture.

6.4 CONSUMPTION OF SOY PROTEIN

Trade estimates of the quantities consumed in the United States in 1967 and 1969 are as follows:

	1967 (m.lbs)	1969 (m.lbs)
Soy flours and grits	105 - 110	200
Soy concentrate	17 - 30	20
Soy isolate	22 - 35	18 - 20

It is estimated that the consumption of soya bean protein products competing directly with natural meat rose from 30 m.lbs in 1967 to 50 m.lbs in 1969 [15].

6.5 TEXTURED VEGETABLE PROTEIN (T.V.P.)

The professed attributes of non-meat protein are illustrated by an advertisement for T.V.P. - Textured Vegetable Protein - in a trade journal [2]. Accompanying a two-page full colour photo of an appetising casserole is the following script:

"

A FABULOUS NEW FOOD

T.V.P.

Add fresh vegetables and see what you can do with it

This dish was made with fresh vegetables and beef flavour chunks of TVP textured vegetable protein. You could also include meat. Either way, it could hardly look or taste better ... or be more economical. TVP is exciting, nutritious, new all-vegetable protein source from ADM (Archer Daniels Midland Company). It is available in granular, chunk, dice, strip and chip forms. It comes unseasoned, or with flavouring of almost any kind - meaty, nutty, tangy, salty - even fruit flavours. Easy to handle and to store and completely controlled in texture, flavour and colour. TVP is exceptionally well suited to institutional feeding and restaurants. It's an excellent enrichment for casseroles, snacks, stews, gravies, ground meats and many convenience foods. .....

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15. Figures quoted by Sault and Gale [11, p.213].

The manufacturers of textured vegetable protein claim substantial savings per serving from its use. The figures they quote are given in the following table.

Meat cost/lb	Per serving	Saving per serving using T.V.P. at $0.50/lb (dry)
$	$	
0.25	0.070	0.039
0.30	0.085	0.053
0.40	0.113	0.081
0.50	0.141	0.110
0.60	0.169	0.138
0.70	0.197	0.166
0.80	0.225	0.194
0.90	0.253	0.222
1.00	0.281	0.250

Source: Archer Daniels Midland/Gottlieb Duttweiler Institute Quoted in /15/.

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