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Production and Marketing
of Fruits and Vegetables

By E. G. Hall

Division of Food Preservation, CSIRO, Ryde, N.S.W.

The fruit and vegetable industries, particularly the former, are facing difficult problems; the world market for the three principal fresh fruits (apples, oranges, and bananas) is nearly saturated and production is still increasing. The costs of production and marketing are relatively high, so quality must be improved and costs reduced. The author considers that only growers operating on a large scale can obtain the full benefits of mechanization and meet the problem of costs and the competition from processing companies growing their own fruit and vegetables. This article is based on an address given to the N.S.W. Branch of the Australian Institute of Agricultural Science on May 29, 1967.

THE PROPORTION of the consumer's income spent on food decreases with increasing affluence of the society. In the U.S.A. it is now less than one-fifth, and in Australia a little more than one-fifth, of the average income and in both countries about one-fifth of the food budget is spent on fruit and vegetables. Consumers adopt different attitudes towards fruit and vegetables in that the latter, particularly potatoes, are eaten as an essential part of the main daily meal and are commonly accepted as being staple foods, while fruits, despite their special nutritive properties, are generally regarded more as luxury foods. Consequently the demand for fruit is affected much more than the demand for vegetables by changes in purchasing power.

The production of fruit and vegetables is a major part of agriculture and its value in Australia is probably of the order of $1000 million. It also has a relatively high labour requirement and is therefore very important to the economy.

Australia follows the U.S.A. closely in food habits, notably in the rapidly developing sophistication of the marketing, processing, and presentation of food. These changes are critical to the farmer, who is increasingly being required to produce to the processor's demands. This sophistication also increases costs of marketing and increases the disparity between the price the consumer pays for the food and the price paid to the grower. In the U.S.A. the total costs of food marketing are now three times the return to the farmer; in 1940 they were about equal. The costs of marketing are increasing but the farmers' returns are, if anything, falling. The consumer is paying a high price for convenience foods and so to support the food processing industries, now one of the largest groups of industries in the U.S.A. and probably also in Australia.

Marketing includes assembly, transportation, packaging, storage, processing, wholesaling, retailing, and, increasingly, commercial meal preparation and serving. In the U.S.A. about 25% of the food consumed is commercially served and eaten in restaurants or canteens. From 1929 to 1959, the number of full-time jobs in marketing food products in the U.S.A. increased by 40%, mainly due to the increased volume and diversity of marketing services, while the number of farm workers decreased by 33%, mainly due to increased mechanization (Burk 1961). Undoubtedly the trends in Australia are similar, though developing later. Food marketing is changing constantly, due to the development of new products, improved technology, changes in retailing, and social factors such as changes in consumers' incomes, population shifts, and employment of more married women.

Production and Consumption

Recent Australian production and consumption of fruit and vegetables are listed in the tables.

It has been suggested (Trout 1967) that Australians do not eat enough fruit and vegetables. Trout points out that some nutritionists consider that for best health, sufficient fruit and vegetables, which are base-forming foods, should be eaten to counteract the acid-forming meat, eggs, and cereals in the diet. On this basis, Australians should increase their consumption of fruits and vegetables by about 2 lb per week to a yearly amount of about 550 lb.

Fruit Production, Australia, 1966/67

Apples	19·4 million bushels*
Oranges	10·7 ,, ,,
Pears	6·5 ,, ,,
Peaches	5·9 ,, ,,
Pineapples	6·0 ,, ,,
Bananas	4·9 ,, ,,
Apricots	2·4 ,, ,,
Grapes, drying	420,000 tons
table	26,800 ,,
wine	238,000 ,,
total	685,000 ,,

* 390,000 tons (approx.).

Vegetable Production, Australia, 1964/65

Potatoes	508,000 tons
Tomatoes	147,000 ,,
Green peas	100,000 ,,
Onions	70,000 ,,
Green beans	30,000 ,,

Processing

In the last 15 years, annual consumption per head of processed fruits and vegetables in the U.S.A. has increased from 60 to 215 lb and is now almost equal to the amount eaten fresh, and the proportion is still increasing. The consumption in Australia is about 60–70 lb per head and is increasing rapidly as the advantages of transferring food preparation from the kitchen to the factory are more fully realized. However, this has brought new problems, particularly in the control of spoilage by microorganisms. Therefore research and the improvement of technology flowing from this research are of paramount importance. There is still much to be done to improve the quality of processed fruits and vegetables through improving the quality of the raw material. Better quality control during processing and storage, especially the latter, and application of new techniques of preservation are ways of doing this.

There are two classes of raw material used in processing operations:

Low-grade and surplus production.—For example, approximately 20% of the Tasmanian apple crop is canned or converted to juice. Generally the prices to the producer barely cover costs and can only be justified if removal from the fresh market of the fruit processed improves returns for the fresh produce.

Crops specifically grown for processing.—These account for most of the processed output and are usually essential for a high-quality product.

The characteristics required in fruits and vegetables for processing are commonly quite different from those for the fresh market and they also vary according to the kind of processing. The Red Delicious apple is popular when eaten fresh but is unsuitable for processing; the Sturmer is excellent for canning as solid pack (pie apple), while the Granny Smith and Jonathan are very good for juice. Where the product is either a concentrated juice or dried material such as dried fruits, potato flakes, or powder, an initial high solids content is a decided advantage. The price of fruit for juice production is now often determined by the soluble solids content.

The plant breeder is being asked to produce new varieties, with specific characteristics, especially for processing, for example, with a more uniform maturation of the crop for mechanical harvesting. He has had considerable success with vegetables, berries, and peaches. Freedom from developed bitterness in the juice is an essential characteristic of oranges for juice production, therefore seeded oranges on *Poncirus trifoliata*, or similar stock, are preferred; Navel oranges, particularly on the common rough lemon stock, yield a bitter juice and are unsatisfactory for processing.

Processed Fruits and Vegetables

In recent years big increases have occurred in the production of processed vegetables, firstly in canned and later in frozen vegetables, especially frozen peas, and now the major development in the U.S.A. is in frozen French fry potatoes. The consumption of canned fruit has increased steadily though not spectacularly, but there is now a tremendous increase in canned and frozen fruit juices, especially concentrates. In Australia pineapple juice led this trend, followed by orange and then apple juice. As in the U.S.A., mixed juices and nectars are becoming popular, while tomato juice is a major item. Frozen orange concentrate is a major product in the U.S.A.—about 75% of the Florida crop of over 4 million tons goes to concentrate and only 15% to the fresh market. In Australia the main concentrate is apple juice, which is concentrated to about 70° Brix, most of the flavour being deliberately removed in the process. Cordial makers are the chief purchasers because 5% of pure fruit juices in their products qualifies them for a considerable reduction in sales tax, and they prefer the bland and almost colourless apple juice concentrate. This is very important to the apple industry as it takes about 2 million bushels, which is 10% of production. In 1965 nearly half the U.S.A. apple crop was processed into pie apple and juice. In the U.S.A. more than 97% of all commercially produced green peas are processed, in Australia the figure is about 50%.

Production of Processed Fruits and Vegetables

1967/68	
Canned fruit	
Pears	252 million lb
Peaches	239 ,, ,,
Pineapples	65 ,, ,,
Total	655 ,, ,,
Canned vegetables	174 ,, ,,
	(peas 20 ,, ,,)
Frozen vegetables	97 ,, ,,
	(peas 62 ,, ,,)
Jams, etc.	90 ,, ,,
1966/67	
Wine	42 million gallons
Fruit juice	
(*a*) Single strength	
Total (incl. pineapple)	13·6 million gallons
Apple	889 thousand gallons
Citrus	2768 ,, ,,
Grape	79 ,, ,,
Black currant	27 ,, ,,
Pineapple and other juices	Not disclosed
(*b*) Concentrated	
Citrus	540 thousand gallons
Grape	97 ,, ,,
Other	599 ,, ,,
Tomato juice	2·6 million gallons
Tomato paste and purée	2·8 ,, ,,
Tomato pulp	181,000 cwt
Dried vine fruits	106,704 tons
Dried tree fruits	10,515 tons

About 80% of the Queensland pineapple crop is processed. The initial product was canned fruit but in recent years pineapple juice has become important. This was a result of research into the utilization of waste cores and skins. Demand for the juice increased and now large quantities of whole fruit go directly into juice. With the production of pineapples mainly for processing, the industry is rapidly becoming mechanized, bulk bins are widely used for transport, and mechanical aids to harvesting are being developed. A new machine developed in Queensland enables five men to pick and store one ton of fruit in eight minutes.

The prune industry, centred around Young and Griffith in New South Wales, almost failed a few years ago. Public demand for the old-style dry prunes in cans was poor and retailers were reluctant to carry this product. As a result of research, partly carried out by the CSIRO Division of Food Preservation, continuous steam processing and packaging in flexible film pouch packs of convenient size have transformed the industry from gloom to prosperous activity. About 40–60% of the crop is still exported and most of the remainder is processed into the soft eating prune, now mainly in plastic pouches. There are no old stocks and growers are even making new plantings of trees.

Continued rapid growth is forecast for the frozen vegetable industry in Australia. In 1963/64 the annual consumption per head was 4·7 lb in Australia compared with 12·8 lb in the U.S.A. and 3·9 lb in Britain. Australian consumption is expected to rise to 9·2 lb by 1974/75 and production from about 50 million pounds in 1963/64 to 125 million pounds, when the main items will be peas, as at present, and potatoes.

Potatoes are the dominant vegetable crop in Australia; currently only about 6–7% of the crop of about 0·5 million tons is processed, mainly into crisps. In U.S.A. almost half the crop is processed, mostly into frozen French fries. The CSIRO Division of Food Preservation is undertaking a programme of research into processing as frozen chips and potato crisps and, with potato agronomists, is continuing research into the quality of potatoes. New varieties for processing will have to be developed, important qualities being high solids content, good colour after processing, and uniform shape. In tests so far, the Sebago variety has been consistently of better quality than the many others studied. Browning of crisps and chips is a serious problem, due mainly to the sugar content of the potato, which depends on conditions of storage. It has been found that low potash increases browning, probably through the amino acids, since this browning is mainly non-enzymic and is caused by sugar–amino acid reactions.

Consumption of potatoes in the U.S.A. had steadily decreased and in 1950 it was about 80 lb per head, only half that in 1910. In 1956 it had increased to 108 lb, and in 1960 was up to 114 lb, entirely due to the ready acceptance by consumers of the processed article, especially frozen French fries. There has been a similar sharp decrease in Australia in recent years, from 124 lb in the three years ended 1948/49 to 86 lb in the three years to 1960/61. From the U.S.A. experience, processing should increase this figure substantially. In fact the consumption per head per annum in Australia has risen to 93 lb in 1964/65 and 112 lb in 1965/66.

Fruit and Vegetable Consumption, Australia, 1965/66

Fruit	
Oranges	34 lb/head/yr
All other fresh fruit	89
Canned fruit	20
Dried fruit	7
Jam	7
Total fruit (fresh equiv.)	180 (approx.)
Vegetables	
White potatoes	112 lb/head/yr
Root and bulb vegetables	35
Tomatoes	31
Peas	20
Beans and greens	44
Other	38
Total vegetables	280
Beverages	
Wine	1·3 gal/head/yr
Beer	24·3

The Fresh Market

Despite these new developments the fresh market will remain the chief one for most fruits and vegetables for a long time. Outstanding exceptions are peas, sultanas (although fresh seedless sultana grapes of improved quality are finding an increasing market), pineapples, and peaches, and perhaps in the foreseeable future, oranges.

Australia is an affluent society, the consumer is becoming more discriminating and prepared to pay for a better product. Nevertheless, price still largely determines demand, especially as consumers generally regard fruit as a luxury and not a necessity. Promotion is also important, provided quality is acceptable. Quality depends on variety, growing conditions, and maturity at harvest; improvement is in the hands of the grower, aided by the plant breeder and other specialist horticultural officers.

In a study of quality preference and demand for fresh peaches in the U.S.A., Gislason and Harrington (1961) found that price and display were more important than the rather small differences in quality. A 1% change in price gave a 1·28% change in sales, in the opposite direction. However, the Australian consumer is still, and often justifiably, suspicious of fresh fruit. This lack of public confidence is perhaps the greatest handicap to increased sales. One Sydney wholesale fruit firm is building a large and expanding business on the large, unsatisfied consumer demand for high-quality fruit. The firm's main problem is getting regular supplies of the desired high quality from growers.

Even to hold the existing market for fresh fruit and vegetables, the industry must greatly improve quality, reliability, and uniformity. Returns to growers are now relatively so low that it will be difficult to reduce costs of production very much.

However, the now disproportionately high costs of packaging can be reduced by bulk handling in transport, as well as in harvesting and storage, and mechanized packaging in the main market centres to suit specific retailing requirements. While pre-packaging and self-service selling are now widely practised, older methods will continue, especially in the local fruit shop, which usually offers a good standard of service, even if quality is often lacking.

Without uniformity of presentation and improved quality, fruits and vegetables will be less and less able to compete with heavily promoted and attractively presented processed foods arrayed provocatively in the supermarket and chain store. To improve quality, which consists of appearance, eating quality, keeping quality, and nutritional value, the last being least important in the consumer's assessment, processing treatments must be increasingly applied to produce marketed as fresh.

Research can offer treatments to prevent decay and certain physiological disorders, to retard moisture loss and wilting, and to retard ripening during marketing. Such treatments are washing, fungicidal treatment and waxing of oranges, bananas, and other items, treatment of apples to prevent storage scald, controlled-atmosphere storage of apples and pears to prolong cool storage life and improve quality and shelf life out of store. Packing in box liners of polyethylene film is now widely used in the cool storage of pears and some varieties of apples and is being applied to bananas and other tropical fruits. Nevertheless, temperature primarily determines the rate of deterioration during transport and marketing, and refrigeration is being used more and more, in the retail shop as well as during storage and transport. Pre-cooling and refrigerated transport are greatly improving the quality on the Sydney market of stone fruits and grapes from distant areas such as the Murray and the M.I.A. Cheaper evaporative cooling has been introduced to the Murray area for pre-cooling oranges and this greatly reduces ageing and moisture loss due to evaporation in hot weather. Evaporative cooling can be very valuable in marketing table grapes and has an important place in retailing perishable produce in dry climates during the summer months.

Consumers in the U.S.A. want eating apples that are red, juicy, sweet, unblemished, and of medium to large size. Therefore Red Delicious is most popular, but because of high eating quality Golden Delicious is now also in demand. These and the Jonathan and the ever-popular Granny Smith are also preferred by Australian consumers. Oranges should be well coloured, thin-skinned, juicy, easy to peel, and preferably seedless—hence the popularity of the Navel for eating fresh.

Stone fruits should be large and well ripened; there should be no market for the small, green fruit so commonly seen. Tomatoes should be well ripened throughout the year. Winter temperatures in the south are commonly too low for good ripening but controlled ripening would greatly increase acceptability and demand for winter tomatoes during the cooler weather.

Export

The agricultural and pastoral industries earn about 80% of Australia's export receipts, wool contributing about 35% and meat, dairy produce, wheat, sugar, and fruit contributing 45–50% (Holmes 1967). However, our export markets are changing rapidly. Before the war more than 50% of Australia's exports went to Britain; Western Europe as a whole, the present EEC and EFTA region, took more than 70%. Today our markets are more diversified, Britain takes only 17% and Western Europe as a whole 36%, Japan takes 17%, other Asian countries 14%, North America 14%, and Oceania (mainly New Zealand) 10%. A swing towards the Pacific Basin is also occurring in imports.

The Australian fruit industry is very dependent on export and the main markets for our fresh, canned, and dried fruit are still Britain and Europe, with Canada an important outlet for canned and dried fruit. If Britain joins the European Common Market, competition will become even stronger. Australia will have less tariff protection and will have to comply with EEC standards in grading and packaging, which will mean, in some cases, considerable changes; fresh fruit is already being affected. For example, all packages will probably have to fit the EEC standard 120 × 100 cm (48 × 40 in.) pallet with no overlap, and 90% space utilization.

In transport, the use of bulk containers is introducing new handling and packaging problems and, for refrigerated fresh produce, new problems of cooling and temperature control. However, it also offers reduced handling costs and reduced handling damage as well as the possibility of simplified packaging. Unitization of cargo on pallets is an alternative which will have an important place in transport.

Exports, 1966/67

Apples	6·8 million bushels
Pears	1·4 ,, ,,
Oranges	1·2 ,, ,,
Grapes	88 thousand bushels
Dried vine fruit	162 million lb
Dried tree fruit	8 ,, ,,
Canned fruit	166 ,, ,,
Wine	1·7 million gallons

Despite high production costs and freight costs it is desirable to try to keep the European market. There is now world over-production of apples, pears, oranges, and bananas, and new markets will be very difficult to find. However, as can be seen from the export figures, the export market is critical for Australian dried vine fruits, canned fruits (especially pineapples, peaches, and pears), fresh apples and pears, and probably also for oranges. Because of our high costs and their generally low incomes significant increases are unlikely in sales of Australian fresh or processed fruits to Asian countries, or indeed in the Pacific Basin generally. Japan may accept more of our produce in return for freer import of Japanese manufactures into Australia, but this may be politically unacceptable even if it is economically possible. Also, at present there are quarantine restrictions on entry of our fresh fruit into Japan, as well as into many other countries. Such problems may be overcome technically by further research similar to the successful work on fruit fly infestation in citrus and pears, but the politico-economic problems may remain.

Conclusion

The fruit and vegetable industries, particularly the former, where export markets are so important, are facing critical times. World markets for most fruits are almost saturated and world production and Australian production of apples and oranges are increasing rapidly. Our costs of production and of marketing overseas are comparatively high. It is important therefore to improve quality and at the same time reduce costs. We must eliminate unwanted varieties, and selection and inspection of all export fruit must be much more rigorous.

In Australia the fruit and vegetable industries are not yet able continuously to supply the long lines of uniform quality at the price required for pre-packaging and retailing in supermarkets. Wholesalers and buyers are increasing in size and becoming fewer in number and the terminal market is declining in importance. Processing, with its specialized requirements, will take more and more of the crop. In addition there is a 'cost price squeeze' which will not lessen. A pomologist with a lifetime of service to the industry recently said that the apple industry was near bankruptcy and he was glad to be leaving it soon. Perhaps this is an exaggeration but much of the fruit industry is not prosperous.

To meet this situation growers must become bigger and stronger by engaging in large-scale production, for only by such methods can the full benefits of mechanization be realized and the processing and pre-packaging industries efficiently supplied. The private grower is meeting direct competition as big processing companies go in for large-scale production of fruit and vegetables.

Some years ago an American marketing specialist reminded the fruit industry of the economic truism that many little sellers are no match for a few big buyers. This is the message for the Australian fruit and vegetable industries today.

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Canning Technology Overseas

By P. W. Board
Division of Food Preservation, CSIRO, Ryde, N.S.W.

Some advances and trends in the canning industries of Japan, the U.S.A., Britain, and Europe, noted by the author on an overseas visit, are reviewed in this article.

Harvesters

The high labour cost and the problem of finding a large work force for harvesting for short periods of the year have caused the wide use of specialized field equipment. For example, self-propelled combine pea harvesters capable of operating on 25% slopes fore and aft and 40% slopes on contour are now in production. Hydraulic drives are replacing gears wherever possible and automatic levelling devices are also used in these harvesters. Particular attention is being given to the setting of the beaters in viners because of a growing market preference in the United States of America for small immature peas. The production of pink- or purple-eyed peas for freezing and canning in the southern states of the U.S.A. is increasing but yields are at present only of the order of 1500 lb/ac. The welfare of the machine operators is receiving more attention; a mobile tomato harvester was inspected which had an enclosed air-conditioned work area fitted with equipment to broadcast music.

Transport

Mobile tomato-pulping plants are in use in some areas of the U.S.A. The machinery, including the boiler, washing, sorting, and trimming equipment, and the pulping unit, is often mounted on trailers and is set up on bitumen-sealed areas in the tomato-growing region. The use of such mobile units reduces the distance the raw fruit has to be hauled for processing, and the waste material is readily disposed of in the growing areas. The pulp from these units is transported in road tankers to the central factory and converted to paste for subsequent reprocessing.

Increasing quantities of tomato paste are being stored and transported in bulk containers in the U.S.A. Aseptic filling of 55-gallon heavy-gauge tinned-steel drums or lacquered black-plate drums has been used, but the drums must be used twice to be economic, and are difficult to clean because of the small diameter of the closure. There is now a trend towards storage of tomato paste in tanks of many thousands of gallons capacity. These tanks are sterilized with peracetic acid and steam and filled aseptically with sterilized and cooled paste. The tanks are fitted with pressure gauges to detect gas production from fermentation if contamination occurs. Techniques have also been developed for aseptically transferring the paste to sterile road tankers for transport to reprocessing plants. At present, bulk storage is used only for pumpable acid foods, but similar procedures will probably be developed for low-acid foods.

Transport of frozen pineapple juice concentrate from Hawaii to mainland U.S.A. is another interesting example of bulk handling. The concentrate is frozen in 315-gallon polyethylene bags supported in plywood cases. After delivery the plywood cases are collapsed and returned to Hawaii to be used again. The cases usually survive three to five trips and occupy little space when collapsed.

Preparative Equipment

Although pipe blanchers have been produced for some 20 years they are not as widely used in the Australian industry as overseas. These units are commonly used for such operations as blanching peas, beans, and diced potato, and for rehydrating prunes. By arranging the pipes to give a hydrostatic head, high-temperature water treatments can be applied, e.g. 6 min at 235°F is commonly used for prunes.

Automatic colour sorting units seem to be more widely used in some overseas countries than in Australia. These sort dry particulate products such as beans, peas, lentils, barley, and tapioca. The particles pass the colour-measuring head of the machine in a falling stream at about 25 particles/sec. Off-coloured particles are detected and ejected from the main stream by a short blast of compressed air. Similar machines are also available for sorting wet particulate foods, such as diced vegetables, which pass to the sorter in a stream of water.

Despite the bulk storage of tomato paste in the U.S.A., considerable quantities are still processed in A10 cans which also are mainly used for tomato paste in Australia. A unit was inspected in the U.S.A. which automatically opens the can, washes out the paste, and then crushes the empty can. The cans are placed in line on a heavy horizontal chain conveyor which carries them under a vertical power-driven metal spike of about 3 in. diameter. The spike is driven through the top of the can and out the bottom and is then withdrawn, so that most of the paste pours out of the can and is collected in a tray under the belt. The can is then carried by the belt to the next station where a metal pipe fitted with a spray head is automatically inserted into the can and high-pressure jets of water wash residual paste from the can. The empty cans are removed from the conveyor belt and crushed between two converging heavy-duty metal belts.

Fillers

Machines to fill such products as fish chunks and Vienna sausages were observed in Japan and the U.S.A. These machines work on similar principles, so only the Vienna filler will be described. The smoked and skinned sausages about 18 in. long are hand-packed in bundles onto a horizontal chain conveyor. The sausages are held on the chain by several curved plates somewhat shorter than the length of the can into which the sausages are to be filled. The chain carries the sausages under a helical blade which rotates between the curved holder plates and cuts the long sausages to the required length (about $2\frac{1}{4}$ in.) for filling. The individual bundles of cut sausages are then turned at right angles to the direction of movement of the chain and a piston pushes the bundles horizontally into the cans that are supplied, on their side, in a path parallel to the chain. After the cans are filled the curved holder plates again turn through a right angle and are carried by the chain to the loading point. About six operators are required to load the long Viennas on the chain and the unit fills about 400 cans per min.

Can Closers

Can closers in general have two contoured rollers that spin in turn against the rim of the end of the can to form a double seam. The main developments in can closers have been units with several closing heads and an increase in the operating speed of each head. A major innovation in closing technique has been the replacement of the contoured rollers by two grooved bars that form the seam as the can is carried along the bars by the chuck and base plate of the closer. These machines are known as double differential closers and are operating in Britain at speeds up to 600 cans per min.

Processing Equipment

Spiral-type continuous pressure cookers are well established in the canning industry in Australia and abroad and new units are in continuous demand. These units are now being developed for processing glass-packed foods. Five pressure shells are used; in the first two the bottles are heated in stages to avoid excessive temperature shocks, the heat process is completed in the third shell, and in the last two shells the bottles are cooled in stages. The bottles are automatically enclosed in perforated canisters before entering the cooker and automatically removed from the canisters at the end of the process. Debris from occasional breakages during processing is retained in the canisters. The first of these units is designed to process baby feed bottles containing a milk formulation; the teat is in place on the bottles during processing and is protected by a tear-off aluminium cap.

Spiral-type cookers are used in the U.S.A. for high-temperature processing of cream-style sweet corn. The corn will stir in the can if consistency is carefully controlled, and processes of 20 min at 268°F can be used instead of the commonly used processes of about 1 hr duration.

Another use of spiral-type cookers is to warm canned beverages above the dew point to prevent condensation damage to the cans and cartons. These units are often linked to the beverage cooling system to use the waste heat from the refrigeration to heat the filled cans.

Flame sterilization is now well established; in December 1966, eight flame sterilizers were in commercial use in France and one in the U.S.A., and more were under construction. They are mainly used for processing button mushrooms in brine, but may be used for other foods that heat by convection. Since there is no superimposed pressure on the cans during flame sterilization, only cans up to about 3 in. diameter may be processed without risk of distorting the ends. The construction of the flame sterilizer is shown in Figure 1. The cans first roll through a steam tunnel to give a high uniform initial temperature to the product. They then roll across banks of propane flames to heat the product to sterilizing temperature. Sterilization is completed in the holding section and the cans are cooled under water sprays and discharged. The exterior of plain or lithographed cans is not damaged by the flames and improvements in quality and drained weight are claimed for mushrooms processed in these machines as compared to conventional processes. The flame and water-spray sections of the machine are open so the cans may be readily removed for measurement of temperature at almost any point in the process.

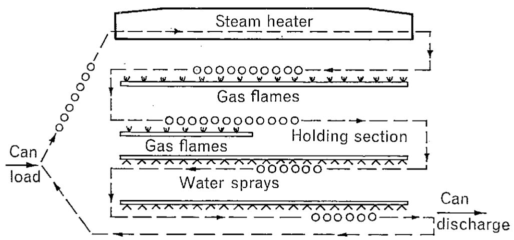


Fig. 1.—Flame sterilizer.

The Flash-18 unit (Fig. 2) is another example of a novel processing unit which consists essentially of a horizontal cylindrical pressure vessel of about 15 ft diameter housing conventional filling, closing, can washing, and cooling machinery. The vessel is maintained at 18 lb/sq in. gauge, at which pressure water boils at about 255°F; under these conditions the hot-fill–close–hold and cool method may be used for canning low-acid foods just as for canning acid foods at atmospheric pressure. The foods are prepared in the factory space outside the pressure vessel and are pumped into a heat exchanger where the temperature is raised to about 267°F by direct steam injection. The product then enters the pressure chamber where it is flash-cooled to about 251°F and deaerated. Since the product is so hot, the cans must be filled to within $\frac{1}{8}$ in. of the rim to obtain the usual net weight. The cans are immediately closed, held in water at about 255°F for 8 min, and then cooled. Heat-sensitive products, such as cheese sauce, and minced meat in tomato-based gravy, can be processed in large cans, e.g. A10, without loss of quality and the unit is mainly used for this type of product in large cans. Five operators work a 5-hr shift within the unit and spend 10 min in an air-lock for pressure equilibration when they enter and leave the pressure space. Atmospheric conditions in the pressure vessel and temperatures in the heat exchanger are controlled by another operator outside the pressure space.

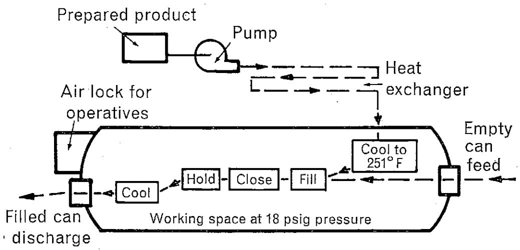


Fig. 2.—Flash-18 sterilizer.

Another processing unit that is creating interest overseas is the Robins Hydrolock continuous sterilizer (Fig. 3) described by

Lawler (1967).* Cans are transported into the pressure vessel of this machine on carriers mounted on a chain; the chain and carriers pass through a rotating mechanical port sealed under water. Water is forced past the rotating port as the chain and can carriers enter and leave the pressure vessel and is returned to the pressure vessel by an external pump and used for initial cooling of the processed cans.

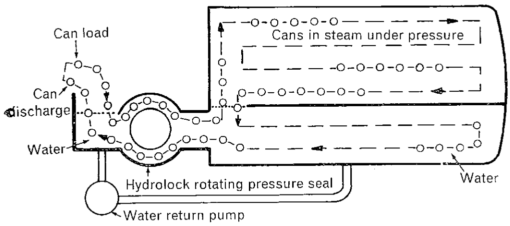


Fig. 3.—Robins Hydrolock continuous sterilizer.

Handling of Filled Cans

The most significant overseas development in handling processed cans is the increased emphasis being placed on the problem of post-processing contamination. Following the outbreak of botulism in Detroit, attributed to post-processing contamination in canned tuna, the feasibility of using a higher concentration of chlorine in the cooling water was investigated. Ten p.p.m. free chlorine in cooling water was found to inactivate spores of *Cl. botulinum* in 20 min and caused negligible corrosion of cannery equipment.

In Britain post-processing contamination of cans after they leave the cooling water is being investigated. Dirty can-handling equipment, such as conveyors and races, and the dirty hands of factory personnel have been found to be important sources of contamination, especially if the can seams are wet. Many canneries have installed can-drying equipment and have instituted sanitizing programmes for the can-handling equipment. Chlorinated water sprays (100 p.p.m. free chlorine) are recommended and counts of less than 100 organisms/sq in. of surface are considered desirable. Some can races and parts of the can discharge section of some hydrostatic cookers have been fitted with steam-heating coils to prevent build-up of contaminants, and factory operators who handle cans are encouraged to maintain high standards of personal hygiene. These precautions are not a substitute for producing the best possible double seam on the can, but it is generally accepted that even with good seams some cans may leak immediately after processing, perhaps because the sealing compound is affected during processing.

* Lawler, F. K. (1967).—New sterilizer made in France. *Fd Engng* **39**(7), 73–5.

Research and Extension

A major impression of the overseas canning industry is the close ties existing between the industry and industrial research establishments and some universities. In several cases, committees comprising technical people from the canning industry have been established at the invitation of the research bodies to advise on research programmes. Such committees inform the research groups of problems and trends in the industry and in turn, committee members hear at first hand the result of the work of the research groups. Such liaison has resulted in much commercially important work being done by research groups, and rapid application of new developments in the industry. In addition to research activities, many research groups conduct short-term schools on topics such as plant sanitation and can closing, and distribute a wide range of technical information to personnel in the industry.

Foam-mat Drying of Bananas

By S. Singhagajen*
Ministry of Agriculture, Bangkok, Thailand

and

D. McG. McBean
Division of Food Preservation, CSIRO, Ryde, N.S.W.

Early efforts to process bananas were not highly successful but in recent years acceptable dried bananas have been produced in the form of chips, flakes, and powder. This article outlines how Australian bananas were dried to produce a powder by the foam-mat procedure. The dried banana had an odour and flavour characteristic of the fresh fruit.

FOAM-MAT DRYING was developed at the Western Utilization Research and Development Division of the United States Department of Agriculture at Albany, California (Morgan *et al.* 1959). It can be applied to any homogenized food which on whipping forms a stable foam. Most foods require the addition of a small amount of stabilizer to produce a foam that will withstand such operations as pumping, spreading, extrusion, and drying. The large surface area exposed as a result of foaming permits rapid drying of the food and the porous structure of the dried product allows it to be removed readily from trays.

Processing

Production of banana powder by foam-mat drying involved peeling, pulping, addition of a foam stabilizer and sulphur dioxide, then whipping to a foam which was spread on trays and dried in a stream of hot air. Fully ripe Cavendish bananas were used in all experiments.

Pulping

The fruit was peeled by hand and pulped in a food blender.

Additives

The most suitable stabilizer of those tested was glyceryl monostearate† (GMS, Myverol 18–00), added to the pulp at the rate of 2% of banana solids. To be effective the stabilizer should be blended in hot water (145–155°F) for 1 min, to give a 5–10% dispersion in the form of a stiff suspension without visible particles. The temperature at which the blending occurs is probably critical.

The addition of sulphur dioxide to banana before drying caused the dried fruit to be lighter in colour than if no SO_2 was used. In this respect, it resembles other dried fruits. Sulphur dioxide was applied by adding sodium metabisulphite (dissolved in a minimum of warm water) to the pulped banana just before foaming. The loss of SO_2 was rapid during whipping and even more pronounced during drying. Thus it was necessary to add 5% sodium metabisulphite to the pulp to obtain banana powder with about 1000 p.p.m. SO_2 (0·1%).

Foaming

The mixture of banana pulp, dispersed stabilizer, and SO_2 was foamed in a Hobart mixer using a wire whip attachment at room temperature (20–25°C). Maximum expansion, to about 3 times its original volume, occurred in 4–5 min. Foams were stiff and easily spread on wire mesh trays to a depth of about ⅛ in.

In the U.S.A. the foam is spread by a special applicator and the layer is then 'cratered' by blowing compressed air through holes in the base of the perforated trays (Morgan *et al.* 1961). This procedure speeds drying but was not used in the present tests.

Drying

Banana foam was dried in a cross-flow

* Mrs. Singhagajen was a Colombo Plan Fellow at the Division of Food Preservation, CSIRO, from September 1965 to March 1966.

† The food regulations of the Australian States do not permit the addition of this chemical to dried fruits.

dehydrator using the following schedule of air inlet temperatures: 30 min at 210°F, 30 min at 180°F, then at 150°F until the foam was dry. The average air speed was 1000 ft/min.

Foams dried for a total of 2 hr contained about 5% residual moisture. An additional 2 hr was necessary to reduce moisture contents to 2–2·5%. In the United States where the previously mentioned 'cratering' of foam is used together with higher air speeds, drying times as low as 30 min have been reported.

Even under the less effective drying conditions tested in Australia, water loss was very rapid during the early stages of drying, for example at 210°F water content fell from 80% to 12·5% in 15 min (Fig. 1), but subsequent water loss was slow. The dried foam broke up into fine flakes or powder during removal from the trays.

Storage

Samples of foam-mat dried banana were stored in sealed cans for periods of 2, 4, and 9 weeks at 30°C to assess their potential storage life. Moisture-proof containers were necessary for this product as it is hygroscopic. Two levels of moisture, 2·5 and 5%, and two levels of SO_2, 0 and 1200 p.p.m., were used as variables.

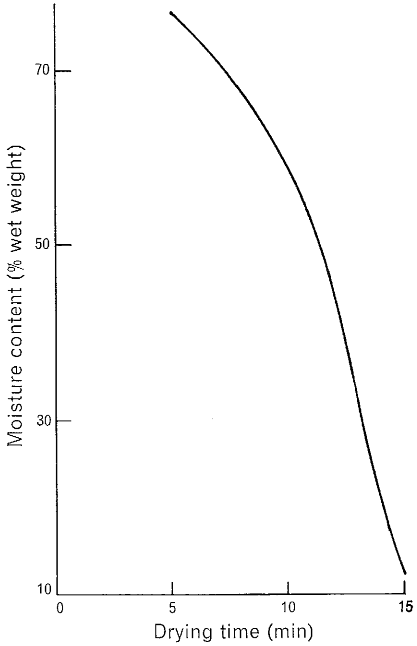


Fig. 1.—Rapid fall in moisture content of foamed banana during the early stage of drying at 210°F.

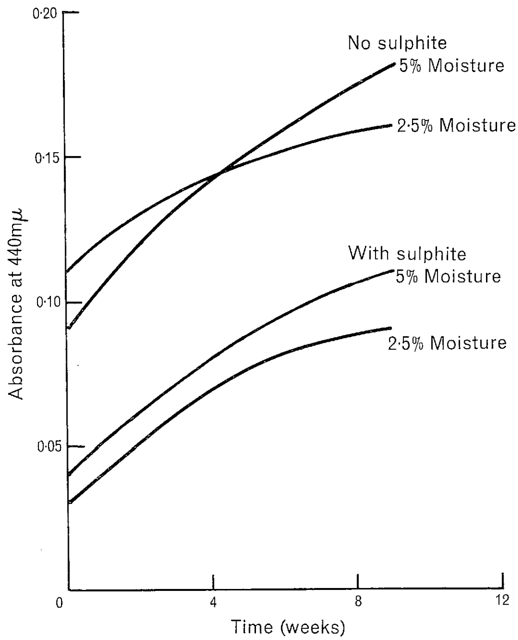
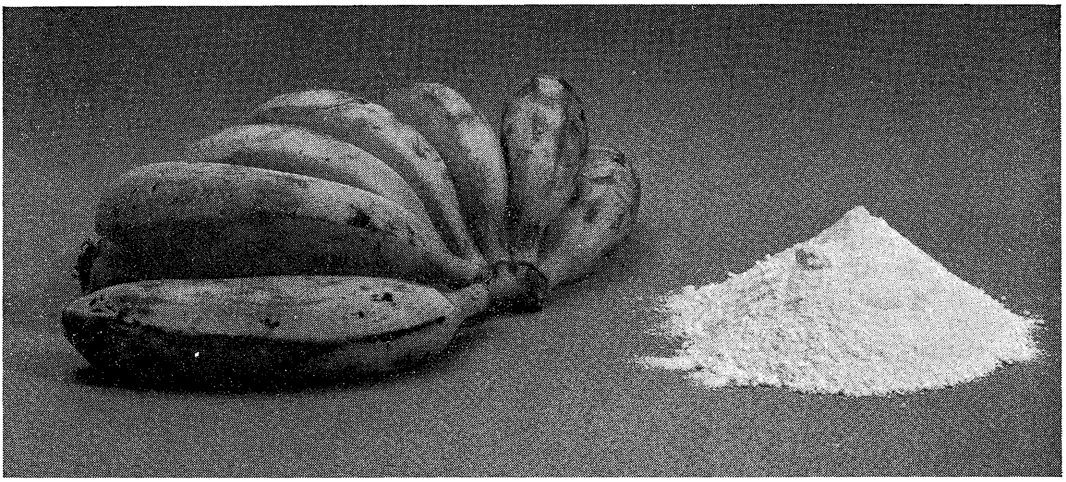


Fig. 2.—Increase in 'browning' of foam-mat dried banana during storage at 30°C (86°F).

Deterioration was assessed by determining the loss of sulphur dioxide and the development of brown colour during storage. The former was determined by the Monier–Williams method as modified by Shipton (1954). The brown pigment was extracted with 50% ethanol and the optical density of the extract was measured at 440 mμ.

Sulphur dioxide was lost rapidly from dried banana, little remaining in the product after 9 weeks at 30°C. The rate of loss was similar at each of the two moisture levels. It is not known whether this loss was due to desorption of SO_2 from the porous product or to its chemical combination with components of the fruit.

In contrast, the rate of development of brown pigment during storage was fairly slow, as shown in Figure 2. Samples that had not been treated with SO_2 were initially darker than those containing the preservative but during storage their rates of darkening were similar. All samples were still acceptable after 9 weeks' storage. There was a tendency for dried banana with 2·5% moisture to darken more slowly than that with 5%, but



The yield of banana powder obtained from bananas by the foam-mat drying procedure.

because of the shortness of the storage periods this result was not clearly defined. Under temperate conditions (20–25°C) dried banana would probably remain acceptable for 9–12 months.

Market Possibilities

Banana powder is produced in Brazil and Ecuador by spray or drum drying for export to the U.S.A., the German Federal Republic, and Japan. In the U.S.A. it is used as a flavouring material in ice-cream and cream fillings for biscuits, also as a component in dry cake mixes.

There is a small but persistent demand for a dry banana product by Japan and countries in Western Europe.

Conclusion

The drying of ripe Cavendish bananas using the foam-mat technique resulted in a free-flowing powder with the characteristic odour and flavour of fresh fruit.

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Better Apples through Controlled-atmosphere Storage

The Division of Food Preservation, in conjunction with the New South Wales Department of Agriculture, will conduct an extension school on controlled-atmosphere (C.A.) storage of apples on March 6, 1969.

It will be held in the important apple-growing centre of Orange, primarily for the benefit of growers and store operators. The aims will be to ensure that the industry is fully aware of the special technical requirements so that maximum benefit for both grower and consumer can be obtained from this improved method of storage, which no only increases storage life but also better maintains initial quality and doubles shelf-life after storage.

The theme of the school will be quality control, with special attention to construction and operation of C.A. rooms, selection and preparation of the fruit, and marketing. Expert speakers will cover both research and practice. Further information can be obtained from either the Division of Food Preservation or the Regional Supervisor, Department of Agriculture, P.O. Box 435, Orange, N.S.W.

Salmonella in Foods

By F. H. Grau

Meat Research Laboratory, Division of Food Preservation, CSIRO, Cannon Hill, Qld.

Increasing appreciation of the importance of salmonella bacteria in causing food poisoning has focused attention on the distribution and control of these organisms.

SALMONELLAE are a large group of rod-shaped bacteria whose normal habitat is the intestine of man and animals. There are about 1000 different serotypes distinguished from each other by rather precise serological tests which in a sense fingerprint the structure of the body of the bacterial cell and the flagellae, the organs used for locomotion. Serotyping is a convenient and very useful method of identification which has proved invaluable in tracing the history of epidemics and the spread of a particular salmonella serotype in any environment.

The best known and the most dangerous salmonella types are *Salmonella typhi* and *S. paratyphi* A, B, and C. Of the paratyphoid types, *S. paratyphi* A is more common in the Orient, *S. paratyphi* B in western Europe and North America, and *S. paratyphi* C in central and eastern Africa. *S. typhi* and *S. paratyphi* characteristically infect man only, and rarely if at all infect other animals. *S. paratyphi* B has been frequently isolated from animals, particularly pigs, but most of these isolations have been *S. paratyphi* B var. *java* which tends to cause gastro-enteritis rather than paratyphoid fever.

S. typhi causes typhoid fever, and may give rise to epidemics such as the notorious Aberdeen outbreak of 1964 (Milne *et al.* 1964). It is much more infective than other types. After ingestion of small numbers of *S. typhi*, the bacteria penetrate the gut wall, move to the local lymph nodes, where they multiply, and are released into the blood stream. Other tissues are infected and bacteria are released back into the intestine. Erosion of the blood vessels of the gut, gut puncture, or toxaemia may eventually cause death. The incubation time before symptoms develop varies with the dose and can be as long as 14–18 days. Symptoms are a high fever with a slow heart rate, enlarged spleen, red inflamed spots on the thorax and abdomen, abdominal pain, and bloody diarrhoea.

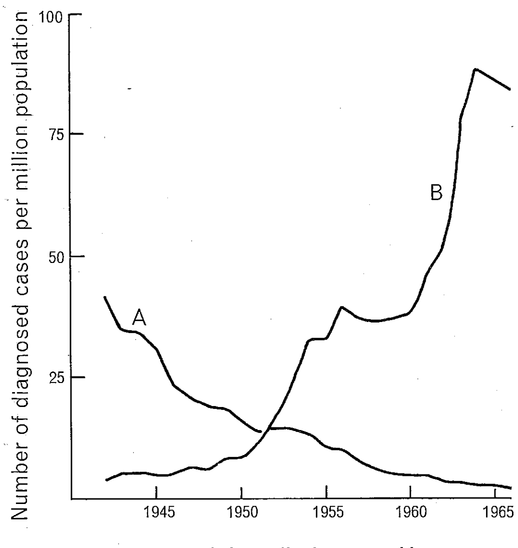
Paratyphoid fever is caused by several types of *S. paratyphi* and is a somewhat milder disease. The penetration and spread of these bacteria through the body are similar to that of *S. typhi*, but tissue injury tends to be less and fatal cases fewer.

The other 1000 salmonella types can readily infect both man and animals and in this differ from *S. typhi* and *S. paratyphi* which are specific for man. These other salmonellae generally cause a much milder disease. The infective dose varies from about 100,000 to millions of cells. As most foods initially contain only small numbers, growth of these salmonellae in the food has to occur before food poisoning results. Symptoms of salmonellosis usually occur within 24–48 hours of ingestion and can include nausea, diarrhoea, and a mild temperature lasting 1 to 3 days. The disease can at times cause a more severe gastro-enteritis with invasion of the blood stream, rapid body dehydration, bloody diarrhoea, and death.

The most common salmonella causing gastro-enteritis is *S. typhimurium* and is the cause of 25% or more of cases in man. However, it must be emphasized that many different types of salmonellae can and do infect both man and animal. The young, the elderly, and the sick seem to be most susceptible to this disease. Of the *known* human cases of salmonella infection in the United States in 1963–65, about 40% were in children under 4 years old (Anon. 1966).

In many countries it appears that salmonellae are the main cause of bacterial food poisoning. Although a more severe disease is caused by *S. typhi* and *S. paratyphi*, the other salmonellae occur so frequently that they are important causes of illness and in some countries account for more deaths than typhoid and paratyphoid fevers.

Some idea of how serious food poisoning caused by these salmonellae can be in terms of persons *known* to be affected is shown by the statistics for Britain, Europe, and the United States. The graph on this page shows the number of known human cases clinically diagnosed for typhoid fever compared with other salmonelloses in the United States over the period 1942–66. It is immediately apparent that while the incidence of typhoid fever has been reduced, the incidence of salmonella food poisoning has increased dramatically until the year 1964. While some of this increase is due to better medical reporting, some of it is real. This is probably because bulk marketing of foodstuffs and the long chain of handling from manufacture to consumption increase the risk and spread of contamination. In the period 1964–66, the incidence of salmonellosis has been somewhat stationary. In the United States during this period, considerable efforts have been made to identify and control food and other materials contaminated with salmonellae. Eickhoff (1966) has estimated that to those involved the cost of gastroenteritis due to salmonellae in the United States was between 10 million and 100 million dollars. In terms of national gross income or output, the total economic loss would certainly be higher.



Reported incidence of clinically diagnosed human salmonellosis, United States, 1942–66. *A*, Typhoid fever. *B*, Salmonellosis other than typhoid fever. (Data replotted from Salmonella Surveillance, Annual Summary 1966. U.S. Public Health Service, 1967.)

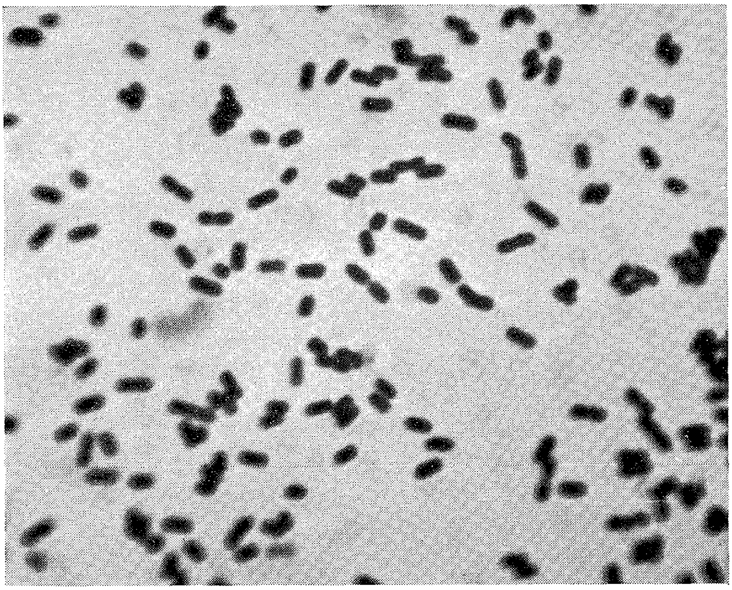
In Britain the rapid rise in food poisoning incidents known to be caused by salmonellae began during the war years and extended till 1954–55. The level seems to have been relatively stable since then, with a fall in the incidence of *S. typhimurium* infections but a rise in the incidence of other salmonelloses (Taylor 1962).

An example of how huge a single outbreak or epidemic can be is one that occurred in Sweden in 1953, when salmonella food poisoning associated with meat contaminated with *S. typhimurium* produced by one abattoir caused 10,000 human infections and 110 deaths (Pantaléon 1963).

Sources of Salmonella Food Poisoning

Before World War II it was generally accepted that the most important cause of human salmonellosis was contamination of food by the human carrier. However, even then, it had been pointed out that animals were the main reservoirs of salmonellae and that surveys of animal strains and their association with food poisoning were needed. Investigations in many countries during and since the 1940s have shown that animals are very important sources of food and human infection. As has been already pointed out, *S. typhi* and *S. paratyphi* are specific for man so that the spread of typhoid and paratyphoid fevers is caused directly or indirectly by the human carrier. The presence of *S. typhi* or *S. paratyphi* in drinking-water or food strongly suggests that these have been contaminated in some way by human faeces. However, the presence of other salmonellae in food, particularly uncooked egg and meat products, is most often caused by contamination from animal sources.

The most common foods involved in salmonella food poisoning are egg and egg products, meat and meat products, sometimes dried milk, seafoods, coconut, and peanuts. Salmonella contamination of the last four usually arises from unhygienic preparation or raw material from contaminated environments. Contamination of dried milk powder apparently occurs after pasteurization (Foster 1966). The manufacturing process does not involve a temperature high enough to kill salmonellae and seems conducive to salmonella growth, especially in the operation of



Salmonella oranienburg. This serotype has been found associated with fowls, eggs, and egg products and has caused several outbreaks of food poisoning. It has also been found in the bovine rumen. × 1850.

agglomeration to make instant dry milk (Lawler 1966). Liquid milk has in the past been responsible for numerous outbreaks of salmonellosis. However, since pasteurization, milk is only rarely involved, although it can still occasionally cause quite large outbreaks. Drinking-water, too, has been the cause of epidemics, particularly of typhoid and paratyphoid fevers, but with modern control and chlorination of drinking-water the risk from this source is very much reduced.

In May 1965 a large outbreak of salmonellosis in California was caused by *S. typhimurium* in a municipal water supply. It is estimated that there were 16,000 cases of gastro-enteritis over about 10 days. Chlorination of the water system led to a dramatic decrease in the incidence within 48 hours (Anon. 1966).

Egg and Egg Products

During World War II, spray-dried egg was imported into Britain from Canada and the United States. British workers showed that salmonellae could be isolated from at least 10% of samples (Wilson 1964). There was soon evidence to implicate this spray-dried egg in numerous and sporadic cases of food poisoning. Salmonella types not previously found in Britain were now found in human patients and corresponded both in time and in frequency with the types isolated from this egg product.

After the war the spray-dried egg was replaced by various forms of frozen egg from China, Australia, Holland, and other countries. This imported bulk egg was also often contaminated with salmonellae. However, as most of this processed egg was being used by bakers and confectioners, it was thought that salmonellae would be destroyed by normal cooking procedures and that it would be relatively safe.

For a number of years outbreaks of paratyphoid fever had occurred without any obvious explanation. A high percentage of these followed consumption of cream buns, cream-filled cakes, and similar products. Examination of processed egg from various countries showed that though it often contained salmonellae, only Chinese egg regularly contained *S. paratyphi.*

Investigations of two outbreaks of paratyphoid fever in 1955 showed that in both, the cream-filled confectionery had been made from frozen Chinese egg. The same phage type of *S. paratyphi* was found in the patients and in the frozen egg. Further work showed that in 1955 and 1956 the phage types found in Chinese egg were responsible for 80% of human infections. This British work actually rediscovered German work of the early 1930s, in which ice-cream poisoning was shown to be due to *S. paratyphi* in Chinese egg-yolk.

Apart from causing paratyphoid fever,

bulk egg was also shown to contribute very significantly to the milder forms of salmonellosis. In 1955 and 1956 Chinese egg was thought to be responsible for much gastro-enteritis caused by *S. thompson*, an organism that for many years was the third most common cause of salmonellosis. In 1959 all but 6 of 39 different serotypes isolated from egg and egg products were also isolated from human patients. Harvey and Phillips (1961) stated that almost every sizable outbreak of salmonellosis in Britain in the 1950s was associated with bakers' confectionery. It was possible to relate sporadic and widespread cases of *S. typhimurium* infection with a particular batch of home-produced or imported egg material carrying the same phage types as the patients (Hobbs 1963).

Similar work in Denmark, the United States, and Canada has also often connected egg products with salmonella outbreaks. In Canada widespread salmonellosis appears to have been caused by cake mixes containing dried egg contaminated with salmonellae.

Meat and Meat Products

Outbreaks of salmonellosis originating from beef, calf, and pig meats have been known since 1888. Originally these were associated with animals showing clinical signs of salmonellosis. With improvements in the handling, inspection, and hygiene of meat the position was improved. However, healthy animals showing no sign of disease can carry salmonella and many investigations, particularly since 1964, have produced convincing evidence that meat animals are still a cause of human gastro-enteritis. For instance, Newell *et al.* (1959) in Northern Ireland found the same salmonella type in the bone and fish meal fed to pigs, the pigs on the farm, the pigs at abattoirs, the sausages made at these works, and the neighbouring population suffering food poisoning.

Similar findings were made by Dutch workers who found that salmonella types previously unknown in Holland were isolated from imported animal feed, were later found in the animals, and were subsequently isolated from cases of disease in the human population. German work in 1959 found a time correlation between the isolation rate of five serotypes from animals and from man (Pantaléon 1963).

In 1961 and 1962, thirty-two abattoirs scattered over England and Wales were sampled and the types and numbers of salmonellae isolated were compared with human isolates in the abattoir area. Cattle appeared to contribute most salmonellae to the abattoir isolates and sheep the least, with pigs occupying an intermediate position (Public Health Laboratory Service 1964).

Thirty-five serotypes were isolated from both abattoirs and human infections. Eighteen of the serotypes were also isolated from animal tissue and these eighteen were responsible for 90% of human infections in the area. The five most common isolates from abattoirs, butchers' shops, and meat accounted for 75% of the human outbreaks.

A comparison of the phage types of *S. typhimurium* most commonly isolated from abattoirs with those from human infections also showed a good correlation. Of the 10 most common abattoir isolates, 7 were in the 10 most common human isolates. Of 648 human isolates which were typed, 92% belonged to the phage types found in local abattoirs.

Boneless frozen meat imported into Britain has also been found to contain salmonellae in substantial numbers. Hobbs (1965), reporting for the years 1961–63, found that 18·5% of veal, 15·2% of beef, and 9·8% of mutton sampled contained salmonellae.

From 1949, meat and its products have been the commonest known vehicle of salmonella infection in the United Kingdom. Meat has been shown to be implicated in many of the less dramatic, but widespread, outbreaks and in sporadic cases of salmonellosis. Workers in the United States have also implicated chicken and turkey meat containing salmonellae with the spread of salmonellosis in man. Anderson, Crowder, and Woodruff (1964) investigated some unusual types of salmonella isolated from human cases in Adelaide, and found them in kangaroo meat sold as pet food.

It is important to realize that it is not always the originally contaminated item of food which causes infection. Salmonellae may be transferred from food to food through the contamination of utensils and equipment and by hand, or by human carriers who continue to shed salmonellae in their faeces. It is not only the particular item of contaminated food which is of importance but the introduction of salmonellae into the food preparation area. For example, even contaminated pet food, which will not be eaten by man, can cause human disease. It is handled by the housewife, cut up with knives used in the kitchen, and stored in the refrigerator near other food so that food for human consumption can be contaminated. The pet food is fed to animals who may develop clinical gastro-enteritis, or who may merely shed the salmonellae in their faeces. The pets then become a danger to human health as sources of salmonellae, particularly to children who may handle the animals.

Growth and Death of Salmonellae

A knowledge of some of the factors controlling the growth and death of salmonellae can help in the control of the spread of the organisms and of food-borne salmonellosis in man.

Salmonellae will not grow on foodstuffs when the water activity is below about 0·94 (Christian and Scott 1953). However, on foods with a water activity below this value, salmonellae can survive for quite long periods without growth occurring. There have been innumerable references to the finding of salmonellae in dried egg, flour, powdered milk, and on the surface of sausages whose water activity is considerably less than 0·90.

Salmonellae are able to grow in food within a pH range of about 4·5 to 8·5 (Banwart and Ayres 1957), but the actual range allowing growth in a particular food will be influenced by the composition of the food and the temperature. Outside this pH range salmonellae may die. The rate of death is determined mainly by temperature and the type of acid present (Mossel 1963). The higher the temperature, the more rapid is the death rate. At low pH, acetic acid is particularly effective in destroying salmonellae. For instance, in mayonnaise containing acetic acid at pH 3·8 and held at 15°C, a 100,000-fold reduction in salmonellae has been observed in 6 days. However, in many foods of a relatively low pH, salmonellae can survive for some time, and such foods can serve as vectors for spreading salmonellae, although the organisms will not grow in them.

Salmonellae can grow at temperatures from 7°C to about 45–46°C (Angelotti, Foter, and Lewis 1961). A food, then, which is stored below 7°C will not allow salmonellae to increase. Salmonellae survive in chilled and frozen foods, and many cases of human disease have been traced to salmonellae in ice-cream, butter, eggs, meat, and chicken. Salmonellae have also been detected in ready-prepared frozen meals.

Temperatures above 46°C are considered lethal for salmonellae. Ng (1966) tested about 300 cultures of salmonellae and found, in a laboratory medium at pH 6·8, that the average decimal reduction time at 57°C was 1·4–1·5 min, but for the heat-resistant *S. senftenberg* 775 W the time was 31 min. Heat treatments can often be used to ensure that a food is salmonellae-free. For example, Schaffner *et al.* (1967) have described a hot-water treatment of coconut to destroy salmonellae. The lethal effect of high temperatures may be modified by the characteristics of the food, such as water activity and pH. With dehydrated materials relatively severe heat treatments are used, since the lethal effect of high temperatures is much reduced at low water activity. Prost and Riemann (1967) point out that increasing the water activity of meat and bone meal to about 0·90 caused a considerable drop in the heat resistance of salmonellae.

The use of pasteurizing doses of radiation has also been suggested as a means of destroying salmonellae in foods. For a ten-million-fold reduction in salmonellae a radiation dose of about 0·5 rad is required, a dose relatively well tolerated by dehydrated and frozen foods (Mossel 1963).

Control of Salmonellae in Foods

The control of salmonellae in foods involves obtaining the raw material in a salmonella-free state, manufacture, storage, and distribution under conditions where the salmonella content is not increased, and ideally a terminal process treatment that destroys any salmonellae present in the food.

As already indicated, meat and meat products, egg and egg products, milk, drinking-water, and seafoods have all been involved in salmonellosis in man. With milk and water, techniques have been applied for some time now to prevent salmonellosis. Milk is usually obtained under hygienic conditions in which faecal contamination is kept to a minimum, and is refrigerated before and during processing, pasteurized, and stored under refrigeration until consumption. Drinking-water is usually obtained from water supplies where contamination by intestinal products is kept low, and is chlorinated to destroy any salmonellae and distributed so that no cross-contamination can occur between sewerage and water pipes.

In recent years various agencies have required that bulk egg material also be pasteurized by a terminal heat treatment. Care is needed to prevent post-pasteurization contamination. Meat and bone meal prepared from abattoir by-products are also given a heat treatment during their manufacture. However, salmonellae are often detected in the finished product, usually as a result of inadequate hygiene leading to post-processing contamination.

Fresh meats and seafoods present a slightly different problem. At the moment there is no acceptable method of terminal processing that destroys any salmonellae present. The problem with meats is aggravated by the fact that all meat-producing animals can harbour salmonellae in their intestines, various organs, and lymph nodes, without there being any clinical sign of their presence. For instance, Grau and Brownlie (1965) found that of 193 apparently healthy cattle examined at slaughter in five works in south-eastern Queensland, 45% contained salmonellae in the rumen. Kovacs (1959) found that the mesenteric lymph nodes of 31·5% of 200 cattle and pigs at slaughter in Western Australia contained salmonellae. It appears that much of this infection of meat animals occurs after the animals have left the farm.

Because of this high incidence of salmonellae in animals at slaughter, correct pre-slaughter treatment of animals and good abattoir hygiene are essential if salmonella contamination of meat is to be minimized. Good techniques are required on the slaughter floor to prevent intestinal contamination of carcasses, and prompt refrigeration to prevent growth of salmonellae. Boning must be carried out under hygienic conditions to limit the spread of contamination and to prevent an increase in salmonellae at this stage. The application of American regulations to the Australian meat industry should result in an improvement of the salmonella status of boneless beef. Refrigeration of boning rooms prevents growth of salmonellae on the meat and work surfaces, and the replacement of wooden equipment with stainless steel further reduces the possibility of proliferation of salmonella on working surfaces. Refrigeration to 7°C or below at all stages to final cooking and consumption is essential.

Salmonellae in seafoods usually come from raw material taken in estuaries and bays where the water is contaminated with faecal material, or from workers in the processing plant who are carriers of salmonellae. The same general principles of plant hygiene and refrigeration apply here as to other foods.

Summary

Animals used by man for food production are vast reservoirs of salmonellae and it is not surprising that such foods as egg and egg products, and meat and meat products, contain salmonellae and so cause human infection. Although food contamination by human carriers is important, a much greater problem appears to be the natural salmonella population in food animals. From the viewpoint of food microbiology there are three aims:

- Avoidance of contamination at the source of production.
- When such contamination is unavoidable, provision of some terminal processing, e.g. heat pasteurization of coconut and liquid egg and possibly radiation pasteurization of meat.
- Safeguard food by refrigeration. Perishable foods should be kept at less than 7°C before cooking, and, if not eaten immediately, they should be cooled rapidly to less than 7°C. With the exception of *S. typhi*, all food-poisoning bacteria need to grow in food if they are to cause infection or intoxication.

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Ageing of Beef

By P. E. Bouton

Meat Research Laboratory, Division of Food Preservation, CSIRO, Cannon Hill, Qld.

Improving the quality of beef by ageing is a long-established procedure in the meat industry. The improvement is the result of a marked increase in tenderness. Other factors in eating quality, flavour and odour, are affected only slightly but loss of weight and deterioration of colour are disadvantages accompanying ageing.

Investigations on Ageing

Storage Conditions

Through the years, many investigations have been carried out to determine the best conditions for holding meat while it ages. It was established that near-maximum tenderizing effects could be obtained by storing meat for 14 days at a temperature of 34–36°F. These conditions of storage are used now as the standard for comparing results obtained under other environmental conditions.

The ageing process can be accelerated by raising the storage temperature to promote enzymic activity. Ewell (1940) showed that the rate of tenderizing, which might on theoretical grounds be expected to double for each 18°F rise in temperature, increased even more rapidly. Sleeth, Kelley, and Brady (1958) studied the effects of length of ageing, initial quality of meat, temperature, humidity, air velocity, and ultra-violet radiation on weight losses and organoleptic characteristics of the product. Their results showed that grade, period of ageing, and relative humidity of the storage room affect shrinkage. Tenderness, flavour, aroma, and juiciness values of beef quarters and ribs aged for 2–3 days at 68°F are comparable to those aged for 12–14 days at the normal ageing temperature, 34–36°F.

Bouton, Howard, and Lawrie (1958) studied the influence of holding first-grade and canner beef carcasses under commercial conditions at 32 and 68°F on weight losses and eating quality, and they compared the results with the drip from and the eating quality of such meat after freezing and storage. Their results showed:

- Evaporation losses during holding increased and drip losses after thawing decreased with length of holding period and increase of holding temperature. A period of 2 days at 68°F was approximately equivalent to 14 days at 32°F.
- Tenderness and overall acceptability of unfrozen meat increased and juiciness decreased with time of holding.
- Colour darkened and flavour became more intense, though not significantly. In general, these effects were more marked with canner beef than first-grade beef.

Meyer *et al.* (1960) studied the quality of grain-finished and grass-finished beef as affected by ageing at 33 ± 3°F and a relative humidity of approximately 85%. Tenderness of both types of beef increased significantly. The flavour of the lean of the grain-finished beef improved up to 21 days of ageing, but thereafter scores for flavour decreased significantly. Flavour of fat of both types of beef was significantly impaired by 21 or more days of ripening. Some free fatty acids developed between 21 and 42 days of ageing. Juiciness was not significantly affected.

Howard, Lee, and Webster (1960) found a correlation between ageing and the hypoxanthine content of meat, and considered the process of ripening to be at its optimum when the hypoxanthine content rose to $1\cdot5$–$2\cdot0$ μmole/g. Further work by Lee and Webster (1963) confirmed their previous findings and showed the rate of hypoxanthine production to be in agreement with the temperature–time relationship for the ripening of beef given by Kuprianoff (1953), namely,

$$\log T_\theta = 0\cdot0515(23\cdot5-\theta),$$

where T_θ is the time in days at any temperature θ between -1 and 37°C.

Packaging

More recently the trend in industry has been towards ageing meat as smaller boned and wrapped cuts. If meat is to be packed and aged in the bone-out condition, attention should be given to the temperature at which the material is held during onset of rigor. Indications are that a muscle which has been cut or excised in a pre-rigor condition may, after the onset of rigor and cooking, be tougher than expected.

Locker and Hagyard (1963) examined the shortening which accompanies or precedes onset of rigor at different temperatures and found that excised fresh bovine muscle contracted appreciably when exposed to temperatures near the freezing point. Shortening was minimal at about 15–20°C, and, within limits, increased progressively as the pre-rigor holding temperature departed from this range. Marsh and Leet (1966) reported that the tenderness of meat removed from the carcass in a pre-rigor condition was highly dependent on the extent of shortening which occurs after excision. Toughening increases rapidly with a shortening of over 20%, reaching a peak of several times its original value (in terms of shear force) at a shortening of about 40%.

Investigations on storage of pre-packaged meat have shown that the quality of the finished product is influenced by the kind of wrapping or packaging used. Recent work in the CSIRO Meat Research Laboratory in Brisbane on ageing different muscles of the hindquarter packed under vacuum in Cryovac bags for 14 and 21 days at a temperature of 35–36°F showed a very significant increase in tenderness, although the effect was more pronounced on certain muscles than others. No deterioration in flavour, odour, or colour of the cooked product was observed. Because of the low levels of oxygen within the bags, the colour of the uncooked meat was dark, but it returned to a normal bright red after unwrapping and standing in air for about half an hour. The main disadvantage of this type of wrapping was the exudation of fluid by the meat after 1 to 2 days' storage. It gave an unsightly appearance to the package and constituted a loss of weight by the meat.

Microbiological Aspects

Packaging in a film relatively impermeable to gases, such as Cryovac, inhibits the growth of the common low-temperature spoilage organism *Pseudomonas*, which requires oxygen for growth and is inhibited by carbon dioxide. The meat and the bacteria both use residual oxygen in the package, producing an atmosphere low in oxygen and high in carbon dioxide, which favours the growth of *Microbacterium* and *Lactobacillus*. These organisms do not produce the 'slime' usually associated with spoiled unpackaged meat but they bring about a 'souring' of the product.

In a gas-impermeable film meat may be expected to have a storage life of 30 days at 35–36°F. In polythene, or any other gas-permeable wrap, *Pseudomonas* will not be as effectively inhibited, so that slime will develop and the storage life may be only 12–14 days. Ageing in films like Cryovac that are efficient oxygen barriers at temperatures of 50°F and above is a potentially dangerous practice as this may allow growth, or toxin production, by human pathogens such as *Salmonella*, *Staphylococcus*, and *Clostridium*. For this and other reasons additional microbiological experiments on the ageing of meat, especially at high temperature, are needed.

Recommendations for Ageing

Having regard to the experimental results described above, the following conditions are recommended for commercial ageing of beef.

Quarters and Large Cuts

For quarters and large cuts, such as butts, loins, and rumps:

(1) Meat for ageing should be prepared under strict hygienic conditions.

(2) Temperature of the storage room should be controlled within ±2°F.

(3) Relative humidity in the storage room should not exceed 90% and preferably be not less than 85%.

(4) Air flow in the storage room should just maintain the above-mentioned temperature and humidity conditions around the meat. Higher air speeds will increase weight loss.

(5) Storage times recommended are
14–16 days at 32–36°F
or 7–9 days at 41–45°F

These conditions will produce near to maximum tenderization. Longer storage will result in more weight loss and more risk of spoilage.

Under the above conditions weight losses of G.A.Q. (first quality) beef should not exceed $2\frac{1}{2}$% for hindquarters and $3\frac{1}{2}$% for forequarters.

Small Cuts

The recommendations for preparation and storage of large cuts apply also to small cuts such as topside, fillets, and strip-loins. Small cuts for ageing should preferably be boned after normal chilling, as meat boned hot should not be exposed to near freezing temperatures.

The cuts should be packaged in wraps with low gas permeability such as Cryovac and Saran, as the wraps will extend their storage life by 50%. Control of humidity in the storage room is not essential when impermeable wraps are used. Temperatures of 50°F and above are not recommended for packaged meat.

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Pie Fillings

By D. G. James

Division of Food Preservation, CSIRO, Regional Laboratory, Hobart, Tas.

Canned fruit pie fillings are produced in large quantities in many overseas countries and they may become important items in Australia. Investigations at the Hobart laboratory of the CSIRO Division of Food Preservation have shown that high-quality pie fillings may be made from Australian fruits, especially berry fruits and apples.

THICKENED, canned fruit-pie fillings containing 30–40% sugar solids have become popular in the U.S.A., Canada, and Britain (Strachan *et al.* 1960; Blanchfield 1964). They consist basically of fruit, sugar, and a thickening agent such as a modified starch (Garrick 1965), and can be produced relatively cheaply and easily without sophisticated equipment. The need to diversify, particularly within the Tasmanian small fruit processing industry, is recognized and pie fillings, which could be supplied for the retail market or in bulk packs to bakers and pastrycooks, may be salable products.

Experimental

An experimental programme to investigate the formulation and manufacturing possibilities of fruit-pie fillings was undertaken by the CSIRO Division of Food Preservation, Hobart. Raspberries, black currants, and apricots and mixtures of raspberry and apple and of black currant and apple were used in these experiments. These blends of berry fruits and apple have been successfully used in Canada in experimental packs by Moyls *et al.* (1955). Initial trials were conducted using two commercially available modified starches. One of these, Col-Flo 67,* was found to be superior and was used in subsequent experiments. Other thickening agents available in Australia were not tested but may be equally satisfactory. One possible disadvantage of starch as a thickening agent is that the product may not have sufficient gloss. Research overseas has shown that the gloss and clarity of the pie filling may be improved by replacing part of the starch with sodium alginate† (McDermott 1963); a starch alginate treatment was therefore included in the experimental programme.

* Australian Bakels (Pty.) Ltd.

† Filtered food grade: Alginates (Aust.) Co.

The raspberries and black currants were packed without sugar and were frozen and stored at 0°F for periods up to six months before being used in the pie fillings. The apricots were halved, pitted, and then mixed with dry sugar and ascorbic acid (4 kg fruit, 1 kg sugar, 2 g ascorbic acid) before freezing.

The following formulations were used to make up samples of pie filling for taste testing and storage trials.

	Fruit (kg)	Sugar (kg)	Starch (kg)	Water (kg)
Raspberry	10	3	0·35	
Raspberry / Apple	6 / 4	3	0·35	
Black currant	10	4	0·26	
Black currant / Apple	5 / 5	4	0·26	
Apricot*	12·5	1·2	0·46	10

Methods of Preparation

The raspberries or black currants were thawed and mixed with sugar in a steam-jacketed jam pan the temperature of which was raised to 212°F. The solids were checked during this period and adjusted by addition of water. As soon as the temperature reached 212°F, starch that had previously been blended to a slurry with a small quantity of water was added. The pan was stirred vigorously for 1–2 min until gelatinization occurred, when it was immediately vented. For the apricot product the water and sugar were mixed and brought to the boil, and the

* As frozen apricots: 4 fruit, 1 sugar.

starch was added as a slurry with water. The thawed apricots were then added to the gelatinized mixture with thorough stirring. The berry and apple blends were first made by heating the sliced apple, berries, and sugar and then adding the starch slurry. This procedure gave a product with large unattractive pieces of apple, so in later trials the sliced apple was heated with sugar until it began to break down, and the berries and starch slurry were added later.

After heating to 210°F the products were quickly filled into 301×308 Epon-lacquered cans so that the product temperature did not fall below 185°F. The cans were immediately closed and inverted for 5 min and then cooled in running water until the average product temperature was 100°F. Cans may be processed in boiling water if the hot filling procedure cannot be used.

In the experiments with starch and alginate combined, 25% of the starch was replaced with a smaller quantity of sodium alginate; 4 parts by weight of starch were replaced with one part by weight of alginate. The alginate was dispersed in a small quantity of the sugar which was made up into a heavy syrup, and added to the sugar and fruit mixture before heating. The starch was added in the same manner as in the previous experiments.

Product Examination

The consistency, colour, flavour, and texture of samples of all trial batches were assessed in taste tests at Hobart and in the Division's laboratories at Ryde shortly after processing and at 6-month intervals during storage for two years at room temperature. Samples were also baked in pie shells to determine the behaviour of the product at baking temperatures.

In the raspberry pie filling there was no whole fruit as would be expected after cooking at 212°F. However, the filling presented an attractive appearance. The raspberry and apple filling was judged to be superior to that prepared from raspberries alone. Although the colour of the raspberry filling was slightly better, the flavour was too intense and the texture not as good as that of the raspberry and apple filling. The colour of both these fillings faded slightly with time but both were still acceptable after two years.

The samples of black currant filling retained whole fruit which showed up well when the contents were turned out of the can. However, the consistency was too stiff, the flavour and colour too heavy and intense, and the product slightly sour. The black currant and apple filling had an excellent consistency, flavour, and texture but considerable 'purpling' had taken place. This discoloration was probably caused by dissolved tin which was present in the canned solid pack apple used in making this product. Other samples made with fresh or frozen apple did not exhibit this discoloration.

The apricot filling was excellent; the halved fruit was suspended in a clear gel of good consistency, and the flavour and texture were very good.

In the samples where the starch was partly replaced with sodium alginate the appearance, glossiness, texture, and the mouth-feel of the gel part of the filling were improved. The quantities of starch required to produce good gels without alginate tended to give a pasty or cloying feeling in the mouth which was not apparent when alginate was used in conjunction with starch. Examination of the cans showed good vacuums, and freedom from corrosion or pitting of the internal surfaces of cans after storage for up to two years.

Apple pie filling was not produced in these experiments but it has proved extremely popular overseas. The following recipe would be expected to give a good product from fresh or frozen Tasmanian apples:

Sliced apple	10 kg
Sugar	3 kg
Salt	25 g
Water	5 kg
Starch	300 g

The apple should be a firm variety such as Sturmer, Jonathan, or Granny Smith. It should be cooked until soft with the water, 1 kg sugar, and the salt. The starch, blended with some water, should then be added and gelatinized. After this the remaining 2 kg of sugar should be stirred in; small quantities of cinnamon and lemon juice may also be added to improve the flavour.

All the above recipes are suggestions which have given good products but they could be modified to suit individual requirements.

Conclusions

The results of these experiments show that Tasmanian fruits in particular are very suitable for the production of pie fillings. The ease with which fruit can be frozen and stored for future processing would enable processors to produce this type of product out of season. At present there is a limited market for fruit pie fillings, but, as pointed out earlier, the fillings have become very popular overseas. If sufficient attention is paid to promotion and marketing there is reason to believe that pie fillings could become a profitable product in Australia.

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Financial Contributions, 1967-68

In the year ended June 30, 1968, the Division of Food Preservation had a budget of $1,385,271, of which $1,159,367 came from the Commonwealth Treasury. The balance was mostly accounted for by contributions for specific investigations, from government departments and statutory bodies within Australia, and in one case from the U.S.A. In addition the Australian food industry and associated industries contributed $19,020 to a Food Industries Equipment Account operated by the Division, and a number of companies donated or lent items of pilot-scale food processing equipment, or provided facilities for experiments within their food processing plants.

It is with pleasure that we place on record the names of the organizations and companies which have so generously contributed to the work of the Division.

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 Board
Investigations on mechanical skinning of sheep

Australian Meat Research Committee
Research on the quality, processing, storage, and transport of meat

Banana Research Advisory Committee
Investigations on storage and ripening of bananas

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 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

Contributors to Food Industries Equipment Account 1967–68

Abattoir Construction & Engineering Co. Pty. Ltd.
Anderson Processed Foods Pty. Ltd.
W. Angliss & Co. (Aust.) Pty. 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
Australian Packaging Industries Pty. Ltd.
James Barnes Pty. Ltd.
Bender & Co. Pty. Ltd.
Lewis Berger & Sons (N.S.W.) Pty. Ltd.
Berri Co-operative Packing Union Ltd.
Berri Fruit Juices Co-operative Ltd.
Blue Moon Fruit Co-operative Limited
A. J. Bush & Sons Pty. Ltd.
Campbell's Soups (Aust.) Pty. Ltd.
G. Centofanti & Sons
Cerebos (Australia) Ltd.
Chilton Thompson & Co. Pty. Ltd.
Citrus Products Co.
Coca-Cola Export Corporation
Committee of Direction of Fruit Marketing
Conkey & Sons Ltd.
Sidney Cooke (Printing Inks) Pty. Ltd.
Corona Essence Pty. Ltd.
Cottee's General Foods
Craig Mostyn & Co. Pty. Ltd.
Cygnet Canning Co. Ltd.
Dark's Ice & Cold Storage Ltd.
Darling Downs Co-operative 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 Aust. Pty. Ltd.
J. Gadsden Pty. Ltd.
W. G. Goetz & Sons Ltd.
Gordon Bros. Pty. Ltd.
W. R. Grace Aust. Pty. Ltd.
Griffith Producers Co-operative Co. Ltd.
Gumeracha Fruitgrowers Co-op. Ltd.
C. & N. A. Heighway
H. J. Heinz Company Aust. Ltd.
Hunter Valley Co-operative Dairy Co. Ltd.
Jusfrute Limited
Kyabram Preserving Co. Ltd.
Lawley & Housego Pty. Ltd.
Leeton Co-operative Cannery Ltd.
Henry Lewis & Sons Pty. Ltd.
McCarron Stewart Ltd.
Marrickville Margarine Pty. Ltd.
Mayfair Hams & Bacon Co.
P. Methven & Sons Pty. Ltd.
Muir & Neil Pty. Ltd.
Nestlé Company (Aust.) Ltd.
Northern Pear Growers Association Ltd.
Nugan (Griffith) Pty. Ltd.
Orange Fruitgrowers Co-operative Cool Stores Ltd.
P. & O. Lines of Aust. Pty. Ltd.
Harry Peck & Co. (Aust.) Pty. Ltd.
W. C. Penfold & Co. Pty. Ltd.
Pick-Me-Up Food Products
Thomas Plaimar Pty. Ltd.
Producers Cold Storage Limited
Producers' Co-operative Distributing Socy. Ltd.
Queensland Cold Storage Co-operative Federation Ltd.
Reckitt & Coleman Pty. Ltd.
Schweppes (Aust.) Ltd.
Scotts Provisions (Holdings) Ltd.
Shepparton Preserving Co. Ltd.
Sidac-Rayophane (Aust.) Pty. Ltd.
South Australian Fishermen's Co-op. Ltd.
Sou-West Frozen Food Packers Ltd.
Swift Australian Co. (Pty.) Ltd.
Taubmans Industries Ltd.
Unilever Australia Pty. Ltd.
Union Carbide Aust. Ltd.
United Fruit Company Pty. Ltd.
Vegetable Oils Pty. Ltd.
F. J. Walker Limited
White Wings Ltd.
Woolworths Ltd.
XLNT Food Pty. Ltd.
Arthur Yates & Co. Pty. Ltd.

Gifts and Loans of Equipment

Alfa-Laval Pty. Ltd.
- Centritherm evaporators
- Plate heat exchanger
- Pusher centrifuge

Berri Fruit Juices Co-operative Ltd.
- Test juice extractor

Degna (Aust.) Pty. Ltd.
- Reitz disintegrator
- Spray drier
- Thermoscrew

F.M.C. (Aust.) Limited
- Juice extractor

United Development Corporation Pty. Ltd.
- Screening centrifuge

NEWS FROM THE DIVISION OF FOOD PRESERVATION

New Editor

Mr. G. J. Walker has been appointed to succeed the late Dr. G. Cunningham as editor of publications and reports in the Division of Food Preservation. Mr. Walker is a graduate of the University of Melbourne where he took his M.Sc. in chemistry in 1950. For several years, Mr. Walker was on the staff of the former CSIRO Information Service. For the past ten years he has been in charge of the Chemistry Division of the Research Laboratories of the Postmaster-General's Department in Melbourne. He brings to his new position, which he assumed on September 23, 1968, considerable experience in scientific and technical writing and editing.

Other Appointments

Dr. June Olley has joined the Division of Food Preservation to undertake research on processing and preservation of fish, other marine organisms, and their products. Dr. Olley has an extensive knowledge of theoretical and practical aspects of the fishing industry. She was formerly on the scientific staff of the Torry Research Station, Aberdeen, Scotland, and is now working in the CSIRO Tasmanian Regional Laboratory, Hobart.

Two additional appointments were made to the research staff at the Division's Meat Research Laboratory, Cannon Hill, Qld., in the latter half of 1968. Dr. D. J. Horgan, a graduate of the University of Queensland and a post-doctoral fellow in the Biochemistry Department, University of California, San Francisco, is to undertake biochemical research on mammalian muscle. Dr. P. V. Harris, a graduate of the University of London who has had experience in scientific research in the food and chemical industries, is to investigate the mechanical properties of meat.

Overseas Travel

Dr. R. M. Smillie, Joint Leader of the Division's Plant Physiology Unit, spent the latter half of 1968 at the Oak Ridge National Laboratory, Tennessee, U.S.A. The main purpose of his visit was to study techniques for investigations on transfer ribonucleic acids. These techniques will be useful in current studies at the Plant Physiology Unit on organelle biogenesis in plant cells and in related studies on the biochemistry of ageing in plant tissues. Dr. Smillie delivered a paper to the meeting of the American Society of Plant Physiology at Amherst, Massachusetts, in September.

Dr. R. P. Newbold, a senior biochemist from the Meat Research Laboratory, Cannon Hill, Qld., was absent from Australia for three months from August 30, 1968, visiting meat research centres in Europe, North America, and New Zealand.

Dr. W. J. Scott, Assistant Chief of the Division and Officer-in-Charge of the Meat Research Laboratory, spent two months overseas from September 29. Dr. Scott attended an international symposium in Japan on the freezing and drying of microorganisms, and an international conference on culture collections, at each of which he delivered a paper. He also visited university departments, research institutes, and industrial laboratories engaged on meat research in Europe, Canada, and the United States.

Dr. Judith A. Waltho attended the 12th International Congress of Genetics in Tokyo, Japan, and visited a number of laboratories carrying out research in genetics, especially the genetics of microorganisms. Dr. Waltho was absent from Australia from the middle of August to the end of September 1968.

Dr. W. G. Murrell accepted an invitation to attend the 4th International Spore Conference at the University of Illinois, Urbana, U.S.A., from October 4 to 6, 1968, and to present the opening address.

Dr. T. M. Reynolds was invited to attend the 5th Biennial Symposium on Foods, held at the Oregon State University, Corvallis, U.S.A., from July 23 to 25, 1968. At the Symposium, devoted to the role of carbohydrates, she delivered a paper on sugar–amine interactions in non-enzymic browning.

Mr. J. D. Mellor attended the 6th International Symposium on Rarefied Gas Dynamics at the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A., from July 22 to 26, 1968.

Guest Worker

Professor J. M. Lyons, Chairman of the Department of Vegetable Crops at the University of California, Riverside, U.S.A., is spending the period September 1968 to August 1969 in the Division's Plant Physiology Unit at the North Ryde laboratories, where he is investigating the ripening of fruit by ethylene.

United Nations Fellow

Mr. Z. J. de Martin, a food technologist from the Tropical Centre of Food Research and Technology, Campinas, São Paulo, Brazil, is spending a year in the food technology section of the Division of Food Preservation. Mr. de Martin has been awarded a fellowship under the United Nations Development Programme for Brazil. On his return to the Centre at Campinas, Mr. de Martin will assist with the development of production and processing of tropical fruits.

Audio-visual Aids to Training

The Division of Food Preservation has bought recently from the National Canners Association, U.S.A., three sets of slides for use in training the staff of canneries.

They are:

Can Handling: leaker spoilage due to can handling equipment and procedures. A set of 50 coloured slides accompanied by a recorded commentary on $3\frac{3}{4}$ ips tape and a printed script of the commentary.

Using SQC: use, value, and meaning of statistical quality control charts. This is explained in a non-technical manner without the use of detailed mathematics. A set of 46 coloured slides and a 17-minute tape recording.

Planned Sanitation: reasons for sanitation programmes in food processing plants and their scope. A set of 50 coloured slides and a 20-minute recorded commentary.

These may be borrowed by application to the Librarian, CSIRO Division of Food Preservation, P.O. Box 43, Ryde, N.S.W. 2112. Telephone 88 0233.

N.C.A.'s older kit, *For the Retort Operator*, consisting of 70 slides and a 40-minute tape recording is also still available on loan.

Recent 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).

ANET, E. F. L. J. (1968).—Mechanism of formation of 3-deoxy-glycosuloses. *Tetrahedron Lett.* **1968**, 3525.

ANET, E. F. L. J. (1968).—6-*O*-Benzyl-*D*-galactose and its dimethyl acetal. *Carbohyd. Res.* **7**, 84–5.

ANON. (1968).—Freezing times of boneless meat. *Aust. Refrig. Air Condit. Heat.* **22**(3), 41.

ANON. (1968).—Storage temperatures for frozen meat. Meat Res. Lett. 68/1.

BATE, H. G. (1968).—Refrigeration facilities at new CSIRO research laboratories. *Aust. Refrig. Air Condit. Heat.* **22**(3), 49–50, 61.*

BOARD, P. W., HOLLAND, R. V., and BRITZ, D. (1968).—Solid electrode chronopotentiometry for studying the reaction of erythrosin on tinplate. *Br. Corros. Jnl* **3**, 31–3.

BURLEY, R. W. (1968).—Lipid–protein interactions in abnormal egg yolk: a comparison of the major lipoprotein fractions from normal eggs and from the eggs of hens fed methyl sterculate. *Can. J. Biochem.* **46**, 851–7.

CASIMIR, D. J., MCBEAN, D., and SHIPTON, J. (1968).—Fluidization techniques in food processing. *Fd Technol. Aust.* **20**, 466–7, 469.*

CHANDLER, B. V., KEFFORD, J. F., and ZIEMELIS, G. (1968).—Removal of limonin from bitter orange juice. *J. Sci. Fd Agric.* **19**, 83–6.

* No copies for distribution.