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The Chilling, Freezing, and Prepackaging of Beef

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IT IS not uncommon for the public to be persuaded to change from a fresh to a processed food. Indeed in many cases the latter may have marked advantages. In the case of meat, however, the public at present seeks a large proportion of its requirements fresh, and is prepared to pay a premium for the fresh product. This attitude may change, but in the meantime it is to the industry's advantage to satisfy the demand for fresh meat.

CURRENT PRACTICES

Changes during Storage

Unprocessed meat, like most other fresh foods, is unstable. Since the lean or muscular tissue is the most subject to change, we can concentrate our attention on this. From the time the animal is slaughtered a series of changes take place in the chemical and physical properties of the muscle. Some of these are independent of outside agencies and others are caused by microorganisms on the surface of, and to a less extent within, the carcass. Almost all of these changes are slowed down by decrease of temperature and are very slow though not necessarily zero at sub-freezing temperatures. They are not necessarily detrimental to the quality of the meat and, in their initial stages, those not due to microbial action are desirable as they result in increased tenderness and flavour. However, at a later stage microorganisms develop on the surface, causing souring and off-odours, and these, together with the unattractive appearance of the larger colonies of bacteria, yeasts, and moulds, are in most cases responsible for the ultimate rejection of the stored fresh product. At the same time there is normally a steady loss of moisture from the surface of the stored product. While the accompanying reduction in weight is a disadvantage from an economic point of view, the removal of moisture reduces loss of bloom, and retards the development of microorganisms. However, excessive evaporation may produce darkening and wrinkling of the muscle surfaces and a parchment-like appearance of the connective tissue.

Control of Changes

All these changes are retarded by reduction of temperature, but if the adverse changes in the tissue associated with freezing are to be avoided (see page 3), the temperature must not be lowered too far. The limit to the life of unfrozen meat is set by bacterial action, hence, if we wish to extend this life and cannot use lower temperatures, we must look for other means of reducing the detrimental effect of the microorganisms. The number of organisms initially present on the carcasses may be reduced, or methods adopted to retard their growth. It is for the latter purpose that an atmosphere of 10 per cent. carbon dioxide is used when chilled beef is shipped overseas. At 30°F such an atmosphere slows down the rate of growth of typical organisms on chilled beef to about half the rate in air. As yet we know of no more effective atmosphere in which to hold chilled meat.

On the question of reduction of initial contamination, the operations on the killing floor and in the chillers have been standardized and most works turn out a product with much the same level of contamination. New methods must be found if the level is to be further reduced.

Shipping of Meat

The practices now followed in preparing and transporting fresh beef give a good out-turn for short voyages of 30–40 days provided the initial quality of the meat is good. Bacterial contamination is fairly uniform and temperature and concentrations of carbon dioxide are well controlled. Humidity, and consequently the evaporation from the carcasses, is not controlled so effectively. On the other hand, with long voyages of 50 days or over microbial development may become excessive with unsightly growth of bacterial slimes and mould whiskers. Excessive evaporation may also occur, resulting in economic loss and in wrinkling of areas such as the shank where there are large muscle areas thinly covered with connective tissue, shrinking of the cut surfaces, and development of extensive yellowish parchment-like areas on connective tissue.

It is possible that faster, more frequent, and more regular shipping services will ultimately permit the export in chilled form of the entire Australian surplus of chiller-grade beef. In the meantime it is of value to consider the export of beef in other forms as well.

Moreover, it may not be profitable to export our meat at all times of the year and thus periodically come in competition with peak production in the importing country. Since some Australian meatworks cannot operate on a seasonal basis, we need to consider methods of holding meat so that it may be exported during the more profitable periods. Therefore before contemplating possible developments in handling chilled beef we must consider the alternatives. At present the methods of preservation which do not depend on cooling, for example canning and pickling, all result in drastic changes during the treatment, so that we are no longer dealing with fresh meat. We are therefore forced to consider the possibility of further lowering the temperature so that the meat becomes frozen.

Frozen Carcasses

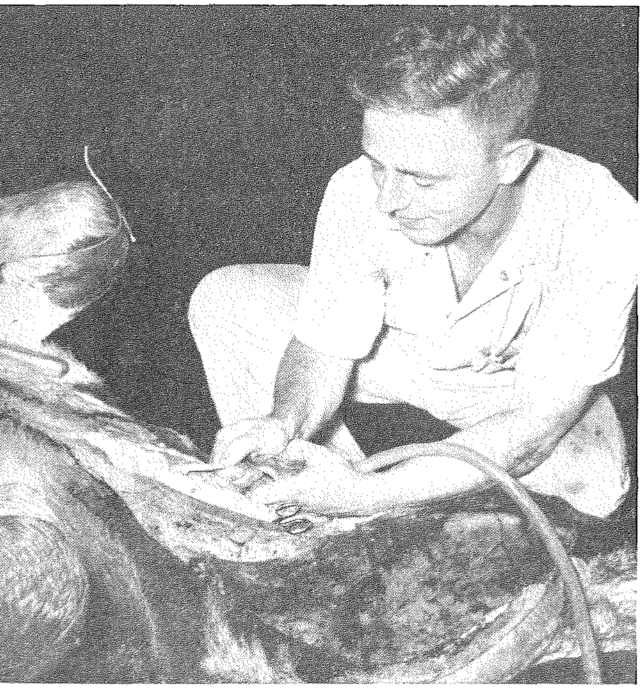
It is possible to lower the temperature of meat to a level where there are virtually no physical, chemical, and bacteriological changes during storage, and little or no difference is noted in the quality of the product when it is stored for periods of months or even 1–2 years. This is, however, not the whole story. Although little change occurs during the storage period, changes do take place during the actual freezing and thawing operations.

The surfaces of the muscles in beef which has been frozen, stored, and then thawed are generally rather darker than in fresh or chilled meat, and there are frequently differences in the translucence of the surface fat, but the cooked meat does not differ appreciably in appearance. There is no difference between the flavour of chilled and frozen meat held for the same time, and meat flavour does not change appreciably over quite long periods of frozen storage. Frozen meat is definitely less juicy than fresh meat from the same carcass, but no difference in juiciness can be observed between chilled and frozen meat stored for the same time. Hence juiciness decreases on storage irrespective of whether the meat is frozen or chilled. No attempt has been made to prove directly that chilled meat held for a period equivalent to export shipment becomes less juicy. Frozen meat cooked after thawing for 48 hr is slightly, though measurably, less tender than the same meat held in chilled storage and cooked at the same time. This difference can, however, be reduced by extending the time at which the frozen product is held at the thawing temperature. Thus there is little or no difference in the two products when cooked.

Problem of Drip

There is, however, another factor. As a result of the freezing process, the thawed-out meat has a tendency to exude a viscous reddish brown fluid known as "drip". This fluid is a solution of proteins and differs little in nutrient value from muscle juice. The amount of drip is largely dependent on the area of cut surface from which it can exude. Hence, while it may not be of much economic importance while the meat is in quarters or large cuts, it can become important with cuts such as steaks or small roasts, and in all cases it is aesthetically unattractive.

There is a third aspect of drip. It has been Australian policy, quite correctly, to limit chilled beef export to the best carcasses. This is necessary, since poor carcasses with poor fat coverage suffer excessive desiccation resulting in economic loss and a less attractive appearance. The poorly covered areas also tend to darken even when they have not been dried out. The change is due to the penetration of oxygen into the muscle tissue, and is largely prevented by a uniform covering of fat. Thus the public finds that Australian



Meat Research Laboratory, Cannon Hill: Experimental injections of solutions into the carotid artery immediately after slaughter.

chilled meat is better than Australian frozen meat, but does not realise that this is due to a large extent to the selection of the carcasses, not wholly to the processing. The presence of drip and to a less extent the colour of the meat serve to identify the frozen carcass and hence to discriminate against it. The process becomes self-perpetuating: the more the consumer is prepared to pay a premium for the chilled product, the more will exporters tend to fill available chilled beef shipping space with the best carcasses, and so confirm the British housewife in her unjustified opinion that chilled beef is inherently better than frozen in terms of eating quality.

While elimination of drip would probably not immediately place the two products on an equal footing, it would go a long way to doing so. There are certain conditions which will minimize drip if brought about in the musculature of the animal either before or after slaughter. Research on these methods is illustrated in the accompanying photographs.

Control of Acidity.—One of the conditions for minimizing drip is a reduction in the normal acidity of the muscle. After an animal is slaughtered glycogen, a starch-like material in the muscle, is converted into lactic acid and this process continues until either the supply of glycogen runs out or the level of acid reaches a certain figure at which the action stops. If only a little acid is present, drip can be markedly reduced. This applies if the initial glycogen supply is low and hence little acid is produced, or if the acid is neutralized after it is formed by injecting alkali into the dressed carcass. This may seem promising, but unfortunately the situation is complex. First of all, a decrease of acidity modifies the flavour and also makes the meat more susceptible to bacterial action. A small decrease in acidity makes the meat tough, but a further fall makes it tender again, and eventually the cooked meat has an undesirable mushy texture. These remarks apply to the effects of reducing acidity by treatment of the animal before slaughter. We are not sure how far they apply to injection treatments after slaughter, but we do know that bacterial action is accelerated, and that very tender samples can be produced which are described by some tasters as mushy. Thus complete prevention of drip by reduction of acid can only be obtained at the expense of other aspects of quality. There is a possibility of obtaining a partial but worthwhile reduction in drip without excessive reduction in quality. The matter is, however, complicated by the fact that the effect of a treatment on a particular animal is highly unpredictable, depending on the animal's history of nutrition and stress and possibly on its genetic make-up. Consequently our chances of success in any individual case are not great. In the same way, when we attempt to neutralize the acid after slaughter, we are at a loss to know just how much neutralization is required for each animal.

Other Modifications.—Other modifications of the muscle can reduce drip. If the general level of dissolved solids in the muscle fluid is raised sufficiently, or if the amount of certain specific components is varied, drip can be considerably reduced. There is no way of bringing about such changes by treatment of the living animal, but another approach to the problem would be by injection into the dressed carcass.

SUMMARY OF PRESENT SITUATION

By applying existing knowledge and techniques and by exercising care Australia can ship good-quality beef carcasses to the United Kingdom under controlled temperature, and in a controlled atmosphere containing 10 per cent. carbon dioxide. If the voyage does not exceed 40 days there are good prospects of selling the Australian product in competition with home-grown beef or chilled beef shipped from other countries. To extend the storage period of chilled beef much beyond this figure is to risk excessive weight loss, poor appearance, and microbial attack with associated off-odours and unattractive appearance. The consequences will be excessive trimming and extensive reduction in value. As an alternative, all grades of carcasses may be stored and exported frozen. Initial quality being equal, the frozen product is, when cooked, difficult to distinguish from the chilled, and has the advantage of being easier to handle, cheaper to carry, and not at the mercy of the shipping time-table or fluctuations in production in Australia or the importing country. On the other hand, frozen beef in its present form requires facilities for thawing out, and drip is a heavy handicap since it makes the displayed meat unattractive and distinguishes it sharply from the chilled product.

LIKELY DEVELOPMENTS

It is interesting to discuss the possibility of overcoming the difficulties we have outlined, but we will exclude long-range prospects such as radiation sterilization and the use of antibiotics. Radiation sterilization of meat is still in the experimental stage and its commercial application under Australian conditions can only be considered as a remote possibility. Antibiotics are, for various reasons, unlikely to find widespread acceptance in the food industry.

The most obvious solution is to arrange for meat to be shipped from Australia as fast as it is produced and discharged at ports within 40 days. There has been some improvement in this direction, but shipping is not likely to provide a complete answer.

Extension of Storage Life

To extend the storage period without lowering the temperature of storage the only courses available are:

- To reduce the initial number of organisms on the carcass
- To reduce the rate of development of organisms on the carcass after dressing so that the numbers do not become excessive in the desired storage period
- To combine the two methods.

Reduction of Bacterial Load.—The major advances in the immediate future are more likely to be brought about by the first of the above methods, that is, by reducing the bacterial load at the end of the slaughtering or chilling periods. A chilled beef carcass with good treatment will have something of the order of 10,000–50,000 organisms on every square inch of its surface. A reduction to one thousandth of these values would mean an extension of 10 to 14 days in the storage life of a carcass. While this is not a great extension it would be very useful and, if combined with more rapid voyages, could mean that storage for reasonable periods before shipment might be considered.

It is worth considering how such an improvement can be brought about. The bacterial load on a carcass is derived almost wholly from the organisms on the hide of the animals entering the slaughter floor, hence the reduction in the number of organisms present on the hide should bring about an almost proportional reduction in contamination on the carcass. However, the results of some laboratory-scale trials suggest that the cost of disinfectants would be prohibitive.

In the past the emphasis has been on preventing organisms reaching the carcass rather than destroying those that lodge on it. But it should also be possible to apply sterilizing techniques at one or more points on the line and especially at the completion of dressing, and so have a low load at the beginning of the storage period. These avenues are being intensively studied at the moment.

Inhibition of Bacterial Growth.—In the second approach to the problem of extending the storage period without lowering the temperature (see above) it was proposed to reduce the rate at which organisms developed on the carcass after dressing. Possible ways of doing this are to modify (1) the meat, or (2) the gaseous atmosphere.

At present it is not obvious how the meat can be modified in a way which will help.

Acidity can be reduced, but this only makes the meat more susceptible to attack by bacteria. Modification of the gaseous atmosphere should be considered in conjunction with humidity. There is evidence that shippers are operating very close to the stage at which any increase in evaporation during overseas transport is reflected in shrinkage of the carcass, and this detracts from its appearance. In addition, of course, all evaporation means so many pounds of meat less for sale. A possibility which should be actively studied is carriage at reduced humidity followed by a relatively short period at high humidity at the end of the voyage. This treatment would permit surface moisture content to rise again.

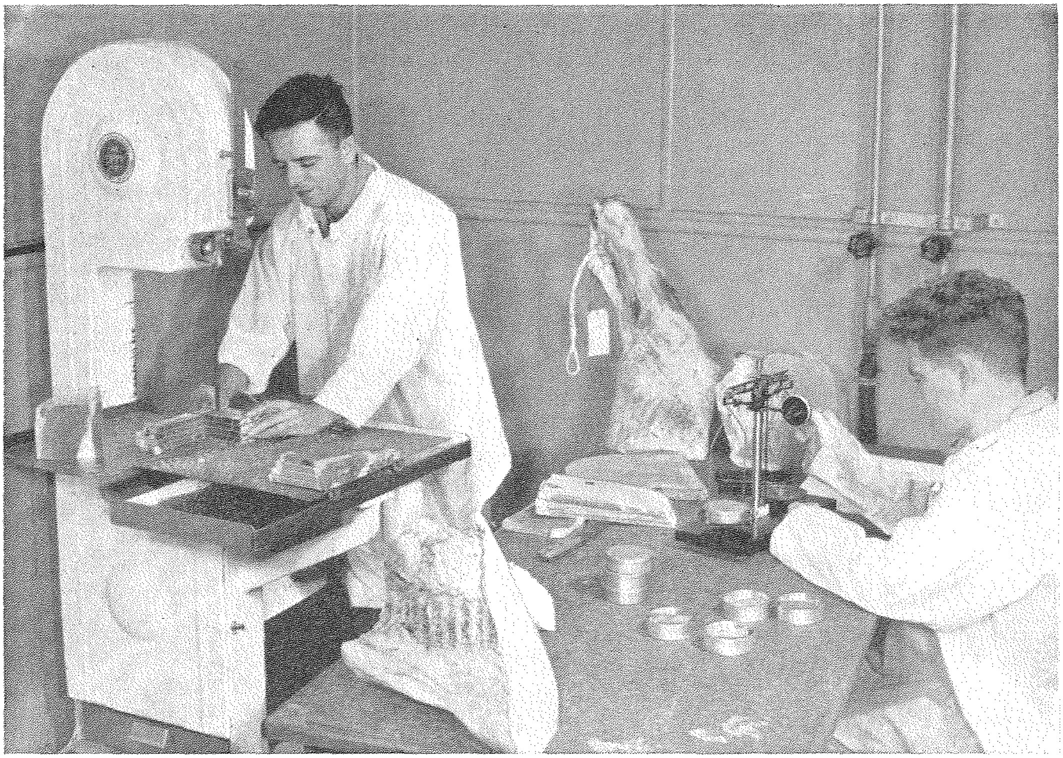
Use of Ozone.—A new development is needed similar to that of the introduction of carbon dioxide storage which gave a 50 per cent. reduction in growth rate. A further 50 per cent. reduction would mean that it would be safe to load at any port in Australia, even if the vessel were going to spend several more weeks on the Australian coast. A much fuller knowledge of how carbon dioxide restricts growth would help us to improve its use or to develop other suitable storage atmospheres —but this is a possibility only. Much nearer to probability is the use of ozone as an adjunct to the use of carbon dioxide. Ozone at high concentrations can destroy many organisms but it also has undesirable effects. At lower concentrations these effects are proportionally reduced and so too are its effects on microorganisms, their growth being delayed rather than prevented. It is conceivable that there is a level of concentration at which the undesirable effects are negligible and the bacteriostatic effects still worthwhile. Ozone may well become a feature of techniques in the near future, probably as an adjunct to the use of carbon dioxide.

Ultraviolet Light.—This has found application in the extension of the shelf life of small goods, and it has been tried for the shipment of chilled beef. Rather naturally it was tried on voyages of short duration. The results suggested that it was as effective as carbon dioxide, but unfortunately there was nothing to indicate that on these short voyages the meat might also have carried well in air, without carbon dioxide and ultraviolet light. A crucial test is needed to establish the value of ultraviolet light on both long and short voyages, since there are reasons to doubt its value when light from the lamps reaches only a small portion of the carcass, and the carcasses are wrapped in stockinet. Should a crucial test (using no carbon dioxide) show that carcasses carry better in the presence of ultraviolet light than in its absence, it will still be necessary to establish whether the effect is a direct one of radiation from the lamps, or an indirect one due either to the presence of very small amounts of ozone, or to a lower humidity caused by heat input from the lamps.

Weight Loss

Success in reducing bacterial load will have the effect of re-opening the question of optimum weight loss, for, if we have a margin of safety in storage, we will be able to carry the meat at a higher humidity. Weight loss could then be reduced, and shrivelling and other signs of excessive desiccation lessened.

I am optimistic that we will be able to cope with longer storage periods and still achieve results equal to the best achieved at present. However, this would not be a complete answer to the problem unless we were assured of shipping to provide chilled cargo space for all meat works at least once a week throughout their working seasons. It is doubtful whether any existing meat works has adequate chilled storage space to hold more than a week's kill. In the meantime exporters must rely on frozen storage, which is much more economical of space. In any case, much of Australia's exportable surplus, such as heavy-weight steers and the poorer carcasses with light fat coverage, is not suitable for chilling, hence the storage and transport of frozen beef will always figure to some extent in our export programme. There remains the outstanding problem of frozen beef, namely drip. I am not optimistic about modifying the meat by pre-slaughter treatment, but more hopeful of post-slaughter treatments. It is possible to reduce drip without marked deterioration of quality by incorporating common salt or certain phosphates into the tissue. At the moment the problem is to introduce appropriate quantities of these chemicals without at the same time introducing too much water. If the salt or phosphate can be introduced in a small amount of solvent at discrete points from which it diffuses through the tissue,



Meat Research Laboratory, Cannon Hill: Preparation of samples of frozen meat for the study of water-holding properties.

drip will be drastically reduced. The products could not be regarded as unmodified fresh meat, but all the potentially useful chemicals are acceptable food additives.

Frozen Packs

Another possibility is the prepacked frozen cut to which attention has been drawn by its export in cartons to U.S.A. So far as density of stowage is concerned, it is obviously less economic to transport frozen carcasses than carton packs. The advantage in the costs of the freezing process will lie with the carton products, especially when the works have been designed specifically to handle them. A properly designed plant should be able to freeze a cartoned pack in under 24 hr, compared with 2 days or more for carcass meat. Moreover, the carton freezer can be designed to operate continuously, whereas carcass freezing is at present essentially a batch process. The economic gain from the resulting conservation of freezer space could be considerable.

Comparison with Frozen Carcass Meat.— When properly packed with adequate vapour-proof wrapping the quality of meat frozen in cartons should, when thawed out, be little different from frozen carcass meat. Thawing will be rather more rapid, so less thawing space will be needed. On the other hand, drip will be evident from the beginning of thawing. For cartons of normal thickness, that is, not less than 4½ in., the rates of freezing, though higher than with carcass meat, are not sufficient to reduce the drip. Drip is not serious in meat frozen in bulk for manufacturing or institutions, but for retail distribution there is probably little to choose between the frozen bulk pack and the individual frozen cut when they are thawed out. There is, however, one important difference in that the frozen cut, provided it is separately wrapped, does not need to be thawed out before cooking. Cooking of frozen cuts does involve some modification of conventional cooking times and temperatures, but drip will only be evident as fluid in the gravy.

It is probable that more and more meat will be exported in frozen packs and cuts. Research will be largely technological and concerned with wrapping materials and methods, evaporation losses, and the comparison of freezing before and after packing. Much of this development can be carried out by the meat industry itself, as instanced by the relative ease and rapidity in swinging over to the current trade in cartoned meat between Australia and U.S.A.

Animal Husbandry

In this discussion it has been assumed that the technologist is content to accept the animals offered to the works, and to confine his interests to processing. It is, however, pertinent to inquire to what extent the technologist, working with the animal husbandryman, can influence the type of animals which reach the works. In the first place he can obviously supply an additional yardstick, namely eating quality of the processed product, to supplement those already used by the husbandryman: pounds of dressed carcass, show ring performance, and carcass appraisal. Also, there must be the closest collaboration between husbandryman and technologist in studying the influence of animal production techniques on eating quality. The technologist must also study the influence of the practices used in transferring the animal from the growing or fattening area to the slaughter floor. At present we can only describe the effects of animal production practice in terms of eating quality in a very crude way. For instance, tenderness of meat is considered to be related to age of carcass, but we find it difficult to agree as to what other husbandry factors are important. Flavour and tenderness may be modified by the practices immediately before slaughter, but at present we cannot predict how a particular animal will react to these practices. Recent evidence suggests that reaction to pre-slaughter treatment and also tenderness are genetically controlled, but this aspect is rarely considered in breeding programs. I feel confident that work on these lines would be repaid handsomely in the improvement of the material submitted to the works whether it be for chilling or freezing, bulk handling or prepackaging.

FISH HANDLING AND PRESERVATION—VI*

Preparation of Fish for Canning

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CANNED fish may be preserved in one of three ways:

- By heat sterilization
- By pasteurization, (i.e. partial sterilization)
- By treatment with chemicals or spices before filling the cold product into the can.

The products of the last two processes are often called semi-conserves.

In canning by heat sterilization, heat is applied to the product in hermetically sealed containers to destroy moulds, yeasts, and microbial and tissue enzymes, and to destroy or inactivate bacteria likely to cause spoilage. Some bacteria form heat-resistant spores which it is impossible to destroy completely without adversely affecting the appearance, texture, or flavour of the product. The fish canner is therefore compelled to limit his objective to *commercially sterile* products, in which the microorganisms likely to cause spoilage *during commercial storage* have been destroyed.

In pasteurization the can contents are heated sufficiently to destroy yeasts, moulds, microbial and tissue enzymes, and the vegetative forms of bacteria, but not bacterial spores. The safe storage of such products usually depends on the addition of large amounts of salt to the raw material, or storage below 45°F.

In some types of canned fish products the contents are not heat-processed, but they may be preserved for limited periods by

* Earlier articles in this series appeared in *C.S.I.R.O. Food Preservation Quarterly*, Vol. 18 (1958), pp. 6–11, 35–38, 76–78; Vol. 19 (1959), pp. 2–9, 42–48.

treating the raw material with suitable acids, or by adding salt and spices, and storing at relatively low temperatures.

Irrespective of how it is to be canned, fish should be carefully selected, handled, and stored.

SELECTION

The suitability of fish, shell fish, and crustaceans for canning depends on the species and its condition, handling, and other treatment before processing.

Species

In general, surface species are the most suitable for heat-sterilized products. The delicately flavoured white flesh of deep-water species is affected to a greater extent by exposure to heat, and the flavour of the product is less attractive to the consumer. The influence of species on flavour is not so pronounced under pasteurization or in the absence of heat processing. Some species of fish are not suitable for heat-sterilized products: for example the partial breakdown of urea in the flesh of edible sharks during cooking results in the formation of ammonia and causes objectionable flavours.

Biological Condition

The biological condition of the species at the time of catching will also influence the quality of the canned products. Most species are in the best canning condition when spawning is approaching. In advanced spawning the texture tends to deteriorate and off-flavours sometimes develop during processing and subsequent storage. For some time after spawning the oil content of the flesh of oily species such as herring and pilchard falls appreciably, and this is reflected in a fall in quality of the canned fish.

Microbiological Condition

The microbiological condition of live fish infected with a protozoal parasite, *Chloromyxum*, will sometimes render the species unsuitable for canning. If the flesh is severely infected by this parasite it may soften so rapidly after death that it is impossible to obtain a satisfactory texture in the canned product. At times certain species of shell fish are infected by a dinoflagellate, *Gonyaulax catenella*, which produces a dangerous toxin. If spoilage of fish before processing is accompanied by the development of bacterial toxins, notably by *Clostridium botulinum*, pasteurized or raw canned products may be fatal to the consumer. When spoilage of the raw material is accompanied by a large increase in the numbers of heat-resistant bacterial spores, a severe heat process may be required and this may reduce the quality of the canned products.

Other Changes

Other undesirable changes may also occur prior to canning. A rapid development of softness in the flesh sometimes takes place as the result of the activity of digestive enzymes in "feedy" fish. Fish which have been held in frozen storage for long periods, or under unsatisfactory conditions, often develop pronounced rancidity in the body oils and excessive toughness in the muscle fibres.

The use of poor-quality raw material for canning can lead also to discoloration of the product and the container through chemical reactions with the tinplate. Gases liberated during heating in the closed can may also seriously reduce the vacuum obtained in the cans after retorting and cooling.

HANDLING AND STORAGE

In deciding the measures required to keep the raw material in the best possible condition up to the time of canning, the length of the intervening period and the nature of the prevailing conditions must be taken into account.

Holding Alive

Under special conditions fish may be held alive between catching and preparation for canning. For example, small fish such as pilchards, brisling, anchovies, and immature herring may be held alive in the nets in which they are caught or in special enclosures in sheltered sections of the harbours, bays, or estuaries close to the canneries. After holding in this manner for a few days, the intestinal tracts become free from decomposing food materials, and the fish may then be canned without gutting. Stocks of small fish held in this way may be drawn upon for several weeks or even longer to supply the canneries with good-quality raw material. In Australia a species known as Australian salmon (*Arripis trutta*) has been held in fairly shallow sea water in protected lakes close to the sea for several months in fenced enclosures. Clams, oysters, and other shell fish may also be held alive, and starved until the intestines are emptied.

If the period between catching and processing is short and the temperature of the fish at the time of landing and of the surrounding atmosphere is low, special precautions may not be necessary. For long periods of holding, or if the temperature of the fish is high, refrigeration will be essential.

Chilling

Fish which are iced or cooled rapidly after catching and held thereafter at temperatures below 34°F should generally remain in good canning condition for about 6 days. Nowadays, cooling is sometimes done by immersing the fish in chilled weak brine or seawater at 30–31°F. By cooling the flesh to this temperature promptly after catching, some species may be held in good canning condition for as long as 10 days. As the delay between catching and cooling increases, the safe holding period is progressively reduced. Small fish such as pilchards, which are frequently caught in very large hauls and which are difficult to refrigerate on the catching vessels, may be held in good condition for only 1–3 days after cooling at the cannery.

Cooling and holding of gutted fish in salt solutions tends to increase leaching and to cause uptake of salt by the flesh, but these disadvantages are more than counterbalanced by the better preservation.

Fish which are susceptible to softening by digestive enzymes from the gut or by natural tissue enzymes should be gutted as soon as possible after catching and quickly cooled if they cannot be processed promptly. The prompt bleeding of tuna after catching will enhance the colour and appearance of the canned product.

It is generally considered essential that crustaceans (lobsters and crayfish), and shell fish such as oysters and clams, should be alive when received for processing. While this ensures that the raw material is in perfectly fresh condition, it is quite possible to keep the flesh in good condition by cooling it promptly after catching. Shrimps often remain in good canning condition for several days on ice and other crustaceans should not differ in this respect. With lobsters and crayfish, however, long holding after death may lead to the escape of enzymes from the stomach and digestive glands, and these may attack and partially digest and soften the nearby tail flesh. This danger could be avoided by separating the tails with shell intact and holding them on ice.

With clams and oysters, in which the edible flesh comprises only a very small proportion of the overall weight, disproportionate quantities of ice would be required for cooling. If facilities are available for opening the shells and removing the meats soon after catching, or before the death of the shell fish, the raw material could be iced or otherwise cooled and safely held in suitable containers for several days. However, the usual commercial practice is to open the shells by exposure to steam—hence cooling facilities are unlikely to be found except at canneries.

Freezing

When the fish are to be held for relatively long periods before canning they should be frozen. The freezing of fish was discussed in detail in the fourth article in this series (see footnote, page 8), but the relevant points are reiterated here. The fish should be as fresh as possible at the time of freezing. If freezing is to be carried out on the catching vessels it is often most convenient to immerse the fish in a brine almost saturated with common salt. A preliminary chilling of the freshly caught fish in the round, in circulating sea water or weak brine, at temperatures of 30–31°F will reduce the refrigeration load during freezing, and at the same time help to clean the fish.

Although brine freezing has special advantages over air freezing in the restricted space usually found on fishing vessels, there are certain disadvantages which may affect the quality of the canned products. During the freezing cycle the immersed fish takes up some salt. The extent of absorption varies widely, and depends on such factors as the concentration of salt in the brine, the temperature of the freezing medium, the time required to hard-freeze the fish, the size and thickness of the individual fish, and the periods for which it is held in the brine after freezing. In practice it is customary to remove the fish from the brine after freezing and store it in cold air at the required temperatures. This is the usual commercial method for freezing and storing tuna on catching vessels required to hold fish longer than a week before reaching port. Salmon have also been frozen and stored by this procedure. The irregular uptake of salt by the flesh sometimes makes it difficult to produce uniformly salted canned products, even though some of the salt is leached out when the fish (e.g. tuna) are steamed prior to canning. In species which are not pre-cooked, it may be even more difficult to estimate the amount of salt required.

The presence of salt in fish muscle during frozen storage accelerates the development of oxidative rancidity in the body oils, and this can result in off-flavours in the canned products.

Whatever method of freezing is adopted it is most important that the fish should not deteriorate during the freezing cycle. The rate of freezing is of little importance so far as canning quality is concerned, but it must be sufficiently fast to prevent bacterial spoilage. In many cases the containers used for marketing fish packed in ice are too large to obviate spoilage, particularly if the freezing is not efficient. By whatever method the fish are frozen the thickness of the layers should be restricted, so that freezing to a centre flesh temperature of about 10°F should be accomplished within 36 hr.

The onset of rancidity during frozen storage may be retarded by using temperatures not higher than 0°F, and glazing the surface of the fish with ice. Low storage temperatures will also help to retain a desirable texture in the flesh for longer periods.

PRETREATMENT

Apart from gutting, scaling, and cleaning, fish is sometimes subjected, before canning, to treatment aimed at producing the best possible colour, flavour, and texture in the processed material.

Colour

Changes in colour are unavoidable during canning, particularly when the contents of the container are heated sufficiently to sterilize them. The most common change is a darkening, ranging from light to dark brown, of the flesh and liquor. It is caused largely by a reaction between sugars and amino acids in the muscle. Another example of colour change during canning is the fading of the red pigment in salmon.

Brown discoloration is relatively more important in light-coloured flesh such as lobster or crayfish. South African workers (Dreosti and van der Merwe 1954, 1955) found that immersion of crawfish tail flesh for about 15 min in running water removed sufficient of the substances concerned in the browning reaction to enable the production of significantly better colour in the canned product.

At the Vancouver Experiment Station of Canada's Fisheries Research Board it was found that fading of the natural red colour of salmon could be prevented by short dips in solutions of sodium nitrite (Anon. 1954).

Pretreatment of the flesh of crustaceans with various organic acids to reduce the pH below 6·4 before canning is often effective in reducing the tendency for the flesh to develop grey, black, and blue or blue-green discolorations. These are due to reactions between copper in the blood and flesh and sulphides and ammonia in the tissues (Harrison and Hood 1923, Elliott and Harvey 1951).

The characteristic dark flesh of some species does not give an attractive colour in the canned fish. Harmless bleaching agents have been used in attempts to lighten the colour, but it has been found difficult to avoid the development of undesirable flavours. The author (unpublished data) has found that a reddish pink colour develops, after canning, in the dark flesh under the skin of the Australian salmon if the flesh is soaked in a solution of sodium nitrite. This method of treatment should be effective in other species in which the flesh contains the muscle pigment myoglobin in quantities sufficient to produce the masking red colour. Nitrite has no such effect on fish which have white flesh.

The colour of the edible oil added to some fish packs before processing is adversely affected by juices which exude from the fish during heating in the can. The contamination may be prevented by removing sufficient water from the fish by heating or drying.

Artificial colours are sometimes used on raw material to be canned: annatto confers the yellow to orange colour on the surface of smoked fish, and rhodamine the reddish-pink colour on fish pastes.

Flavour

It is possible to modify the flavour of canned fish products by subjecting the raw material to various treatments prior to canning. Amongst these are removal of the skin, trimming, pre-soaking in water or salt solutions with or without vinegar and spices, pre-cooking, and smoking.

In some species the skin imparts a strong and unpleasant flavour to the canned product. The removal of the skin from the Australian jack mackerel (*Trachurus novaezelandiae*) has been found by Empey and Montgomery (unpublished data) to bring about a noticeable diminution in off-flavour.

Trimming away the surface layers of flesh which have been exposed to the air during frozen storage under unfavourable conditions will often remove a source of rancid flavours. It is also desirable to remove the dark lateral subcutaneous flesh in species such as tuna, since it has a strong characteristic flavour. This flesh is, however, often suitable for fish pastes or strongly flavoured products.

Soaking the raw flesh in water or a solution of salt may improve the flavour by removing substances associated with browning.

Improvement in the flavour of canned fish has been obtained by pre-smoking the fish in or out of the cans. It is customary to smoke lightly for this purpose.

Texture

The canner's main problem is to turn out products with firm flesh and a minimum of liquid in the can. The moisture content of the raw material must therefore be reduced before the cans are closed and processed, and this is done by pre-cooking or pre-drying the fish either in or out of the open can. Harrison and Roach (1952) describe a vacuum-drying treatment of pre-cooked fish to remove water and some undesirable volatile substances from the flesh.

It has been claimed by Schoonens (1952) that pre-cooking is unnecessary if the fish are treated beforehand with a water-binding agent, for example by dipping for 5 min in a solution of a sodium salt of carboxymethyl-cellulose. This treatment is said to be successful with herring packed in oil or tomato purée.

The use of proteolytic enzymes to tenderize the coarse flesh of large tuna has been investigated in Norway by Mathieson (1954) who reported that, although tenderizing was achieved, the texture became too granular.

The flesh of canned Australian salmon, particularly after long frozen storage of the raw material, has been found to be significantly improved in tenderness by pre-soaking for about 12 hr in a 5 per cent. solution of common salt (Empey, unpublished data).

Toughness in the canned flesh is characteristic of some species of clams, which are therefore usually minced and incorporated in dishes such as chowders.

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CORRIGENDA

VOLUME 19, NUMBER 4

Page 62, footnote to G. Hamoir: *For* the Director *read* Associate Professor.

Page 66, reference to Hamoir, G. (1956): *Read J. Physiol.* (*Paris*) **48**: 155.

Characteristics Required of Vegetables for Processing

By J. Shipton
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TWO major phases can be discerned in the development of vegetable marketing. The first covers the evolution from the market garden to large-scale commercial growing and distribution of the produce through centralized markets. The second, which is still in progress, has seen the emergence of processed vegetables as a significant factor in the distribution system. The social and economic changes responsible for these developments are continuing and it is probable that future demands for vegetables will be satisfied more and more by the processed forms.

The growing importance of processed vegetables in the United States is illustrated in the accompanying tables. Unfortunately comparable statistics for Australia are not available but it is believed that a similar pattern exists, although the absolute values may be different.

The present and anticipated status of processed vegetables justifies a close examination of the production of vegetable types meeting the specific needs of processing.

During the transition from market garden to centralized marketing the quality of vegetables was notably improved by the efforts of plant breeders and agronomists. Major advances were made in yield, disease resistance, and environmental adaptation. The plant breeder and agronomist have no less important roles in the development of vegetables for processing. Indeed they have already made valuable contributions.

Food preservation may be considered in two parts: the raw material and the process. At present three major processes are in use—canning, quick freezing, and dehydration. The successful application of each demands compatability between the process and the raw material. Where this compatability is incomplete it becomes necessary to modify either the process or the raw material. The former is usually attempted first. However, in many cases, modification of the raw material is required, and it is with this aspect that this paper is concerned.

Consideration of the raw material requirements of processing reveals a general group of required characteristics, which is largely independent of type of vegetable or process, and a second group, which is specific to one of these components.

GENERAL REQUIREMENTS

Modern vegetable processing is being increasingly mechanized, both in the field and the factory. Virtually complete mechanization has been achieved for a number of vegetable crops, e.g. peas, sweet corn, potatoes, and beans. For other crops, e.g. tomatoes, a similar position may eventuate ultimately. It must be expected that, in future, mechanization will be applied to an increasing extent.

The requirements imposed on the raw material by mechanization may be divided into two groups, harvesting and processing.

Relative Consumption of Fresh and Processed Vegetables in the United States

Adapted from *Vegetable Situation* (U.S.D.A. Agricultural Marketing Service) No. 125, p. 29 (July 1957)

Year	Consumption of Fresh Vegetables (% of Total)	Consumption of Processed Vegetables (% of Total)		
		Total	Canned	Frozen
1937–39 (av.)	67·1	32·9	32·3	0·7
1952	55·1	44·9	38·9	6·0
1953	53·7	46·3	40·1	6·2
1954	53·8	46·2	39·3	6·9
1955	51·8	48·2	40·6	7·6
1956	51·1	48·9	40·6	8·3

Mechanical Harvesting

Mechanical harvesting is practised with some fresh market vegetables, e.g. potatoes. However, its major application is to crops grown for processing. The characteristics required for efficient and economic mechanical harvesting include:

- Uniform maturation, so that a major proportion of the crop is at optimum maturity when harvested (e.g. the pea variety Cooper's 75 reasonably meets this requirement whereas Greenfeast flowers and matures over an extended period).
- Predictable maturity, to enable crop planting to be designed to give the required succession of crops reaching optimum maturity.
- Growing habits which facilitate mechanical harvesting (e.g. beans must have adequate root anchorage and the pods must hang away from the stem).
- Uniform size within a range adapted to the harvester.

Mechanical Processing

The features needed for efficient mechanical handling in the factory include:

- Uniform size and maturity to minimize the need for grading. For the majority of vegetables there is also an optimum size range for processing.
- Freedom from hidden defects (e.g. hollow heart in potatoes, white rings in beetroot, internal rot in tomatoes).
- Extended seasonal availability to provide an acceptable relationship between capital investment and seasonal production.
- Minimum peeling and trimming losses (e.g. short blunt-end carrots preferred to long tapering types).
- A shape amenable to mechanical trimming and handling (e.g. potatoes with a smooth shape and shallow eyes—in this respect the variety Sebago is superior to Bismarck or Snowflake).

Quality

The costs of processing, packaging, and distribution are high. Indeed, in some cases, the initial cost of the raw vegetable is a minor part of the ultimate retail cost of the processed product. These costs demand that only vegetables of high organoleptic and nutritional quality be processed.

Improvements in vegetable quality achieved to date have involved mainly yield, disease resistance and environmental adaptation. Some attention has been given to colour and rather less to the intrinsic qualities of flavour, texture, and nutritional value. Further improvement of these qualities would be very valuable to the processor and would also be beneficial in fresh marketing.

Pesticide Residues

Chemical compounds used for pest control may persist on vegetables. Since they may cause off-flavours or pose a toxic hazard, their presence in the processed product is undesirable and, for some types, subject to legal restriction. The processor, therefore, must remove them. This presents a difficult problem. Removal of chemical pesticide residues is often expensive and may involve considerable wastage of raw material. The ideal solution to the problem would be genetic resistance or biological pest control.

SPECIFIC REQUIREMENTS

Dehydration

The outstanding specific processing requirement is posed by dehydration. The economics of this process are dependent on the solids content of the raw material. This determines the amount of water which must be evaporated to reach a "safe" moisture content and also the required yield. The total and soluble solids contents of vegetables are both influenced by variety and environment. For dehydration the soluble solids fraction should include a low content of reducing sugars, as these react in the dry state with organic and/or amino acids to produce undesirable brown pigments.

Vegetables

It is beyond the scope of this paper to deal in detail with the required characteristics of all vegetables used for processing. Attention is confined to the more important types and to those features in which further improvement is desirable.

Tomatoes (canned pulp, paste, and juice)

- High total and soluble solids content.
- Uniform rich red flesh colour and, in particular, freedom from green shoulders.
- Improved resistance to damage during transport. The factors involved probably

Per Capita Consumption of Selected Vegetables in the United States

Adapted from *Vegetable Situation* (U.S.D.A. Agricultural Marketing Service) No. 125, p. 30 (July 1957)

Vegetable	Form	Consumption (Fresh Equivalent—lb)					
		Average 1937–39	1952	1953	1954	1955	1956
Asparagus	Fresh	1·20	0·80	0·80	0·70	0·70	0·70
	Canned	0·70	0·87	1·03	0·99	0·88	1·00
	Frozen	0·08	0·30	0·33	0·33	0·31	0·32
Lima beans	Fresh	0·80	0·40	0·40	0·40	0·30	0·30
	Canned	0·50	0·66	0·66	0·70	0·72	0·75
	Frozen	0·23	1·59	1·62	1·47	1·59	1·64
Snap beans	Fresh	4·60	3·40	3·50	3·30	3·40	2·80
	Canned	1·45	2·51	2·58	2·67	2·93	3·02
	Frozen	0·06	0·67	0·72	0·81	0·84	0·91
Green peas	Fresh	2·23	0·50	0·40	0·40	0·40	0·30
	Canned	8·11	8·63	8·33	8·26	8·07	8·17
	Frozen	0·48	3·35	3·52	3·92	3·78	4·21
Spinach	Fresh	2·67	1·50	1·40	1·10	1·00	1·10
	Canned	0·83	0·93	0·91	0·68	0·83	0·94
	Frozen	0·03	0·90	0·94	0·94	1·04	1·01

include skin thickness and toughness and insoluble solids content.

Green Peas (canning, freezing, dehydration)

- Colour is not a major problem in canning, owing to the unavoidable thermal degradation of chlorophyll, but for freezing and dehydration a bright deep green colour is most important.
- Skin texture is frequently objectionably tough, especially in frozen peas. The origin of the defect is uncertain. It may be partly genetic (Thomas Laxton is regarded as a tough-skinned variety in the United States), and partly agronomic (there is evidence of an association with calcium). Processing technique may also affect skin texture.

Green Beans (canning, freezing)

- Fibre development in stringless beans is sometimes objectionably high at optimum maturity.
- Deeper, brighter colour is required for freezing.
- A greyish-brown discoloration sometimes occurs in processed beans owing to presence of leucoanthocyanins and their conversion to anthocyanins. Types free from these compounds should be sought.
- Bean varieties with white seeds are preferred to those with pigmented seeds.
- Long straight pods with ovoid to circular cross section and blunt ends are needed.

Dry (Navy) Beans (canning)

- Seeds should be white and of small to medium size.
- Navy beans often have a hard centre after processing. This arises from inferior water absorption capacity, but the primary causes are unknown. Genetic, agronomic and processing factors may all be involved. Hence it is desirable that texture of the processed product be considered in future breeding and cultural evaluation programmes.

Onions (dehydration, pickling)

- Australian dehydration plants have relied on Australian Brown and Brown Globe types. These have excellent storage life and pungency, but are difficult to peel, of poor texture, and because of their purple or yellow flesh yield a product of unsatisfactory colour. The ideal type for dehydration would be medium to large size, near spherical shape, resistant to twinning, easily peeled, white, and of high pungency and high solids content. It should also have a long storage life. A combination of the best features of the Australian Brown and White Spanish varieties would fulfil most of these requirements.

- Many onions used for pickling in Australia contain the flavonoid, quercetin, which, under the acid conditions of pickling, produces unsightly yellow spots on the bulbs.
- Attention should be given to the development of cocktail-type onions, of which whiteness and small uniform size are the essential features.

Cauliflower (canning, freezing)

- Pink discoloration is encountered in canned cauliflower. It is due to an anthocyanin which is derived from a leucoanthocyanin. The conditions governing the conversion are not fully understood. Varieties appear to differ in their susceptibility, which is also influenced by growing conditions.
- Frozen cauliflower tends to darken during frozen storage at 0°F. The extent and rate of darkening appear to be affected by solar irradiation, either before or after harvesting, and by processing methods. Varieties having a full leaf cover over the curd until they reach harvesting maturity should be less susceptible to darkening.
- For optimum texture and appearance in the processed pack, the curd should be dense and smooth with small floweret stalks.

Potatoes (dehydration)

- The qualities sought in potatoes for dehydration are medium size, smooth rounded shape, shallow eyes, freedom from flesh pigmentation, long storage life, resistance to transport damage, high total solids, low reducing sugar content, and high culinary quality. The variety Sebago, which also yields well, is satisfactory in all respects except storage life and resistance to transport damage. If these deficiencies were rectified Sebago would be very satisfactory for most processing requirements.
- For the manufacture of mashed potato powder it is essential to have potatoes which mash very freely. In England, the variety King Edward, grown under specified environmental conditions, is used almost exclusively for this process.

FUTURE NEEDS

Further progress in vegetable processing will depend, in no small degree, on the ability of plant breeders and agronomists to provide the types of raw material needed. It will depend on close collaboration between plant breeder, agronomist, and food technologist. The technologist will be responsible for defining, in quite precise terms, the characteristics required in the raw material.

To enable plant breeders and agronomists to give proper attention to the needs of processing it would be most desirable to prepare detailed raw material specifications for each vegetable used in processing. This task will not be simple. Indeed, there is uncertainty about the origin of some defects in processed vegetables, and it may not be possible to prepare embracing specifications immediately for all vegetables. However, it is only by the provision of such specifications that the plant breeder and agronomist will be made fully aware of the requirements of the processing industry.

The Foreman in the Food Plant

THE FOOD TECHNOLOGY ASSOCIATION of New South Wales announces that during 1960 it is sponsoring a Winter School on "The Foreman in the Food Plant".

The School, which is residential, will be held during the week commencing Monday, June 27 at the Hawkesbury Agricultural College, Richmond, N.S.W. The fee, including meals and accommodation at the College, is £10 0*s*. 0*d*. per student.

The course has been designed for factory foremen and will cover such topics as functions of the foreman, principles of preservation, quality of raw material, principles of quality control, vermin control, plant sanitation, packaging, materials handling, factors affecting costs, food plant instrumentation, and production planning.

Enrolment forms may be obtained from the Secretary, Food Technology Association of New South Wales, 12 O'Connell Street, Sydney.

Vegetable Marketing Trends in Australia

By E. G. Hall

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

IN recent years methods of marketing fruit and vegetables have changed greatly, particularly in America and a number of European countries. In U.S.A. the big change in wholesaling during the period 1930–50 was the increase in direct selling, that is, in selling which by-passed the central market (Anon. 1952). According to the *Sydney Morning Herald* (August 17, 1959) business at the New York Central Market has fallen 40 per cent. in the last few years, largely because of prepackaging and quick-freezing.

The changes in America have been attributed (Anon. 1952) mainly to the development of the motor car and the motor truck, leading to self-service retailing, one-stop shopping from motor cars, a big increase in roadside selling, and much more road freighting of fruit and vegetables. Improved transport, rail as well as road, and better market information have brought about the development of specialized areas of production and have greatly extended the market geographically. Large-scale production, centralized packing, and uniform grading have been introduced to meet the vast demand for standardized vegetables. In addition, the grower is being called upon more and more to produce commodities which are ready for sale at a particular time, or are a particular variety or grade.

A survey (Awes 1958) showed that in 1957, 47 per cent. of all supermarket produce sales in America were prepackaged. There is a general trend towards prepacking at the point of production, and this is increasing the demands for better packaging and better transportation. New packaging and new marketing methods in U.S.A. are placing more and more emphasis on vegetable quality: this has lead to demands for improved varieties, better grown produce, more critical harvesting maturity, more careful handling, and greater use of refrigeration.

In Australia fresh fruit and vegetables are sold at the wholesale level almost exclusively in large central markets in the capital cities of each State and thus serve 54 per cent. of the country's population in their immediate vicinity. Except in Perth, where produce is sold by auction, selling is by private treaty through wholesale commission agents, growers, and grower-agents. Most perishable vegetables are produced within or near the metropolitan areas and are sold in the market by growers. Aspects of our present system of centralized marketing have been discussed (Anon. 1958; Barrett 1958; and Honan 1958), but the authors have not considered changes in marketing and their effects on production.

New South Wales, with 38 per cent. of Australia's population, grows only 16·7 per cent. of the total production of the 10 principal vegetables, the greatest deficiencies being in onions and potatoes (see accompanying table). Victoria, on the other hand, produces a surplus of most vegetables. Queensland supplies summer vegetables in winter to southern markets, and Tasmania exports large quantities of potatoes and turnips. South Australia and Western Australia are, by and large, self-sufficient. Thus an important feature of vegetable marketing is the interstate trade, particularly from Victoria, Tasmania, and Queensland to Sydney. According to the New South Wales Chamber of Fruit and Vegetable Industries, two-thirds of the fruit and vegetables on the Sydney market come from other States.

Production of Principal Vegetables in Australia

Vegetable	Total Production (10^3 Tons)	Percentage of Total Production					
		N.S.W.	Vic.	Qld.	S.A.	W.A.	Tas.
Potatoes	473·6*	10·8	39·8	7·8	8·8	10·3	22·3
Tomatoes	98·7*	18·3	48·6	15·9	9·1	7·3	0·9
Cabbage and sprouts	78·0†	24·2	40·2	16·7	12·0	4·8	2·1
Cauliflower	79·1†	23·3	49·6	7·8	10·3	6·3	2·6
Pumpkin	75·7†	24·8	17·7	45·6	6·6	4·9	0·4
Carrots	37·4†	20·1	51·2	5·3	10·5	8·4	4·4
Onions	47·2*	3·4	50·7	25·3	10·9	9·5	0·3
Green peas	40·2*	36·2	24·5	1·6	10·0	2·3	24·5
Green beans	21·2*	33·2	15·8	34·9	4·6	11·1	0·3
Turnips	21·0†	32·7	11·5	3·0	10·0	6·0	36·8
Percentage of population in each State in 1955 (Total = 9·313 millions)		37·9 (38·2 incl. A.C.T.)	27·4	14·5	9·0	7·2	3·5

* Average of 5 years, 1952–3 to 1956–7.

† Average of 2 years, 1952–3 and 1956–7.

IMPORTANCE OF TRANSPORT

It is clear then that transport is a key part of our vegetable-marketing system. Locally produced vegetables are transported by road. Rail transport is still most important for carrying vegetables long distances, but the use of road transport is increasing rapidly. The change is most marked between Sydney and Melbourne, and in Western Australia, where vegetables are sent 650 miles by road from Carnarvon to Perth. Two factors which favour road transport are reduced handling and quicker point-to-point delivery, but rail transport is cheaper for bulk consignments. The evidence suggests that, as vehicles and roads improve, the quantities of vegetables carried by road transport and the distances hauled will increase.

SPECIALIZED PRODUCTION

Many changes are taking place in vegetable marketing in Australia. With improved transport, vegetables are being taken greater distances to market, and a greater range of vegetables is available to the consumer throughout the year. There is a tendency to specialized production. One area may devote itself to a crop which it can grow very cheaply, another to supplying out-of-season markets. Substantial quantities of tomatoes from Geraldton (W.A.) or Bowen or Redland Bay (Qld.) are sold on southern markets in the winter. Green beans are also available all the year round in Sydney, Brisbane, and Adelaide. Inland irrigation areas are tending to produce more; one grower on the Murrumbidgee Irrigation Area is specializing in quantity production of carrots and lettuce, and is developing new methods of packaging and marketing.

SELF-SERVICE SELLING

Although no data are available it is clear that self-service selling of vegetables in Australia is here to stay, and as it develops prepackaging will increase, though perhaps not as rapidly as in America and some other countries. The vegetable industry should therefore be thinking about the requirements of prepackaging. It will certainly be called on to supply, over long periods, considerable quantities of clean, sound, high-quality vegetables of suitably uniform size and maturity.

Such supplies would be difficult to obtain at present. Standardization of price as well as grade would be desirable; in other words supplies on a long-term contract basis would best serve chain store prepack requirements.

ROADSIDE SELLING

As motor cars become more numerous roadside selling increases, especially on the outskirts of cities. Supplies come mainly from the central market, but it is likely that more growers will supply direct, and also that the stalls will carry more prepacks. It is reasonable to expect the consumer to demand better quality vegetables, presented in a form which reduces waste and the labour of preparation. These developments are likely to affect all forms of selling—the traditional fruit and vegetable shop, the supermarket, and the roadside stall. The grower will, therefore, face a stronger demand for standardized lines of better quality produce.

PRODUCTION RESEARCH

Those concerned with production research should be thinking ahead and preparing to help producers meet the changing demands of the market. The most important developments needed in vegetable production are:

- Improvement of quality
- Introduction or development of new varieties
- Production on a large scale

Improvement of Quality.—There are three aspects of quality to consider:

- Consumer quality, which comprises attractive appearance, palatability, and high nutritive value
- Marketing quality—the ability to withstand handling without seriously impairing consumer quality
- Storage quality—possessing the attribute of deteriorating only slightly during storage.

New Varieties.—It will be necessary to introduce or develop new varieties, or select strains having the characteristics sought by the market.

Large-scale Production.—It will be very important to develop the most economical methods of large-scale production in the most suitable areas. If the latter are a long way from markets the grower should select types of vegetables which are not harmed by transport over long distances.

As the market becomes more specialized and more discriminating—and this has been the experience in other countries as living standards rise and the economy becomes more highly developed—growers will have to pay more attention to other matters such as control of disease, manuring, maturity at harvest, handling and grading, in addition to packing and transport.

MARKET RESEARCH

At present the vegetable industry is ill-equipped with data on marketing. Before the effects of methods of marketing and of changes in methods on production research can be properly assessed, much more effective research into marketing problems will be needed. In particular, surveys should be made to determine consumer preferences and market demands. Strong (1958) has stated that marketing research is a relatively neglected field in Australia and we cannot afford to let it remain neglected. This applies particularly to fruit and vegetables, where distribution is a major problem.

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NEWS FROM THE DIVISION OF FOOD PRESERVATION AND TRANSPORT

PERSONAL

DR. H. L. EVANS has returned to the staff of the Division after two years' post-graduate study at the Imperial College of Science and Technology, University of London. He was awarded a Diploma of the Imperial College, and was admitted to the degree of Doctor of Philosophy by the University of London for a thesis on the theory of heat and mass transfer through laminar boundary layers. At Homebush Dr. Evans will continue his researches on heat and mass transfer, and undertake other theoretical and experimental studies on the physics of food.

PUBLICATIONS BY STAFF

Compression of Dehydrated Mutton and Beef Mince. A. R. Prater, G. G. Coote, and E. A. Roberts. *C.S.I.R.O. Aust. Div. Food Pres. Transp. Tech. Pap.* No. 13 (1959).

By compression it is possible to save packing space for dehydrated mince meat and to lengthen its shelf life. These advantages are partly offset by breaking of the meat particles. A detailed study of the compression characteristics of dried mutton mince has been made. Two methods of block preparation were compared, the first using conventional blocking methods, the second including pre-treatment of the mince with fat before compression. Suitable methods for the production of both types of block have been defined. The variables studied were moisture and fat content (natural and added fat), mince size, temperature of mince, blocking pressure, and duration of pressure (dwell).

The shelf life of beef mince blocks, prepared by the two methods of blocking from two sizes of beef mince, was compared with that of loose packs in air and nitrogen. Small ($\frac{1}{4}$ in.) mince had a longer storage life than large ($\frac{1}{2}$ in.) mince; the order of preference for packing methods is (i) in nitrogen, (ii) in blocks of mince pre-treated with fat, (iii) in blocks of mince not so treated, and (iv) in air.

Substances in Plants of the Order Malvales Causing Pink Whites in Stored Eggs. F. S. Shenstone and J. R. Vickery. *Poultry Sci.* **38**: 1055–70 (1959).

When hens eat certain plants of the order Malvales, or fats derived from these plants, a pink discoloration of the whites of their eggs appears after storage, caused by iron diffusing from the yolk and combining with albumin in the white. The disorder is accompanied by a mottled discoloured appearance of the yolks and a pasty condition when cold.

Oils from many plants of the order Malvales, including cotton and mallows, give a positive reaction to the Halphen colour test and the constituent which gives the colour reaction has been shown by the authors to cause the "pink-white" disorder of eggs. They have named it malvalic acid. Sterculic acid has been found to have the same effects. Both acids contain a *cyclo*propene ring in their structures. This paper describes experiments in which these acids were included in the diet of hens and doses of 25 mg per day were found to cause pink whites. Other fatty acids from the same plants did not give the Halphen colour reaction nor cause pink whites. Closely related *cyclo*propane acids and Feist's acid were also inactive.

Ionic Relations of Cells of *Chara australis.* J. Dainty† and A. B. Hope. *Aust. J. Biol. Sci.* **12**: 395–411 (1959).

† Biophysics Department, University of Edinburgh.

Copies of papers mentioned above may be obtained from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O., Homebush, N.S.W. (Telephone: 76 0274, UM 8431.