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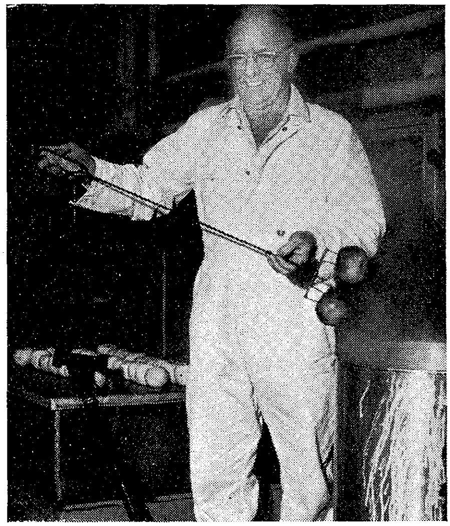
# Trends in Apple Processing in the U.S.A.

By M. J. Powers

Department of Food Science and Technology,
Washington State University, Pullman, U.S.A.



Professor Powers is an authority on apple processing and spent a sabbatical year at the Division of Food Research in 1971; the photo shows him conducting experiments on lye-peeling of apples in the pilot plant at the CSIRO Food Research Laboratory.

The U.S.A., West Germany, and Italy are the world's leading producers of apples and together supply nearly half of the world apple crop (Table 1); other major producers include France, Japan, and Britain. The U.S.A. produces about 150 million bushels each year, 19·4% of the total, and Australia about 22 million bushels or 2·8%. Only about 10% of the world apple crop is traded internationally. Leading exporters are Italy, France, Argentina, and Australia, while West Germany and Britain are the principal importers.

Table 1

World Production and Trade of Fresh Apples*

(Millions of 42-lb bushels)

| Region and country | Production Aver. 1968–70 | Exports Aver. 1967–69 | Imports Aver. 1967–69 |
|---|---|---|---|
| N. AND S. AMERICA | | | |
| U.S.A. | 149·1 | 2·9 | 2·2 |
| Others | 57·9 | 16·8 | 8·0 |
| EUROPE | | | |
| West Germany | 103·2 | <1 | 30·3 |
| Italy | 101·0 | 19·6 | <1 |
| France | 94·4 | 18·1 | 3·0 |
| Britain | 22·1 | — | 13·7 |
| Others | 111·5 | 6·4 | 18·6 |
| PACIFIC | | | |
| Japan | 57·0 | 1·1 | — |
| Australia | 22·5 | 7·1 | — |
| New Zealand | 6·2 | 2·3 | — |
| WORLD TOTAL | 776·2 | 87·5 | 79·0 |

*Condensed from U.S. Department of Agriculture (1971).

The main varieties of apples grown in the United States, the quantities produced, and the production areas are shown in Table 2. The leading producing States are Washington (21%), New York (15%), and Michigan (12%), followed by Pennsylvania, California, and Virginia.

### Apple Products

About 45% of the U.S. apple crop is processed; this percentage has slowly increased in recent years and is expected to rise considerably in the future. Of the apples processed in 1970, 44% were crushed for juice, cider, and vinegar, 43% were canned, 7% were frozen, and 6% were dried, mainly in Washington and California. Washington State, which produces 21% of the national crop, sells 80% of these apples on the fresh market. Of the 20% processed, half is dried, and most of the remaining portion crushed for juice or related products. Over 95% of Washington State apples on the fresh market are now highly polished for cosmetic effect by the use of spray-on self-polishing waxes based on shellac and carnauba wax.

Americans have now learnt how to utilize their apple crops almost fully—a contrast

Table 2
Production of Fresh Apples in the U.S.A. for 1970*

| Variety | Harvest time | Production (million lb) | Leading producing States |
|---|---|---|---|
| Delicious | Winter | 1816 | Washington, California, Virginia, New York |
| Golden Delicious | Winter | 823 | Washington, Pennsylvania, Virginia, New York |
| McIntosh | Winter | 720 | New York, New England |
| Rome Beauty | Winter | 526 | New York, Pennsylvania, West Virginia, Washington |
| Jonathan | Fall | 429 | Michigan, Missouri, California |
| York Imperial | Winter | 357 | Pennsylvania, Virginia, West Virginia |
| Stayman | Winter | 284 | Pennsylvania, Virginia |
| Winesap | Winter | 211 | Washington, Virginia |
| Yellow Newtown | Winter | 175 | California, Oregon |
| Cortland | Winter | 167 | New York, New England |
| R.I. Greening | Winter | 155 | Eastern States |
| Northern Spy | Winter | 133 | Eastern States |
| Gravenstein | Summer | 103 | California |
| Baldwin | Winter | 72 | New York |
| All others | | *c*.484 | |
| Total all varieties | | 6455 | |

*Condensed from U.S. Department of Agriculture (1971).

with the situation in certain areas in the past, when large surpluses had to be abandoned. The proportion of the U.S. apple crop not utilized was only 0·41% in 1968, 1·63% in 1969, and 2·2% in 1970; this year, there is actually a serious shortage of apples for processing.

### Production Trends

Data on the production of canned apples and other fruits in the U.S.A. are given in Table 3. The large production of apple sauce is of interest since the figures approach those for canned pineapple, and are greater than those for fruit cocktail or canned pears. Apple sauce is often the least expensive of canned fruits in the U.S.A. and many Americans eat it as a principal meal item rather than a condiment as in Australia; it is an 'instant food', a favourite of many children, and is often home-canned or freshly prepared. Apple sauce is also a popular food in Germany, Switzerland, and the Netherlands.

Canned sliced apple, which is used mainly by bakeries for pies, is meeting strong competition from both fresh-peeled and frozen slices. The production of canned apples averaged 3·6 million cases during 1960–64 and increased to a maximum of 4·1 million cases in 1965, but has since declined. Production of canned apple juice is somewhat less than of tomato, grapefruit, and orange juices.

Table 3
Production of Canned Apple Products and other Leading Fruit Products in the U.S.A.*

| Canned product | Production calc. as millions of cases of 24 × $2\frac{1}{2}$ cans 1965 | 1970 |
|---|---|---|
| Apples† | 4·1 | 2·1 |
| Apple sauce | 15·9 | 14·1 |
| Apple juice | 9·7 | 14·5 |
| Peaches | 30·0 | 33·4 |
| Fruit cocktail‡ | 14·5 | 13·1 |
| Pineapple | 15·0 | 16·9§ |
| Pears | 6·4 | 8·6 |
| Red sour pitted cherries‡ | 2·4 | <1 |
| Tomato juice | 30·6 | 27·9 |
| Grapefruit juice | 12·2 | 20·1 |
| Pineapple juice | 13·6 | 13·6 |
| Orange juice | 14·1 | 17·1§ |

*Condensed from Anon. (1970).
†Mainly pie-pack. ‡California only.
§Production for 1969; 1970 not available.

Production figures for dried and frozen apples are not available, but it appears that the production of dried apples has been relatively constant at about 8% of the apples processed while the production of frozen apple products, mostly as slices for pies, has been gradually increasing and now accounts for about 10% of the apples processed.

### Apples for Processing

The older concept of classifying apple varieties into categories for 'dessert use', 'processing', or 'dual purpose' is disappearing. The approach now is to aim for major profits from fresh market sales, and to be aware that some varieties may be stored longer or may be processed more readily than others. Surpluses of existing varieties are used for processing as part of an integrated operation. In the Pacific Northwest there are three large grower-owned companies each of which packs and markets both fresh and processed apples. The different varieties of apple are used according to their suitability for making into particular products, and quality standards are modified to suit the characteristics of these varieties.

These points are illustrated by the commercial use of dessert and summer apples for the production of apple juice. Red Delicious and Golden Delicious, the leading dessert varieties, have very low titratable acidities (0·2–0·3% malic acid) and thus failed to meet earlier standards set by the United States Department of Agriculture (U.S.D.A.) for apple juice, which required between 0·35 and 0·7% acid. Recent sales of juice made from these varieties were so successful that U.S.D.A. agreed to reduce the minimum acidity for Grade A juice from 0·35% to 0·25% malic acid. In addition, a new category, Grade B, was introduced with an acidity not less than 0·20% malic acid and with the minimum soluble solids content reduced from 11·5° to 10·5° Brix.

A new style of apple sauce having a very bright golden colour, coarser texture, and added malic acid is now being made from Golden Delicious apples. This sauce is being sold at premium prices and in good volume by two major Pacific Northwest canners. The Gravenstein apple, a summer variety of high flavour, is being very successfully processed into juices, purées, and solid packs, most of which sell at premium prices, and these products again supplement fresh market sales.

Prices paid to growers vary with the use of the fruit. Tukey and Doran (1969) reported that the following average prices were paid to growers for all varieties in Washington State during the period 1958–67:

| | |
|---|---|
| Fresh market | $US122 per tonne |
| Canning and freezing | $US56 per tonne |
| Drying | $US40 per tonne |

The apples used for processing were mainly sort-outs from fresh market sales.

### Technological Developments

Apples for processing are ripened, washed, and graded for size, and fruit that is obviously defective is removed. Small apples are usually diverted to juice production. Apples for other processed products are usually peeled and cored.

*Peeling*

Much fruit is still peeled on the earlier types of mechanical peeler. These peelers are not costly and are suitable for irregularly shaped fruit but they require labour for hand-feeding. Peeling losses are usually in the range 15–25%, then the losses from coring, seed-celling, and trimming bring the total losses to about 35–40%, ranging up to 50%.

Spinning-knife mechanical peelers* are now widely used, and are especially suited to smooth, rounded fruit. These units may reduce weight losses, including losses from cores and seed cells, to 30% or less. They automatically orient and feed the apples to the peeling and coring operations. In Australia these peelers have been adapted to work satisfactorily on pears.

Peeling of apples by chemicals, heat, and mild abrasion is now being introduced; remarkably low peeling losses of 5–8% are obtainable. Wax solvents or softeners are used during the lye treatment because apples have a waxy coating. Recent developments have included the use of alcohols, detergents, or fatty acids as wax softeners. Harrington and Hills (1964, 1968) reported that either ethyl or isopropyl alcohol worked well at the U.S.D.A. Eastern Regional Research Laboratory. A mixture of fatty acids called Faspeel has been developed and patented by the Wyandotte Chemicals Corporation. Fas-

*Atlas Pacific Engineering Co., 34 Queens Road, Melbourne, Vic. 3004.

peel is an approved additive in the U.S.A. and is effective at 1% concentration in 20% sodium hydroxide at about 66°C.

A new peeling process developed by the FMC Corporation* involves immersing the apples in warm lye, containing sodium or potassium hydroxide; after a short holding time the apples are given a brief high-pressure steam treatment; they are then rinsed for 4 s under water sprays at 415 kPa gauge (60 p.s.i.g.). The commercial installation at the Diamond Fruit Growers' plant, Hood River, Oregon, has attracted much interest and a description of the process has been published (Anon. 1971). A commercial apple peeler is shown in Figure 1, and a pilot-scale unit installed in the author's laboratory at Washington State College is shown in Figure 2.

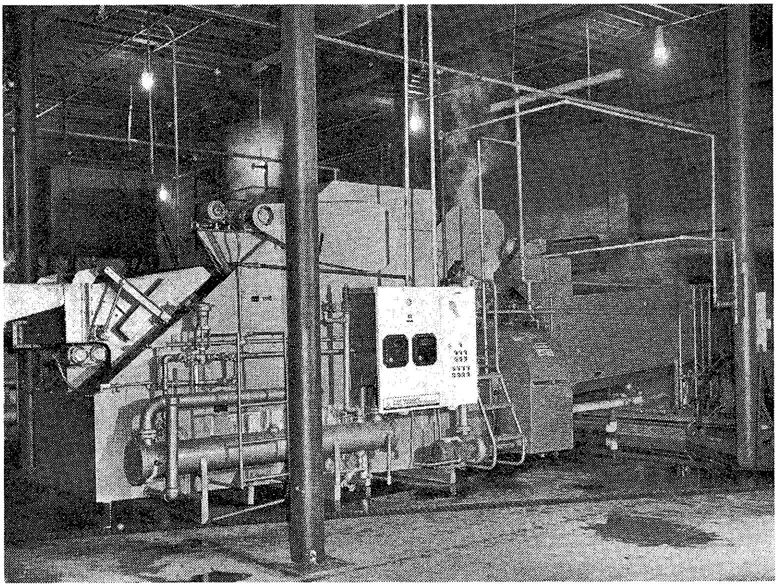


Fig. 1. — Commercial FMC apple peeling line.

*Coring and Seed-celling*

Apples for coring are oriented by hand operators, or by floating the fruit in water and completing the orientation with small mechanical 'feelers'. The automated procedures give better results with round or oval apples than with apples with a squarish shape such as Red Delicious.

'Seed-celling', or enlarging the core cavity to remove carpels, may be done either at the time of coring or after coring. Machines are available for coring and/or seed-celling, and slicing, and a new FMC machine is one example (Figs. 3 and 4). On this machine two women are enough to watch the six lines of peeled apples to ensure that the cores are oriented correctly for coring and slicing, which are entirely automatic. Other companies are reported to be working on corer–slicers with good prospects for success.

## Canning and Freezing

*Blanching*

Sliced apples for canning are blanched to inactivate enzymes, displace intercellular air, soften the tissue, shorten the heat sterilization process, and help in packing the required weight.

Water and steam blanching have generally been replaced by vacuum blanching. One popular type of equipment for vacuum blanching was described by Atkinson (1956)

*F.M.C. (Aust.) Ltd, 58 Whiteside Road, Clayton, Vic. 3169.

and consists of a battery of several tall, slender cylinders which are filled at the top and emptied at the bottom through a tapered cone, closed with a hinged metal door. The blanchers are often placed above the filling tables so that the treated slices may be delivered by gravity to the filling operation. The vacuum is applied for 3–10 min depending on the vacuum achieved and the size of the pieces of apple, and is then broken by admitting clean steam until atmospheric pressure is reached. The free liquid formed during vacuum blanching may be added as permissible liquor to fill voids between slices in the can.

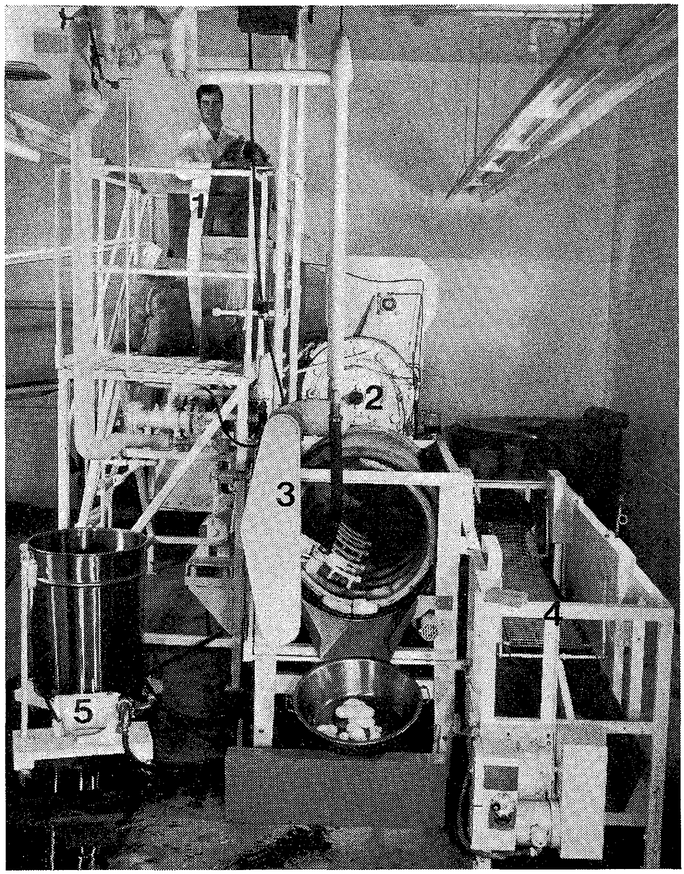



Fig. 2. — FMC pilot plant, Washington State University, comprising (1) rotary alkali peeler, (2) steam pressure valve, (3) rubber-lined reel washer, (4) dry-peeler (optional), and (5) pump.

Vacuum blanching equipment incorporating a barometric leg was described by Kitson in 1967. In a similar blancher used in Washington State, the belt conveyor in the elevated vacuum chamber has been replaced by a twin-screw conveyor. Vacuum blanching using this equipment involves pumping the slices of apple in cold dilute brine to a vacuum chamber 10–11 m high and conveying the slices through the vacuum chamber for 4–10 min. The slices then descend through a pipe filled with cold dilute liquor and are discharged to the atmosphere. A vacuum pump is required to remove the gases given off by the slices at the top of the barometric leg. The slices impregnated with liquor by the vacuum treatment are blanched in hot water or steam before canning. Blanching times are slightly reduced in the impregnated slices and the resulting texture is good; the process is automated and continuous and therefore requires less labour than conventional methods. There is, however, some leaching, and two operations are required, i.e. passage through the barometric leg and subsequent heat treatment.

softening; moreover, this treatment is favoured by public health authorities.

*Vacuum Filling with Ascorbic Acid*

I have found that the following solution is suitable for vacuum impregnating apple slices:

| | |
|---|---|
| Ascorbic acid | 0·25% |
| Citric or malic acid | 0·25% |
| Sodium chloride | 0·10% |
| Sucrose | 10·0% |

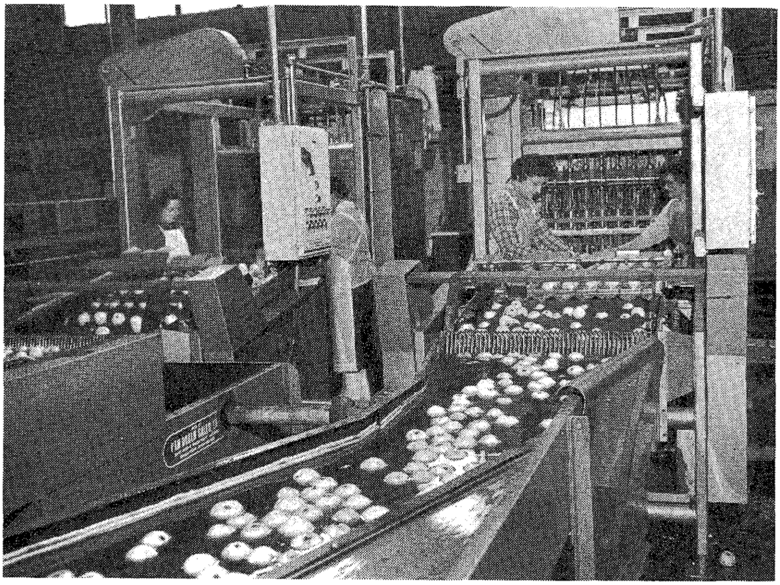


Fig. 3. — Peeled apples flumed to corer–slicer.

Apple slices for freezing are blanched as for canning to inactivate oxidative enzymes, or vacuum infiltrated with antioxidants such as sulphites or ascorbic acid in order to prevent darkening.

Sulphiting is commonly used and is very effective, but sulphites impart an astringent off-flavour which becomes objectionable at higher concentrations unless removed by cooking. Blanching usually softens the texture, but this undesirable effect may be reduced by vacuum filling with water before blanching. Vacuum filling with ascorbic acid solution, usually with some added sugar and salt, may become the preferred treatment since there are no problems of off-flavours or

The thin-cut slices are immersed in the solution for 6 min at 49·5 cmHg vacuum, the vacuum is released, and the slices are kept immersed for 2–3 min while the solution penetrates. After treatment the slices are drained, packaged, and frozen.

In order to evaluate the colour stability of the final product, the slices should be frozen, thawed, and held in air for three hours, or preferably made into pies. If additional protection is desired more ascorbic acid or a very low level of sulphite may be added.

*Sulphiting for Freezing*

The slices are immersed for 1–2 min in a solution of about 1·0% sulphur dioxide, and are then held until there is complete penetration of the sulphite. Some processors prefer to prepare the sulphite solutions from dry chemicals and use a solution of 2·0% sodium bisulphite (58% $SO_2$) and 1·0% citric acid. Complete penetration is needed to prevent browning of the centres of the slices after freezing and thawing. Principal factors influencing the rate of sulphite penetration are the type of apple, thickness of cut, acidity of solution, and temperature. A solution of 1% catechol applied to a broken section of the slice is used to show how deeply the sulphite has penetrated. Pies made from properly sulphited slices have a bright appearance and are free from browning.

*Freezing*

Many processors have converted from solid-pack freezing to the freezing of the separate apple portions on wire-mesh belts with vertical-flow air. This system may induce some flotation or tumbling of the slices and with air temperatures of −35°C to −40°C very rapid freezing occurs.

Most of the frozen slices are used by bakeries and institutions. Some are packed in lacquered, 14-kg friction-top cans, but increasing amounts are being packed in less costly and more compact cardboard cartons with polyethylene liners. All apple pie filling must be in the form of tender slices or chunks; a mushy or sauce-like filling is not commercially acceptable.

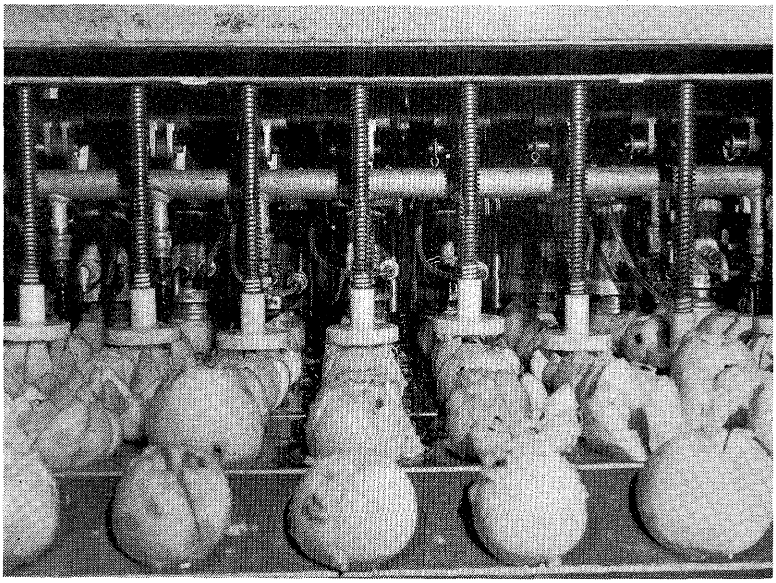


Fig. 4. — Apples leaving corer–slicer.

Frozen apple slices are a principal raw material for unbaked apple pies for retail sales. These pies are assembled in lightweight aluminium dishes, with a thin bottom crust of unleavened dough, a fruit–sugar–gel filling, and a thin, perforated, unleavened dough cover. The pies are packaged in attractively decorated cardboard boxes which carry directions for baking when taken directly from the commercial or home freezer. There is a moderate demand for prepared apple pie mixtures which usually contain vacuum-blanched slices with added sugar, spices, and gelling agents, often alginates.

*Spiced Apples or Apple Rings*

Apple rings, cuts, or sometimes crab-apples are artificially coloured red or green and canned in spiced syrup to be used as a condiment or garnish. Because the product is colourful it is often packed in 455-g glass jars to enhance sales appeal. The fruit texture must be firm and free of breakdown. These packs are expensive and are mainly used for festive occasions such as Thanksgiving and Christmas.

### Apple Sauce

Apple sauce is a cooked sieved apple product which consumers expect to be juicy and succulent, and to flow or spread when poured onto a flat surface. As has already been mentioned, it is widely sold in the U.S.A. either canned or packed in glass.

The best apple sauce is made from ripe fruit, which is peeled, cored, and trimmed, cooked by clean steam in screw-cookers, and passed through a finisher. Sucrose or corn syrup is added to give a soluble solids content of at least 16·5% by refractometer, or more commonly around 18%, together with citric or malic acid and sometimes a very small amount of salt. Premium prices are paid for the yellow sauce prepared from Golden Delicious apples, and for the sauce of distinctive flavour from Gravenstein apples.

Apple sauce may be spiced with cinnamon and nutmeg, and is then so labelled. When ground spices are used the colour may be considerably darkened but this darker colour is considered acceptable. Sometimes berry fruits such as raspberries are added to apple sauce and the product is sold under the registered trade name of Appleberry Sauce.

### Fresh Apple Slices for Bakery Use

Fresh, peeled, cored, and sliced apples are often used for pies by bakeries. The apples used are sound fruit but may have inferior skin colour or quality. They are mechanically peeled and cored, hand-trimmed, and fed to slicers. Immediately after slicing, a mild sulphite treatment is given and the slices are held at −0·6°C to 4·4°C. Since the slices are not frozen the sulphite does not need to penetrate to the centre of the slice. The product is packed in plastic-lined cartons, or in lacquered cans holding 13·5 kg.

A sulphite treatment that is claimed to give improved texture, decreased sulphite content, and good retention of colour for up to 21 days, is described by Bolin *et al.* (1964). Slices are first dipped into a solution of 0·25% sodium bisulphite ($NaHSO_3$) for 45 sec, then into a 0·20% solution of dibasic potassium phosphate ($K_2HPO_4$) which has a pH of 8·8. The higher pH value is believed to modify the surface constituents of fresh cut apples in such a way that enzymic browning is greatly diminished.

### Dried Apple Products

U.S.D.A. standards define *dried* apple as having less than 24% moisture and *dehydrated* or *low moisture* apple as having less than 2·5% or 3·5% moisture. The apple drying industry is making steady progress; the products have good quality, production methods are flexible, and labour costs are being reduced by mechanization.

*Sulphiting for Drying*

The original procedure of treating apple slices in sulphur houses using burning sulphur is being replaced by dipping and spraying in sulphite solutions, as has been described for freezing. Sulphiting is sometimes done by immersing the slices in a trough containing the acidified sulphite solution; the slices are carried through the trough and kept submerged by a draper belt fitted with paddles. Alternatively, sulphite solutions are sprayed onto the apple slices as they are conveyed in a thin layer on a stainless belt. Equipment should be designed so that all surfaces of the apple are treated. Efficient ventilation is needed in areas where sulphiting with $SO_2$ gas is performed, to protect the health of the operatives; conversely, if sulphiting must be done near workers, a solution of sodium sulphite ($Na_2SO_3$) may be used.

*Drying of Apple Slices*

Slices are dried with air heated by heat exchangers or directly by burnt fuel gases. In general, better drying efficiencies are obtained when the hot air passes *through* the product rather than over it. With the through-flow system drying is more uniform and loading densities may be higher. The hot air is moved by fans or blowers at speeds in the range 60–300 m/min. In modern dryers the dry-bulb temperature of the air is automatically controlled and recorded. Wet-bulb thermometers are used to determine humidity, and to estimate the efficiency of drying. Kiln and tunnel dryers are still used but belt-trough, continuous-belt, bin, and vacuum-shelf dryers are now common. Kilns have been improved by using perforated aluminium or stainless-steel sheet to support the apple instead of wooden slats; the tendency of the apple to stick to the metal can be reduced by coating the sheets with vegetable oils, silicones, or waxes, and by turning the apples at intervals. Mechanical loading and unloading of the trays used in tunnel dryers has reduced labour costs, and 'curing' or moisture-equalizing bins are used after some tunnel dryers to overcome the problem of uneven drying.

For large-scale, continuous, labour-saving operations, continuous-belt dryers are used. Redistribution of the layer of apple slices by dropping down a stepped series of belts improves the uniformity of drying. The belts are frequently made from perforated metal plates that are coated to reduce sticking. Heat is usually supplied by direct gas flame heating or by heat exchangers heated by steam. The initial cost of these dryers is high but their high output usually warrants the initial expenditure.

Belt-trough dryers (Lowe *et al.* 1955) are in limited use for drying apples and they perform well with diced apples. The apple being dried is supported in a trough formed by a moving stainless-steel wire-mesh belt. The input end of the trough is several inches higher than the outlet so that the apple dice tumble up and down the slope of the trough as the belt moves, and also move slowly towards the discharge port. Air for drying is usually heated directly by a gas flame and is driven through the tumbling apple by a blower. Operation is continuous and drying times are adjusted by varying the slope of the trough. Belt-trough dryers are best used to bring the moisture content of apple down to about 30%. Drying is then completed, to a moisture content of 23% or lower, by transferring the apple to bins with perforated bottoms, through which hot dry air is passed from heat exchangers and blowers. The bins may be fitted with castors and tapered air-inlet ducts for easy coupling to the hot-air sources. A bed of apple about 25 cm deep dries quickly under these conditions. Apple is too sticky a material for drying by the fluidized-bed technique.

Vacuum dryers are frequently employed for producing low-moisture (2·5–3·5%) apple from higher-moisture (20–24%) apple slices, which may be further subdivided at this stage by cutting or mincing. Heat is applied, by hot water or steam, to the pipes or hollow shelves within the dryers that support the trays of cut fruit. Because the final dried products are hygroscopic, low-moisture air is provided in the rooms around the dryers to prevent the products regaining moisture during unloading and subsequent packaging. Low-moisture apples have superior stability for storage and are easy to use. They are especially sought for military and institutional usage.

*New Non-sulphited Dried Apple Slices*

Various pressures are developing within the U.S.A. to avoid the use of sulphur dioxide in food products. These pressures come from government agencies, ecologists, and consumers of 'organic foods'. It is possible to prepare dried apples of acceptable stability without sulphur dioxide but the processing is more troublesome and expensive. One general procedure involves treatment of apple slices with sugars, salts, and antioxidants (ascorbic acid) followed by fairly rapid drying at reduced temperatures to low moisture levels (5–10%). Initial tests of stability in storage for 6 months at 38°C have shown unexpectedly good retention of colour in both Golden Delicious and Winesap apples.

## Dehydrofrozen Apple Slices

Dehydrofrozen apple slices are apple slices dried to half of their original weight (i.e. to about 70% moisture), and then frozen. They are prepared by processors located in the eastern United States and are used by some of the large bakeries in the same area. Bakers like this product because it is easy to use and is free of 'drip' when thawed. Powers and Miller (1971) have shown that there are advantages to be gained if dehydrofrozen apples are dried to one-third or one-quarter of their original weight before freezing.

## Apple Powder

Drum-dried apple powder is a new product used in cake mixes and in baked pastries for retail sales; it also appears to have good potential for direct retail sales and for use as an item for feeding military personnel. It rehydrates readily, and may reasonably be termed 'instant apple sauce'.

Considerable amounts of this drum-dried apple powder are now being produced by three processors in the Pacific Northwest. It may be prepared by grinding low-moisture dried apples, or preferably by drum-drying apple purée (Lazar and Morgan 1966). Apples are peeled, cored, cooked in clean steam, and dried on a double drum dryer of the type once used for drying milk. This equipment is usually modified by plating the steel rolls with chromium and by installing air ducts to cool the dried product as it leaves the drum. The purée is applied to the drum by a travelling spray feeder which distributes it uniformly on the upper surface of the drum.

### Apple Butter

Apple butter is a spiced fruit butter with a soluble solids content not less than 43%. The apples may be fresh, frozen, canned, or dried. Additives may be other fruits, fruit juices, spices, flavourings, acids, various sugars including brown sugars and honey, artificial sweeteners, and salt. The colour ranges from reddish brown to moderately dark brown. The butter forms a moderately rounded mass when placed on a flat surface, and has little or no free liquor. The product is frequently cheaper than jams or jellies and is used as a spread for bread or bakery products.

### Apple Juice Products

Rack-and-cloth presses which require much manual labour and tend to introduce sanitation problems are being replaced by self-loading presses, and more use is being made of centrifuges for juice extraction.

Single-strength apple juice is prepared as clear juice, cloudy juice, and occasionally as a preparation from milled fruit, known as 'liquid apple'. There are wide variations in personal preferences for apple juice, but in general a rather strong and pleasant volatile flavour is preferred. Children, who are important consumers, prefer products with less acid; as was explained earlier, the U.S.D.A. standards for acidity have recently been lowered, and so processors have more flexibility in this respect.

There is a small production of full-flavoured, frozen apple juice as a four-fold concentrate, and some unfrozen apple juice concentrates are also prepared for use on breakfast pancakes or waffles, in candies, and in other specialty products.

### Fermented Products

A recent important development is the addition of fermented apple juice to low-cost wines or wine-like drinks, which are being produced at an increasing rate in the U.S.A. Other types of fermented apple products are cider and vinegar, but cider has a low popularity in the U.S.A. Cider produced and sold in Canada as a carbonated beverage is a product of good quality.

Apple vinegar made from cider is a common and popular item, but is meeting increasing competition from other vinegars. Much apple vinegar is made from whole apples, but some is made from peels and cores and must be so labelled. Generally, it is still produced in trickling-filter generators in which cider is pumped over acetic acid bacteria growing on beechwood shavings in large wooden tanks. However, better types of vinegar-generators are coming into use and these new designs give better control of temperatures and more efficient production of acetic acid with less evaporation.

### Additives

Vitamin C and volatile flavours are added to some apple products in the U.S.A., and this trend is rapidly increasing.

Vitamin C is added to most single-strength Canadian apple juice, and to most diluted juice drinks in the U.S.A. It is used to help retain fresh quality and also for its nutritional value. American food regulations are relatively tolerant toward this additive but the regulations may be changed as there is a tendency to over-exploit it.

*Volatile Flavours*

Much of the typical aroma of apples is lost with the water vapour when apple products are concentrated or dried. Fortunately it is now possible to restore some of the lost volatiles using either fluid essences or essences entrapped in dry sugars. The volatile flavours for adding back are obtained from apples or are formulated from chemicals. The quality of both natural and synthetic flavour additives varies from poor to excellent. More than 135 different compounds have been identified in apple volatiles and at least three are known to be especially important. The preferred method for producing natural apple essences is to strip about the first 10% of vapours from whole apple juice, sometimes concentrate this material, and then add this component to the fully concentrated apple juice. An alternative is to use one-hundred-fold or two-hundred-fold concentrates of volatile essence obtained from processors of surplus apples, peels, and cores. Nearly all 'full-flavoured apple juice concentrate' is produced by these methods.

Concentrated essences may be converted to a solid form by mixing them with molten sugar to form emulsions and then cooling and making into pellets. Successful production of dry powdered apple aroma has been achieved by Sugisawa *et al.* (1970) of the Canadian Department of Agriculture by incorporating an aroma concentrate in a mixture of a sugar polymer and glycerine which is foamed and dried.

The synthetic apple essences available from many proprietary sources are added to bakery goods, pudding mixes, fruit drinks, frozen desserts, and confections. Such usage must comply with the requirements of the U.S. Standards of Identity and be declared on the label.

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# Load Cell for Measuring Small Weight Changes in Carcasses

By D. A. Lovett
Division of Food Research, CSIRO, Cannon Hill, Qld.

The weight lost by evaporation of water from animal carcasses during chilling in abattoirs is normally about 1–3% of the dressed carcass weight, and is thus an important economic factor in the Australian meat industry. An accurate and inexpensive instrument for measuring these weight losses has been developed at the Meat Research Laboratory.

There are a number of devices available commercially for measuring changes in weight (Anon. 1970), but, for reasons of accuracy and economy, these proved unsuitable for our experiments with animal carcasses and it was decided to make a special instrument. The problem was to develop an automatic weighing device that would be robust, capable of operating at the low and variable temperatures (0–25°C) and high relative humidities (up to 100%) found in abattoir cold rooms, and capable of measuring small weight changes in large loads (60 g in 200 kg).

The unit developed to meet these requirements is shown in Figure 1. It consists of a high-tensile, nickel–chromium steel ring, 4·80 cm wide, 0·279 cm thick, and with an internal diameter of 18·82 cm, mounted in an insulated enclosure in which temperature is controlled. In order to reduce effects from any

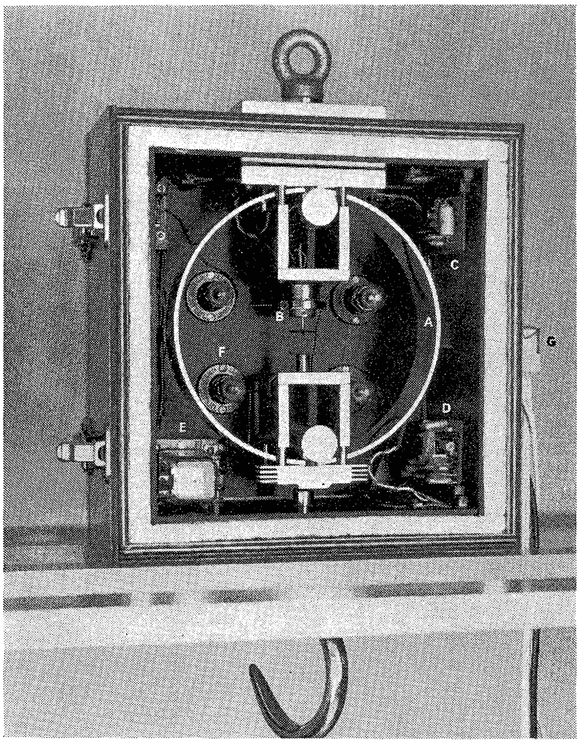


Fig. 1. — The proving ring and part of the electrical circuitry.
A, Load-bearing ring.
B, Direct current differential transformer.
C, Regulated voltage supply for differential transformer.
D, Temperature control circuit.
E, Switching relay for heaters.
F, Heaters.
G, Input–output plug.

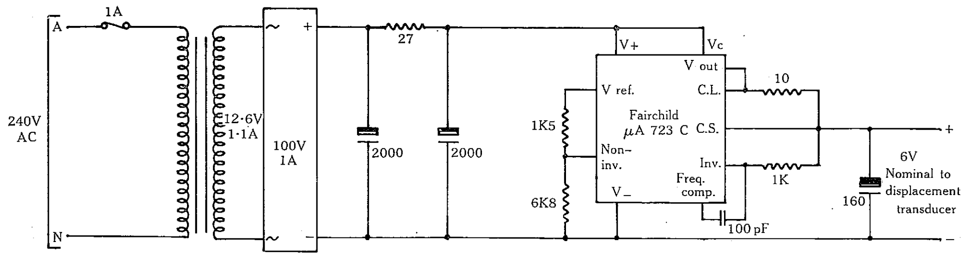


Fig. 2. — D.c. voltage source for displacement transducer for load cell.

anisotropic crystal structure in the steel, the ring is machined from a solid bar. The elongation of the ring along the vertical diameter is related to the applied load and is measured by an electrical displacement transducer: as the carcass loses weight during chilling, the ring contracts in the vertical direction. Power to the unit is supplied from a separate power supply. Changes in weight may be read from a suitably calibrated indicating or recording voltmeter.

## Operating Principles

The operation of the instrument relies on the measurement of the strain produced along the vertical diameter of an elastically stressed ring.

For such a ring under load $W$, and when $R > 4y$, the strain or elongation is approximately given by the following equation (Morley 1960):

$$\delta = \frac{2WR^3}{EI}\left(\frac{\Pi}{8} - \frac{1}{\Pi}\frac{A}{A'}\right) \tag{1}$$

and the maximum intensity of stress is (Morley 1960)

$$P = \frac{W}{\Pi(A' - A)}\left(1 - \frac{A}{A'}\frac{R}{R + y}\right). \tag{2}$$

The value $A'$ in these equations may be obtained from

$$A' = Rb \ln [(R + y)/(R - y)].$$

The sensitivity of the present ring is approximately 50 $\mu$m per kg load, while the maximum intensity of stress is $7 \cdot 6 \times 10^5$ kPa at 200 kg load. The yield point of the steel used (Comsteel R5, specification: BS970, 1955, En26) is $9 \cdot 0 \times 10^5$ kPa.

The elongation of the ring due to changes

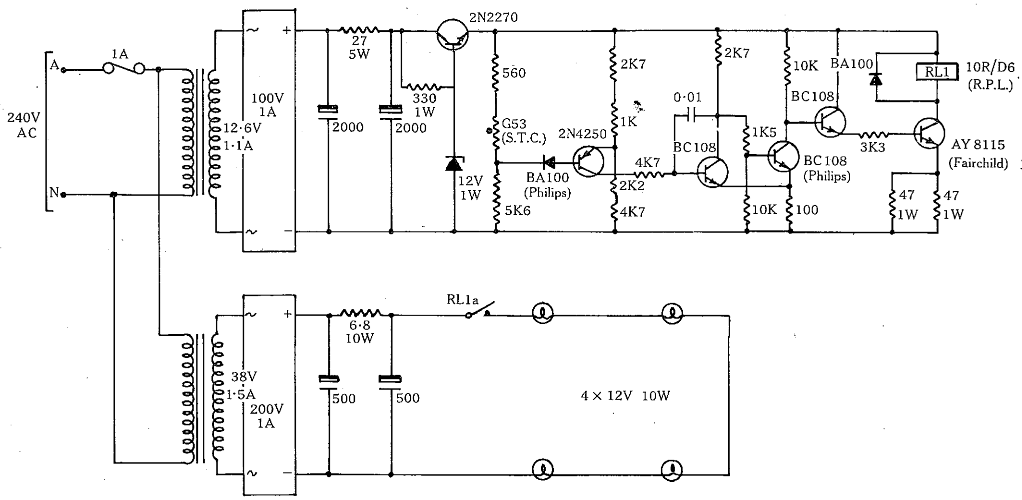


Fig. 3. — Temperature control circuit for constant-temperature enclosure.

in load is measured by a differential transformer (Hewlett Packard type 7DCDT–050), the transformer being rigidly attached to the top, while the movable transformer core is attached to the bottom of the ring. The transformer is supplied from the d.c. voltage source (Fig. 2), located in the constant-temperature enclosure as a plug-in module. The d.c. output from the transformer (which is related to the location of the differential transformer core and hence to the load) is typically in the range 0–10 mV and may be read on a d.c. voltmeter or recorder.

Although not essential to the operation of the instrument, the constant-temperature enclosure enables the load cell to be used to its maximum sensitivity, by minimizing temperature-induced changes in the elastic modulus of the steel ring. Control of temperature is maintained by a simple on/off regulator (Fig. 3). Incandescent bulbs are used as heaters, while a thermistor, attached to the ring, serves as the temperature sensor. The control temperature used is approximately 28°C, but any suitable temperature, within the capacity of the heaters, may be used.

## Performance

Calibration of each load cell has been found necessary, but equation (2) may be used to give a good initial estimate of sensitivity. Sensitivity ($\mu$V/g), however, varies slightly with load and hence must be determined at a number of points in the weight range (Fig. 4).

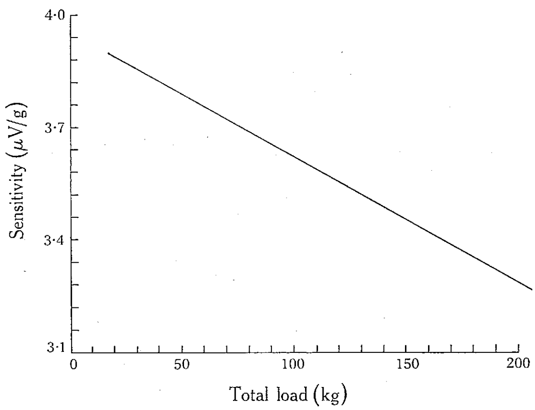


Fig. 4. — Typical variation in sensitivity of load cell with total load (measurements taken during actual experiment).

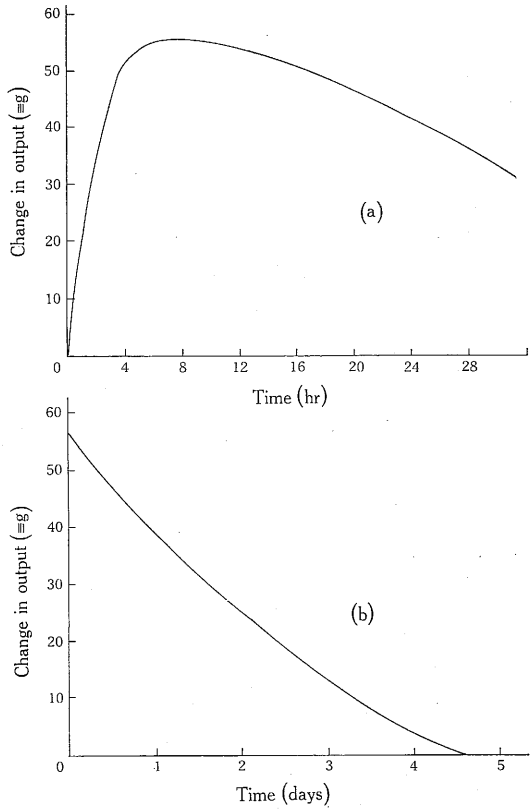


Fig. 5. — (*a*) Typical change in output of load cell under constant load (200 kg), due to an instantaneous change in ambient temperature of 25 degC. (*b*) Typical change in output of load cell over an interval of time, at constant ambient temperature.

In order to display sufficient accuracy of weight change on analogue recorders or voltmeters, the signal indicating change in weight from a preset arbitrary value is the commonly used output, rather than the signal indicating the actual total load.

The two major sources of inaccuracy in the instrument are:

- change in output due to change in ambient temperature (Fig. 5(*a*)), and
- drift in output due to slight changes in value of the electronic components over an interval of time (Fig. 5(*b*)).

Where the load cell is not enclosed at a constant temperature, the change in output is approximately 0·04% total load per degC.

## Conclusion

The load cell described in this article has been found to be a robust and reliable tool for studying evaporation of water from carcasses during chilling in abattoirs. No doubt there are many other industrial applications for a sensitive automatic weighing device of this type.

## Nomenclature

$\delta$ = elongation of vertical diameter of stressed ring (m)
$W$ = load (mass) applied to ring (kg)
$R$ = outside radius of ring (m)
$y$ = half-thickness of ring (m)
$b$ = width of ring (m)
$E$ = Young's modulus ($N/m^2$)
$I$ = moment of inertia of ring cross-section ($= by^3/12$) ($m^4$)
$A$ = area of cross-section of ring ($m^2$)
$p$ = intensity of stress (tensile) at top outer surface of ring ($N/m^2$)

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# Preparation of Pre-peeled and Pre-sliced Potatoes


By R. S. Mitchell

Division of Food Research, CSIRO, North Ryde, N.S.W.


Potatoes are supplied to many outlets in a partly prepared form ready for cooking by baking, boiling, or frying. Besides its convenience to the user, this method of preparation at a central location has several advantages: it permits bulk buying of potatoes and the use of premises in a lower rental area, and it utilizes labour and equipment to the fullest extent.

A drawback to the more widespread use of central preparation of pre-peeled and pre-sliced potatoes is the black or brown discoloration that rapidly appears on the cut surface of a potato, as the result of chemical reaction between phenolic compounds naturally present in the potato and oxygen. Discoloration may be avoided for a short time by immersing the cut potatoes in water.

Temporary preservation of cut potatoes for about five days can be achieved by dipping them in a solution containing sulphur dioxide and then storing the potatoes at 0°C to 4°C. This use of sulphur dioxide to prevent enzymic darkening of peeled potatoes is practised widely throughout the world. It is not, however, specifically permitted under pure food regulations in Australia. The cooked potato product reaching the consumer should contain no detectable sulphur dioxide.

## Preparation and Preservation

Potatoes are mechanically peeled in an abrasion peeler, and in the process the water sprayed over the potatoes washes away the pieces of peel and loose pulp abraded from

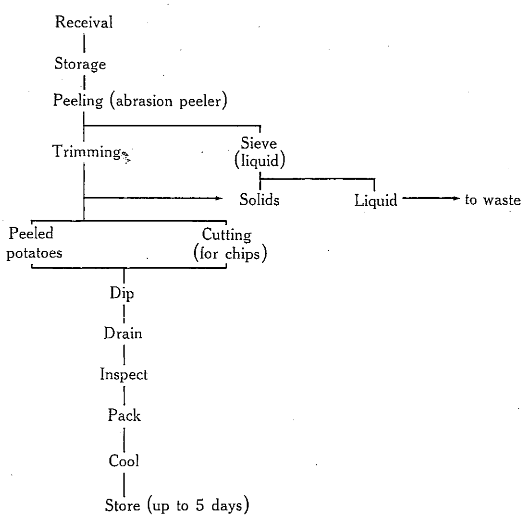



Fig. 1.—Flow sheet for pre-treated potatoes. The dip solution is specified in the text.

the surface. They are then trimmed by hand to remove blemishes and deep eyes. Potatoes for chips are sliced in a mechanical slicer.

The most convenient method of sulphiting is to dip the potatoes in a solution containing sodium metabisulphite. An immersion time of 30 sec in a dip containing 0·2% sodium metabisulphite, 20–30 g in 10 l of water (3–4 oz in 10 gal), is adequate for most potatoes. Some consignments of potatoes will darken even after this treatment and concentrations up to 0·5% (50 g in 10 l or ½ lb in 10 gal) may be used. The brief immersion time is adequate as the action is restricted to the cut surfaces, but it may be extended to several minutes if this fits in better with production methods. A fresh solution should be made up each day.

Potatoes are then drained and packed; polyethylene bags may be used. The packaged potatoes are cooled and stored under refrigeration at a temperature between 0°C and 4°C.

### Precautions

The method described is not always successful. Potatoes from some sources still darken, and the only way to avoid this is to obtain potatoes only from districts known to yield satisfactory material.

The time interval between preparation and dipping should be as short as possible, as the sulphite treatment will not reverse any actual or incipient darkening. The duration of immersion should be limited to a maximum of five minutes from the time of adding the first part of a batch. If immersion time is too long an exudate forms on the potato surface, an unpleasant smell develops, and flavour is adversely affected.

All cut surfaces should be exposed to the dip solution. It is better to pour rather than dump pieces into the solution, and some stirring may be needed to separate pieces that stick together.

After removal from the dip, potatoes should be adequately drained to avoid accumulation of solution in the bottom of packets and consequent over-exposure of the lower pieces to the solution. To ensure that cooling takes place in a reasonable time, containers should be small and should be stacked so that the circulation of air is not impeded. The time for cooling may be shortened by mechanically cooling the dip solution.

Surfaces in contact with the potatoes should be non-corrosive; stainless-steel or plastic containers (polyethylene or PVC) are suitable. Water discharged from the abrasion peeler is usually passed through a fine mesh screen to separate as much as possible of the solid material for disposal; the water containing suspended starch is then frequently discharged into the sewage system. However, disposal of both solid and liquid wastes is a matter for arrangement with local authorities.

# Checking Mercury-in-glass Retort Thermometers

Retort thermometers should be tested for accuracy against a known accurate standard thermometer upon installation and at least once a year thereafter or at any time their accuracy is questioned. New thermometers may or may not be accurate when received from the manufacturer and should be checked by the user against a known standard thermometer. The services of the CSIRO National Standards Laboratory, or of any laboratory registered by the National Association of Testing Authorities, may be used to standardize one or more of your retort thermometers. If the thermometer must be shipped, be certain that it is packed securely in a rigid container and insured.

### Equipment Needed

(1) Standard thermometer; one with a 9-in. (23-cm) scale is preferable, but a 7-in. (18-cm) scale is sufficient.

(2) Cross made of 0·75-in. (2-cm) pipe fittings for holding three thermometers.*

(3) A supply of 0·75-in. (2-cm) pipe fittings, plugs, and reducers, so that the equipment can be installed on any type of retort.

(4) Warding file to file scale plate slots.

(5) Tin snips to cut scale plates when too long.

(6) Screws, taps, drill, flashlight, pliers, etc.

### Procedure

(1) Remove a retort thermometer and install the testing equipment.

(2) Remove the thermometer to be tested. Use an adjustable wrench for removing thermometers because it is less likely to slip and there is less danger of damaging the surfaces or breaking the stems.

(3) Remove the faces from the thermometers and place two of them in the test equipment. The standard thermometer should be in the middle. Check for loose stems by attempting to move them up and down. (If loose, destroy or return to manufacturer for repair.)

(4) Bring the retort to the required temperature, making certain to vent sufficiently long to eliminate all air.

(5) Open the valve on the test equipment and allow the thermometers to come to equilibrium; this will require 15–30 min. If the temperature fluctuates, it may be steadied by throttling the control valve.

(6) Loosen the screws on the temperature scale and adjust to read the same as the standard thermometer. If it cannot be moved enough to make the adjustment, remove the scale from the thermometer and file the screw slots longer, or cut off the end of the scale, whichever may be necessary.

(7) Tighten the scale adjustment screws and take another reading to make certain the thermometers are properly standardized. Thermometers should be checked at about the temperatures at which they are to be used, i.e. 240–260°F (115·6 to 126·7°C).

(8) Clean the case glasses and replace thermometer faces.

Experience has shown that case temperature corrections are not necessary if a 15–30 min equilibrium period is used and only ±0·5 degF or ±0·3 degC accuracy is required.

*National Canners Association (1968).—'Laboratory Manual for Food Canners and Processors.' Vol. 1, p. 288. (Avi Publishing Co.: Westport, Conn.)

### Acknowledgment

Permission to adapt this extract from their *Research Information* No. 183, February 1972, was granted by the National Canners Association, Western Research Laboratory, Berkeley, California.

# News from the Division

### Ministerial Statement

The Minister for Science, Mr W. L. Morrison, has reviewed CSIRO policy on patenting inventions and granting licences for patents. He approved the continuation of the existing policy on patents, but made several changes in the policy on granting licences:

> 'The Executive of CSIRO is authorised to grant non-exclusive licences in Australia on condition that the licensee is of Australian ownership and that the annual royalty is $100. All other licences will be submitted to me for approval.
>
> 'I shall require CSIRO to submit information on the ownership of the firm or firms involved and a report from the Australian Industry Development Corporation.
>
> 'In keeping with the Government's intention to expand the role of the Australian Industry Development Corporation, the requirement that the Corporation provide a report on proposed licences of CSIRO patents will, I believe, ensure that all the alternatives for the development and exploitation of CSIRO patents have been fully explored to achieve the maximum national technological and economic advantage.
>
> 'In addition, I have directed that CSIRO, in consultation with the Attorney General's Department, incorporate in licence agreements adequate provisions covering the disposition of the licence in the event of the licensee being taken over.'

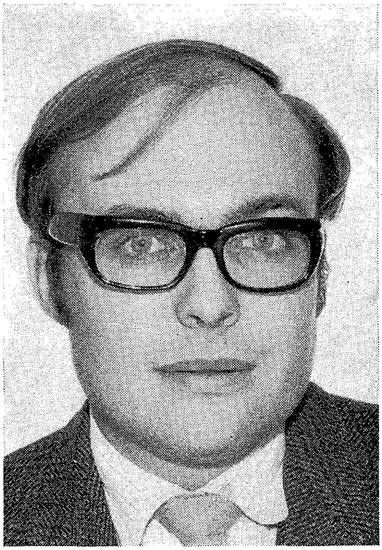
Further information may be obtained from the Secretary (Industrial and Physical Sciences) at CSIRO, P.O. Box 225, Dickson, A.C.T. 2602.

### Appointments

Mr P. F. Rylands has been appointed to the FRL at North Ryde as a Scientific Services Officer.

Mr Rylands will be the liaison and information officer concerned with the handling, packaging, storage, and marketing of fresh fruits and vegetables. He will develop close liaison with State Departments of Agriculture and the industries dealing with this produce.

Mr Rylands is a graduate in Agricultural Science from the University of Sydney. He comes to the Division from Bayer Australia Ltd where he was closely concerned with herbicides and the development of weed control programmes in agriculture, horticulture, and other areas.



Mr P. F. Rylands.

Miss P. L. Conway, B.Sc., has joined the staff at MRL; she began research work at the end of February on the production of single-cell protein from meatworks wastes.

The implementation of CSIRO's licence agreement with Dalgety Agri-Lines Pty Ltd to carry out research with polyunsaturated ruminant products has involved the appointment of extra staff:

Mrs K. A. Aicken, B.Sc. (Food Technology), joined FRL early in February 1973 to help with work on the chemical and physical changes that occur in polyunsaturated meat and dairy products when cooked.

Mr B. H. ter Huurne, B.Sc. (Chemistry), has joined the FRL staff to study the oxidative stability of polyunsaturated ruminant products.

In addition, MRL's Mr H. A. Bremner, A.R.M.I.T., transferred from other work to study the properties of ruminant meats containing high proportions of polyunsaturated fats, with particular emphasis on oxidative changes during storage. He is also interested in possible differences in the manufacturing properties of this type of meat.

### Industrial Effluent Treatment

CSIRO held a Conference on Industrial Effluent Treatment in Canberra in March. The purpose of this meeting was to bring together representatives from the Executive, the Head Office Secretariat, and some 25 Divisions of CSIRO, to review the major present and future problems relating to water-borne industrial effluents (including sewage) from selected industries.

Effluents from the textile, food, forest products, chemical, petroleum, tanning, mining, and metallurgical industries and from municipal waste waters were considered, in relation to the ability of the receptor media—land and water, both fresh and marine—to receive them.

PROBLEM URGENT

New regulations on water quality that have been or are about to be promulgated by the environment protection agencies in the States will place serious constraints upon many industries in the very near future. Some companies will face problems of great urgency, particularly those with limited technical resources. Several Divisions of CSIRO are evaluating these problems and the means of tackling them, especially in order to assess those situations where research is needed.

Effluents from food industries often carry very high loads of suspended and dissolved wastes which already necessitate treatment before discharge, but it is certain that new legislation will require greatly improved standards of treatment which will have major effects on many industries. In many cases the technology already exists to overcome the problems; State Government instrumentalities, private consultants, CSIRO Divisions, and some university departments are all able to give advice regarding particular problems. However, research by CSIRO and others will be required in some instances.

GUIDELINES FOR RESEARCH

The general directions in which research may assist the food industry with problems of waste disposal are these:

- reduction in total amounts of wastes by more efficient handling of raw materials
- processing with the use of less water
- conversion of wastes to useful foods and by-products by microbiological methods
- recycling of wastes wherever possible, e.g. in the form of animal feeds.

WORK ALREADY STARTED

The considerable research effort on environmental problems that is already under way in CSIRO is outlined in a booklet entitled 'CSIRO activities and the quality of the environment', available from the Communications Services Section, CSIRO, P.O. Box 225, Dickson, A.C.T. 2602.

In the Division of Food Research, work has begun on the utilization of whey, something that is a considerable problem in the dairy industry; on the treatment of effluent in meatworks and the possible use of microbiological methods for the recovery of usable constituents; and on ensiling as a means of converting certain fish processing wastes to stock feed or fertilizer.

A microbiologist is shortly to be appointed to the Division to work on some of the basic microbiological problems of waste disposal in the food industries.

It is hoped to publish articles in this *Quarterly* from time to time describing the Division's activities in the abatement of pollution.

### Symposium

The First International Symposium on Heat and Mass Transfer Problems in Food Engineering, organized by Dr Leniger of the Agricultural University of Wageningen, was held at the International Agricultural Centre at Wageningen from 23 to 27 October 1972. Mr J. Middlehurst and Mr J. D. Mellor from the Division presented papers.

Forty-six papers were presented: seven on drying processes, six each on non-Newtonian fluids, membrane processes, and freeze drying, four each on sterilization and freezing, three on heat-generating foods, two each on thin film evaporation and spray drying, and six on miscellaneous problems.

HIGH STANDARD

The standard of all the papers was particularly high and there was much animated discussion. More than half the papers offered methods of solving practical problems, many of them likely to be successful. Some problems, however, were particularly intractable, e.g. the design of pressed plate heat exchangers.

By the end of the conference, areas where more work is urgently needed became clear. For example, practical results are needed on reverse osmosis and ultra-filtration as means of concentrating proteins; more exact models must be developed to describe the cooling and drying of stacks of real, heat-generating foods, and more research is needed on the transport of vapours and flavour volatiles through packaging membranes and foods.

It is hoped that the second symposium in a few years' time will produce the answers to these and other problems in food engineering.

### Guest

The Duke of Edinburgh was a guest of the Executive at lunch in Canberra on 15 March. Many of the foods and drinks that were served at the meal had been grown or processed by CSIRO and the Division provided polyunsaturated steak and cheeses, and a banana drink.

### Meetings

The Armed Forces Food Science Establishment (Commonwealth of Australia) will hold a Convention on freeze drying at Scottsdale, Tasmania, from 4 to 6 September 1973. Details of the programme and enrolment forms may be obtained from the Director of the Establishment at P.O. Box 147, Scottsdale, Tas. 7254. Attendance is free but numbers will be limited, and early application is desirable.

Meetings of Commission D3 (Refrigerated Sea Transport) and Commission B2 (Refrigerating Machinery) of the International Institute of Refrigeration will take place in Tokyo, Japan, from 2 to 4 March 1974. Details may be obtained from the Organizing Committee, c/o Japanese Association of Refrigeration, San-ei Building, 8 San-ei-cho, Shinjuku-ku, Tokyo 160, Japan.

## *Book Review*

Recommendations for the Processing and Handling of Frozen Foods. 2nd Ed. International Institute of Refrigeration, August 1972.

This publication, in French and English, is designed to replace the first edition of 1964; it has been compiled by a team of 19 authoritative members of the Institute (no Australian, incidentally, is included among the authors).

The text has been reorganized to incorporate much new material, and completely rewritten; one result is that it is now more than twice as long. One completely new section—on specifications for storage of products—has been included, and other sections, particularly that relating to the scientific background of the freezing process, have been expanded.

The work covers physical, physico-chemical, and biochemical aspects of freezing, microbiology, hygiene, packaging, transport, display and retail sale, and nutritional aspects of frozen food and their application to the consumer. There may be quibbles over some generalizations made in the book, but the authors are to be congratulated on their concise, accurate presentation of an enormous amount of up-to-date information supplemented by a bibliography of publications up to 1971. A well-laid-out index facilitates reference to specific topics.

Items of particular interest to readers in Australia will be the definitions of high-quality storage life and practical storage life, the significance of thermal radiation in open display cabinets, methods of temperature measurement of frozen foods, and the section on retail cabinet design. This book is an essential reference for those in industry, education, or government who are concerned with frozen food. It is available in a paper-bound edition for $US9 or F45 from the International Institute of Refrigeration, 177 boulevard Malesherbes, F75-Paris, 17e, France.

K.C.R.

Printed by CSIRO, Melbourne

## *READERSHIP SURVEY—YOU LIKE US...*

This time last year, by means of a 'Readership Survey', we asked you to give your comments on the quality and effectiveness of the *Quarterly*, besides any suggestions for improving it. The response was lively and informative.

Most replies were very favourable and showed an appreciation of the *Quarterly*'s accuracy and practical interest; indeed, the suggestion most frequently made was that we should increase its size and publish more frequently! This was good to hear, but perhaps even more valuable to us, as editors, were the occasional salutary criticisms and the enthusiastic flow of suggestions.

## *BUT...*

The most frequent criticism was that the range of subjects was too restricted and did not give an adequate reflection of the work being done at the three Laboratories. Other readers asked for more photographs and a more attractive design. Nearly everyone offered suggestions for making the publication even better—ways of improving layout, ideas for colour supplements, subjects for articles, and possible new features.

There is no doubt that the *Quarterly* will benefit from this informed criticism, even though we cannot hope to contain in its pages the whole cornucopia of plans and possibilities that you have offered us.

We should like to thank those who replied to the Survey, and to remind all readers that their comments on the *Quarterly* are always welcome.