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Meat Processing in Developing Countries
Vienna, Austria, 13 - 17 October 1975

FACTORS AFFECTING THE GROWTH OF INDUSTRIAL
PROCESSING OF MEAT PRODUCTS ^{1/}

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Industries Research Association, Leatherhead, England.

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Summary

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RESUME

FACTEURS QUI INFLUENT SUR LE DEVELOPPEMENT
DU TRAITEMENT INDUSTRIEL DE LA VIANDE^{1/}

par

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^{1/} Les vues et opinions exprimées dans le présent document sont celles de l'auteur et ne reflètent pas nécessairement les vues du Secrétariat de l'ONUDI.

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Meat products have been made at the domestic level from the earliest history of nearly all peoples, as practical solutions to the problems of (a) the palatability of the carcasses of animals which do not give good results by simple cooking methods, and (b) the preservation of whole or part carcasses in excess of what could be consumed soon after slaughter. The transition from this stage to manufacture by specialists, the butchers, also occurred early in the economic development of most countries, with the growth of towns. The range of products available to increase slowly, but the reasons for them remained constant and the requirement to consume most of the meat soon after butchering ensured that enterprises remained small and close to their customers. A very high proportion of meat product manufacture in Europe is still made in this way. Improvements may be made by applying modern technology without fundamentally changing the system.

Centralised industrial manufacture is only slowly replacing these ancient, strong and effective traditional patterns. The traditional products have changed little except for (a) wide diversification in countries with mixed immigrant populations, eg. USA, Australia, and some diversification in others, and (b) modifications due to new technology, especially canning and freezing, applied to the preservation problem.

Though the actual products vary widely between countries, the fundamental pattern of development appears to be universal. Changes in developing countries may be expected to be similar.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche

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Introduction

In many present day industrialised countries the meat products industry is a well established and complex partner of the industry which produces fresh meat. This paper seeks to trace its growth in relationship to social, economic and technological developments from earliest days until now. Although presented, inevitably, from the writer's own standpoint, that of a modern European, it is hoped that the analysis will reveal enough common ground to be helpful to those of other backgrounds who must ask the question: "What developments should occur next in our situation and how should we foster them?"

1. BACKGROUND AND HISTORICAL EFFECTIVE

For many purposes it is simplest to regard the term "meat products" as including all the various ways of preparing meat which are more complicated than what is commonly understood as "fresh meat". This definition is a little too wide, for it would include the results of ordinary meal cookery such as roasting or broiling; since we are here concerned ultimately with questions of industrial production, domestic cookery for more or less immediate consumption may be excluded.

The "meat products" which remain may be divided into three groups, with a fair amount of overlap between them:

- (a) Preserved Products - meat which has been treated in some way so that it need not be consumed within the comparatively short space of time dictated by the perishability of fresh meat (eg. dried meat, salted meat)
- (b) "Improved" Products - made from low-grade parts of the animal carcass, to make them more palatable and less liable to be wasted (eg. sausages)
- (c) Specialities - versions of domestic dishes which combine both heightened palatability and a measure of preservation, (eg. pies, canned stewed meat).

Though the anthropological evidence of Man's descent from the higher apes suggests that at first he may have been vegetarian, it is clear that he learned to eat meat in very primitive times. The earliest known stone tools, which could have been used for cutting through animal hides and dividing the meat, are dated approximately 2m years ago. It is not certain when the control of fire was first learned but its use for cooking appears to have been well established 500,000 years ago: the site where Peking Man was found has evidence of fire together with cooked bones and bones cracked open, probably to remove the marrow⁽⁵⁾. Grilled and spit-roasted meat must therefore have been available at that time. The discovery of cooking in water, which enormously extended the possible ways of preparing meat, was probably much later. It cannot however have been much later than the earliest known pottery vessels, made about 9,000 years ago⁽⁵⁾, and there is a possibility that pot-holling was known even earlier. This is a rather laborious process in which

water contained in a vessel such as a hollowed tree or a hole in the ground is boiled by the addition of red-hot stones (8).

There is good prehistoric archaeological evidence, therefore, that before the beginning of recorded history most of the main methods of fresh-meat cookery and many meat products which we could recognize today, were already in use. The earliest records confirm that this was indeed the situation by then. For instance, paintings in the Egyptian pyramids (5000 to 4000 years ago) depict the selling of meat among the everyday tasks of that time; Homer (800 years ago) described sausages made of liver, lungs and kidneys contained in a length of gut and cooked by roasting on a fire; 500 years ago the Roman architect wrote a detailed cookery book (9). Meat products, of the three main types noted above, were being widely made.

From those days to the present we can see three distinct stages in the complete development of meat products manufacture, overlapping considerably in time and place and corresponding closely to the stage of development of the societies concerned.

1. The domestic or village stage

This was and is the arrangement in the most primitive cultures but it persists alongside the later developments even in advanced societies, where it can be found on some farms or wealthy houses. The producing unit is the individual household or small collection of families. The ideal production throughput is one animal carcass at a time, hunted or slaughtered by members of the household and usually cooked and served as fresh meat. In times of surplus, after a too-successful hunt or when furred animals must be slaughtered at the end of the summer feeding season, or in preparation for a long journey, as much fresh meat as possible may be eaten in a great feast but the remainder must be preserved, traditionally by drying, salting or smoking. "Improved" products and specialties are developed as part of the normal work of the cook to make food more interesting.

2. The butcher or town stage

One of the features of the art of living in towns is the emergence of specialist tradesmen. One of these is the butcher, to be found in all civilisations, ancient and modern. Initially concerned with slaughtering and selling fresh meat to his fellow-townsmen (the South German word 'Metzgerer' and the Italian 'Macellaria' both derive from the Latin 'Mortuum')

or "batch") being available because of the "take-meat" practice (6), the throughput for raw beef is not limited, and can be met with a comparatively large number of customers. The ability to limit the fresh meat from the animals can be disposed of quickly. The size of the enterprise is in fact limited by the number of customers who are prepared to travel to the shop, for the meat must be sold before it spoils. The larger throughput gives the customer a wider effective choice of fresh meat, and less wastage, to accept the lower grade cuts, and he tends to accept more meat in the improved products. His technology usually differs little from that of the domestic cook, though he may be better adapted to take advantage quickly of new developments - such as refrigeration - as they occur.

This stage of development has proved remarkably successful and stable; even in the most developed European countries today, 40-50% of all meat products are made in individual butcher shops (1,2,3).

3. The factory or city stage

This is the most recent development, where a single manufacturer produces meat products, often of special cut type, for a very large market.

As the emergency and persistence of the butcher is associated with town life, so factory production is only possible in the conditions of general development which lead to the industrial city. These include reliable finance, credit and banking facilities, general familiarity with large-scale commercial methods and the necessary background technology to ensure sound transport, building construction, power supplies, machinery repairs etc. More direct support will probably be required.

Direct support from ancillary industries such as tin making, plastic packaging or refrigeration equipment. If the manufacturer wishes to operate in some specialized field, this may require corresponding specialization in some other sector of the meat business, for instance new developments in the wholesale meat trade may be necessary to allow him a supply of certain cuts of meat only.

The products themselves, with some exceptions, remain closely similar to those already developed by the town butcher and acceptable in his locality. It sometimes appears as if the range of products may be greatly widened on industrial output but this is not necessarily so:

- (a) As the geographical area served by a factory increases it may come to include new customers with different requirements. This however is not a true demand for different products if the equivalent production by butchers in the new area is being displaced.
- (b) In some countries, notably the USA and Australia, industrialisation occurred simultaneously with the immigration of people of "new" backgrounds and food preferences. Again, the factories took advantage of this market but they did not create it.
- (c) It is sometimes suggested that the foreign holidays enjoyed by citizens of developed countries lead to demand for foreign foods, but effects of this are usually small.

Finally, the manufacturer's technology may be much more advanced than that of the traditional butcher making a similar product, especially in the application of modern preservation methods to extend the shelf life of his product and therefore the area over which he can distribute it. The particular advances which are possible will be considered in the next chapter.

11. MEAT PRESERVATION

A. Pre-Modern Meat Preservation - Ancient

1. Air-drying or Drying

This was almost certainly the first process used for preserving meat, having been discovered by accident. Though still widely used for fish it is not now common for meat, mainly because of the very poor, tough, quality after reconstitution.

Its modern counterpart is dehydrated meat. Even from modern equipment, air-dehydrated meat is usually unacceptably tough but freeze drying produces meat of good initial quality. To prevent deterioration it must then be packed with the complete exclusion of air, normally in cans flushed with nitrogen. The drying and packaging processes are both expensive and therefore only used for a few high-value applications.

2. Smoking

The beneficial results of exposing meat to wood smoke were probably also discovered accidentally at an early stage. Some of the benefit is due to partial dehydration, sufficient water remaining in the meat to avoid the toughening associated with air drying, but the major effect is due to the anti-microbial action of phenolic substances deposited from the smoke onto the meat surface. The flavour of the meat is favourably affected. Frequently combined with salting, smoking has continued in use throughout history as an effective method of preservation.

Modern developments include the use of carefully designed smoke generators and exposure cabinets to ensure even deposition of smoke on the meat and accurate control of degree of drying. Scrubbers and electrostatic precipitators may be applied to the smoke stream to reduce the content of undesirable substances such as the benzopyrenes. Liquid smoke essences, conferring smoke flavour and sometimes a preservative effect but free from benzopyrenes, may be used.

3. Salting

The preservative action of salt has also been in continuous use since its early discovery. 6% or so, calculated on the water present (equivalent to 4% on the lean meat) confers reasonable stability but for safety in the absence of accurate control, higher concentrations may frequently be aimed at. Lower concentrations, even in some parts of the meat only, lead to early spoilage

and it is necessary to treat the pieces of meat so as to ensure complete and uniform penetration. Elaborate soaking or massaging processes are therefore common. Hand operated injection needles or multi-needle machines are modern aids to this end.

The salt used in ancient times was almost always dried sea salt containing a number of impurities including some nitrate. Microbial action in a brine or in meat may convert this nitrate to nitrite which has an especially powerful preservative action, causes a characteristic red colour in the cured meat and a pleasant flavour. The practice has grown in the last few centuries first of adding saltpetre (sodium or potassium nitrate), then more recently adding nitrite to the curing salt in order to produce these desirable effects more controllably. Because of possible toxic reactions, both directly and in some cases indirectly through nitrosamine formation, it is necessary to control the use of nitrites and nitrates with great care.

4. Other pickles and cures

Wine and vinegar have been used, like salt, because of their preservative action but their use is not so common nowadays. Preservation by acid, similar in principle to the action of vinegar, may be obtained when a controlled microbial fermentation is permitted in the meat, producing lactic acid. Fermented sausages are made on this principle; there is considerable art in controlling the process successfully.

5. Cooking

The preservative effect of cooking should not be overlooked. The spoilage bacteria are largely, sometimes entirely, destroyed by thorough cooking and if the meat can be protected from re-contamination it will keep.

The earliest application of this was probably in products like potted meat, where cooked minced meat was protected by a jar with a layer of solidified fat or jelly on top. This however is not completely reliable and the full potential of the process was only realized in the canning and bottling developments of the nineteenth century.

D. Preserved Meat Products - Modern

1. Meat Freezing

As just indicated, meat processing depends for its success partly on reliable resistant packaging to prevent re-contamination of the heated

material. Along with air-tightness, cans or, recently, sealed plastic or foil containers, are therefore necessary, together with the more or less sophisticated machinery to handle them.

The other essential element in successful heat processing is a clear understanding and accurate measurement of the degree of heating needed to pasteurise or sterilise the contents of a pack without overcooking them. Any errors may have serious consequences: underprocessing, in particular, causes real hazards of spoilage and of fatal poisoning.

Given accurate calculations and sound packaging, the canning industry's record in practice has been outstandingly reliable.

3. Refrigeration

One can argue that the spread of refrigeration methods has been the most potent single factor in recent times in assisting industrialisation of the meat industry by permitting longer shelf-life while maintaining or improving quality. The benefits, here again, were known in antiquity - the Romans transported ice from the Alps to preserve their food in summer - but full exploitation had to await the development of mechanical refrigeration in the last century.

The microbial growth which causes meat to spoil is slowed down considerably at chill temperatures (about 0°C) and halted when the meat is deep-frozen (about -18°C). Adverse effects on the meat are insignificant apart from some toughening if carcasses are chilled or frozen too rapidly after slaughter, and possibilities of drip and microbial growth on meats handled without proper care on removal from cold store and during thawing. These problems are reasonably well understood and the correct procedures for avoiding them are known; however there are often difficulties in ensuring that both the necessary facilities and understanding are applied at each link in a "cold chain". This often means that refrigeration may be operated well at the stages of meat slaughtering, wholesale butchery and manufacturing, where equipment and qualified personnel are used effectively, but increasingly badly as the meat moves through distribution to retail sales, through an increasing number of smaller, less well operated refrigeration units. A recent survey has shown a less than satisfactory performance in the United Kingdom (4); in a similar situation the dangers would be greater in any country with higher average temperatures.

3. Anti-microbial preservatives

As well as the long established preservative substances discussed earlier (smoke, salt, nitrite, alcohol, acids), a number of other preservatives may be used in some cases. One of these, sulphur dioxide, was used in times for other foods, others which have been considered include benzoates, sorbates and nisin.

The scope for using these is restricted: many countries prohibit the use of all such preservatives, others permit only certain substances to be used under closely specified conditions. Any potential new application ought therefore to be viewed against the prevailing climate of opinion in countries where legislation already exists.

4. Irradiation

Sterilisation or pasteurisation with atomic radiation was intensively studied in a number of countries in the 1950's. There are of course difficulties in the safe management of the radiation sources but it was also found that in most cases, including meats, the radiation doses necessary for sterility also cause very unpleasant flavours. Apart therefore from a few marginal cases, e.g. pasteurisation of meats already semi preserved with salt and nitrite (7), there is little current interest in this process.

C. "Improved" Meat Products

These products exist in great variety - it is said that there are over 1500 types of sausage in Germany (3) - and there are large regional and national differences in raw materials used and in the kinds of product preferred. The products may be made for preservation as well as for upgrading the meat, using salting, drying or other processes, but against this it should be noted that they frequently involve coarse or fine comminution which increases the exposed surface area of the meat, distributes contaminating bacteria more widely and therefore has an unfavourable effect on perishability.

They are conveniently categorized by the raw materials used.

1. Offals

There is much diversity among cultures about which of the animal offals are acceptable food (so there is also about animal species). In fact every part, including the animal's own food in its stomach, has been used at one time

or another. Vital organs such as liver, kidney and heart are almost universally prized and are commonly prepared by fresh meat methods. Liver finely minced with fat before cooking produces a paste or pâté of wide acceptance. Blood is also highly prized by many people, in some cases being taken fresh from the live animal. It coagulates on heating and forms the basis, with added cereal, of a wide variety of sausages and puddings. Guts and stomachs have been used as casings for such products since antiquity and are only recently being replaced in large scale manufacture by artificial casings made from hide, cellulose or other materials. The cracking of bones to extract the marrow has previously been referred to as modern meat deboning machines which retrieve residual meat from trimmed bones also extract significant proportions of marrow.

2. Heads, feet and tails

The difficulty in dealing with these parts by simple culinary methods is that their complicated bony structure and the sinewy attachments of the muscles make it difficult to separate the small proportion of meat after light cooking. Prolonged cooking in water softens the connective tissues and extracts gelatin also from the bones, giving a product which is rather low in lean meat content but high in jelly and fat.

With pigs the skin yields similarly to long cooking in water and may therefore be included. Separated skin from other parts of the body can also be used in a wide range of products.

3. Tougher, more collagenous meat and meat with included fat

The neck, chest, shoulders and limbs of a carcass are comprised of smaller, generally tougher muscles than the back and haunches. The belly or breast regions, especially in domesticated animals, contain alternate layers of muscle and fat. All of these parts can be cooked and served quite satisfactorily by ordinary cooking, but it is found in almost all societies that as people become wealthier they prefer the more tender and less fatty meat and tend to decline the tougher and fattier. The whole development of sausage and other comminuted meat products has come about as an alternative means of dealing with these slightly less desirable cuts; there are also opportunities to include fat trimmed from the outside of the "better" cuts, and offals and some skins as already mentioned.

The technology of sausage making has certain distinctive features:

- (a) comminution - cutting, mincing or grinding the meat enables homogeneous mixtures to be made in which high proportions of fat are found to be more palatable than they would be in the form of large pieces. At the same time the connective tissues of the lean meat are broken, improving tenderness. Modern flaking equipment does this still more effectively.
- (b) mixing with salt - this makes the raw comminuted lean meat plastic and cohesive so that it retains the fat, with some added water and gives a firm well-knit product on cooking. Fillers such as bread may be incorporated. The mixture is commonly called a meat "emulsion" though this is probably not a scientifically correct description in most cases. The action of the salt may be enhanced, notably by small additions of polyphosphates and the effects may be modified by changes in mechanical features of the mixing operation.
- (c) other treatments - any of the preservation processes alone or in combinations, may be applied. Cooking may be done at the time of manufacture or delayed until consumption.

Variations in the raw materials and the details of the process give rise to the enormous number of different types of sausage already noted. The technology is of very wide application, for instance to meat pie fillings, canned luncheon meats, or re-formed pieces of meat. The mixing-with-salt treatment is now also being applied to medium-sized pieces of meat to produce coherent, sliceable blocks of cooked meat, for instance poultry rolls, "picnic ham", made in mashing machines or "tumblers".

Corned beef is rather different and a very interesting example of the comparatively recent development of a new meat product - in a developing region. In South America in the mid-nineteenth century the production of cattle hides was a major industry but in the absence of refrigerated ships - not developed until thirty years later - there was a surplus of meat which could not be exported and was wasted until Julius Liebig decided to convert into a meat extract by boiling it and concentrating the stock. This quickly became an article of commerce, but still left a surplus of cooked meat.

Canning technology was available, so the residual meat was canned with salt and "corns" of sulphate to make the first corned beef, another highly acceptable product.

0. Specialities

The origins of these products are typically to be found in the work of chefs in cultivated households rather than in butchers' solutions to marketing problems, but many were quickly adapted to the butchers' trade. Usually a separate business of speciality production grew up, often associated with the butchers' established meat products business but frequently becoming independent. This pattern is still normal in Western Europe. Typical products are meats in pastry containers - pies and filled paste goods such as ravioli or cossioni - and cooked meats.

With the introduction of canning and deep freezing has come the possibility of preserving these dishes and marketing them through more general shops without the usual requirements for almost immediate sale and consumption. It is not possible to do this in very many cases because of different processing requirements in different parts of a complex product: where it can be done the details must be worked out individually for each set of circumstances.

III. FACTORS AFFECTING INDUSTRIALISATION

It is clear that meat products production exists in almost all societies and that its progress towards industrialisation appears to follow a similar pattern everywhere. Although the industrialisation of any sector of this production in any particular place will be determined by the precise conditions applying there, some general principles can be extracted from the foregoing discussion which may serve as a check-list of points to consider when such questions are raised.

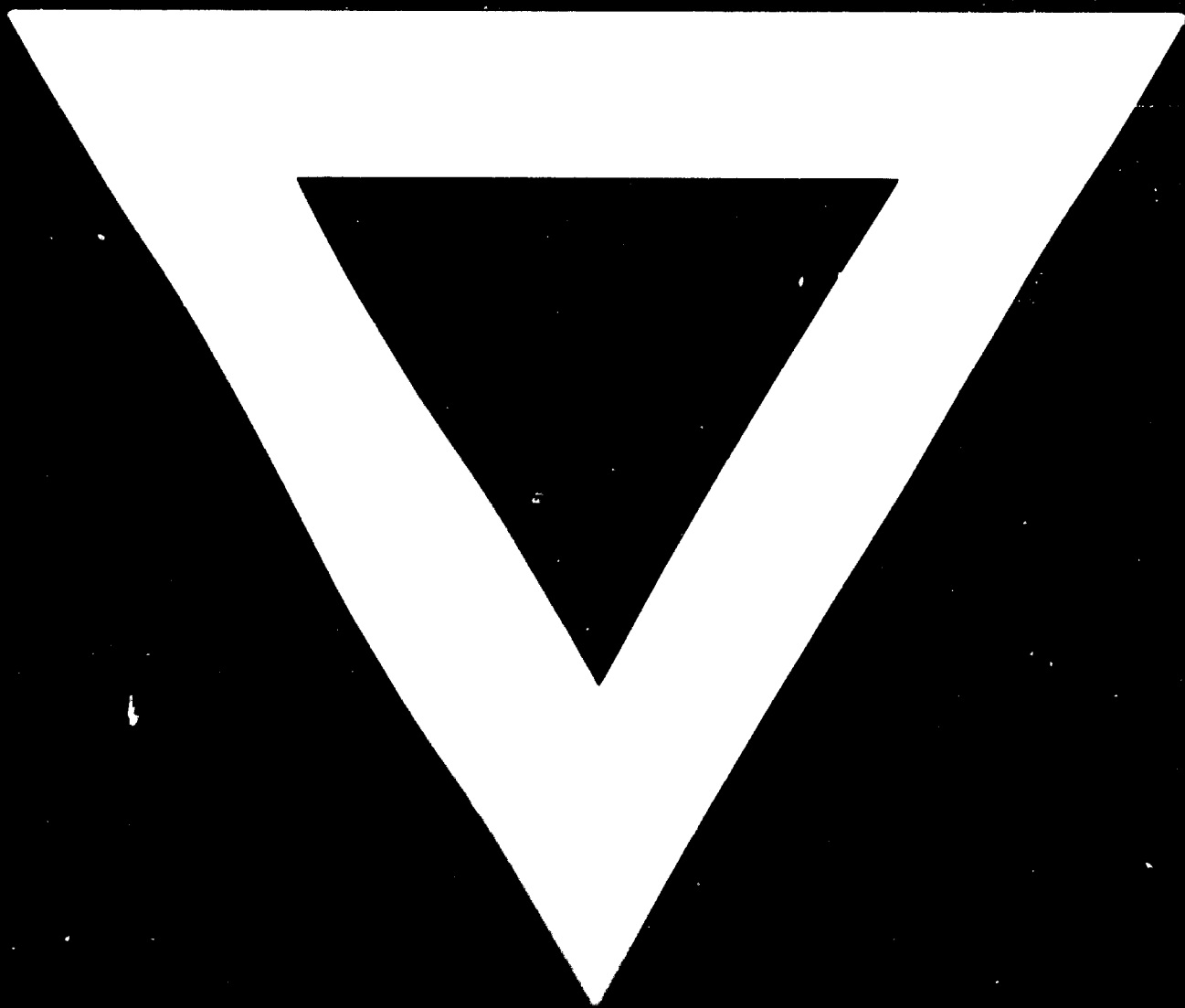
1. The stability and persistence of the local butcher suggests that in some cases it may be better to improve efficiency at that stage than to attempt to supersede it by a larger scale industrial operation.
2. Increases in scale of meat products manufacture are likely to be productive only where corresponding developments are already effective
 - (a) in earlier stages of the meat industry - animal production, slaughtering, wholesale trade,
 - and (b) in the economy as a whole.
3. The example of corned beef is rare and most developments will be to satisfy local markets with products already familiar and acceptable. In some cases products may be made for export: these will mostly be to satisfy the importer's preferences.
4. Industrialisation in a local market implies a wider area of distribution than the butcher can satisfy. This may require a parallel growth of refrigerated transport and storage; ensuring this raises social and economic questions which may be very far-reaching.
5. Alternatively the standard and acceptable product may be modified by canning or freezing to extend its shelf life. In either case the modified product must be confirmed to be still acceptable and suitable handling facilities must be available.
6. When all these questions are correctly answered the managerial and technological problems of the new process remain to be learnt and overcome. Here too the managerial aspect may be the more difficult - it is usually comparatively easy to learn technology, the right things to do, are

difficult to manage so that they are always done properly.

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