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PRESERVATION OF FISH. PART 2.

FREEZING.

Although the preservation of fish by freezing has been practised commercially for many centuries, until recently there has been a strong prejudice by the consumer against frozen fish. Intensive investigations during the past twenty years have gone a long way towards defining the nature and causes of deterioration in frozen fish and thus laid the foundation for improved methods of handling this product. At the present time, particularly in America, where the results of research have been applied in commercial practice the former prejudice has been broken down to such an extent that frozen fish are often preferred to the fresh fish marketed in the unfrozen condition. The marked improvement in quality of the frozen product has been brought about by close attention to four essential conditions.

(a) Freshness of fish at time of freezing.

(b) Use of quick-freezing methods.

(c) Maintenance of low temperatures during frozen storage.

(d) Protection of the frozen fish from drying.

Freshness of Fish.

It cannot be emphasised too strongly that freezing and storage of fish initially inferior in quality will invite a prejudice which may be difficult to overcome. For the reasons outlined in Part 1. of this series fish deteriorate very rapidly when held at ordinary air temperatures after removal from the water. Since the rate of these adverse changes is reduced with the lowering of temperature, it is essential to ice the fish thoroughly immediately after capture, to hold it in that condition up to the commencement of freezing, and to begin freezing as soon as possible.

Under ideal conditions, as practised on many overseas refrigerated fishing boats, freezing is commenced within 30 minutes of catching. The industry has not yet developed to this degree of efficiency in Australia, where fish freezers are frequently dependent upon the markets for their supplies. Although fish obtained in this way may be well iced and cooled at the time of purchase it is often difficult, except in the case of obviously spoiled material, to obtain an estimate of their treatment in the vital period between catching and icing. An approximate idea of the time since death can be obtained from the degree of firmness or stiffness of the flesh which is associated with the state of "rigor mortis", but it is possible that the onset of this condition may be independent of temperature as in the case of mammalian muscle. With fish held in ice rigor reaches its peak within 24 hours and then begins to subside with an accompanying reduction in firmness of the muscle tissues; at 48 hours the fish are generally entirely free from stiffness.

Iced fish should be frozen before or during full rigor: further storage beyond one day in ice favours the earlier development in the flesh of "off" odours and impaired texture during frozen storage with a consequent reduction in palatability of the cooked product. In this laboratory, fish held eight days in ice prior to freezing have retained satisfactory condition in frozen storage at 0°F. for about three months as compared with five months in the case of similar fish one day in ice before freezing, the shorter life in the former being due mainly to the earlier onset of rancidity. Overseas experiments have indicated that holding fish at 68°F. for several hours before icing and subsequent freezing reduced the storage life at 0°F. by one to two months.

In the case of fish freezing plants receiving regular consignments supplied from sea fishing vessels, freshness of the product before freezing is maintained by a combination of cooling and sanitation. A description of the procedure adopted in the Gloucester plant of the General Seafoods Co., U.S.A., is given by D.K. Tressler in "Municipal Sanitation", April 1930. This plant is equipped to freeze about 9 million pounds of fish, principally haddock, annually.

"The haddock brought aboard the fishing vessel are first slit down the abdomen from the gills to the vent and the viscera and gills removed. The gutted fish are then thoroughly rinsed in a tub of sea water, and placed in the fish-hold where they are packed in small bins with a generous quantity of crushed ice."

"When the fishing vessel arrives at the plant the fish are thrown by hand into one hundred-pound canvas baskets and hoisted out of the hold, and then dumped into a wash tank of running chlorinated sea water; this washing removes much of the slime, ice and other matter. This recently introduced method of handling is infinitely superior to the old procedure of forking the fish from the fish-hold to the deck of the vessel, then again forking onto the wharf and finally into the weighing boxes. Frequent forking of fish punches them with many holes and introduces bacteria into the deep areas of the flesh."

"The fish are carried by an automatic conveyor from the wash tank and deposited in a wooden box, in one side of which is a hinged door. Six hundred pounds of fish are placed in each box. A layer of crushed ice is placed on the bottom of the box, a further layer after it is half filled with fish and a final layer after the

[...]ing with fish is completed. The iced boxes of fish are [...]ediately hauled to a refrigerated room at about 37°F. at the [...]ceiving end of the fish filleting plant where they are held some[...]mes as long as forty-eight hours, never longer, awaiting filleting."

"Preparatory to filleting, the fish are either scaled, [...]ashed with chlorinated sea water and conveyed to the cutting tables, [...] if skinned fillets are being packed they are merely washed and [...]onveyed to the filleting tables".

"Fish to be scaled are dumped into the hopper of a [...]caling machine where the scales are removed under a spray of sea [...]ater. The fish are then automatically conveyed through a washing [...]ank, through which chlorinated sea water is flowing and then to the [...]utting tables for filleting. Fillets to be skinned pass to the [...]kinning machine which is operated under a spray of sea water."

"All fillets selected for freezing are passed into a [...]rining machine where they are immersed for about one minute in a [...]alt brine containing a small amount of sodium hypochlorite. The [...]rined fillets are placed in monel metal pans and conveyed to monel-[...]opped packing tables where they are weighed and individually trade-[...]marked, wrapped in moisture-vapour-proof transparent cellulose [...]ilm and packed in cold-waxed cartons in which they are frozen."

"Sanitary control measures. Although the flesh of live fish is sterile, the fish when unloaded from a fishing vessel are highly infected and spoil rapidly unless kept cold. During gutting prior to packing in ice in the hold of the vessel bacteria from the highly infected digestive tract become spread over all cut surfaces and the infection is carried from one fish to another by water from the melting ice".

"Unless the fish are thoroughly washed nearly free from slime with chlorinated water before they reach the filleting table, and unless the bacterial content of the dip used in brining the fillets is kept under control, the bacterial count per unit of fish will increase rapidly as the fish pass through the filleting and packaging process. In addition it is necessary to keep the floors, tables and trays as nearly sterile as possible by frequent washing or scrubbing with chlorinated sea water."

"In this plant the water used in washing fish tables, machinery, etc., is sea water taken from the outer harbour and chlorinated to about seven parts per million on the suction side of the pump. A portion of the chlorine is used up in oxidizing the organic matter in the water so that by the time the water reaches the 10,000 gallon tank in the tower of the factory the free chlorine content is about five parts per million. The pumps are operated continuously day and night, thus ensuring a freshly chlorinated supply of nearly sterile water at all times. In passing from the large tank to the wash tank on the receiving wharf and the several machines on the dressing floor, the content of free chlorine drops from five to one to three parts per million. Thorough washing with chlorinated sea water of this strength is sufficient to reduce greatly the number of bacteria on the surface of the fish but has little effect on those beneath the scales, in the centre of the gill clusters, and in the flesh.

"This chlorinated water is used not only to wash the fish on the receiving wharf and just prior to filleting but is also sprayed on the fillets just before they enter the brining machine so as to lessen contamination of the brine. The salt brine itself is treated hourly with a measured quantity of sodium hypochlorite so that it constantly contains from one to three parts per million of active chlorine.

"The plant is one which may be easily cleaned and disinfected. The floors are of granolithic concrete and are sloped to frequent drains. The walls are of tile and the ceilings of concrete, both being painted with white enamel. The trays for holding the partially prepared fish are of monel metal and the tables have monel metal tops. Other equipment is constructed of corrosion-resistant material. The monel pans or trays in which the fillets are supplied to the packing tables are thoroughly scrubbed with a dilute (seven parts chlorine per million) sodium hypochlorite at least once daily. The floors amd machines are frequently flushed during working hours with chlorinated sea water and at night are scrubbed and washed with a strong hypochlorite solution.

"In order to keep a careful check and record of the quality of the product of this modern plant, careful records of the important points in the purchase and production of each lot of fillets are kept. In addition, two samples taken at random from each lot are examined bacteriologically and tested by cooking. All of these data are recorded on Lot History Sheets which are examined by a responsible member of the laboratory organisation before any portion of the production covered by these sheets is released for shipment.

"The cleanliness and care with which the fish are handled during preparation and packaging are reflected in the quality of the product." <u>The details given here for this model plant might well be taken as a guide for the construction of new plants or the reconstruction of old plants in Australia</u>.

<u>Quick-freezing Methods</u>.

The advantages of rapid over slow freezing are that the frozen fish are of better texture and lose less muscle juice or drip" during thawing, but for fish that are to be held in the frozen state for long periods, e.g. six months, the factors of the initial freshness of fish and the temperatures at which the frozen fish are stored are relatively more important. Nevertheless it has been proved that, when all other conditions are similar, a superior product is produced by rapid freezing. From the commercial standpoint also the weight of fish which can be frozen in a given time is much greater so that considerably less actual space is required for freezing a given quantity of fish.

From laboratory experiments it has been demonstrated that the adverse effects of freezing are reduced to a minimum when the time taken to pass through the +"critical zone" of freezing, 31°F. to 23°F., is not longer than fifteen minutes, but that the deterioration in quality as judged by commercial standards is not very apparent even when this time is two or three hours.

In recent years many types of refrigerating plants have been designed for freezing fish within the time limits specified, but, provided that the necessary rate of freezing is obtained and the fish are not damaged by contact with the freezing medium, there should be no biological advantage of any particular system over another.

There may, however, be differences in design which bring about certain advantages such as greater efficiency of cooling, increased flexibility of operation, saving in space, and reduced depreciation of plant. It may sometimes be possible to make use of existing equipment which can be adapted for quick-freezing, thus reducing the costs of a special plant which may be used only intermittently. It should be borne in mind, however, that a flexible type of freezer may be used for other products when fish are not available.

Further details of freezing methods will be found in a circular which will shortly be issued by the Council for Scientific and Industrial Research.

+When fish are placed in a freezing medium, their temperature is reduced relatively rapidly until the freezing point of the flesh is reached (approx. 31°F.) at which stage there tends to be a balance between the heat of crystallization of ice and the cooling effect of the freezing medium and the so-called latent period of freezing is manifested. As an example, the time occupied in this period of freezing (between 31° and 23°F.) may be ten times as long as that taken for the fish to fall from 70°F. to 31°F. After passing through this zone, the fish temperature falls more rapidly to that of the freezing medium.

Limiting thickness of fish for quick-freezing. The limiting thickness of fish which can be quick-frozen will depend on a number of factors such as the nature and temperature of the refrigerating medium, its rate of movement over the fish, and the presence of coverings such as moulds and wrapping or packaging materials. For unwrapped fillets or single fish frozen under the most favourable conditions the limiting thickness will be approximately 4 inches. In commercial practice, blocks of fillets to be frozen are usually half to one inch in thickness.

Some data on the rates of freezing of fish in air have recently been reported by workers at the Torry Research Station, Aberdeen.

(1) Unwrapped fillets or single fish up to a thickness of five inches were frozen in less than three hours in air at minus 30°F. moving at ten feet per second.

(2) Fillets and split herrings packed in shallow metal trays (20" x 15" x 1¾") were frozen in four hours in still air at minus 22°F. By moving the air at fifteen feet per second the freezing time was reduced to one and a quarter hours.

In experiments at Homebush blocks of fillets one inch in thickness wrapped in waxed paper and packed in metal moulds immersed in well stirred brine at 0°F., were reduced to the temperature of the freezing medium in about thirtyfive minutes, including fifteen minutes in the "critical zone".

Preparation of fish for freezing. Fish may be frozen in the round without beheading, scaling, or gutting, but although the extent of drying during freezing (in air) and in subsequent storage will be less than in similar beheaded and gutted fish - which have a greater area of exposed cut surfaces - the fish occupy more space in storage. Torry research workers advocate freezing of whole fish when they are intended for smoking after frozen storage.

For the general trade, fillets are preferable to whole fish since they meet the requirements of the consumer while the elimination of waste prior to freezing effects marked economy in freezing and in space taken up in storage. Half-pound blocks are a suitable size for sale to householders while five-pound blocks will be more in demand for supplies to institutions, hotels, cafes, etc.

Protection from Drying.

Fillets may be packed in suitable moisture vapour-proof wrapping papers before freezing and although there will be some increase in freezing time, the extent of drying will be greatly reduced. In addition, the wraps applied before freezing will adhere more closely to the frozen blocks than those used after freezing and there will be less tendency for the fish to dry during subsequent storage.

During freezing in air, unwrapped fish will lose from two to three per cent. of their weight and, according to Torry workers, this loss can be considerably reduced by freezing the fish in a wet state in which case the evaporation will be mainly from the water adhering to the fish.

This series on the preservation of fish will be continued in a future issue with an article on the storage of frozen fish.

BACTERIA IN CANNED FOODS.

In its bare essentials the commercial canning of food depends on the application of heat to a product which is packed in a sealed container from which the air is partially excluded. The heat process serves to destroy micro-organisms. The exclusion of air decreases strain in the can during heating at high temperatures, and causes collapse of the can ends under ordinary conditions of climate. The collapsed state of the can is important because it represents the only method of judging the soundness of the contents without opening the container. This method of judgment is accepted because most, although not all, bacteria which may grow in canned foods produce gas which destroys the vacuum and may eventually distend and burst the can. For this reason any cans lacking a partial vacuum when cool are considered unfit for consumption, even though other causes of loss of vacuum are known to exist.

Although certain canned foods may on occasion be spoiled by yeasts and other fungi, bacteria are the most important agents of spoilage. This is due largely to the great resistance to heat which is inherent in the spores formed by some types of bacteria. For this reason bacteria only will be discussed in this article.

When the contents of a can of food are examined for the presence (or absence) of bacteria one of the three following conditions will be found.

1. The can contains no living bacteria.

The can contents then are said to be "sterile" in the absolute sense. This condition obtains when the heat process has been adequate to destroy all spores and the can has been sealed in a manner which has prevented subsequent contamination. The contents of such cans will keep indefinitely from a bacteriological aspect, although slow chemical changes may impair the qualities of the product after very prolonged holding. A rarer condition is to find a spoiled can in which no living bacteria can be found. This may be due to the bacteria responsible for the spoilage having been destroyed by an accumulation of their own end-products or by other causes. Cans, of course, may also be spoiled by purely chemical reactions, e.g. hydrogen swells.

2. The can contains living bacteria which do not grow in the can.

This condition is known as "commercial sterility" and in general is the condition which the canner aims to provide. It is not necessary to provide severe heat processes to destroy all bacteria when less drastic heat processes are sufficient to destroy those which will grow in the product as packed. One of the commonest examples of "commercial sterility" is the occurrence of bacterial spores in acid products such as certain fruits and fruit juices. Such foods are usually heated to temperatures less than 212°F. which are sufficient to destroy those non-spore-forming bacteria which are able to grow in the acid product. Another example is the occurrence of the spores of thermophilic bacteria in some canned foods. Thermophillic bacteria grow only at high temperatures and foods containing such spores may be marketed with safety in temperate climates. However, where the cans are exposed to temperatures greater than 110 to 120°F. the thermophilic bacteria may grow and spoil the product. Many other factors are often important in preventing the growth of bacteria in canned foods, but they cannot be detailed here. One condition of interest, although fortunately it is not serious from a commercial point of view, is that of "dormancy" in spores. This occurs when spores remain alive but do not germinate in the canned food until long periods have elapsed. They may then germinate, and spoil the can. It is only very rarely that living spores do not germinate during a brief incubation, although "dormancy" for periods up to three years has been reported.

3. The can contains living bacteria which have grown and spoiled the contents.

It is obviously desirable to avoid this condition and some of the causes and control measures will be detailed in a later article. The bacteria causing spoilage may have survived the heat process or they may have gained entry after processing was completed. The first alternative will usually be associated with the occurrence of only one type of heat resistant or otherwise specialised bacteria. The second alternative is indicated by the occurrence of mixed miscellaneous types which may not be resistant to the condition of processing. For properly sealed cans the types of bacteria which will spoil canned food depend, very largely, on the product. In all cases except the "flat sour" and "sulphide" types (see below) the bacteria may produce gas which swells the can.

(a) Acid Products.

In products with an acidity corresponding to a pH of less than about 4.5 any spoilage bacteria will be found generally to be species of *Lactobacillus* or *Leoconostoc*. Neither type forms spores and therefore they are destroyed at temperatures below 212°F. In the event of their survival, they may grow and produce gas in such acid products. Spore-forming bacteria may survive the heat process, but do not cause spoilage in these products under normal conditions.

(b) Non-acid Products.

When products have a fairly low acidity as shown by pH 4.5 or greater the growth of spore-forming bacteria may take place. Such products require greater heat processing to destroy the spores, and this is achieved largely by using steam under pressure to 250°F., or sometimes higher, within the can. The heat process required may be calculated when the susceptibility of the spores to heat, and the rate of heat penetration into the can contents are known. The process should at least be capable of destroying the spores of *Clostridium botulinum* (the toxin of which causes botulism) when this organism is known to grow in the product.

The following general classes of spoilage in non-acid products may be recognized.

(1) Flat-Sour Spoilage.

As the name implies the cans are not swelled but as the bacteria produce acid the contents may be soured. In certain products of a semi-acid nature the increase in acidity may not be sufficient markedly to affect the flavour, although the increased acidity is always readily detected chemically. This type of spoilage which is common in vegetable products, is caused by highly heat-resistant spore-forming bacteria which are facultative anaerobes (they grow in the presence or absence of atmospheric oxygen) and which grow at temperatures above 120°F. Spoilage, therefore, may not always arise unless the cans are subjected to such elevated temperatures.

(2) Thermophillic Anaerobic Spoilage.

This is often known as "T.A." spoilage and owing to the production of gas the cans are swelled to various amounts. The flavour and texture of the product may be damaged by the bacteria which are spore-forming and obligate anaerobes (grow only in the absence of atmospheric oxygen) and which grow only at elevated temperatures (above 110°F.). The spores of the organisms are not quite as heat-resistant as those causing "flat sour" spoilage.

(3) Sulphide or "Stinker" Spoilage.

This condition is marked by the presence of the malodorous gas hydrogen sulphide. As the gas is soluble in water the can does not swell. The can contents are also darkened with this type of spoilage, which is most common in vegetable packs. The organism is another obligate anaerobe which grows only at elevated temperatures (above 110°F.) and its spores are not as heat-resistant as the two previous types.

(4) Putrefactive Spoilage.

This occurs in a wide variety of products, particularly meats, and is marked by swelling of the can and varying degrees of putrefaction of the contents, which may or may not be blackened. The condition is caused by a number of organisms which however are all obligate anaerobes and which grow best at temperatures below 110°F. The resistance of the spores to heat varies considerably with different organisms. A few strains produce spores which are very resistant to heat.

(5) Swelled Cured Meats.

Certain cured meats may be spoiled by bacteria which produce gas and swell the can. No other changes may be obvious. The spoilage is caused by spore-forming bacteria which ordinarily grow only in the presence of air, but are able to grow in its absence in the presence of cured meats and sugar. The bacteria, which usually grow best at temperatures less than 120°F., produce spores which are not particularly resistant to heat.

All the foregoing remarks apply only to bacteria in foods canned according to recognized procedures. Where the cans are faulty, or are grossly underprocessed, numerous other types may appear.

THE FOOD VALUE OF VEGETABLES.

In an attempt to alleviate the general food shortage and, in particular, to make up for the shortage of imported fruits, Great Britain has instituted a "Grow more Vegetables" campaign, which has stimulated interest in the nutritive value of vegetables. In a recent symposium in London on this subject existing scientific knowledge was reviewed and certain fresh information brought forward. This article is a summary of the papers presented in that symposium.

The subject is of considerable importance in this country at the present time not only because larger quantities of fresh and processed vegetables are being consumed by the Defence Services but also because the average housewife has only vague ideas as to the relative food value of the common vegetables. It may be noted that the potato, being somewhat of a class to itself, has not been included in the discussion.

With the exception of legumes, e.g. peas, navy beans, haricot beans, etc., vegetables are primarily "protective foods" i.e. they supply needed vitamins and minerals. Proteins and carbohydrates are present in such small amounts as to form only an insignificant proportion of the total energy intake. In the average diet, vegetables supply only about 3.5 per cent. of the daily calorie requirement. In a wisely planned diet vegetables can supply all the vitamin C, probably all the vitamin A, a substantial proportion of the iron and some of the calcium needed for good nutrition. It is instructive to rank the common vegetables in order of nutritive value. The order of decreasing content of vitamin C is as follows:- Brussels sprouts (boiled), mustard and cress, broccoli (boiled), orange, lemon, spinach (boiled). The citrus fruits are included for comparison. It is calculated that 4 ounces of boiled cabbage contains as much vitamin C as ½ pint of orange juice.

In the case of vitamin A, the ranking is broccoli (boiled), watercress, spinach (boiled), tomato, lettuce, mustard and cress, Brussels sprouts (boiled), carrot (boiled). It is apparent that the vegetables with dark green leaves are the best. Broccoli, watercress, mustard and cress (vegetables not commonly used in Australia), Brussels sprouts and spinach are high up on the list, the sought-after white-hearted cabbage is further down. The tomato and carrot are useful vegetables but are not high in vitamins. Onions, asparagus, celery, cucumber, marrow and pumpkin are extremely low in nutritive value. Of these, onions and celery are amongst the canned foods used in Service rations. However, it should be pointed out that the value of a foodstuff cannot be judged solely on chemical analysis. Questions of palatability and digestibility must be considered. Thus in order to render certain other foodstuffs more palatable it has been necessary to include in Service rations vegetables of low nutritive value and such materials as herbs and pickles. For the same reason acreage has been allotted in Great Britain for growing such materials.

The Effects of Home Cooking.

A loss of vitamin C, averaging 60 per cent., in green vegetables and 40 per cent. in root vegetables, is inseparable from the usual methods of home-cooking vegetables; losses of other nutrients are not considered significant. The loss of vitamin C is chiefly by leaching into the cooking water and only to a small extent by destruction, so that dry methods of cooking, e.g. baking and frying cause rather less loss of vitamin C than the wet methods. Loss of vitamin C is minimised by rapid boiling in the minimum amount of water and by avoiding overcooking. The practice of "keeping hot" is definitely to be condemned as vitamin C is rapidly lost from the hot, cooked product. This point is particularly important in relation to cooking in institutions and public eating places and probably in military camps. There is no conclusive evidence that the use of either salt or bicarbonate of soda has any deleterious influence on the nutritive value of vegetables.

The Effects of Canning.

Loss of nutritive value may occur at three stages during the manufacture of a canned food. In the period between picking or lifting the vegetable and arrival at the cannery the losses are negligible if the vegetables are used fresh. In this respect, some canners have a distinct advantage over the domestic purchaser in obtaining their materials fresh from the field, and the canned product may have a higher nutritive value than the home-cooked. Shop-purchased vegetables have been found to contain only about half the amount of vitamin C in fresh vegetables.

The greatest losses in nutritive constituents occur during the canning operations. During preliminary washing, or soaking in the case of dried legumes, the losses are small. Blanching is the operation most open to criticism but it is necessary as a cleansing operation, to destroy enzymes, to expel occluded gases, to cause the vegetables to shrink and sometimes to improve colour and flavour. Even a three minute blanch may leach out 20-40 per cent. of the soluble constituents. The losses during processing, at the usual temperatures 240-260°F., are small. There may be some loss of vitamin C and vitamin B1, particularly in products which are processed for long periods at high temperatures e.g. baked beans.

During storage of the canned product and its preparation for the table there may be gradual destruction of some nutrients, e.g. vitamin C, owing to chemical changes. A more important effect, however, is the migration of soluble constituents into the liquor which is usually discarded. The loss may amount to 45 per cent. but need not occur if the liquor is used for soup or gravy stock.

The combined effect of all stages of the journey from the field, through the cannery, to the dinner table on individual nutrients may now be considered. Vitamin A, in the form of its precursor carotene, is protected by low solubility in water and high heat stability and negligible loss occurs in canned foods. The B vitamins are soluble in water and fairly readily destroyed above 212°F. Losses therefore occur by leaching during blanching and by destruction during processing. The total losses are of the same order as in home-cooked vegetables but, in any case, vegetables are not an important source of the B vitamins. Vitamin C, being readily soluble in water and easily oxidized, is subject to loss by leaching and destruction. Heavy losses may occur during preparation of the product if the tissues are broken and an oxidase is present e.g. Sliced beans showed 40 per cent. loss in 30 minutes, peeled turnip 30 per cent. loss in one hour. Peas three hours after shelling and Brussels sprouts two days after trimming showed no loss. Therefore, vegetables which are peeled, sliced, shredded, etc. before canning should be blanched as rapidly as possible. During blanching a large proportion of the vitamin C may be lost by leaching most of which occurs in the first two minutes. Vegetables of large surface area, e.g. peas and leafy vegetables, show the greatest losses (25-50 per cent.), root vegetables only 10-20 per cent. Losses during processing which may amount to 10-30 per cent. are lessened by having minimum headspace and a good vacuum in the cans. During storage there may be a gradual loss of 10-20 per cent. in 6-9 months. The total losses of vitamin C in canning may be 30-70 per cent. in green vegetables and 20-50 per cent. in root vegetables calculated on the drained solids but should not exceed 40-50 per cent. if the liquor is used. The loss of mineral constituents is of the same order as that of vitamin C.

In conclusion it might be stated that no essential nutritive factor is absent from canned foods. This fact is indicated by numerous feeding trials with animals. There is less evidence regarding human nutrition but a French polar expedition is recorded as having lived in perfect health for thirteen months entirely on canned foods. Canned vegetables are at least equal in nutritive value to home-cooked vegetables and, in general, are higher in vitamin C.

NOTES ON THE ECONOMICS OF DRYING POTATOES AND ONIONS.

The advantages of dehydrated foodstuffs in wartime are primarily the improvement in keeping qualities and the saving in weight and space occupied in transporting the product. A further very important factor at the present time is the saving in tin-plate by the use of dehydrated rather than canned fruits and vegetables. From the nutritional aspects, however, the relative proportions of fresh, canned and dried foodstuffs which should be included in the diet will depend upon their respective food values.

As there has been no large scale commercial production of air-dried vegetables in Australia to date no information is available from commercial practice, but estimates suggest that from raw potatoes at £5 per ton, dried sliced potato could be prepared on a large scale for 1/3d. per lb. f.o.b., packed in four-gallon tins, and from onions at £12 per ton, dried onion rings at about 2/6d. per lb. packed. The following table shows a comparison between the costs, weights, tin-plate used to secure the equivalent of one ton of fresh unpeeled potatoes and onions in, say Malaya or Darwin, reckoning freight and handling costs at £8 per ton and allowing for wastage of 20 per cent. shipping and storing the fresh vegetables in the tropics.

	Fresh	Canned	Dried
Quantity	1¼ tons	92 doz. 30 oz. cans @ 8/-	340 lb. net @ 1/3d.
Weight packed	1¼ tons	1 ton	420 lb.
Shipping space	50 cu.ft.	50 cu.ft.	25 cu.ft.
Cost f.o.b.	£6.25	£37	£21
Freight, etc.	£10	£10	£5
Cost delivered	£16.25	£47	£26
Tinplate used	Nil	360 lb.	Nil to 90 lb.

Notes:
(i) Costs based on potatoes at £5 per ton.
(ii) Fresh potatoes shipped in bags (extra costs and space necessary if crated).
(iii) Dried potatoes can be packed in tins or in sisalkraft lined cases.

Onions at £12 per ton.

Equivalent of 1 ton unpeeled at the Kitchen.

	Fresh	Canned	Dried
Quantity	1¼ tons	110 doz. cans @ 8/-	185 lb. net @ 2/6d.
Weight packed	1¼ tons	1.2	220 lb.
Shipping space	50 cu.ft.	60 cu.ft.	12 cu.ft.
Cost f.o.b.	£15	£44	£23
Freight, etc.	£10	£12	£2
Cost delivered	£25	£56	£25
Tinplate used	Nil	460 lb.	Nil to 50 lb.

Note; It must be emphasised that these figures are estimates only but are believed to be reasonably close to what could be obtained in large scale commercial operation.

THE STORAGE OF APPLES.

Fruit Respiration.

It is essential to realise at the outset that fruit is living material and as such is continually respiring and losing water in the form of water-vapour. The process of respiration involves the taking in of oxygen from the air, combining it with carbon, which in the case of fruit comes principally from the sugar and other carbohydrate reserves, and giving off carbon dioxide in approximately equal amount. The carbon dioxide given off can be collected and measured and the rate of carbon dioxide production is a measure of the activity of the life processes in the fruit and is the most accurate measure of the effect of temperature and treatments on the storage life of fruits. The process of respiration is exothermic, that is, heat is given off. After the sensible heat or initial heat due to the temperature of the fruit is removed the main work in cool storage is in removing this respiratory heat which is being constantly produced by the stored fruit.

The Effect of Temperature and Composition of the Atmosphere on Metabolism.

The efficiency of storage is measured by the degree to which it slows down the life processes, i.e. the metabolism, and thus delays ripening without otherwise injuring the fruit. After harvesting the life of the fruit is sustained on its own food reserves and there is thus a gradual loss of these during storage. For every 18°F. reduction in temperature the rate of ripening is slowed down to about half and the storage life is approximately doubled. The composition of the atmosphere also has an important effect on the rate of the life processes of the fruit. Until recently it was thought that the nearer the composition of the atmosphere was to that of fresh air the better it was for the fruit. It has been found, however, largely as a result of the pioneering work carried out in England, that if the carbon dioxide content of the storage atmosphere is allowed to rise to several per cent, and the oxygen content kept correspondingly low the rate of ripening at any temperature is about half of that in ordinary air. By a combination of both temperature and atmosphere control - "refrigerated gas storage", fruit can often be kept much longer than in ordinary cool storage and the green colour and firmness retained to a remarkable degree. As the gas storage of fruit was dealt with separately in No.2 of this volume it will not be further considered here.

Skin Coatings.

More recent work has shown that thin films of protective materials, applied by dipping the fruit in emulsions or solutions of waxes and oils, control the composition of the atmosphere inside the fruit itself and greatly reduce the loss of water. Thus the storage life of the fruit is increased and its condition improved by the great reduction in shrivelling.

The effect of skin coatings is being intensively studied at the Food Preservation Laboratories at Homebush and we have demonstrated the benefits of their use and obtained much fundamental information concerning fruit metabolism. The commercial development of skin coatings would enable apples to be held much more successfully in common storage.

Cool Storage of Apples.

Maturity at Picking.

The stage of maturity at which the fruit is picked has an important effect on its storage life and quality. Immature fruit has the longest potential life but ripens to poor quality and is liable to the rapid development of particular disorders of which bitter pit and superficial scald are the most important. Over-mature fruit has only a short potential life, as the ripening processes are well on their way to completion and such fruit is liable to particular disorders of which breakdown is the most important. More mature fruit is also more susceptible to rotting and in Jonathan's to soft scald.

It is difficult to define the optimum stage of maturity at which fruit should be picked for storage but there are several indications and tests by which the grower can be guided. The most useful indication is probably the change in ground colour, which during maturation changes from the full green of immaturity to the full yellow of ripeness. Generally speaking, for coloured varieties, the ground colour should be yellow-green, whereas for green varieties in which the retention of green colour is important the ground colour should be fairly green.

Prompt Storage.

Prompt storage after picking is essential for all those varieties which are not very susceptible to superficial scald. The latter disorder can be considerably reduced by delay before storage. The only important N.S.W. variety which need not be placed in store as soon as possible is Granny Smith which is commonly delayed for two to four weeks before storage to control superficial scald. Prompt storage is particularly important in the cooler districts for short-keeping earlier varieties like Jonathan where two to three days' delay at the high temperatures often prevailing at picking will greatly shorten the storage life.

In this connection, too, picking the fruit while hot should be avoided and the fruit should be cooled down overnight before being placed in store. Taking advantage of the cooler night temperatures to reduce the sensible heat due to the temperature of the fruit reduces the load on the refrigeration plant and enables the fruit to be brought down to the storage temperature more quickly.

Temperature of Storage.

In the past it has generally been considered that a temperature of 34°F. is the most satisfactory for apples. Experimental work and recent commercial experience has shown that best results are only obtained when different temperatures are used for different varieties.

Granny Smith.

Generally speaking, the best temperature is 33-34°F. but from our experiments fruit which is required to be stored until the end of the year is better picked a little later and stored at 32°F. If fruit is picked at the right time a long delay is generally not necessary to control scald.

Jonathan.

The most satisfactory schedule of temperatures for Jonathan is 36-37°F. for a period of six weeks and then 32°F. for the rest of the storage period. By this means a compromise between control of soft scald and control of Jonathan spot is aimed at and the maximum cool-storage life is obtained.

Delicious.

For this variety, a temperature of 32°F. is desirable. If immature, they will scald to some extent, but if picked at the right stage of maturity they are much better at 32°F. than 34°F., and they retain quality better and will keep longer. There is less breakdown and mould at 32°F.

Democrat.

If picked at right maturity a temperature of 32°F. is best, but if immature this variety is liable to scald. There is less breakdown and mould at 32° than at 34°F.

Rome Beauty.

If picked at right maturity a temperature of 32°F. gives good results as there is less mould and breakdown.

London Pippin.

If picked at right maturity, 32°F. is satisfactory; there is less mould and breakdown.

Romes at times develop superficial scald even in the commercial picking and there is generally somewhat more scald at 32°F. than at 34°F. With the last five varieties, scald in air stored fruit can be satisfactorily controlled by the use of oiled wraps alone.

Types of Wastage.

Granny Smith.- immature fruit - Superficial scald; bitter pit; lenticel blotch. Superficial scald worse at lower temperatures.
overmature fruit - breakdown; late scald; core flush; worse at higher temperatures.

Jonathan.- immature fruit - bitter pit; sometimes lenticel blotch; occasionally superficial scald.
mature fruit - more soft scald and breakdown.

Jonathan spot can develop in all pickings but there is usually more in the more mature fruit and in fruit of smaller size.

There is generally more breakdown at the lower temperatures and most soft scald at 32°F. Jonathan spot and mould increase with rise in storage temperature.

Delicious - immature - bitter pit and sometimes superficial scald. Bitter pit not usually serious.
overmature - breakdown and often much mould; more scald and less breakdown and mould at lower temperatures; Delicious also liable to mouldy core which is increased at the higher temperatures.

Democrat - immature - superficial scald - sometimes serious, bitter pit not very common.
overmature - breakdown severe in large fruit occasionally soft scald.

Romes - immature - superficial scald, sometimes bitter pit
mature - breakdown and soft scald.

London Pippin - immature - bitter pit; some superficial scald
mature - breakdown

Rots.

All varieties are liable to rotting, but susceptibility to rotting increases with maturity and also with temperature.

We have consistently observed more mould in fruit stored at 34°F. than at 32°F. particularly after two weeks post storage.

If fruit is picked soon after rain it is more susceptible to rotting.

From storage experiments with apples carried out at Homebush over the last two years it has been shown that rotting can be an important source of wastage in stored apples and has often been responsible for more than half the total wastage recorded. Rotting of apples follows injuries to the skin and our experience shows that in order to reduce wastage careful handling is just as important as it is with other fruits.

N O T E S.

THE WAXING OF CITRUS FRUITS.

In America, citrus fruits, particularly oranges, have been waxed on a large scale for some years and the practice is now well established as one which is essential to the success of the industry. By waxing is meant the coating of each fruit with a very thin film of wax which may be applied by any of several methods. The fruit may be passed through a heated chamber into which a fog of molten wax is sprayed; this is known as the "hot fog" process and is covered by patent rights. The fruit may be passed through a chamber into which a solution of wax in a volatile solvent is sprayed, or as in the "cold slab" method it may pass over revolving brushes which transfer wax to the fruit from a slab of wax held against the underside of the brushes. The other commonly used process consists of dipping the fruit in an aqueous emulsion of wax which, on drying, leaves a fine film of wax on the fruit.

At the present time in America waxing is mainly carried out by the cold slab method as this is the cheapest process. In California a slab of 120°F. melting point paraffin wax, shaped to fit the brushes is used in both winter and summer. The inclusion with the paraffin wax of a proportion of hard wax such as carnauba as is done in the "hot fog" process and as is usual in commercial emulsions improves the lustre and lasting qualities of the film on the fruit.

It is reported that, in operation in America, the cold slab method is the least efficient although the superiority of the fog and emulsion methods is not apparent unless the fruit is shipped to distant markets.

In Australia, a number of citrus processing sheds have waxing plants installed and almost all the waxed fruit is treated by the emulsion or the cold slab methods. The results with the latter method have not always been satisfactory, the general fault ng that the paraffin wax used has been too hard for winter time application.

In one shed in New South Wales the plant was altered for experimental purposes to enable waxing to be carried out by a modified hot fog method and the results have been very satisfactory.

Considerable experimental work on the waxing of citrus fruits has been carried out in Australia during the last few years and it has been shown that waxing will considerably improve the condition of the fruit by reducing the rate of shrinkage. This shrinkage is caused by the evaporation of water from the fruit and in numerous tests which have been carried out some of commercial emulsions have reduced the rate of such evaporation to sixty per cent of that from untreated fruit. Modified hot fog waxing has reduced the rate of shrinkage to fifty per cent and some laboratory-prepared emulsions have reduced the rate of shrinkage of oranges to forty per cent of that from untreated fruit without any harmful effects on the flavour.

In experiments with emulsions it has been found that the alkalinity of the emulsion diluted for use varies considerably according to the method of preparation and that, for greatest efficiency in retarding evaporation, the alkalinity of the emulsian should be kept as low as possible.

Oranges are commonly passed through a cleaning bath containing some detergent solution which is usually alkaline in reaction. The use of such alkaline detergents greatly increases the rate of shrinkage of the fruit unless a wash in clean water follows the alkaline bath. When the fruit is so treated the use of some method of waxing is particularly desirable. The effect of some citrus cleaning preparations on the rate of shrinkage is very great and cannot be overcome entirely by subsequent waxing of the fruit. However, there is one commercial preparation available which cleans the fruit very well without increasing wilting.

In the various tests carried out no method of waxing has consistently affected wastage due to mould, and for practical purposes it can be taken that waxing will not reduce rotting of the fruit and may even increase such wastage under certain conditions of operation. On the other hand, there is a definite tendency for spotting in cool storage to be reduced by waxing.

For the control of mould wastage in citrus fruits, dipping the fruit in a five per cent solution of borax or in a one quarter of one per cent solution of Shirlan W.S. is recommended. As borax is alkaline, its use increases the ra e of wilting of the fruit. If it is rinsed off there is a loss of efficiency. When borax is used it is therefore very desirable that the fruit be waxed afterwards.

Shirlan can be added to the emulsion bath, but if the borax is added to the emulsion wilting is increased.

Thus a complete process which will clean citrus fruit and protect it from mould attack and loss of condition requires firstly, passage of the fruit through a detergent solution, which should be rinsed off with water if alkaline, then treatment with a fungicide, and finally waxing.

Waxing is particularly useful in the storage and curing of lemons and grapefruit. If the fruit is treated with a fungicide and waxed after picking, the storage life will be considerably prolonged, normal curing will take place and the fruit will remain bright, attractive, and free from serious shrinkage even after long storage.

EQUIPMENT FOR CONTROL OF MICROBIAL SPOILAGE IN FRUIT JUICES.

The spoilage of untreated fruit juices may occur by chemical change in which naturally occurring constituents may be converted to unpalatable end-products. Juices may also spoil owing to the activity of micro-organisms, the most usual effect being the production of alcohol by fermentation. Biological stabilization involves the inactivation of yeasts, moulds, and other organisms, either by destruction or by the maintenance of an environment in which normal growth and reproductive processes are inhibited. The application of heat for this purpose is known as pasteurization. Many other methods of stabilization are known, but all of them differ from pasteurization in that they aim at total destruction, whereas the heat process while proving lethal to yeasts, permits the survival of mould organisms. Processes other than pasteurization, designed to eliminate microbial spoilage of fruit juices, may therefore be linked under the general head of sterilization.

The method of pasteurization varies according to whether the juice is to be heat treated in bulk, under continuous flow, or in the marketing container. Bulk pasteurization involves the provision of a steam or hot water jacketted kettle, or a tank preferably equipped with an agitating coil through which steam or hot water may be circulated. When the desired temperature is reached the juice is run off into cans or preheated bottles and sealed. Cans are then inverted and bottles laid horizontally for several minutes to sterilize the lid or cap, after which they are cooled by suitable means. The cork of the bottle cap should preferably be covered with a hygienic liner as recontamination is otherwise likely to occur.

Container or "in-the-bottle" pasteurization requires a water tank with a false slatted floor below which is a well distributed steam coil. The juice-filled bottles are placed horizontally on the false bottom and heated to temperature after which they may be gradually cooled by the introduction of cold water into the bath.

Pasteurization in bulk and in the stationary container involve lengthy periods during which the juice is at an elevated temperature. As this treatment may injure the delicate aroma of juices from most fruits, an accelerated process, in which the container is rotated during heating, has been evolved. The Thermo-Roto machine is a continuous feed type in which cans or bottles are rotated at an optimal rate during their travel. At the same time they are sprayed from above with hot water, or, alternatively, totally immersed in the heating medium. The containers pass from the heating to a further section where they are rapidly cooled by rotation under cold water sprays. The container rotation method permits a remarkable reduction in time of treatment, and, in fact, may be considered as akin to a flash pasteurization process.

The patent Stero-Vac process pasteurizes juice in a can equipped with a cap of special design. The contents are brought to temperature by steam injection, and it is stated that the amount of water added by condensation is balanced by that lost during deaeration.

The continuous flow method of flash pasteurization utilizes the principle of high temperatures and short times of exposure to heat in contrast with the comparatively low temperatures and longer times involved in bulk and container processes. Equipment for the purpose differs radically in design according to the bias given to a particular virtue, e.g., accessibility in cleaning.

The Baumann bell pasteurizer is a convenient form of flash pasteurizer which can be readily dismantled for cleaning. The output varies from 25 to 100 gallons per hour. No provision is made for cooling to bottling or canning temperature.

Tubular pasteurizers may consist of a single water or steam-jacketted coil, or the multitubular type in which a series of parallel tubes pass through a single heating chamber, or are individually jacketted by concentric outer tubes. A number of tubular pasteurizers differing in degree rather than in kind is available commercially.

A plate type heat exchanger of attractive performance is manufactured by the Aluminium Plant and Vessel Co., London, England.

It is in routine use at the Homebush Food Preservation Laboratory of the Commonwealth Council for Scientific and Industrial Research. It consists of a series of corrugated stainless steel plates so arranged that juice and heating water are separated throughout by a single plate. The heating section is followed by a holding chamber and a final section in which the juice is cooled to filling temperature.

Juices that are subjected to brilliant filtration may be rendered completely sterile by what is technically known as the "cold" process. For the purpose, pad filters of the Seitz & Ertel type are employed, while a similar result is obtained by filtration through a fine-pored Berkefeld porcelain-filter candle.

The Katadyn & Matzka processes are dependent upon the effect, known as oligodynamic, of minute concentrations of silver ions at atmospheric and elevated temperatures respectively. Little information is available concerning the Katadyn process, while criticism of the Matzka method is based on the assumption that under certain conditions the heat treatment alone sufficed to stabilize the juice.

The "Electropure" process is a heating method wherein heat is developed by resistance offered to the passage of a 110-volt 60-cycle alternating current. The assumption of a direct lethal effect of the current upon micro-organisms is no longer tenable.

Irradiation of clear fruit juices by allowing them to flow in a fine stream past an "Uster" quartz ultra violet lamp is reputed to give a sterile yield at rates up to 200 gallons per hour. Limiting factors are stated to be layer thickness, turbidity, colouration, and initial degree of contamination. X-rays are likewise known to possess bactericidal activity. The Frank Carbonation preservation process is claimed to sterilize fruit juices effectively by repeated deaeration and carbonation at 60 lb. per square inch pressure. Other sterilization processes worthy of note involve the use of ultrasonic waves or of permitted chemical preservatives.

In general, the use of flash pasteurizers is recommended provided that due regard is paid to efficiency of heat transfer and accessibility for cleaning. Such a recommendation, however, does not necessarily carry with it condemnation of other types of equipment herein described.

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