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Possible Developments in Fruit Canning

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The Australian fruit canning industry is under continual pressure to reduce costs and it is this pressure that will probably determine the technological changes that will take place in the industry in the future. Competition from countries such as South Africa and the United States of America in our traditional markets in Europe and Britain is likely to increase, and our industry will probably have to give more attention to the Asian–Pacific region as an alternative selling area. Much of the Pacific region is poorer than Europe and so further pressure is placed on our industry to reduce production costs. In addition to the marketing problem, our orchards are producing increasing quantities of fruits which must be canned or wasted.

In the last decade or so the Australian canners have invested huge amounts of capital in high-capacity processing equipment which has done much to stabilize costs. Further improvements in equipment must be expected, and further expansion and installation of new types of equipment must be envisaged. Perhaps the time has now come for more attention to factors that influence production costs other than those involving materials handling problems. Probably the important technological advances will take place in this area.

Size of Fruit

The main product of the industry today is the same as many years ago, i.e. halved or sliced pieces of fruit in sugar syrup. Production of this type of pack requires fruit of a minimum size for an attractive appearance and to reduce processing costs. Growers therefore prune and thin to ensure that the fruit reaches the required size, and while these procedures probably reduce the total yield of the orchard, they do increase the yield of fruit of a size acceptable to the cannery. The question that might be asked is, 'What proportion of the crop fails to reach the minimum size and is therefore lost, and should we be trying to utilize this fruit?' It might also be interesting to know whether culture techniques that give less emphasis to sizing and more to total yield would increase the amount of fruit available for processing. While the canning industry continues to manufacture the conventional fruit-in-syrup pack, fruit of at least a minimum size is an economic necessity, but if other styles of pack were feasible smaller fruit might be acceptable and greater effective orchard yields might result.

Fruit/Syrup Ratio

In round figures canned fruit contains about 30% of the contents of the can as syrup, and about 80% of this syrup is water. Much of the syrup from a can of fruit is discarded by the consumer, taking with it perhaps 20% of the flavour and nutrients of the pack. Nevertheless there are sound technological reasons for the presence of this syrup in the can. The shapes of the individual pieces of fruit preclude close packing and the syrup reduces the headspace volume in the can and makes the can appear full. This suggests that if fruit were cut to give units that pack more closely, less syrup could be used. However, the present methods of heat sterilizing the fruit in the can require a certain minimum quantity of syrup to carry the heat by convective currents to the centre of the product. This heat transfer problem, which may be important in close-packed solid fruit having little or no syrup, could be overcome by using hot-fill, close, and hold processing methods, which at the present time are applied mainly to solid-pack apple and some juice packs.

It appears then that technological developments may lead to new styles of pack utilizing fruit of a wider range of sizes than at present, and to packs in which the fruit is diced, rather than sliced or halved to permit close packing, and to products which contain little free sugar syrup. These styles of pack may also use fruit juice as a partial substitute for sugar syrup and this again would give greater usage of fruit. It is also possible that new formulations of fruit packs containing additional ingredients besides fruit and sugar will be processed for the Asian market, and our industry should determine these market requirements without delay. The production of the new styles of pack would, of course, require many changes in processing equipment and in the regulations that control the export of canned fruit.

Can Construction

A large part of the cost of canned fruit is the cost of the can itself. The cost of a can of specified capacity varies with the size and shape and it is interesting to look at the relation between the area of tinplate and the ratio of the height and diameter of the can, and how the required area of tinplate per unit weight of product varies with capacity of the can. Figure 1 shows the area of tinplate used in cans having the same capacity but different shapes. (No allowance is made for the plate in the seams of the cans, or the waste plate left in the sheets of tinplate by the slitting and punching operations.) The minimum tinplate usage occurs in cans that have height equal to diameter. Most cans used commercially have dimensions close to the optimum, as shown by the arrows in Figure 1. (Note that the vertical scale in Figure 1 applies only to cans of 15-oz capacity.) Figure 2 shows that the area of tinplate required to contain unit volume of product decreases markedly as the size of the container increases. (In calculating this relationship the diameter was taken to be equal to the height of the can.) These data then show that, from the point of view of tinplate usage, the industry uses cans close to the optimum shape, and it is more economical to pack in large cans than in small ones.

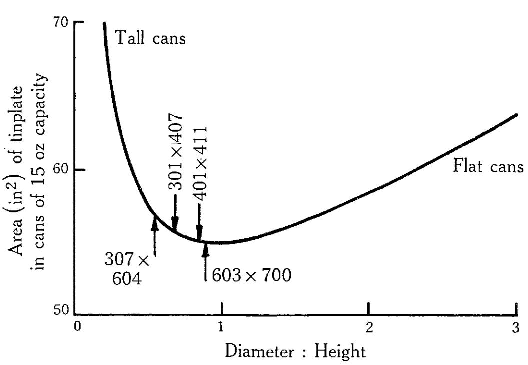

Fig. 1.—Area of tinplate required for cans having the same capacity but different dimensions. The curve is specific for 15-oz cans but the same curve having different values on the vertical axis would apply to cans of different capacity.

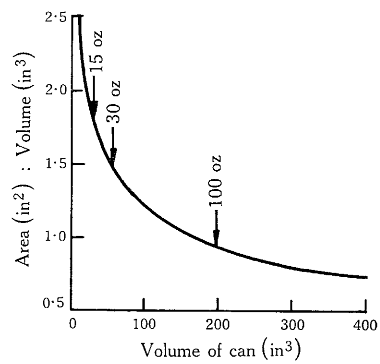

Fig. 2.—Area of tinplate required to contain unit volume of product decreases as the capacity of the can increases. Curve calculated for can in which the diameter is equal to the height.

There are other properties of the can that might be modified to reduce costs. Already in the U.S.A. many fruit canners use special-property tinplate known as Grade K, which is more resistant to detinning-type corrosion than normal electroplate. Usually 0·75-lb tin coatings on Grade K plate give a shelf life equivalent to 1·00-lb tin coating on ordinary tinplate in canned fruit, and 0·75-lb Grade K plate is now used commercially in the United States for many fruit products. In many instances also 0·25-lb coating is used on the outside of cans, whereas in this country 0·5-lb or heavier coatings are commonly used. Lacquered, chrome-plated steel is also being used in increasing quantities in some packs in the U.S.A. at a cost advantage over tinplate, and this material could some day be useful for the top end of cans of fruit.

Large Packs

There is already a demand from some importing countries for Australian fruit in a form which can be reprocessed into other products, even into canned fruit in small cans. Major changes in our technology are needed to produce a product that satisfies this market. The need seems to be for a method of processing fruit, either halved, sliced, or diced, in large containers of at least 4-gal capacity and perhaps even 44-gal capacity. This fruit must receive a minimum heat treatment to avoid excessive softening of the tissue so that it is suitable for reprocessing in the importing country. The most promising method of processing fruit in large containers probably involves an aseptic filling procedure similar to the process used at the present time in the U.S.A. for juices and concentrates. Large quantities of these materials are aseptically packed in 44-gal drums and even in tanks having capacities of many thousands of gallons. At present this method is used only for processing homogeneous pumpable products, but it could probably be modified to handle a product containing large discrete units.

Summary

To summarize, it seems likely that the following technological developments will take place:

- New styles of products, including juices and concentrates and products having new formulations, will appear and these may lead to greater use of orchard production.
- There will be a trend towards the use of more fruit and less syrup in the pack, and this will require new processing techniques.
- Tinplate having lighter coating of tin will be used for cans, and there may some day be some use of lacquered chrome-plated steel for can ends.
- There will be more emphasis on packing in large cans and perhaps in drums and tanks for reprocessing in importing countries.

Hot-room for Incubation of Canned Foods

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For the canning industry a means of incubating canned foods and beverages at a controlled and constant temperature for extended periods is desirable for the following purposes:

- To test sterility of the product. Suitable temperatures are 86–95°F for general spoilage organisms and 122–130°F for thermophilic organisms, which can be a special problem for canned foods exported to the tropics.
- Accelerated shelf-life studies to detect chemical and physical changes in the product and corrosion of the container.
- Incubation of nutrient media for bacteriological testing of processing equipment, etc. However, this requires little space and laboratory ovens are generally used.

This article describes a room that is suitable for these purposes and that can be erected and operated by anyone wishing to maintain a space at above ambient temperature.

Nomenclature

t_A, Ambient temperature—*lowest* likely average outside temperature over a period of 72 hr (°F).

t_S, Space temperature—mean temperature at which canned goods are to be kept (°F).

Δt, Temperature difference, $t_S - t_A$.

c.f.m., cu ft of air per min.

Btu, British thermal unit of heat.

kW, Kilowatt (1000 W) of electrical energy =3412 Btu.

Q, Heat leakage rate (Btu/ft^2/hr).

T, Thickness of insulation (in.).

k, Heat transfer coefficient (Btu/ft^2/hr/degF/in. thickness).

Background Information

The main purpose of incubation is usually to provide temperatures favourable for the growth of living organisms that may be present in a product. Owing to the great variation in the temperature requirements of different types of spoilage organisms, it is obviously not feasible to provide temperatures ideal for all. An acceptable compromise has been suggested by Scott (1953):

$t_S = 86$°F for most spoilage organisms,

$t_S = 122$°F for thermophilic organisms.

Dickinson and Goose (1955) consider that a cannery laboratory should contain two incubator rooms, one at 98·6°F and the other at 131°F for growing mesophilic and thermophilic organisms respectively, the most likely to cause spoilage in canned foods.

The Laboratory Manual for Food Canners of the National Canners Association (1968) suggests that the incubation of samples canned daily is a simple control procedure for canners who do not have the facilities for bacteriological work, and is a valuable supplementary procedure for those who do. A disadvantage is that results are not immediately available since spoilage by butyric and thermophilic anaerobes as evidenced by the swelling of cans may not begin for two days to two weeks at a favourable temperature. To check conditions in the cannery, a bacteriological examination of line samples incubated at 86–95°F and at 122–130°F is recommended.

Apart from any desire of canners to ensure that their products are of good quality and have a satisfactory shelf life, the importance to Australia of the export market makes the provision of means for incubation essential for those engaged in the export trade.

General Requirements

Those wishing to provide incubation facilities should first decide whether or not they need to incubate cans at different temperatures *concurrently*, and hence whether to provide more than one incubation space. This paper deals with the construction of a single room which may be held at any temperature between 86 and 130°F.

The features listed below constitute a minimum requirement for safe and reliable operation over a long period and may be expanded or amplified to suit individual needs:

- An insulated structure.
- A device for heating air.
- A fan for circulating air.
- Shelves or racks to hold canned foods.
- Temperature controls.
- Means of observing conditions in the room.

More sophisticated equipment may be used to provide very close temperature control or to record temperatures automatically. However, the mere provision of sophisticated equipment does not necessarily lead to better results.

The extent to which the design is amplified is a matter for individual decision and will depend primarily on willingness to meet the additional costs involved. However, apart perhaps from providing a *larger* facility to suit particular needs any really worth-while improvements may be quite expensive. The aim here is to keep construction simple and maintenance at a minimum and to take reasonable precautions against the risk of damage by fire.

Design Parameters

The design is based on the following specifications which it is considered would apply to a typical room. Modifications to suit local needs may be made using the information given.

Ambient temperature: 40°F

Space temperature: 86–130°F

Temperature difference:

Maximum at 130−40 = 90°F

Can temperature tolerance: $\pm 2°F$

Room size: Length: 10 ft
Width: 8 ft
Height: 8 ft

Shelving: Along two sides, shelves 2 ft wide with 18 in. vertical spacing.

Storage capacity: Approx. 1000 cans.

Typical Construction

The shape of the room will be dictated by the site selected, possibly within an existing building. However, the design discussed below may be modified to suit the site, the principal consideration being the need to provide for free circulation of air around the stored cans.

It is proposed that the cans be stored on shelves 2 ft wide. This will allow cans of, say, 4-in. diameter to be stored five deep, providing plenty of free air space and unrestricted access. A vertical distance of 18 in. between shelves with the bottom shelf 6 in. above the floor will also contribute to this freedom of air movement and access. Ample working space between the tiers of shelves will be provided if they are 3 ft apart.

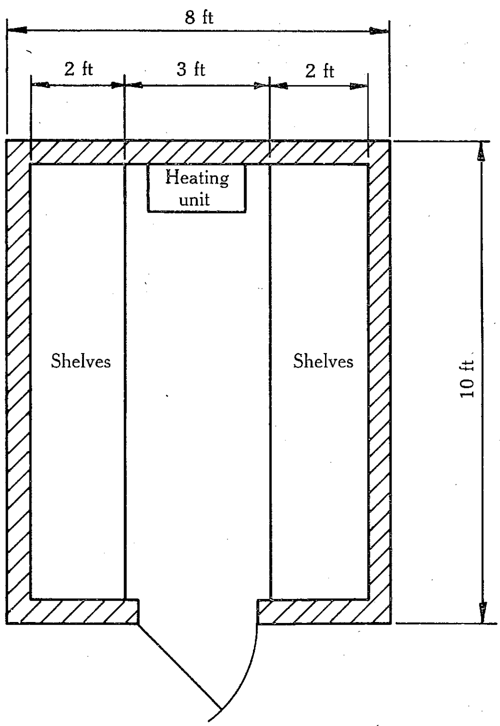

Fig. 1.—Layout plan of shelves and heating unit.

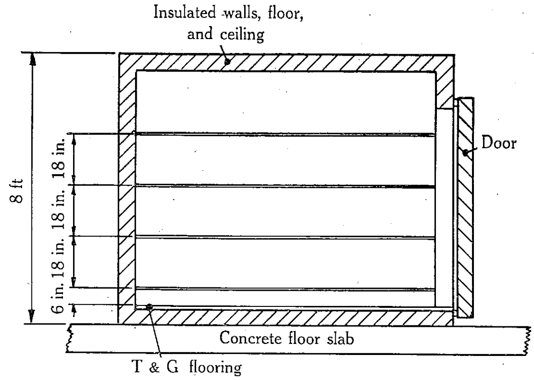

Fig. 2.—Arrangement of shelving in incubation room (longitudinal section).

The room may be constructed of almost any available material, the major consideration being the risk of fire. Obviously a metal structure would be preferable but as the fire hazard is not unduly great timber need not be ruled out.

The shelving layout and location of the heating unit in relation to the door are shown in Figure 1, whilst Figure 2 and Figure 3 show the longitudinal and transverse arrangements respectively.

The timber-framed structure using 4 in. by 2 in. studs and plates is similar to a normal shed construction. The 4-in. studs have been selected not for strength, but to accommodate conveniently the 4-in.-thick batts of insulation; studs may be spaced at 18 in. or 24 in. centres and batts selected to suit. Depending on

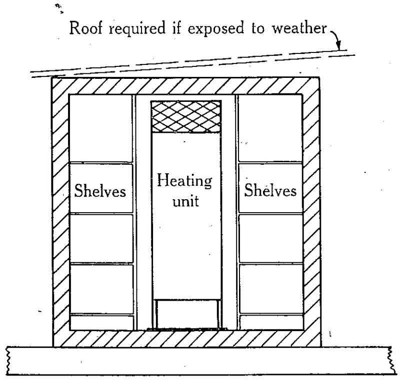

Fig. 3.—Arrangement of shelving in incubation room (transverse section).

individual preferences the internal lining may be hardboard, as also may the external cladding unless it is exposed to the weather, when asbestos cement is recommended and a roof will also be required.

The door may be either swing or sliding; a standard cold-room door could be used or a framed and insulated door made to match the room construction. In the latter case 3 in. of cork insulation is suggested. A gasket will be needed to prevent hot air escaping and this could conveniently consist of a strip of felt 1 or 2 in. wide by $\frac{1}{4}$ to $\frac{1}{2}$ in. thick attached to the door. It is further suggested that a double-glazed small window be fitted in the door to facilitate checking the room without opening the door and that the light switch be located outside the room.

To facilitate free air circulation the shelving should be of open slats or expanded or perforated metal and so arranged that at least two-thirds of the shelf area is open space, e.g. 1 by $1\frac{1}{2}$ in. hardwood slats on edge at 3 in. centres.

Heating and Insulation

Normally the ambient temperature will be lower than the operating temperature of the room or space. However, there will undoubtedly be times when the ambient temperature will be higher than 86°F so that some form of cooling would be required to maintain the controlled temperature. Such conditions are considered to be sufficiently rare to allow the omission of cooling equipment and thus avoid its attendant costs, bearing in mind the definition of ambient temperature as being the lowest average over a period of 72 hours. The provision of a reasonable degree of insulation will ensure that any variation in space temperature from the pre-set control point will be kept to a minimum.

Under the most severe conditions it is desirable to restrict the rate of heat leakage through the insulation to not more than 7 Btu/hr/ft^2 of insulated surface, and as the most convenient form of insulation is slag wool or glass fibre batts we may assume an overall k factor of 0·3 to apply to the insulated timber structure. For other insulants appropriate values of k may be obtained from tables given by Atkins and Hall (1967), adding 10% to allow for the effect of the timber structure within the insulation.

The thickness of insulation T required to restrict the heat leakage rate to Q when the ambient temperature is t_A and space temperature t_S is given by

$$T = \frac{\Delta t \times k}{Q}. \quad \ldots\ldots\ldots\ldots \quad (1)$$

When

$$\begin{aligned} t_A &= 40°\text{F and } t_S = 130°\text{F}, \\ \Delta t &= 130-40 = 90°\text{F}, \\ k &= 0\cdot 3\ \text{Btu/ft}^2\text{/degF/in./hr}, \\ Q &= 7\ \text{Btu/ft}^2\text{/hr}. \end{aligned}$$

$$\text{Therefore } T = \frac{90 \times 0\cdot 3}{7} = 3\cdot 857 \text{ in.,}$$

say 4 in.

Equation (1) may be used to determine the thickness of insulation for a hot room running at other ambient and space temperatures, bearing in mind that provision should be made for the worst likely conditions.

If the surface area of the walls, ceiling, and floor is worked out for our typical room it will be found to be for all practical purposes 450 sq ft, so that with a maximum heat leakage rate Q of 7 Btu/ft^2/hr, the total heat loss will be $450 \times 7 = 3150$ Btu/hr or a little less than 1 kW per hr, which has to be made up by the heating unit. A convenient arrangement would be to provide two heating elements of $\frac{1}{2}$ kW each, as at the lower operating temperatures one element could be switched off to facilitate better temperature control.

To determine the air flow necessary to distribute the quantity of heat, Q, throughout the space and at the same time maintain the desired limits of temperature tolerance specified, namely $\pm 2\cdot 0$ degF, we can use the equation:

$$\text{Air flow (c.f.m.)} = \frac{Q \times 14\cdot 5}{0\cdot 24 \times 60 \times \text{temp. tolerance} \times 0\cdot 8}, \quad \ldots\ldots \quad (2)$$

where 14·5 = Average specific volume of air in ft^3/lb,
0·24 = Specific heat of air in Btu/lb/degF,
60 = Conversion factor for Btu/hr to Btu/min,
0·8 = Heating coil by-pass factor.

Substituting typical figures in equation (2)

$$\text{Air flow} = \frac{3150 \times 14\cdot 5}{0\cdot 24 \times 60 \times 4 \times 0\cdot 8} = 995 \text{ c.f.m.,}$$

say 1000 c.f.m.

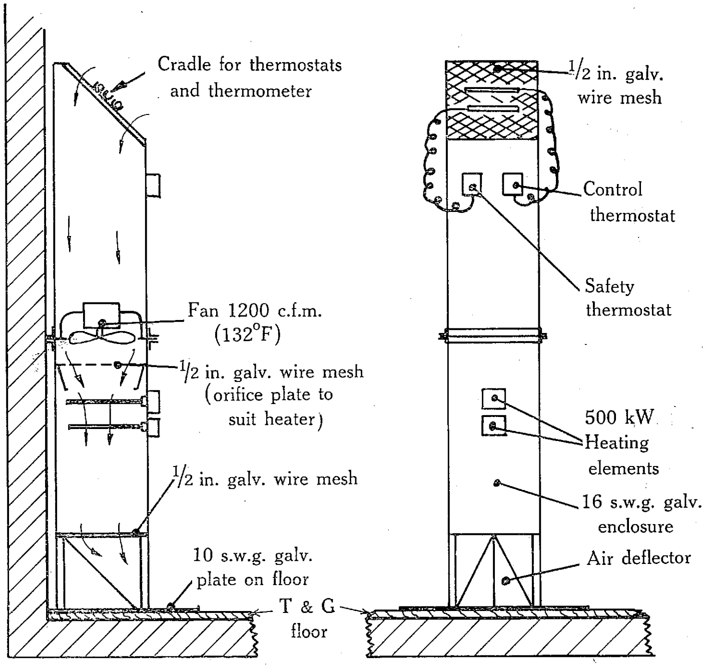

Fig. 4.—General arrangement of heating unit.

For practical purposes a fan handling between 1000 and 1200 c.f.m. free discharge should be selected, bearing in mind that as the motor will have to operate in the hot air stream it should be specified as being suitable for operation in an ambient (for the motor) temperature of, say, 132°F. This may necessitate a motor with Class B insulation or a larger motor de-rated.

Figure 4 shows a general arrangement of the heating unit and it will be noted that the hot air is discharged at floor level so that it rises through the space and is withdrawn by the heating unit near the ceiling.

In detail the heating unit consists of a sheet metal enclosure with a removable top half. The shape suggested is virtually self-supporting, requiring only a simple attachment to the wall for stability. Three wire mesh grids are shown, the top one to prevent light material, e.g. paper, being drawn into the unit and also to keep out inquisitive fingers. The middle one prevents anything falling onto the heating elements and the lower one prevents any hot material falling onto the timber floor.

Internal fittings in the room would normally consist of a twin 40W fluorescent light and a 10-amp powerpoint. Due to the high temperatures, plastic fittings cannot be recommended and for convenience all electric wiring could be incorporated in the heating unit. All wiring should be resistant to high temperatures.

Temperature Control

Control of temperature within the space may be of the simplest type available, namely, a single, small differential thermostat with the sensing bulb located in the air stream before the fan. The fan will run continuously and the thermostat will switch the heating elements on and off as required.

When the room operates in the lower temperature range or in hot weather, one element may be switched off to give better temperature control; experience will indicate the correct use of this facility.

A wiring diagram is shown in Figure 5, from which it will be seen that a safety thermostat has overriding control and will shut the plant down should the temperature rise too high. A further safety feature is incorporated by feeding the heating elements via the fan-isolating switch to ensure that the fan is running while the heating elements are on.

Instruments

The degree of instrumentation adopted is limited only by finance. A minimum requirement would be the provision of one or more good mercury-in-glass thermometers, suitably checked and selected for accuracy. It is surprising how much variation can be found amongst so-called quality thermometers.

The thermometers selected should be located in suitable positions in the room to indicate can temperatures, using empty cans as holders to avoid damage, whilst at the same time providing a degree of thermal inertia to assist in obtaining correct readings. Figure 6 illustrates a simple thermometer holder.

Dial thermometers could be installed so that temperatures could be read without the need to enter the room, and if desired a circular or strip chart recorder could provide a continuous record of temperature conditions within the space.

Conclusions

Incubation rooms are a useful adjunct to quality control in a cannery.

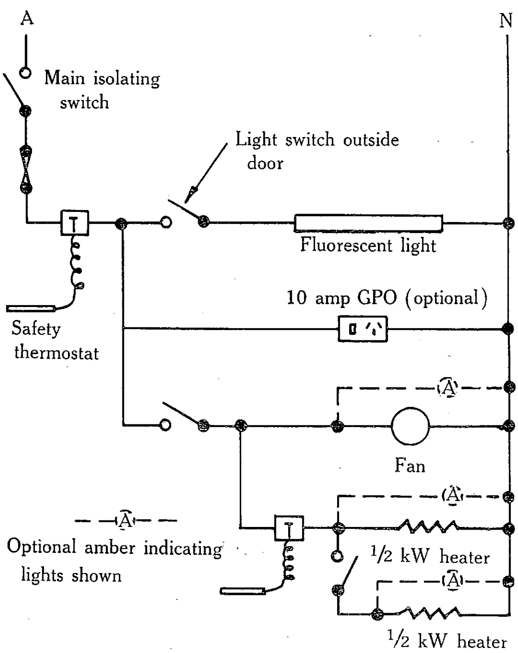

Fig. 5.—Wiring diagram.

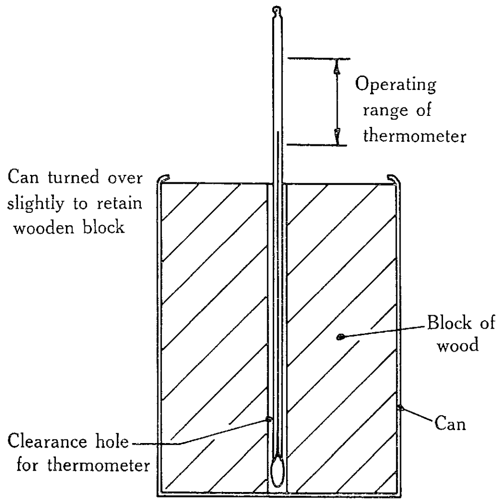

Fig. 6.—Simple thermometer holder.

The two main temperature ranges for the rooms are 86–95°F and 122–130°F.

Individual operational requirements will dictate whether one or more rooms are required and their size and shape.

A choice exists between timber and metal construction and between a do-it-yourself job or the purchase of a prefabricated unit.

The features listed in the typical design and shown in more detail in the diagrams are considered essential for efficient and safe operation.

The degree of instrumentation is a matter for individual choice.

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Improved Dried Pears

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An increase in the production of pears in the next few years has been predicted following recent plantings of Williams Bon Chretien in the Upper Murray area of South Australia and in the Goulburn valley in Victoria. Drying offers a possible outlet for some of the expected surplus pears as well as for certain grades that are not acceptable to canneries at present due to excessive size, over-ripeness, or slight deformity.

This article describes a procedure observed by the author in California for producing naturally dried pears suitable for the United States market. In addition, it reports Australian attempts to produce dehydrated Williams pears which, by various pre-drying treatments, have a more definite flavour than that of naturally dried pears.

PRESENT production of dried pears in Australia is only 200–300 tons annually. They are mainly dried in the sun as halves which are unpeeled and uncored. There is a considerable market for Australian dried pears in the United States provided that certain prerequisites relating to form and appearance are met. Such dried fruit must be pale yellow and translucent in colour, free from core and calyx, and devoid of curling, which occurs during drying following removal of the core. Experiments in this Division in the early 1950s showed that a high-quality dry material was produced if pears were peeled, cored, and dehydrated. On rehydration, it was more like fresh fruit than the dried article now being sold. However, such dehydrated pears are white and opaque, in contrast with the yellow translucence of sun-dried fruit, and would need appreciable sales promotion.

Californian Method of Outdoor Drying

Ripe pears are washed and conveyed to operators who halve and core the fruit in one manual operation. Each pear is halved by pressing it against a fixed, sharpened, triangular blade having a projecting scoop at the rear that removes the calyx. Halved pears are sulphured on wooden trays by exposure to the fumes from burning sulphur. Because of the method of drying, long exposure times of 48–72 hours are required. Sulphuring is judged to be complete when the skin is still intact but the fruit tissue has a jelly-like consistency.

After sulphuring, trays of fruit are placed in direct sunlight for 8–12 hours to ensure surface drying (Fig. 1). They are then stacked so that all subsequent drying is done in the shade. Extended drying for 2–4 weeks is necessary, but curling of the edges is negligible and the required colour results. In such a long drying process most of the absorbed sulphur dioxide is lost from the fruit, and to ensure a residual content of 2000–3000 p.p.m.—a level needed to guarantee a storage life of 12 months—the long exposures to sulphur dioxide mentioned above are necessary. Forty-eight hours' exposure is used when drying temperatures are above 90°F but up to 72 hours are needed if ambient temperatures are lower.

From constant use, U.S. consumers have come to prefer dried pears with a yellow translucent colour. Translucence is due mainly to the long sulphuring treatment, during which breakdown of cell walls occurs and intercellular gas is displaced by liquid leaking from the cells. A similar effect can be produced by blanching pears in steam, but this involves additional equipment including steam-raising facilities.

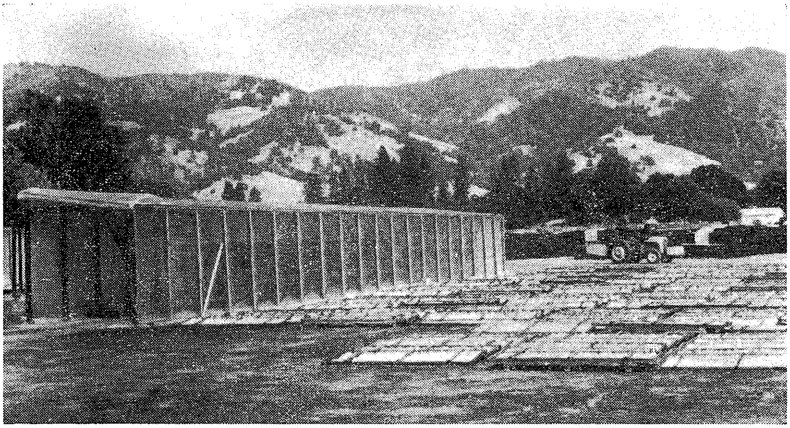

Fig. 1.—Sulphuring and sun-drying of pears near Ukiah, California.

Dehydration and Flavour Enhancement

Experimental Details

Two trials were run using firm–ripe Williams Bon Chrétien pears. In the first, fruit was peeled by exposure to live steam for 35 sec, after which the loosened skin was rubbed off by hand. After cutting and coring, halved pears were dipped momentarily in 0·5% potassium metabisulphite solution to retard enzymic browning. The following treatments were then applied to the prepared fruit.

(1) No treatment
(2) Blanched 5 min in steam
(3) Soaked in passion-fruit juice for 15 min
(4) Immersed in passion-fruit juice and 26–27 in. vacuum was drawn and held for 5 min

All samples were then sulphured for 1 hr in an atmosphere containing 1·5% sulphur dioxide, after which they were dried at 140°F, drying times being 16–18 hr.

In the second trial, pears were hand-peeled, halved, cored, and dipped in metabisulphite solution. The following treatments were then applied.

(1) No treatment
(2) Soaked in 1% citric acid solution for 5 min
(3) Soaked in 3% citric acid solution for 5 min
(4) Immersed in 1% citric acid solution, 26–27 in. vacuum for 3 min
(5) Immersed in 0·5% citric acid solution, 26–27 in. vacuum for 3 min
(6) Soaked in 1% ginger essence for 5 min (1 ml of essence per 100 ml water)
(7) Immersed in 1% ginger essence, 26–27 in. vacuum for 3 min
(8) Soaked in 0·5% clove essence for 5 min
(9) Immersed in 0·5% clove essence, 26–27 in. vacuum for 3 min

All samples were sulphured and dried as in the first trial.

Samples of dried pears were cooked and rated for flavour, texture, and colour by ten tasters. For comparison, samples of canned pears that had been prepared from the same fresh fruit were presented to the tasters at the same time as the dried samples. Dried pears were prepared for tasting as follows: 100 g of dried fruit were soaked in 1 l of cold water for 3 hr. After bringing to the boil the mixture was simmered for 15 min and then 240 g of sugar was added (to give about 20° Brix); simmering was then continued for a further 5 min to dissolve the sugar. Canned and dried samples were held at 40°F overnight and tasted the following morning.

Tasting Results

The flavour of dried pears without any additive was more pronounced than that of the canned material. This difference might have been due to riper fruit being used for drying than for canning, or to a higher level of flavour components in cooked dried pears resulting from their inability to take up as much water during rehydration as had been lost during drying. Treatments with passion-fruit juice imparted a pronounced flavour to pears but it was not plainly distinguishable as passion-fruit. During sulphuring, drying, rehydration, and cooking considerable changes are inevitable in the flavour of passion-fruit absorbed in the pear tissue. Citric acid treatments enhanced flavour slightly but it is doubtful whether the extra step involved in its application would be warranted. Tasters were able to identify the added ginger and clove flavours, but here again improvement over the untreated samples was insufficient to recommend their adoption.

Slight enzymic darkening occurred in pears that were peeled following a short exposure to steam. This discoloration appeared in a thin layer just below the pear surface, near the limit of heat penetration, and was not removed by the metabisulphite treatment. Immersion of peeled pears in passion-fruit juice imparted a yellow colour to the surface. While the above yellow to light brown colours were noticeable in the dried pears, on rehydration during cooking their intensity was reduced to an acceptable level. Hand-peeled pears were free of discoloration when dry and when cooked; commercial mechanical peelers would presumably give the same result. During vacuum treatments most of the intercellular gases were removed from the tissue. Pears treated in this way were translucent and resembled those that had been sulphured for a long period, as in Californian commercial practice, and those that had been steam blanched. This confirms that cell breakdown (plasmolysis) due to long exposure to sulphur dioxide leads to removal of the intercellular gases and that the opaque white colour of dehydrated pears is due mainly to occluded gas. After cooking, vacuum-treated pears were indistinguishable from untreated pears.

The texture of all cooked dried pears was acceptable in these trials. It was softer than that of the canned pears, but again this may have been due either to the fruit for drying being riper initially or to slight over-cooking of dried samples. The soaking time of 3 hours followed by total simmering for 20 minutes might both be reduced in practice and still produce pears of good reconstruction and texture. The times used in these trials are much shorter than those required to rehydrate and cook dried pears as produced commercially at present. The presence of peel on the latter appreciably retards water uptake.

Prospects for Dried Pears

Increases in the sale of Australian dried pears at home and overseas are possible if the quality of the product is improved above that which is at present commercially available. With minor alterations in preparation, sulphuring, and sun-drying procedures, dried pears of a quality acceptable in the United States could be produced in Australia. The

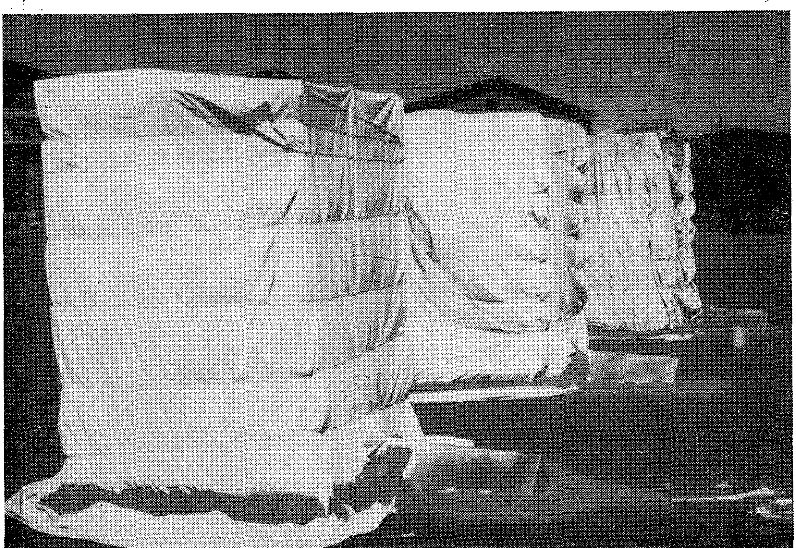

Fig. 2.—Sulphuring pears in P.V.C. tents at Shepparton, Vic.

resulting improved product would also undoubtedly be more acceptable to the local and other overseas markets.

The present trials confirmed experiments done earlier in this Division that showed that peeled, cored, and dehydrated pears of good quality can be produced. However, they are so different in colour and appearance from the sun-dried article, to which users have become accustomed, that they might need some promotion to gain consumer acceptance. In addition, a new system of quality grading would be needed to include this superior product. Treatments aimed at giving the dehydrated product a more distinctive flavour are regarded as unwarranted, since improvement is only slight and, indeed, the flavour of cooked, dehydrated pears was judged to be better than that of comparable canned material. The dehydrated pears contained about 2000 p.p.m. of sulphur dioxide which shows that the sulphuring time can be reduced to one hour—a distinct advantage over the extended times needed to give the same concentration after sun-drying.

These tests were restricted to Williams Bon Chrétien pears but the earlier trials in this Division showed that good-quality dehydrated pears could be produced also from Winter Cole, Winter Nelis, Josephine, and Packham varieties.

Microbial Spoilage in Australian Canned Foods, 1955-68

By K. C. Richardson
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In 1955 a survey was made of the results of the examinations of canned food spoilage carried out in the Division of Food Preservation. By mid 1968, 175 further occurrences had been investigated; in this article the author surveys the causes.

ANY fault which renders a canned food unsalable is considered to be spoilage and a number of different types may be distinguished. In Table 1 the 175 cases studied since 1955 are divided into a number of categories. To allow comparisons, the percentage incidence of the different types of spoilage in the 1955 survey is also included.

Corrosion of tinplate, including hydrogen swelling, is still a significant problem, but from the figures shown some improvements have occurred. Nitrite swelling, which occurs only in canned cured meats containing excessive amounts of added nitrite, has decreased in frequency, while carbon dioxide swells have increased. These latter occur in high-sugar foods stored under warm conditions; the reaction between sugars and organic acids is accelerated, leading to the release of carbon dioxide. The other three categories listed in Table 1 under non-microbial spoilage, viz. discoloration, tainting, and filling problems, are usually accidental and cannot be avoided

Table 1
Classification of Spoilage Cases

	Present Survey No.	Present Survey %	Kefford and Murrell (1955) %
Microbial spoilage			
Under-processing	46	26·3	15·0
Post-processing	64	36·6	31·7
Pre-processing spoilage	4	2·3	
Non-microbial spoilage			
Hydrogen swells	15	8·6	23·3
Other corrosion problems	13	7·4	8·3
Nitrite swells	4	2·3	3·3
Carbon dioxide swells	6	3·4	1·7
Discoloration	16	9·1	5·0
Tainting	2	1·1	6·7
Filling problems	5	2·9	5·0

by laboratory control. Proper factory and process supervision is the best way of minimizing these occurrences.

Incidence of Microbial Spoilage

The disturbing feature of the figures in Table 1 is the high incidence of microbial spoilage and the fact that it remains at least as great a problem as it was 15 years ago. Approximately 12 occurrences of microbial spoilage of commercial significance are examined in the Division each year and it seems certain that the actual incidence is much higher. No sector of the industry is free from spoilage problems and Table 2 shows the distribution of the 114 instances of microbial spoilage surveyed amongst the main classes of canned foodstuff.

Gillespy (1961) in a survey of the canned food industry in Great Britain stated that spoilage losses and complaints resulting from under-processing are now rare. The same cannot be said for the industry in Australia, although the incidence of spoilage from under-processing is considerably less than that from post-processing contamination. There were various causes of the under-processing, yet each was the result of carelessness or lack of technical control in the cannery. Some 70% of the cases examined came from well-established firms with many years' experience in the canning industry. It is unfortunate that the process and quality control procedures in these firms had not been developed to the stage where the possibility of spoilage of any kind had been reduced to an absolute minimum. With little difficulty, an inspection programme can be instituted that will ensure adequate processing of all cans to render them commercially sterile, and also ensure that can seams are correctly formed, thereby eliminating contamination of the product subsequent to processing.

Table 2
Distribution of Microbial Spoilage

Product	Type of Spoilage: Under-processing	Post-processing	Doubtful
Meat	16	21	5
Vegetables	10	20	3
Fruit	10	6	4
Fish	1	12	1
Milk	0	2	0
Pet food	1	2	0

Dreosti and Rowan (1958) in a comprehensive study of the fish canning industry in South Africa concluded that factory inspection of processes afforded a quicker, safer, and less expensive means of ensuring the microbiological soundness of a pack than did incubation and microbiological examination of small samples. This inspection procedure consisted of:

- Laying down minimum time–temperature processes
- Setting standards for retort equipment, temperature recorders, and seamers
- Calibration and daily checking of all retort instruments
- Chlorination of cooling water
- Regular inspection during canning operations of can seams and temperature and chlorination records to ensure that the process conforms to specifications

A similar programme should be within the capabilities of the staff of any Australian cannery. If management finds that this is not so, suitable staff should be employed for the express purpose of instituting and carrying out such a systematic check on processing operations. In their own interests, newcomers to the canning industry would be well advised to postpone production until their plant was staffed and equipped in a manner that allowed them to operate the same check. This type of control programme has the virtue of being a preventive rather than a detective procedure, as is a small-scale can incubation check.

Laboratory Examination of Suspected Microbial Spoilage

When microbial spoilage is suspected, the can is cleaned, opened aseptically, and a sample removed aseptically. The procedure used for subsequent examination is basically unchanged from that reported earlier (Kefford and Murrell 1955). However, nutrient agar is commonly used for aerobic plate counts in preference to brain heart agar. The choice of media for cultural work is governed by the nature of the product and the type of spoilage suspected.

If smears and cultures show a single type of sporing organism from all spoiled cans, i.e. a heat-resistant type, it is strong evidence for under-processing. When smears and cultures show a mixed population, including heat-labile types, cocci, coccobacilli, non-sporing rods, yeasts, and moulds, and the process is known to be adequate to destroy such organisms, then post-processing contamination is indicated. Leak tests on the affected cans usually support these findings. In low-acid foods a definite decision is usually possible, but in acid foods this is not always easy since survivors of under-processing may be similar to the organisms that commonly enter through leaks.

Under-processing

The examples in Table 3 were chosen to illustrate the causes of under-processing encountered during the period surveyed. The principal cause was simply the use of a process that was insufficiently severe to inactivate contaminating microorganisms. Processors who are developing new packs and have no facilities for determining heat penetration data may obtain information from the Division. Although canned foods, including those produced in Australia, have an outstandingly good record in the field of public health, the risk of botulism as a result of under-processing remains. This risk persists only because of the failure of many canners to establish their processes on a scientific basis. The fact that botulism has not been a significant problem to the Australian canning industry is largely a matter of chance.

Other factors resulting in under-processing included faulty retort operation, high initial spore loads in the can, low filling temperatures, and in at least one instance, failure to retort at all. Faulty retort operation can be avoided by regularly calibrating retort instruments, ensuring that correct venting procedures are followed, particularly if divider plates are used in the retort baskets, and

Table 3
Spoilage by Under-processing

	Bacteriological Examination		
Product	Microscopic	Cultural	Comment
Corned beef	Large no. of rods	Anaerobic, sporing rods	6% Incidence; sporing anaerobe of unusually high resistance cultured
Corned beef	Small no. of long slender rods	10^2–10^6 Anaerobic spore formers/g	Inadequate process for each type of organism cultured
Corned beef	Up to 20 rods/field	Sporing rods at 50°C	Process adequate, retort instrumentation or operation faulty
Casserole steak	50–100 Rods/field	Sporing rods at 30 and 50°C	Some meat packed frozen resulting in low initial temperatures
Casserole steak	Large no. of rods and cocci/field	Sporing rods	Standard process given; high initial population probable cause of spoilage
Baby food	Approx. 20 thin rods/field	Thermophilic, anaerobic sporing rods	High spore count in yeast added to baby food
Peas	50–100 Rods/field	Thermophilic, anaerobic, gas-producing sporing rods	90% Incidence at 50°C; organisms which survived the process contained in ingredient sugar
Mixed vegetables	No organisms seen	Short rods; some sporing at 50°C	Normal process not adequate for this organism
Mushrooms in butter sauce	20 Medium rods/field	Small no. of thin rods grew at 50°C. No spores seen	Autosterilization appeared to occur in cans. Source of contamination could not be identified
Pears	30–50 Rods/field	Rods at 30°C on Clark and Dehr (1947) medium	*Cl. butyricum* type survived process
Tuna	20–30 Rods/field; some cocci	10^7 Rods and cocci/g	85% Incidence. No leaks in cans but viable heat-labile types present

strictly adhering to recommended time and temperature schedules for a given product. With some products, e.g. mushrooms, it is difficult to obtain a pack with a low initial spore load. More frequently, however, an ingredient such as sugar, starch, or a spice is the source of a high spore load. Canners can minimize this problem by specifying microbiological standards to suppliers of additives. Periodic spore counts to check whether the ingredients comply with the specification are necessary.

All processes for canned foods recommended by the Division and overseas laboratories are calculated from a minimum filling temperature. When the actual filling temperature is lower than the one for which the process was calculated, the lethality of the recommended process to contaminating microorganisms is reduced. Most processes include a safety margin but if material having a very low temperature is packed, processing may be inadequate to prevent spoilage of the finished product. This is particularly important with some meat-loaf packs to which ice is added in an attempt to minimize fat rendering during processing. If ice remains in the mix when it is canned, under-processing may result if the latent heat required to melt the ice in the initial stages of the process has not been allowed for.

Failure to retort a batch of cans can only result from mismanagement in the retorting area. All baskets or crates containing unretorted material should be plainly marked. Cans of unknown processing history should be discarded.

Post-processing Contamination

Post-processing contamination or leaker spoilage accounted for about 60% of the spoilage outbreaks investigated. The number, 64, reflects lack of process control by both can-maker and canner. Approximately one-third of the demonstrated leaks were at the can-maker's end while the others could be attributed mainly to faults in the canner's closing machine. Since the risk of food poisoning must also be associated with any case of post-processing contamination, quite apart from the considerable financial loss usually occasioned, the canning industry cannot afford to be complacent about present post-processing hygiene standards and handling methods. In addition to cans that blow and can be sorted out, numerous cans undoubtedly are infected by leakage and spoil without blowing. These cans reach consumers and could be eaten or at least tasted. Gillespy (1961), in the survey mentioned earlier that covered the production of 15,000 cans taken at random from 22 canneries, states that at least as many cans are infected by leakage and spoil without blowing as do blow.

A spectacular example of this was seen in the outbreak of typhoid in Aberdeen in 1964. Howie (1968) in a review of this outbreak sets out practical and experimental evidence to indicate how pathogens such as *Salmonella typhi* can infect a can after processing, without any subsequent sign of such infection. He also points out that, under certain conditions, it is quite possible for some pathogenic organisms to outgrow other post-processing contaminants, so mixed infection does not represent any safeguard, since infected cans may still not blow. It is probably true that in Australia staphylococcal food poisoning, rather than typhoid, is more likely to result from leaker infection but neither illness is pleasant and a single outbreak of either proved to be caused by infection of canned foods would severely harm the traditional image of the safety of these products.

In Table 4 a number of examples of spoilage diagnosed as post-processing contamination are set out. The construction of the modern can and the high-speed can-handling techniques currently in use mean that the can-maker and canner must maintain close quality control on all areas of their operations if post-processing contamination is to be reduced.

Pressure leak tests and seam examinations on cans from several periods in each day's production should be run to check the performance of each piece of equipment. Rough handling of cans at all stages of production should be eliminated. Cooling water should be chlorinated and periodic checks carried out to determine the chlorine concentration. Samples for these checks should be drawn from the can cooling area where the chlorine level should be 5 p.p.m. In addition, cans should be dry before discharge into the can handling and storage system, which should be as clean and sanitary as other parts of the

Table 4
Spoilage from Post-processing Contamination

Product	Bacteriological Examination: Microscopic	Bacteriological Examination: Cultural	Comment
Stewed steak	Large no. of cocci and rods	Sporing bacilli, non-sporing bacilli, cocci	Seams leaked at 1–10 p.s.i. (C.E.*)
Stewed steak	Large no. of cocci and rods	Cocci and rods	Seams leaked at 5–15 p.s.i. (C.M.E.†)
Corned beef	50 Rods and cocci/field	Non-sporing rods and cocci	Cans too distorted for leak test but bacteriological evidence indicates leaks
Chicken and vegetable soup	50 Rods, cocci, and yeasts/field	—	Leaks at low pressures at lap (C.M.E.)
Peas	Large no. of non-sporing organisms	—	Seams leaked at 20–30 p.s.i.; perforations at embossing (C.E.)
Peas	Large no. of non-sporing bacilli	—	Both ends leaked at 1–10 p.s.i.
Peaches	Large no. of rods and cocci/field	Heat-labile rods and cocci	Seams leaked at 2–5 p.s.i. (C.E.)
Pears	30–40 Rods and cocci/field	—	Lap leaked at 5–15 p.s.i. (C.M.E.)
Tuna	2–10 Rods/field	10^3 Rods/ml at 30 and 50°C. Some spores	No solder in side seam
Evaporated milk	—	10^4–10^6 Cocci and short rods/g	Seam faulty at junction with side seam (C.E.)

* Canner's end. † Can-maker's end.

cannery. There is strong evidence that risk of infection persists as long as the outside of a can is wet and the avoidance of external contamination of cans while wet is entirely a matter of cannery hygiene.

Pre-processing Spoilage

The four instances of pre-processing spoilage listed in Table 1 occurred in meat products. Microscopic examination of smears taken from the product showed large numbers of heat-labile organisms that did not grow when inoculated on suitable culture media. No leaks could be detected in the cans that were examined and there was no evidence of over-filling, which may cause swelling of cans. Since the organisms had been destroyed by the process, it was concluded that delay between filling and processing of the cans had resulted in the production of sufficient gas to swell the can. This problem should never occur in an efficiently organized cannery.

Many of the outbreaks of spoilage included in this survey resulted in considerable financial loss to the processor and faulty canning practice might even have led to an outbreak of food poisoning, reflecting on the whole canning industry. Without exception the instances of microbiological spoilage examined were caused by carelessness during production or failure to appreciate the fundamental principles of food canning. Such deficiencies have no place in a modern competitive industry and should be eliminated.

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Financial Contributions, 1968/69

As in previous years, the Division of Food Preservation has received considerable support for its work from sources other than the Commonwealth Treasury. In the year ending June 30, 1969, the Division had a budget of $1,651,756, of which $1,354,229 came directly from the Commonwealth Treasury. Various Government Departments and statutory bodies contributed $278,562 and the food industry and related industries $18,965. In addition, the Australian Meat Board and the Australian Meat Research Committee provided a substantial sum towards the capital cost of the final stage of the Division's Meat Research Laboratory at Cannon Hill, Queensland, which was occupied in April 1969. Some of the assistance received from the food industries took the form of reimbursements for expenditure on investigations. Cottee's General Foods Ltd. contributed funds for the modification of a piece of food processing equipment, and Arnotts Biscuits Pty. Ltd. donated a large run of *Chemical Abstracts*.

The Division of Food Preservation is most grateful to the organizations which have so generously assisted its work, and has the greatest pleasure in warmly acknowledging their help.

Government Departments and Statutory Bodies

Australian Apple and Pear Board
Apple and pear storage investigations

Australian Dried Fruits Association
Investigations on dried tree fruits

Australian Meat Research Committee
Research on the quality, processing, storage, and transport of meat; also on the mechanical skinning of sheep

Department of Primary Industry
Fruit fly sterilization investigations (funds contributed by the Commonwealth, six States, and the Australian Banana Growers' Council)

Metropolitan Meat Industry Board, Sydney
Muscle biochemistry investigations

N.S.W. Department of Agriculture
Fruit storage investigations

National Packaging Association of Australia
Investigations on food packaging

Queensland Fish Board
Grant for research on the occurrence and prevention of taints in mullet

U.S. Department of Agriculture (Public Law 480 Funds)
Research on cyclopropenoid compounds

Wheat Industries Research Council
Studies on plant physiology

Australian Honey Board
Research on honey quality

Contributors to Food Industries Equipment Account, 1968/69

W. Angliss & Co. (Aust.) Pty. Ltd.
Ardmona Fruit Products Cooperative Co. Ltd.
William Arnott Pty. Ltd.
Associated Products and Distribution Pty. Ltd.
Australian Bakels (Pty.) Ltd.
Australian Cellophane (Pty.) Ltd.
Australian Consolidated Industries Ltd.
Australian Fibreboard Containers Manufacturers' Association
Australasian Food Research Laboratories
Australian Packaging Industries Pty. Ltd.
Berri Co-operative Packing Union Ltd.
Berri Fruit Juices Co-operative Ltd.
Blue Moon Fruit Co-operative Limited
Campbell's Soups (Aust.) Pty. Ltd.
Cascade Cordials Pty. Ltd.
G. Centofanti & Sons
Cerebos (Australia) Ltd.
Citrus Products Co.
Coca-Cola Export Corporation
Conkey & Sons Ltd.
Containers Ltd.
Sidney Cooke Pty. Ltd.
Corona Essence Pty. Ltd.
Craig Mostyn & Co. Pty. Ltd.
Cygnet Canning Co. Ltd.
Dark's Ice & Cold Storage Ltd.
Darling Downs Cooperative Bacon Association Ltd.
Davis Gelatine (Aust.) Pty. Ltd.
Gordon Edgell Pty. Ltd.
Elmer Products Pty. Ltd.
F.M.C. (Aust.) Limited
Fremantle Cold Storage Co. Pty. Ltd.
Frig-Mobile of Australia Pty. Ltd.
J. Gadsden Pty. Ltd.
W. G. Goetz & Sons Ltd.
Golden Circle Cannery
Gordon Bros. Pty. Ltd.
Griffith Cooperative Cannery
Griffith Producers Cooperative Co. Ltd.
Gumeracha Fruitgrowers Co-Op. Ltd.
Keith Harris & Co. Ltd.

H. J. Heinz Company Aust. Ltd.
Hunter Valley Co-operative Dairy Co. Ltd.
H. Jones & Co.
Jusfrute Limited
Kyabram Preserving Co. Ltd.
Lawley & Housego Pty. Ltd.
Leeton Cooperative Cannery Ltd.
McCarron Stewart Ltd.
Marrickville Margarine Pty. Ltd.
Master Foods of Australia Pty. Ltd.
P. Methven & Sons Pty. Ltd.
Mountain Maid Foods Cooperative Ltd.
Muir & Neil Pty. Ltd.
Nestlé Company (Aust.) Ltd.
Northern Pear Growers Association Ltd.
Nugan (Griffith) Pty. Ltd.
Orange Fruitgrowers Cooperative Cool Stores Ltd.
Overseas Containers Ltd.
Harry Peck & Co. (Aust.) Pty. Ltd.
W. C. Penfold & Co. Pty. Ltd.
Pict Ltd.
P. & O. Lines of Aust. Pty. Ltd.
Pick-Me-Up Food Products
Producers Cold Storage Ltd.
Producers Co-operative Distributing Socy. Ltd.
Queensland Cold Storage Cooperative Federation Ltd.
Reckitt & Coleman Pty. Ltd.
Riverland Fruit Co-operative Ltd.
Roche Products Pty. Ltd.
Schweppes (Aust.) Ltd.
Shepparton Preserving Co. Ltd.
Sidac-Rayophane (Aust.) Pty. Ltd.
South Australian Fisherman's Cooperative Ltd.
Sulzer Bros. (London) Ltd.
Swift Australian Co. (Pty.) Ltd.
Taraxale Brewing Co. Pty. Ltd.
Taubmans Industries Ltd.
Tooheys Ltd.
Uncle Ben's of Australia Pty. Ltd.
Union Carbide Aust. Ltd.
United Fruit Company Pty. Ltd.
F. J. Walker Limited
Western Australian Ice & Cold Storage Association
George Weston Foods Ltd.
Winn Food Products
Woolworths Ltd.
XLNT Food Pty. Ltd.
Arthur Yates & Co. Pty. Ltd.

NEWS FROM THE DIVISION OF FOOD PRESERVATION

Demonstrations for Schools

On July 3 and 4, 1969, the CSIRO Division of Food Preservation, the CSIRO Wheat Research Unit, and the Bread Research Institute of Australia, which are in the same grounds at North Ryde, N.S.W., mounted the following exhibits for the benefit of senior students from secondary schools in the Sydney metropolitan area.

Respiration and ripening of fruits—A demonstration of the biological principles on which the cold storage of fruit is based.

Electrochemistry—A demonstration of the electrochemical methods used in the study of the corrosion of containers made from tinplate and other metals.

Concentration of fruit juices—A demonstration of the physical principles used in modern methods for concentrating or drying liquid foods.

Inheritance of quality in wheat—An exhibit to show that the individual proteins in a grain of wheat are inherited, and may be associated with particular chromosomes.

Application of science to bread-making—A demonstration of how the properties of a natural product (flour) may be modified by physical, chemical, and biochemical means to make a food (bread).

Over 600 students from 78 schools visited the demonstrations, which were given in six 2-hour sessions spread over the two days. The students, with their teachers, were welcomed by Mr. M. V. Tracey, Chief of the Division of Food Preservation, and escorted in parties of about 20 to the five exhibits, where demonstrators delivered lecturettes.

Overseas Travel

Dr. W. G. Murrell, Senior Principal Research Scientist in the Division's Microbiology Section, is spending 12 months working in and visiting overseas laboratories engaged in research on bacterial spores. He left Australia on May 24, 1969, to spend 3–4 months at Colworth House, the Unilever Research Laboratory at Sharnbrook, Bedfordshire, and 4–5 months at the Molecular Biophysics Laboratory in the Department of Chemical Microbiology at Oxford. Subsequently he will visit research laboratories in France, Italy, and U.S.A., returning to Australia early in May 1970.

Mr. E. G. Hall, leader of the fruit and vegetable storage investigations at the North Ryde laboratories, spent June and July 1969 studying the performance on shipboard of modern standard containers conveying apples and pears from Australia to Great Britain, and condition of the fruit at out-turn. After a month on long-service furlough, part of which was spent in Poland, Mr. Hall visited packaging and market research institutions, packing houses, and fruit stores in Great Britain, France, and Italy, and studied the harvesting, packaging, and transport of apples and pears. In September he attended meetings of two commissions of the International Institute of Refrigeration in Budapest, and a Conference on Tropical and Subtropical Fruits in London. In the course of his return to Australia (by late October) Mr. Hall visited fruit research stations in West Pakistan, and made observations in Singapore for the Australian Apple and Pear Board.

Mr. L. E. Brownlie, leader of the industrial liaison and extension group at the Division's Meat Research Laboratory at Cannon Hill, Queensland, spent June, July, and August 1969 studying the latest developments in meat technology in U.S.A. and Canada, in Great Britain, and on the continent of Europe. From June 11 to 16, Mr. Brownlie attended the Conference of the American Meat Science Association at Pomona, California. Later in the month he took part in a course on Salmonella in Food, conducted by the U.S. Public Health Service, in Atlanta, Georgia. In August he attended the Conference of European Meat Research Workers in Helsinki, Finland.

Mr. W. A. Montgomery, who is engaged on fish preservation investigations at Ryde, visited the United States and Canada during July to attend a Conference on Fish Inspection and Quality Control, conducted at Halifax, Nova Scotia, by the Food and Agriculture Organization of the United Nations. Mr. Montgomery also visited laboratories conducted by the U.S. Bureau of Commercial Fisheries and by the Fisheries Research Board of Canada, where he studied the technology of fish, shellfish, and fish products.

Documentary Services of F.A.O.

The wealth of technical, economic, and social information contained in some 25,000 publications and documents produced by the Food and Agriculture Organization of the United Nations (F.A.O.) since its creation in 1945 is now readily available through the services provided by the F.A.O. Documentation Centre.

The monthly *Current Index* published since January 1967, together with the retrospective *Special Indexes* for the period 1945–66, permit the selection of documents of interest in the fields of agriculture, fisheries, forestry, nutrition, rural economy, etc., through thousands of subject matter, author, and title references in each field.

A 'Question and Answer' service provides, on request, *ad-hoc* bibliographies on specific subjects.

Documents of interest can be obtained in original form (printed or mimeographed) or, if out of stock, as photocopies or microfiches.

The *Current Index* is sent, free of charge, on request. Details of other services (Retrospective Indexes, 'Question and Answer' Service, Reproduction Services) may be obtained by writing to: FAO Documentation Centre (Ref. P.69), FAO Headquarters, Via Terme di Caracalla, 00100 Rome, Italy.

Selected Publications of the Division

Copies of most of these papers are available from the Librarian, CSIRO Division of Food Preservation, P.O. Box 43, Ryde, N.S.W. 2112 (Telephone 88 0233).

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