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Practices in Freezing

FREEZING and frozen storage of fish should be carried out in such a way that products closely resembling fresh unfrozen fish can be supplied to the consumer. This requires the use of: fresh fish, rapid freezing, low temperature storage after freezing, protection against drying, oxidation, and drip loss, and special facilities for the distribution and sale of the frozen fish.

FRESHNESS

To gain the maximum benefit from the freshness of the fish, freezing should be commenced within a very short time of catching. This is possible only when freezing facilities are close to the catching areas, e.g. on refrigerated vessels, or where land-based freezing establishments are situated near the points where the freshly caught fish are landed. Some sea-going vessels are equipped with facilities for freezing whole fish or fillets within a few hours of catching, but few land-based factories are able to commence freezing within 12 hours. The adverse effects of delay between catching and freezing depend on the temperature of the fish and the duration of holding. At 70°F bacterial spoilage during 12 hours would be comparable with that occurring during 5 days at 32°F, and in each case the fish could become unfit for freezing. By using a mixture of salt and ice or a refrigerated weak salt brine or sea water, fish temperatures may be reduced to between 30 and 31°F. This will significantly reduce the rate of deterioration as compared with 32°F, the lowest temperature obtainable with water ice.

Under practical conditions the need to cool the fish before freezing will depend not only on the temperature of the fish when caught, the surrounding air temperature, and the time elapsing between catching and freezing, but also on the expected duration of frozen storage. If the period is to be long the need for precooling and holding at a low temperature is greater than for short frozen storage. If cooling by refrigeration is not possible, the freshly caught fish should be kept cool by spreading in shallow layers and protecting from direct sunlight. Spraying or hosing the fish with cool (bacteriologically clean) water will help to keep the fish cool until freezing is begun.

In some parts of the world freshly caught fish are kept alive in nets or wells at the seaboard, close to the processing factories. Most lobsters, crayfish, and crabs are held alive until they reach the factories, but shrimps and prawns are usually iced within a few hours of catching. Shellfish such as oysters and clams should be kept alive in the shell till they are prepared for freezing.

Prompt cooling and freezing are necessary with precooked fish products to avoid oxidative changes which adversely affect flavour, and to reduce the growth of bacteria which may be acquired after cooking.

RAPID FREEZING

The chief advantages of rapid freezing are that drip loss on thawing is reduced, texture is improved, subsequent smoking will give a product with a desirable surface gloss, less refrigerated space is required, and bacterial spoilage is eliminated. When packaged fish are frozen under slight pressure in plate-type quick freezers the elimination of air from within the package reduces the likelihood of oxidation of body oils and thereby extends the storage life of the frozen fish. Distortion of the packages is also prevented by this method of freezing.

The rapid freezing of fish under commercial conditions is limited by the type of refrigeration which can be applied and the thickness of the material which is to be frozen. To reduce fish temperatures through the "critical zone" (32–23°F) within 2 hours by the application of cold air or of suitable liquid refrigeration media, the thickness of the fish should be limited to about 3 inches. Under these conditions the overall freezing time required to reduce fish temperatures to

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and Frozen Storage

about 5°F would be approximately 3 hours. When it is possible to reduce the thickness to about 1 inch, as with fillets, the overall freezing time may be as short as 1 hour. Even shorter freezing times are possible when substances such as dry ice or liquid air are used as refrigerants, but their commercial value is doubtful.

Freezing may be achieved by cold air blast, by direct contact with refrigerated liquids such as sodium chloride brine, by indirect contact through the use of special freezing containers, or by freezing between hollow metal plates cooled by the primary refrigerant.

Blast Freezing

For dealing with fish or packages varying greatly in size and shape the use of an air blast, alone or combined with some form of indirect contact freezing through metal, is the most adaptable method for quick freezing.

The main disadvantage of air as a freezing medium is its low heat capacity. This means that a large volume of very cold air must be brought into contact with the product to freeze it quickly. Desiccation of the surfaces of unwrapped or unprotected material may be detrimental, but this can be greatly reduced by using very low air temperatures and restricting the thickness of the product to about 3 inches.

Tunnel-type Freezing

This type of blast freezing may be used for freezing simultaneously fish which vary in size or method of packaging. If a conveyor system is used the product units should be of uniform thickness, since the speed of the conveyor has to be adjusted for the slowest-freezing unit. Even when air is used for batch freezing a uniform flow is more readily attained if the packaged products are all of the same thickness. Apart from its adaptability the tunnel-type blast freezer requires the product to be handled very little, and it has a high capacity of frozen products per square foot of space. Some of the disadvantages of the tunnel-type blast freezers are:

(1) The operation of a fan requires more electrical energy than is required for quick freezing in plate freezers or slower freezing in sharp freezers (see page 4).

(2) Periodical defrosting results in lost production.

(3) Maintenance costs are usually higher than with plate or sharp freezers.

(4) Small loads cannot be frozen economically.

Direct Brine Freezing

In direct brine freezing the product is immersed in or sprayed with sodium chloride brine. A rapid rate of heat transfer is obtained from the close contact between the refrigerating medium and the product. By immersion in an agitated cold brine solution at 0°F the freezing time for fish of about $2\frac{1}{2}$ inches in thickness is approximately 80 minutes.

The chief disadvantages of direct brine freezing are:

(1) Careful control is necessary to prevent the brine freezing out at −6°F, and possibly bursting the tubes within the brine cooler.

(2) Brine becomes contaminated with fish slime and scales, causing difficulties in pumping and filtration.

(3) The product is likely to be distorted in freezing.

(4) It is difficult to apply protective ice glazes if the brine is not thoroughly washed off after freezing.

(5) Salt penetration into the fish will be excessive if they are not promptly removed at the completion of freezing.

(6) Salt contamination in the surface tissues accelerates oxidation of the body oils and promotes the development of objectionable changes in flavour during subsequent storage.

(7) Shrimps and prawns tend to fuse together in a solid mass on freezing. By using a brine solution composed of salt and sugar, however, fusing can be avoided and at the same time the shrimps can be stored frozen for relatively long periods without dehydration, even when unglazed.

Indirect Brine Freezing

Freezing in containers or moulds obviates contact with the brine and makes possible the use of calcium chloride brine, which has a lower temperature range. The mould also prevents distortion during freezing. This method has limited application since it involves excessive handling and labour, the use of large stocks of various sizes of cans and moulds, and the provision of considerable floor space for plant.

Multiplate Freezing

This method of freezing, by direct contact between the product and movable refrigerated plates, is suitable for freezing packaged products of uniform thickness up to about 2 inches. The packages, distributed on metal trays, are placed on the movable freezer plates previously cooled to about −15°F. Wooden spacers of the same length as the plates and of the same height as the packages are placed between each set of plates to prevent crushing of the packages. After loading, and closing the door of the cabinet, the refrigerated plates are moved down on the spacers by hydraulic pressure, which ensures good contact between the packages and the plates. The pressure of 1–10 lb/sq. in. applied to the packages serves also to remove most of the air entrapped between the wrapper and the product, thereby minimizing oxidation of the surface tissues.

The chief disadvantages of the conventional multiplate freezer are the large storage space required for pans and spacers and the amount of handling in loading and unloading. The latter difficulty is overcome in the continuous-type multiplate freezer by loading and unloading the products automatically. Loading is controlled by electronic devices, and unloading is effected by incoming rows of packages which force out rows of frozen packages from the other end of the freezer at each level.

Packaged fillets should be held only a short time before freezing to reduce wetting of the wraps and cartons with exuding muscle juice.

SLOWER FREEZING METHODS

An overall freezing time of 4 hours is regarded as the maximum for fast freezing. Slower freezing methods include so-called sharp freezing (which uses moderate rates) and relatively slow freezing in a cold room. A conventional sharp freezer room has two banks of refrigerated-coil shelves along each of the two long sides, with approximately 9 inches between each shelf. Round fish in pans or packaged fish fillets are loaded on the pipe coils which are usually run at −10 to −20°F. Fans are sometimes used to provide low-velocity air circulation in the room. With a system of this kind it is possible to freeze fish 3 inches thick or packaged fillets 2½ inches thick in 16–18 hours.

The advantages of sharp freezers are that a fairly high output of frozen fish is possible and that the costs of refrigeration and maintenance are low.

The disadvantages are:

(1) Freezing is slow. In commercial practice layers of fish more than 2 inches thick may take 24–48 hours or even longer to freeze in still air at 0–10°F.

(2) Considerable handling of the products is required. Loading and unloading brings about frosting of the coils, and this increases freezing times and makes frequent defrosting of the coils necessary.

(3) Small packages of fish fillets are apt to become unduly distorted during freezing and weights must be placed on top of them to prevent this.

Some of the disadvantages of the conventional sharp freezer are overcome by using a continuous conveyor to carry the fish into and out of the freezing room. This method reduces handling costs and the need for defrosting.

LOW TEMPERATURE STORAGE

Keeping the temperature of frozen fish as low as possible retards the development of rancidity and of toughness in the texture, and restricts loss of moisture and natural aroma and flavour. By comparison with other frozen foods, frozen fish products are susceptible to more intense oxidative changes, and should therefore be stored at the lowest temperature economically feasible. Temperatures as high as 10°F are permissible for very fresh fish which are to be stored for no longer than one month, but for fish delayed before freezing, or intended for long storage, temperatures between 0 and —20°F are required (see table below). Unglazed fish, particularly if not protected by suitable wrapping to minimize desiccation and oxidation, require lower temperatures than properly glazed and wrapped products. Replacement of the ice glaze is not required so frequently when temperatures are low. Fish which have been immersed in salt solutions before freezing also require low temperature storage, even for short periods, to retard the development of an unpleasant "salt-fishy" aroma.

Low temperature storage is essential for fish which are to be processed by smoking, and desirable for fish which are to be held for long periods prior to canning.

TEMPERATURE AND HUMIDITY

Steady temperatures of 0°F or lower are needed for satisfactory storage, and their attainment involves costly construction and equipment, and may also increase operating costs. In some instances it may be sufficient to run a portion of the total frozen storage space at very low temperatures for holding the better-quality fish products, perhaps for out-of-season marketing.

At any storage temperature high humidity can be obtained by maintaining a minimum difference between the temperature of the cooling coils and the air. Nowadays it is common practice to increase greatly the amount of cooling coil surface above the former ratio of 1 linear foot of 2-inch pipe coil per 6 cubic feet of storage space. This practice together with the use of suitable construction techniques and adequate insulation, to keep heat leakage and air infiltration to a minimum, has made it possible to attain very high humidities. After freezing is completed air movement around the fish should be at a minimum to retard evaporation, particularly for products not protected by wrappers, metal containers, or surface coating.

By using the jacketed system, in which cold air circulates through an enclosed space which completely surrounds the room, it has been found possible to maintain relative humidities as high as 98 per cent. in the storage space. Under these conditions frozen fish would dry out to a very slight extent even at storage temperatures above 0°F. Frozen storage rooms of this type are now used in Canada and the United States for holding previously frozen fish and other products.

Storage Life of Fish

Approximate storage life of fish which are perfectly fresh at the time of freezing and have been adequately protected against desiccation and oxidation

Storage Temperature (°F)	Duration of Storage (months)	
	White Fish	Oily Fish
10	3	1½
0	5	3
–20	10	6

GLAZES

A continuous thin film or coating adhering closely to the product is termed a glaze. It is usually applied by dipping the frozen product in or by spraying it with a solution of the glazing substance and allowing the film to solidify. Suitable glazes retard surface desiccation of the products and reduce penetration of atmospheric oxygen, thus slowing up the development of oxidative rancidity. Glazing is suitable for protecting whole fish frozen singly or blocks of smaller fish or fillets.

When water is used for glazing the temperature is reduced to between 34 and 36°F and the thoroughly frozen fish are immersed therein for a few seconds or, alternatively, the cooled water is atomized and sprayed on the products. The thickness of the ice coating may be increased by repeating the glazing treatment one or more times. The thinner sections such as tails, fins, and snouts of whole fish take only a thin ice glaze because of their low refrigeration capacity, and these areas must be checked and reglazed at frequent intervals to keep the coating intact. The weight of ice glaze formed usually varies from 2 to 7 per cent. of the weight of the fish. The room in which ice glazing is carried out is held at a temperature of about 32°F.

Other methods for protecting frozen products with ice coatings are sometimes employed. When freezing is done in metal moulds, water may be poured over fish before freezing to fill spaces and cover the fish. Alternatively the water may be added to the container after the fish are frozen. In each case the refrigeration load is increased but the protection given to the fish by inclusion in a block of ice is very effective. When small fish are frozen into blocks in pans, the blocks, after removal, are dipped in cold water to acquire the glaze. Shrimps or prawns, after freezing in pans, are removed, placed in cartons, covered with water, and refrozen. Alternatively they are frozen in cartons, opened, and cold water added by immersion or spraying, before returning to the freezer. A simpler and equally effective method is to spread a layer of slush ice at the bottom of the carton and another layer on top after the frozen block has been placed in position.

Reglazing

Periodical examination of the glazed fish will determine the need for reglazing. Renewal of the glaze may be necessary within a few weeks, particularly when the fish are otherwise unprotected from drying and when storage temperatures are high.

Evaporation of the glaze can be retarded by using protective coverings over fish stored in bulk, or by storing the fish in boxes, lined with waxed paper, in corrugated fibre containers, or in waxed cartons. Snow from refrigeration coils may be used to cover stacks of bulk or boxed fish.

Reglazing is often done by spraying cold water on the fish in the storage room. Stacks of frozen fish may be sprayed on the outside every few weeks and the stacks pulled down and completely reglazed every few months.

Brittleness and susceptibility to cracking is the main disadvantage of the ice glaze. Various additives such as alcohols, sugars, and salts have been recommended for overcoming this defect, but their commercial use has been very limited.

Other types of glazes which may be suitable substitutes for ice are edible oils, thermoplastic waxes, alginates, and gelatine-base coatings. Of these, alginates have been used commercially in Norway and some other countries.

CONTAINERS AND WRAPS

Protection Against Drying

Complete protection against drying is obtained by packing and freezing the fish in metal containers so that the frozen mass fills the sealed container, but such an elaborate method is not widely used commercially. In the United States hermetically sealed cans have been used for frozen oysters and shrimps and for cooked products such as oyster stew, chowders, and soups. Cooked lobster meat is often packaged in cans with transparent tops. Prepared fish dinners are put up in aluminium pan packages for freezing, and these are served, after heating, without being removed from the original containers.

Films or wraps and containers are commonly used for protecting frozen fish products against dehydration. Films and wraps should be made from materials which do not impart odours and flavours, and are pliable, easily sealed, durable at low temperatures, and resistant to tearing and puncturing. They should also be greaseproof and highly resistant to the transfer of water vapour.

The following materials may be used for packaging frozen fish: paper coated with paraffin wax etc.; polyethylene; vinylidene chloride ("Saran", "Cryovac"); "Cellophane" coated with polyethylene; aluminium foil; and "Pliofilm". Paraffin tends to crack at low temperatures, but the addition of microcrystalline waxes and polyethylene overcomes this defect and improves its resistance to the transfer of moisture vapour and its sealing strength.

Added protection against desiccation is obtained when the wrapping materials make intimate contact with the surfaces of the frozen fish. Specially prepared vinylidene chloride films ("Cryovac") are useful for irregularly shaped frozen foods. Bags of this material can be made to shrink into close contact with the product by a brief application of heat after the air has been withdrawn from the bag.

Cartons for holding frozen fish are usually made of fibreboard laminated with foil or film resistant to water vapour, or simply coated with improved paraffin wax, polyethlyene, or other plastic materials. Sometimes the cartons are placed in overwraps as an additional measure of protection against loss of moisture.

Protection Against Oxidation

Oxidation by atmospheric oxygen, in some instances aided by catalysts, may cause adverse changes in colour and flavour. Oxidative rancidity of the body oils often leads to rejection of the products. The amounts of oxygen required are extremely small: the quantity dissolved in the tissues of the fish can cause slow development of discoloration and rancidity.

Glazing with ice will retard access of atmospheric oxygen, although the gas dissolved in the glazing water may be sufficient to cause slight oxidation of the adjacent tissues. Ice glazing in conjunction with the use of oxygen-proof wrapping materials is one of the most effective treatments.

If glazing is impracticable, air pockets should be excluded from the blocks of packaged fish, and wrappers and containers effectively sealed. Wrappers should be greaseproof.

Catalysts of oxidation are found in unrefined salt and in sea water. Fish taken from the sea should therefore be washed in fresh water to remove as much sea water as possible, and salt used for controlling drip loss should be highly refined, and free from impurities such as calcium and magnesium. Even the highest grades of salt, may, however, promote the activity of the naturally occurring oxidation catalysts present in the fish. Special precautions should therefore be taken to limit the access of oxygen to fish treated by dipping in salt solutions, and the lowest possible storage temperatures should be used. Steps should also be taken to avoid contamination by copper and iron, which are pro-oxidants.

Low permeability to oxygen is found in specially coated "Cellophane", and "Saran" and "Cryovac". Polyethylene is relatively ineffective in retarding oxygen transfer, but "Cellophane" coated with polyethylene is suitable for this purpose.

Antioxidants are often used to retard the development of rancidity. With fish effective contact between the antioxidant and the oils in the tissue may be difficult to attain. Under some conditions, particularly with fish of comparatively low body-oil content, good protection against rancidity has been conferred by antioxidants such as propyl gallate, ascorbic acid, and nordihydroguaiaretic acid. The rate of discoloration due to changes in the tissue pigments of some species of fish may also be reduced by the use of certain antioxidants.

Antioxidants may be used as dips, or they may be incorporated in the glazing mixtures. Paper wrappers and cardboard cartons impregnated with antioxidants may be useful for fatty fish.

Protection Against Drip Loss

If loss of drip from the thawed fish is likely to be serious, pretreatment by dipping the fillets for 20–30 seconds in a salt brine containing approximately 10 per cent. by weight of salt is of some value. Since this treatment accelerates the development of rancidity it should be applied only when drip is regarded as a serious problem, and where it is possible to apply protective measures against oxidative changes, for example, by glazing, wrapping with oxygen-proof materials, and using low temperatures for long storage.

Drip loss from thawing fish can also be reduced by applying the salt brine treatment to the fish just before or during thawing. An even distribution of fine salt over the surfaces has a similar effect. Application of the anti-drip treatment by these methods avoids the pro-oxidant effect of salt during frozen storage, but control of drip is not likely to be so effective as when the fish are treated before freezing.

FREEZING BEFORE PROCESSING

Under some circumstances it is advantageous to freeze fish before processing. For example, if freezing facilities are available for handling freshly caught fish it may be preferable to freeze them immediately than to hold them several days on ice before processing and freezing.

This method has been adopted to a limited extent in the United States following demonstrations by the U.S. Fish and Wildlife Service showing that fish could be brine-frozen at sea, held for short periods in the frozen condition, then thawed, filleted, and refrozen without any measurable loss of quality. Large fish such as halibut and salmon are sometimes frozen and stored as whole glazed fish. At intervals fish are withdrawn, cut into steaks by bandsaw before or after partial thawing, glazed or wrapped, and packed into cartons, which may be over-wrapped before plate freezing under pressure.

Freshly caught shrimps have also been frozen whole in brine on board and subsequently thawed, peeled, and the flesh refrozen before or after cooking.

Freezing before canning is the chief method for handling tuna in the United States and small quantities of salmon are handled in this manner. The fish are usually frozen in brine prior to frozen storage in air. The maintenance of good canning quality, particularly of salmon, calls for low temperature storage and ice glazing if the fish are to be held for long periods.

THAWING FROZEN FISH

Frozen fish are usually thawed before cooking although this is not essential: frozen fillets or split fish may be placed directly in the cooking medium and the cooking time extended to allow for thawing during cooking. It is even possible to apply batter to the frozen fish before cooking, provided that ice is first removed from the surface and it is wiped dry.

Thawing or partial thawing is necessary to separate individual fillets from blocks or to permit filleting of whole frozen fish. Separation of partially thawed fillets without tearing is facilitated if the layers have been interleaved with paper before freezing.

Differences in the rates of thawing usually found in commercial practice make no material difference to the palatability or texture of the fish. If thawing is unusually slow, however, bacterial spoilage of the outer thawed layers is possible even though the inner layers remain frozen. In commercial practice, fast thawing is generally desirable.

When the thickness of the fish, either in the round or in blocks of fillets, exceeds 2 inches, thawing times in still air at about 70°F will be longer than 4 hours. By using running water at the same temperature thawing times may be reduced to about one-fourth, but there is a risk of the fish absorbing water and of losing some flavouring constituents. This can be avoided to some extent by using a sodium chloride solution of about 0·8 per cent. strength in place of water. If the fish have been wrapped in sealed waterproof wrappers these disadvantages do not arise. Immersion in water can be used for initial thawing to allow separation of fillets from the blocks, and the final thawing may be completed in air.

Thawing times can be reduced by using a forced warm air circulation, but high air speeds and air temperatures above 80°F are apt to produce excessive drying in fish not protected by wrappers impermeable to water vapour.

DISTRIBUTION AND MARKETING

All frozen stocks should be in sufficiently good condition when released to ensure that in spite of holding periods during distribution and marketing, they can reach the consumer in good condition. Lots held in frozen storage should be capable of easy identification so that those held for the longest times can be taken out first. Similarly, those species known from experience to be more susceptible to deterioration during storage should be marketed before others known to withstand storage well.

During distribution care should be taken to prevent undue rises in temperature in the fish before it is again placed in frozen storage. If the intervening period does not exceed 5–6 hours, precooled insulated boxes may be used for transport. For very short periods a closely stacked group of packages may be adequately protected by an insulated blanket, but for longer periods it will be necessary to transport the fish in insulated refrigerated vans.

In the retailers' premises the modern self-service open-type cabinets should be adjusted to operate at a temperature no higher than 5°F, and the recommendations governing their efficient maintenance should be strictly followed.

SUMMARY

To obtain the best quality in frozen fish the following precautions should be observed:

(1) Only first-quality fish should be chosen for freezing. If slight deterioration has occurred before freezing the storage period should be shortened.

(2) Suitable brine dips should be used for fillets which are susceptible to large losses of drip.

(3) Freezing should be started without delay after processing.

(4) Rates of freezing should not be unduly slow.

(5) Protection against oxidation and desiccation should be provided by ice glazing or by using packaging materials which are water vapour proof and resistant to oxygen transfer.

(6) Storage temperatures should be as low as is economically feasible (preferably 0°F or lower). They should be kept as constant as possible.

(7) Storage atmospheres should have high relative humidities, and unnecessary circulation of air should be avoided.

(8) Fish should not be stored long enough to make them unacceptable to consumers. In this connection allowance should be made for the time needed for distribution and marketing.

(9) During distribution and marketing, frozen fish products should be continuously held at low temperatures.

(10) Products which are precooked before freezing should be handled under conditions free from risk of contamination by pathogenic bacteria.

A Simple Method of Applying Diphenylamine to Fruit

By D. Martin

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IT has been known since 1955 (Smock 1955, 1957) that diphenylamine (DPA) applied in aqueous suspension as a dip or spray will control superficial scald in apples. The process cannot yet be recommended for commercial use, since the safety of diphenylamine as an additive to fruit has not been established. Nevertheless the author has considered it desirable to experiment with methods of application likely to be acceptable under Australian commercial conditions. A satisfactory method should apply an even coating of the quantity of diphenylamine needed, and should not waste material nor require expensive equipment.

In 1955 it was found that diphenylamine was effective if incorporated in a wrap. In places where fruit is normally wrapped before storage this is the simplest and most satisfactory method of application, but much of the fruit of the susceptible varieties is stored unwrapped, and is wrapped and packed later. It is therefore desirable that the diphenylamine be applied to the fruit itself. Since dips and sprays of aqueous suspensions have some disadvantages an alternative method was sought.

TABLE 1

Weight of Diphenylamine in Treated Granny Smith Apples

Treatment		Analytical Results*		
Date	Procedure	Date	DPA per 100 g apple peel (μg)	DPA per apple (μg)
23.i.59	1 × 10 sec passage through steam and DPA	27.i.59	638	62
23.i.59	2 × 10 sec passages through steam and DPA	to	1118	120
23.i.59	3 × 10 sec passages through steam and DPA	30.i.59	1800	210

*Analyses by Dr. J. Cerny, Division of Plant Industry, C.S.I.R.O., Hobart, Tasmania.

TABLE 2

Effect of Diphenylamine on Scald in Granny Smith Apples

	Treatment	Occurrence of Scald		
		Slight (%)	Moderate (%)	Severe (%)
Tree No. 1	Control	34	28	8
	1·5 mg DPA wraps	26	6	—
	1 × 10 sec passage through steam and DPA	9	—	—
	2 × 10 sec passages through steam and DPA	4	3	—
	3 × 10 sec passages through steam and DPA	2	—	—
Tree No. 2	Control	49	30	15
	1·5 mg DPA wraps	10	4	—
	1 × 10 sec passage through steam and DPA	20	—	—
	2 × 10 sec passages through steam and DPA	15	2	—
	3 × 10 sec passages through steam and DPA	4	—	—
	4 × 10 sec passages through steam and DPA	1	—	—

STEAM DISTILLATION

Though diphenylamine is almost insoluble in cold water, steam coming from boiling water containing an excess of diphenylamine contains approximately 4000 p.p.m. of that substance. On condensing, the diphenylamine crystallizes out in a very finely divided form.

This property of diphenylamine has been made the basis of a simple and efficient method of application. Fruit is passed through steam impregnated with diphenylamine, and an even coating of fine drops condenses on its surface. The water evaporates quickly, leaving a fine deposit of diphenylamine.

One convenient arrangement is to place a small insulated tunnel over a roller elevator such as a grader elevator, and pass steam into it from boiling water containing diphenylamine in excess of 0·5 per cent. In the present experiments the fruit was in the steam for runs of 10 seconds and in that period approximately 0·05 mg of diphenylamine was deposited on each fruit.

RESULTS

The amount of diphenylamine taken up by Granny Smith apples is shown in Table 1.

The amount of diphenylamine taken up by the peel was found by peeling enough apples to obtain 100 g of peel. The method of determination was a modification by Kennett* of an unpublished method used by Yatsu at Cornell University, U.S.A.

In Table 2, the effect of diphenylamine on scald in Granny Smith apples is illustrated. The apples were picked on April 28, 1958, and stored in an atmosphere containing 5 per cent. carbon dioxide and 16 per cent. oxygen at 35°F for 8 months.

The amount of steam required varies with the quantity of fruit and the intensity of deposition required. A practical commercial model for utilizing the new method of application has yet to be developed.

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*The method will be described in an appendix to a forthcoming paper by E. G. Hall and K. J. Scott on the effect of diphenylamine on scald in Granny Smith apples.

Food Preservation in the Hawaiian Islands

By L. J. Lynch*

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THE food processing industry in Hawaii consists of several large canneries which handle canned and frozen pineapple products, and many small operators who concern themselves mostly with the processing of tropical fruits other than pineapple, and with coconut in various forms.

The large Hawaiian canneries are self sufficient in all respects, having large capital resources, well-planned operations, and trained staffs capable of dealing with technological and production problems as they arise. The transition is abrupt from these factories to the small producers, who are concerned with the production of canned and frozen guava and passionfruit beverages, canned papaya (papaw) and mango, or with the manufacture of roasted coconut chips, jams, fruits in sweet pickle, and such characteristic Hawaiian foods as coconut haupia, laulau, and poi (see pp. 13–14).

FOOD PROCESSING LABORATORY

In 1951 the University of Hawaii and the Economic Planning and Coordination Authority (E.P.C.A.) of the Territory of Hawaii jointly established what is now the University Food Processing Laboratory to foster the food industry in the Islands. Finance for the work and capital costs of building and installation were contributed by E.P.C.A., and supervision of the Laboratory became the responsibility of the College of Agriculture within the University. Since no legislative provision existed for the appointment of a director within the framework of the Territorial Public Service, it was decided to invite a succession of temporary directors until a permanent position was established.

The immediate objects of the Food Technology Laboratory were research into problems of tropical fruit processing, developmental work on new products of Hawaiian origin to aid diversification in production, and the initiation of some fundamental work in food science. The Laboratory was also expected to cooperate in projects with the Departments of Horticulture and Agricultural Engineering, and other departments in the Agricultural Experiment Station.

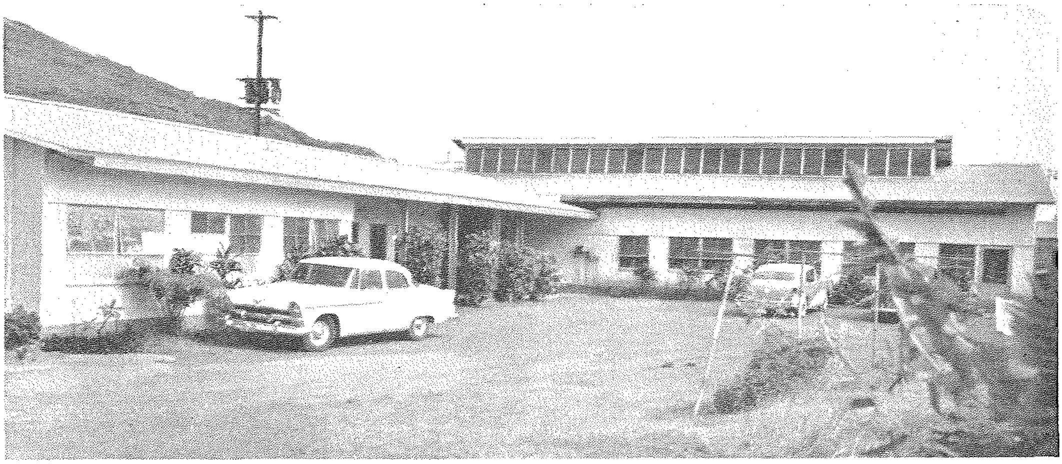
FRUIT AND FRUIT PRODUCTS

Passionfruit

About 1950 the passionfruit was introduced into the Islands from Australia, and in 1953 plantings on a commercial scale were made in an endeavour to establish the industry as rapidly as possible. The prospects of selling the juice locally and in the United States were thought to be good. Successful investigations into the freezing preservation of passionfruit juice were carried out at the University. Through the joint efforts of the Food Laboratory and the Agricultural Engineering Department an efficient juice extractor was developed (Kinch and Shaw 1954). The fruit, after washing and inspection, is sliced and transferred to the bottom of a basket, the sides of which are perforated and slope outward from the vertical axis of the driving shaft. The basket is rotated at sufficient speed to force seeds and pulp through the screen and to cause the skins to discharge over the top. Continuous juice extraction at full plant capacity reduces the time between fruit slicing and the commencement of freezing and improves the quality of the product.

The economics of passionfruit juice production in Hawaii are excellent. Yield of fruit per acre averages 10 tons and rises to 23 tons in the more favoured localities. Growers

*Mr. Lynch was Acting Director of the Food Technology Laboratory in the College of Agriculture, University of Hawaii, September 1957–June 1958.



The Food Processing Laboratory, University of Hawaii.

receive about 6*d.* per lb or a minimum gross return of £500 per acre. Processing costs are low and the quality of the frozen product is excellent. Market prospects on the Mainland were investigated by Scott (1956) who concluded that about £500,000 worth of juice could be retailed annually. This production would require a tenfold extension of existing plantings (400 acres). Large-scale promotional activity would be necessary for the realization of these prospects, and there appears to be some reluctance in official circles and in private industry to make available the finance needed for this purpose.

Guava

Guavas are grown in quantity for processing and are used mainly for frozen purée. The fruit is washed to remove dust and dried blossom ends, and pulped to screen off seeds and fibrous matter. The pulp is returned to a pulper fitted with a 0·014-inch screen, this operation being necessary to extract objectionable stone cells. As an alternative to the latter step one processor passes the pulp through a mustard mill.

Orr and Miller (1954) found that 75–90 per cent. of the initial ascorbic acid was retained in frozen purée stored at 0°F for 52 weeks, and that heat-treated purée lost less ascorbic acid during freezer storage than purée which had not been heated.

Guava purée contains more vitamin C than passionfruit juice, and consumer tests over a period have shown that guava is the more acceptable for quenching thirst.

Papaya and Mango

Canning and freezing investigations on papaya and mango have been emphasized in the programme of the Food Laboratory. These fruits tend to be oversoft at an edible stage, and suffer further texture deterioration when processed. The Department of Horticulture has produced two strains of papaya known as Line 9 and Line 23, both of which bear small firm-fleshed fruits which retain texture satisfactorily when canned. These fruits give a most attractive product when converted to $\frac{3}{4}$-inch dice, spin cooked for 2 minutes, and then cooled.

There are about 30 mango varieties grown in the Islands, and the freezing and canning characteristics of most of these have been tested. The flesh of the mango contains more fibre than papaya, but is nevertheless subject to damage and must be handled with care. Joe Welch and Haden have proved to be outstanding varieties.

Diced papaya and mango, especially the former, have a spongy texture when thawed after frozen storage. Papaya also develops an off-flavour during storage. University workers demonstrated that heat treatment in syrup before freezing reduced sponginess and eliminated off-flavour. It was found also that heat-treated passionfruit juice was more acceptable after frozen storage than that which had received no treatment. These observations have led to the suggestion that the mechanism of off-flavour development may be enzymic in character.

Pineapple

Canned crushed pineapple is commercially processed by preheating ¼-inch diced fruit and draining it over a scroll screen. It is pumped to a holding tank and heated to the recommended temperature, then filled into the can with heated syrup of appropriate Brix, and after closure passed through a fruit cooker and cooled. The time taken in this process is excessive, and the quality of the product reflects the long heat treatment to which it is subjected. The Food Processing Laboratory undertook an investigation of spin-cooked crushed pineapple in an attempt to reduce the thermal process to a minimum. Diced pineapple was filled with cold syrup into No. 2 cans which were rotated at 144 r.p.m. for 3 minutes to a temperature of 195°F. Under these conditions the drained weight of the final product was 12·1 oz, which was below the figure of 15·7 oz required for the official "Heavy Pack". When the fill was increased to accord with the official drained weight the time required to reach the specified temperature was excessive and the shape of the dice was affected. Dramatic improvement in heat penetration rate occurred when rotation was reduced progressively to 100 r.p.m., and a further slight advantage was gained down to 80 r.p.m. When the rotation was decreased below this, the time to reach the standard product temperature increased.

One of the difficulties encountered in this work was the excessive variation in drained weight. This was because the quantities of fruit and juice added varied with the interval between dicing and filling. An attempt was made to standardize the fruit by heating to 140°F and draining for 15 minutes before filling. This procedure reduced can-to-can drained weight variation, which was still further reduced by draining unheated pineapple on a standard ⅛-inch mesh screen for 10 minutes. Under these conditions it was found that approximately one-fifth of the total weight was recovered as juice.

Another matter investigated was the time required for drained weight and Brix equilibration after the thermal process. In general terms it was found that filled fruit weight was increased by one-fourteenth immediately after processing and cooling. A similar increase occurred in the next 24 hours, after which the drained weight stabilized. Brix equilibration was also reached after 24 hours.

As a result of the canned crushed pineapple investigations the following procedure was established:

(1) Convert fruit to ¼-inch dice, and drain cold for 10 minutes on a ⅛-inch screen.

(2) Fill 14 oz into a No. 2 can. Add one-fifth by weight of the recovered juice together with cold 60° Brix syrup to 21 oz.

(3) Vacuum close.

(4) Spin cook for 5 minutes at 80 r.p.m. to 200°F and spin cool.

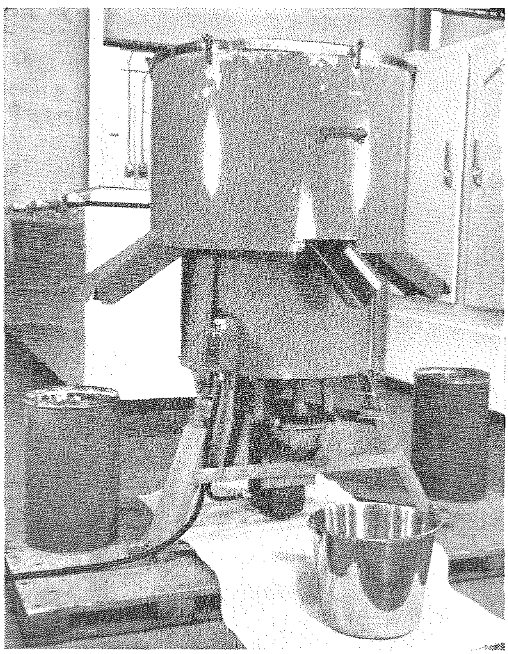
Cut-out tests of pineapple treated in this way gave a drained weight of about 16·4 oz (which is in excess of that required for "heavy pack"), and a Brix of about 25·5° (which accords with that favoured by the industry).

HAWAIIAN DISHES

Haupia

A highly popular product in Hawaii is haupia, which is similar in colour and consistency to blancmange and is made from coconut milk, skim-milk powder, cornstarch, sugar, and water. Until recently haupia was distributed under refrigeration in blocks wrapped in flexible film, but canned haupia is now in commercial production. Investigations showed that the heat discoloration

A passionfruit juice extractor in the Laboratory.



produced during canning could be overcome by the addition of sodium metabisulphite at a rate equivalent to 200 p.p.m. sulphur dioxide.

Laulau

Another Hawaiian dish that is commercially canned is laulau which consists of small pieces of pork and butterfish, taro leaf, and salt—all wrapped in ti leaves which are tied in the shape of a bag. Normally laulaus are steamed for several hours, but for canning purposes they are put up in 8-oz packs, steamed to a centre temperature of 160°F, filled two per can, vacuum closed, and retorted. The product presented some problems in thermal processing because not only is it a conduction heating pack, but it is not necessarily in contact with the sides of the can at all points; nor are the laulaus in complete contact with each other. Despite these factors thermocouple measurements of heat penetration showed marked uniformity from can to can.

Chinese and Japanese Foods

These foods, which are in great demand in Hawaii, may be canned without difficulty. Sweet and sour pork, barbecued spare ribs, sukiyaki, chicken chop suey, and pineapple spare ribs are all most acceptable in canned form, and may be of interest as specialty items in Australia.

Poi

No description of Hawaiian foods is complete without some mention of poi which is a starchy product made from the corms of taro (*Colocasia esculenta* (L.) Schott). Taro is used as a staple food in many parts of the world but its preparation as poi is peculiarly Hawaiian. In the commercial production of poi the corms are cooked in steam retorts and are then washed, peeled, and milled. At this stage the semi-fluid product is strained in a centrifugal basket, and filled into plastic bags which are distributed at room temperature through the usual retail channels. Public health regulations in Hawaii set a lower limit of 30 per cent. total solids for poi, and 18 per cent. for ready-mixed poi which is prepared by dilution with water.

Poi is not a stable product under conditions of commercial distribution. The onset of fermentation due to *Lactobacillus* spp. is rapid, and after several days the initial pH range (5·5–6·0) drops to 3·8–4·0. Fermented or acid poi is greatly preferred to fresh poi as an item of diet, and is recommended by the medical profession for infant and invalid feeding, on the basis of nutritive value, digestibility, and its non-allergenic nature.

Results of work at the Food Processing Laboratory showed that fresh and fermented ready-mixed poi may be satisfactorily canned. The former was filled into cans at 170°F and retorted for 100 minutes at 240°F without heat damage. The fermented poi was heated to 200°F, filled hot, closed, and cooled without further heat treatment. Fresh poi was similarly processed after adjustment with commercial lactic acid to pH 4·0. Canned poi was found to remain in satisfactory condition for several months at room temperature, after which time there was a progressive increase in viscosity due to starch gelation. The thixotropic nature of canned poi permits restoration of viscosity to the original condition after 4 months' storage, but beyond that point the change appears to be irreversible. The storage life is therefore limited, but it is nevertheless sufficient for distribution on the North American continent if reasonable care is exercised.

Poi is an essential component of the Hawaiian feast or Luau. It is served in bowls of 3–4 oz capacity, and is placed to the side—to be eaten in place of bread or rice. It is consumed with a spoon, but, according to some accounts, the original Hawaiians conveyed it to the mouth by means of one or more fingers. One-finger poi or two- or three-finger poi is an indication of consistency, that which requires three cupped fingers for comfortable transfer being excessively diluted. As a matter of interest the remaining chief items at a Luau are Kalua pig which is roasted underground, raw fish, laulaus, haupia, and Hawaiian punch.

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The Cleaning of Citrus Fruit

By J. K. Long and D. Leggo
New South Wales Department of Agriculture

Investigations on the cleaning of citrus fruit have been carried out at the Citrus Wastage Research Laboratory, Gosford, N.S.W., which is operated by the C.S.I.R.O. Division of Food Preservation and Transport in conjunction with the New South Wales Department of Agriculture. The recommendations which follow are based on these investigations.*

THE market value of citrus fruits may be adversely affected by blemishes on the rind. Some, for example black spot, melanose, Septoria spot, and rust mite, cannot be removed without damaging the fruit, but this is not the case with sooty mould, Australian sooty blotch, red scale, and dust.

All these insect pests and fungal diseases can be controlled by field-spraying, and leaflets outlining the recommended treatments are available on request from the New South Wales Department of Agriculture, Sydney. Nevertheless, fruit which is ready for marketing is from time to time affected by these blemishes.

Dust may be removed simply by passing the fruit over rotating horsehair brushes. The disfigurement caused by the red scale insect can usually be removed by washing and brushing if the scales are dead, but live scales can be loosened only by subjecting the infested fruit to jets of water at a pressure of about 80 lb per sq. in. However, this treatment reduces the keeping quality of the fruit.

The superficial moulds—sooty mould and Australian sooty blotch—can be removed from the surface of citrus fruits by:

- Cold dip.
- Mechanical dipping and brushing.

COLD DIP

This method, which is suitable for packing sheds in small orchards, involves dipping the fruit in sodium hypochlorite or chloride of lime, and rinsing in clean water. The fruit is allowed to dry before packing. Both sodium hypochlorite and chloride of lime are bleaching agents, and they are effective by virtue of this property and their capacity to remove the superficial growths from the fruit.

Sodium hypochlorite is usually supplied as a solution at a strength equivalent to 12½ per cent. available chlorine, and the concentrations here recommended are based on a solution of this strength.

Sodium bicarbonate or boric acid will activate the solutions, but sodium bicarbonate is preferred because boric acid is more difficult to dissolve. Sodium hypochlorite and chloride of lime are relatively efficient sterilizing agents, but both are more effective when activated by boric acid, which is therefore favoured when fruit wastage is high.

Chloride of lime has been found effective for many years; but sodium hypochlorite, although more costly, has several advantages:

- The sodium hypochlorite bath retains its cleaning powers for a longer period.
- It appears to have a slightly better cleaning action.
- The dipping solution is more easily prepared.

Concentration and Duration of Dip

For a 2-minute dip the following concentrations are recommended:

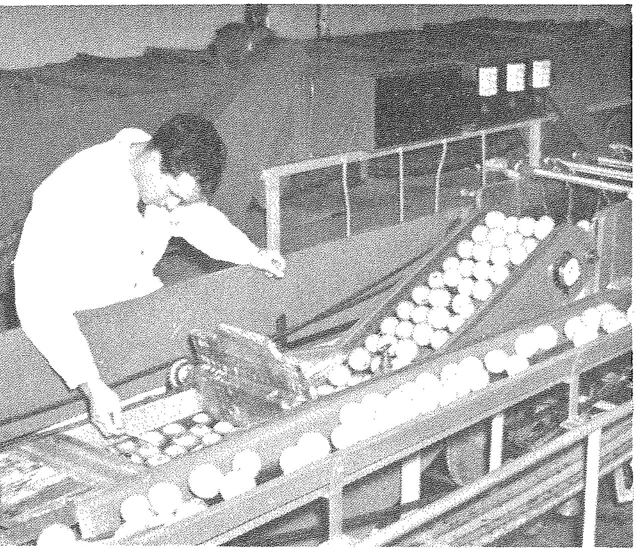
Sooty Blotch Dip

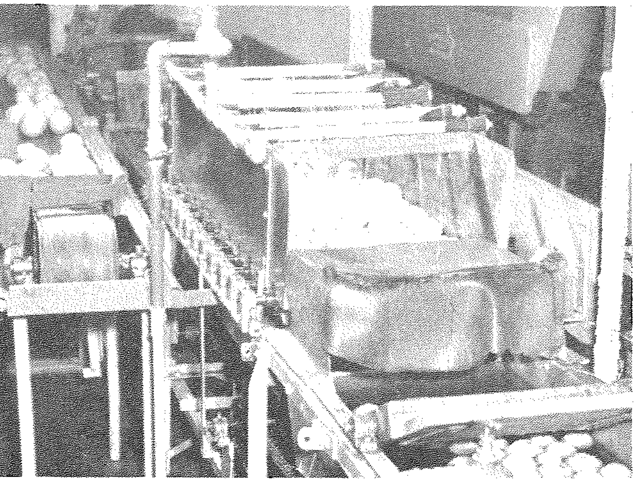
¾ gal sodium hypochlorite
9¼ gal water
1 lb sodium bicarbonate (or ¾ lb boric acid)

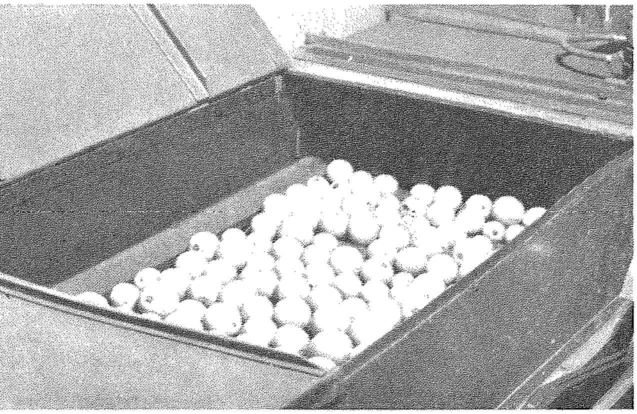
OR

1¼ lb chloride of lime
10 gal water
1 lb sodium bicarbonate (or ¾ lb boric acid)

*This article has also been published in *Agric. Gaz. N.S.W.* **69**: 581–4 (1958).







Sooty Mould Dip

$1\frac{1}{4}$ gal sodium hypochlorite
$8\frac{3}{4}$ gal water
2 lb sodium bicarbonate (or $1\frac{1}{2}$ lb boric acid)

OR

$2\frac{1}{2}$ lb chloride of lime
10 gal water
2 lb sodium bicarbonate (or $1\frac{1}{2}$ lb boric acid)

It will be found possible to vary the duration of the dip according to the intensity of blotch and mould on the fruit, and the strength of the solution. The treatment should be followed by a 1-minute dip in clean water.

Preparation of Solutions

It is extremely important that the bleaching agent be mixed with the total amount of water to be used when preparing the dipping solutions, and the sodium bicarbonate (or boric acid) added last. If this is not done, the effectiveness and stability of the dip will be considerably reduced.

The quantity of solution to be prepared depends on the size of the dipping tank, but to reduce costs only enough should be prepared to ensure that the fruit is covered by the solution. If more solution is needed during dipping, it can be prepared as above (adding the sodium bicarbonate or boric acid last), and added to the tank in the correct proportion.

The solutions have a strong corrosive action on most metal surfaces. A wooden or cement dipping tank is therefore recommended, but metal containers can be protected by bitumen-base paints or other protective coatings.

Dipping the Fruits

Fruit can be dipped in field cases or some type of mesh basket. It should, however, be borne in mind that wire or metal baskets will corrode readily, and cloth containers may rot.

Views of experimental washing equipment at the Citrus Wastage Research Laboratory, Gosford, N.S.W.

Top: *Oranges travelling along a conveyor (in front of picture) into a tank of detergent (on left).*

Centre: *Oranges passing over transverse scrubbing brushes, and being rinsed with water from overhead sprays.*

Bottom: *Steam-heated drying chamber with section of roof lifted to reveal oranges passing through.*

Repeated contact with the solution can cause dermatitis. The operator should therefore wear rubber gloves. It is also advisable to carry out the dipping in a well-ventilated shed to reduce the accumulation of fumes.

After dipping, the fruit should be allowed to dry before being graded, sized, and packed.

Running the fruit over a set of polishing brushes attached to the grader will assist in removing any sooty mould which has been loosened but not removed by the dip.

Renewal of Solution

Ten gallons of the stronger chloride of lime mixture, the chemicals for which would cost about 6*s*., should remain effective for 3–4 days depending on the quantity of fruit treated.

Ten gallons of the stronger hypochlorite solution, the chemicals for which would cost about 12*s*., should remain effective for a week, thus enabling twice the quantity of fruit to be dipped as with chloride of lime.

Before discarding an old solution which is not cleaning effectively, it should be checked by adding 4 or 5 drops of 0·05 per cent. phenolphthalein indicator (which may be purchased from a pharmacist) to a sample of the solution. If a red colour appears, the solution might be reactivated by adding more sodium bicarbonate. If no colour appears it can be concluded that a fresh solution is needed.

The solution will also deteriorate when not in use. It should therefore not be prepared until needed. It should also be stored in a cool dark place.

MECHANICAL DIPPING AND BRUSHING

In this method, which involves the use of a mechanical set-up, the fruit is scrubbed in a bath of detergent. The detergent softens and loosens, but does not necessarily remove mould, dirt, etc. on the surface of the fruit. The actual removal is effected by the scrubbing brushes. It is important to realize that, although the two operations are not independent, each should be carried out effectively.

The Detergent Bath

Of a number of compounds tested, the alkaline detergent sodium metasilicate meets the twin requirements of efficiency and economy. In normal seasons a concentration of 0·2 per cent., i.e. 2 lb per 100 gallons, has been found effective, but for very dirty fruit this may be doubled. The temperature of the detergent bath has a marked effect on its efficacy. It can be used at temperatures up to 110°F with safety, depending on the duration of the dip and the maturity and variety of the fruit being processed, but if the temperature is too high the oil cells in the rind of the fruit will be ruptured.

The following may be taken as a guide to dipping temperatures:

Lemons and early Navels	90°F
Mid-season and late Navels	100°F
Valencias	110°F

In existing equipment it may be difficult to arrange for a specific duration of dip, since this will be determined by the gearing of the machine and the width of the tanks. A long dip makes the most effective use of the detergent, but this is not the only factor to consider. It is recommended that the dip should take 2 minutes, but not longer.

Scrubbing

Scrubbing is carried out by mechanically operated brushes. In the course of their experiments at the Citrus Wastage Research Laboratory, Gosford, the authors used equipment in which the brushes revolved at right angles to the direction of flow of the fruit. The comments which follow apply only to brushes arranged in this manner.

The brushes should be tufted with a fibre of medium hardness and should have spiral strips of longer fibre, arranged in opposed directions on consecutive brushes. The last brush should be plain, that is without spirals. A satisfactory speed is 170 r.p.m. It is not possible to recommend a definite length of scrubbing brush run, as it is the length of time the fruit is on the brushes which is important, and this is affected by the gearing of the machine. If all other parts of the machine are at maximum efficiency and cleansing is not satisfactory, an increase in the length of the brushing unit should be beneficial. Observations have indicated that very dirty fruit should be on the brushes for about 30 seconds.

Spraying

To clean the fruit effectively, water (preferably warm) must be sprayed on to the fruit as it travels over the brushes.

Waxing

The fruit is often waxed after cleaning. This process will be discussed in a subsequent article.

Drying

The fruit is dried artificially. It should be noted that, on cold damp days, the fruit needs to be held in an air current at 120°F for 2 minutes to ensure that the drying is complete. The drying chamber must be provided with fans. Drying will also be facilitated if the fruit is passed through a warm tank immediately prior to entering the drying chamber.

EFFECT OF GREEN MOULD

In districts where green mould wastage is prevalent, the fruit may carry spores of the mould in considerable quantity. Some of these spores will be removed by the detergent bath, and after a period their concentration in the bath will be so great that fruit passing through the bath will acquire spores instead of losing them, and wastage will tend to be increased. It is therefore most important to renew the detergent solution regularly. It is difficult to make a specific recommendation on the frequency of renewal, but it is suggested that the detergent in a 100-gallon tank be changed after 500 cases of fruit have passed through, or at least weekly, whichever is the more frequent. Such frequent changing is not necessary when the fungicide sodium orthophenylphenate is included in the tank solution (Long and Roberts 1954).*

It follows from the above that water used as a spray over the scrubbing brushes should be fresh, that is the same water should not be used continuously.

It is also advisable to disinfect equipment regularly. One of the most effective materials for this purpose is a solution of sodium orthophenylphenate (1 lb in 10 gallons water). The solution should not be brought into contact with the skin, for it may cause dermatitis.

*LONG, J. K., and ROBERTS, E. A. (1954).—A new dip for green mould in oranges. *C.S.I.R.O. Food Pres. Quart.* **14**: 68–70 (also published in *Agric. Gaz. N.S.W.* **65**: 394–5, 412–13 (1954).)

NEWS FROM THE DIVISION OF FOOD PRESERVATION AND TRANSPORT

PUBLICATIONS BY STAFF

Flavour Retention in Processed Foods. J. F. Kefford. *Food Tech. Aust.* **10:** 175–85 (1958).

This paper, presented to the Seventh Annual Convention, Institute of Food Technologists, May 1957, reviews losses of volatile and soluble flavouring substances during processing of foods, and methods for recovery and restoration of flavours. Flavour changes brought about by heat, irradiation, and storage are also discussed.

The Water Relations of *Vibrio Metchnikovi* at 30°C. Betty J. Marshall and W. J. Scott. *Aust. J. Biol. Sci.* **11:** 171–6 (1958).

Comparison with results obtained for some other bacteria shows that *Vibrio metchnikovi* is relatively exacting in its osmotic and ionic requirements. The rate of growth in liquid media and the number of colonies forming on solid media were both greatly increased by reducing the water activity (a_w) from *c.*0·999 to 0·995.

Below *c.* 0·995 a_w both the rates of growth and colony numbers were greater in the presence of salts than in the presence of sucrose or glucose.

Some General Properties of a Psychrophilic Pseudomonad: The Effects of Temperature on Some of These Properties and the Utilization of Glucose by This Organism and *Pseudomonas aeruginosa*. A. D. Brown. *J. Gen. Microbiol.* **17**: 640–8 (1957).

Very little information is available about the physiology of the low-temperature bacteria. This paper describes some experiments to determine the properties of a typical low temperature pseudomonad and to compare them with those of a closely related mesophilic species.

A psychrophilic species of the genus *Pseudomonas* was found to be capable of growth in a simple defined medium with any one of a number of carbon sources. The growth requirements were the same at 0 and 20°C. The organism vigorously oxidized glucose to gluconic and 2-keto-gluconic acids. Rates of O_2 uptake were measured over the range 0–40°C and compared with similar measurements on *P. aeruginosa*. Under the experimental conditions values of Q_{O_2} for the psychrophil were higher than those for *P. aeruginosa* at all temperatures, including those above 30°C at which temperatures the psychrophilic organism does not grow. The values of Q_{O_2} and their temperature coefficients were dependent on conditions of cultivation. It is concluded that the systems involved in the oxidation of glucose and gluconic acid by the two organisms may not be greatly different in those physical properties which determine their temperature relations.

Evaluation of Canning Processes When g is Less Than 0·1. E. W. Hicks. *Food Tech. Champaign* **12**: 116 (1958).

Solubilization in Soap Micelles. M. B. Smith and A. E. Alexander.† *Proc. 2nd Int. Congr. Surface Activity* **1**: 349–56 (1957).

The dissolution of organic compounds in soap solutions, termed "solubilization", is often accompanied by marked changes in physical properties such as viscosity and light scattering, and these changes are usually interpreted in terms of the size and shape of micelles. This paper presents the results obtained from an examination in the ultracentrifuge of the effects of trichlorobenzene, toluene, and methyl*cyclo*hexane when added to the system 0·1M cetyl pyridinium chloride in 0·5M sodium chloride.

†University of New South Wales, now at the University of Sydney.

Aerobic Inhibition of Glycolysis. J. F. Turner and L. W. Mapson.* *Nature* **181**: 270 (1958).

During investigations on the synthesis of sucrose from glucose-1-phosphate and fructose by pea seed extracts it was observed that a glycolytic system was operating in the enzymic digests. It was found that there were differences in glycolytic activity when the enzymic digests were incubated under aerobic and anaerobic conditions.

Polarographic Methods with Special Reference to Trace Analysis. H. A. McKenzie. *Rev. Pure Appl. Chem.* **8**: 53–84 (1958).

A review discussing the basis of methods of measurement of polarography, the limitations of classical polarography, and the newer polarographic methods—their basis, advantages, and limitations.

Studies on Beef Quality. Part VII. The Influence of Certain Holding Conditions on Weight Losses and Eating Quality of Fresh and Frozen Beef Carcasses. P. E. Bouton, A. Howard, and R. A. Lawrie.* *C.S.I.R.O. Aust. Div. Food Pres. Transp. Tech. Pap.* No. 8 (1958).

This paper describes experiments to find out the effects on palatability and drip (after subsequent freezing and thawing) of holding beef quarters for a time above freezing point before freezing. An attempt was also made to relate the assessment of tenderness by tasters to the chemical composition of the meat.

Evaporative losses during holding tend to increase and drip losses after thawing tend to

*Low Temperature Station for Research in Biochemistry and Biophysics, University of Cambridge and Department of Scientific and Industrial Research.

decrease with length of holding period and increase of temperature at holding, a period of 2 days at 20°C being approximately equivalent to 14 days at 0°C.

Tenderness and overall acceptability of unfrozen meat show statistically significant increases, and juiciness a decrease with extent of holding. Darkening in colour and increase of flavour follow a similar, though not significant, pattern. In general, these effects are more marked with canner beef than with first-grade beef.

Freezing tends to reduce or eliminate these trends by shifting all scores to a level which approximates the fully tenderized fresh meat.

The holding treatments are not associated with any change in soluble nitrogen, alkali-insoluble protein, or hydroxyproline. Holding is associated with a reduction in the amount of the peptides, carnosine and anserine, present in muscle extracts. Freezing is shown to bring about a definite increase in pH of the meat.

The influence of temperature and pH on the changes in drip and organoleptic properties is discussed, particularly in relation to different reaction of first-grade and canner carcasses to the holding treatments. The probable identity of the structural and functional units involved in the changes during holding is also discussed. The practical implications of freezing and holding as methods of tenderizing are considered.

The Effect of Sulphur Dioxide on the Keeping Quality of Air-dried Mutton Mince. A. R. Prater and A. G. L. Elliott, *C.S.I.R.O. Aust. Div. Food Pres. Transp. Tech. Pap.* No. 9 (1958).

A study has been made of the effect of sulphur dioxide on the shelf life of dehydrated mutton mince. Three levels of sulphur dioxide (100, 300, and 500 p.p.m.) were compared in air and nitrogen packs stored for 0, 12, and 24 months at 77°F.

The presence of sulphur dioxide had pronounced stabilizing effects, both in the presence and absence of oxygen, and is likely to be an attractive alternative to packing in nitrogen, since it is cheaper, simpler, and more effective in restricting development of off-flavours.

Studies in Canning Processes. II. The Effects of the Variation with Temperature of the Thermal Properties of Foods. H. L. Evans. *Food Tech. Champaign* **12**: 276–80 (1958).

The thermal properties of many conduction-heating canned foods change with temperature. These changes are generally regarded as small enough to neglect when calculating heating and cooling curves. This paper presents theoretical and experimental evidence that the changes in the thermal properties of canned foods, especially those composed predominantly of water, result in heating and cooling curves which differ substantially in slope and lag factor (j) from curves obtained when assuming constant thermal properties. In addition the slope and j value of the heating curve were shown to differ appreciably from the corresponding values for the cooling curve in packs which heat and cool by conduction.

Exchangeable Ions in Beet Disks at Low Temperature. G. E. Briggs,* A. B. Hope, and M. G. Pitman.* *J. Exp. Bot.* **9**: 128–41 (1958).

Measurement of Ionic Fluxes in Red Beet Tissue Using Radioisotopes. G. E. Briggs,* A. B. Hope, and M. G. Pitman. *Unesco Internat. Conf. Radioisotopes in Sci. Res.* UNESCO/NS/RIC/181 (1958).

The Inhibition of Photosynthesis by Oxygen. II. The Effect of Oxygen on Glyceraldehyde Phosphate Dehydrogenase from Chloroplasts. J. S. Turner,† J. F. Turner, K. D. Shortman, and Judith E. King. *Aust. J. Biol. Sci.* **11**: 336–42 (1948).

*Botany School, University of Cambridge.

†Botany School, University of Melbourne.

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: UM 8431, UM 6782, UM 8938.)