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# The Macadamia Nut Industry

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Walter Hill, Director of the Brisbane Botanical Gardens, and Ferdinand Mueller, Government Botanist of Victoria, discovered macadamia trees in the Pine River district on the outskirts of Brisbane in the mid nineteenth century, and named the genus after Dr. John Macadam, Secretary of the Philosophical Institute of Victoria (Anon. 1858). These evergreen trees which are indigenous to the coastal rain forest of southern Queensland and northern New South Wales are among the few trees of the Australian bush that have edible fruit.

Macadamias bear a long tapering inflorescence consisting of numerous small flowers, only a few of which set fruit. At maturity the fruit has a green fibrous husk with a pronounced beak, and a round brown seed with an extremely tough shell. The seed kernel, i.e. the mature embryo consisting of an inconspicuous plant axis and two large hemispherical cotyledons, is an edible, highly acceptable nut, known variously as the macadamia, Australian, Queensland, or bopple nut.

Australia has been tardy in exploiting macadamia nuts as a commercial crop, and has been forestalled in this development by Hawaii.

Commercial production of macadamia nuts first occurred in Hawaii where trees were reported to have been planted as early as 1881. Credit for recognizing the value of the nuts is given to two Jordan brothers who made further introductions from Australia in 1892 (Higgins 1920). However, it was not until the 1920s that the commercial value of the nuts became apparent, and not until the 1930s that the industry became stabilized, following a selection programme.

Macadamia nuts were first processed commercially in Australia in 1954 following collaboration between a nut processor in



Typical cluster of macadamia nuts.

Murwillumbah, N.S.W., and the Queensland Department of Agriculture and Stock (Leverington 1958).

### Botany

Three species of *Macadamia* are now recognized, *M. ternifolia*, *M. integrifolia*, and *M. tetraphylla* (Smith 1956).

*M. ternifolia* produces a very small nut with a cyanogenetic kernel that is unsuitable for commercial use, so these trees are not grown commercially. *M. integrifolia* is usually referred to as the smooth-leaf species. The nuts are 0.5–1.2 in. in diameter, tough and smooth, and commonly known as 'smooth shell'. *M. integrifolia* tends to blossom from June to March and some strains are almost ever-bearing. *M. tetraphylla* is the rough-leaf variety. The nuts are 0.8–1.4 in. in diameter, ovoid to ellipsoid in shape, with a rough surface, and are commonly known as 'rough shell'. *M. tetraphylla* blossoms between August and October and produces one main crop each year.

The cultivated species, *M. integrifolia* and *M. tetraphylla*, grow to 60 ft or more and they can be distinguished in the field by certain leaf and tree characteristics (Smith 1956). Both Johnson (1954) and Beaumont (1956) mention trees with intermediate characteristics which may be natural hybrids.

The common belief that there are soft-shell and hard-shell types of macadamia nuts is incorrect since they are all hard. Shells of *M. integrifolia* tend to be coarse and fibrous, while those of *M. tetraphylla* are similar but more brittle. Shell thickness ranges from 0.02 to 0.25 in., and generally *M. integrifolia* nuts tend to have thicker shells.

The *M. integrifolia* kernel is white with a light-coloured base, tender, uniform in quality, and shrinks only slightly after harvesting; the *M. tetraphylla* kernel is darker with a greyish base, firm in texture, variable in quality, and tends to shrink more after harvesting.

### Macadamia Production

The inherent variability of seedling macadamia trees and the lack of suitable propagation methods handicapped the macadamia industry, particularly in Australia, in the past. Considerable research and extension work was done to obtain satisfactory methods of grafting and to establish efficient orchards.

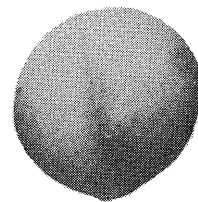
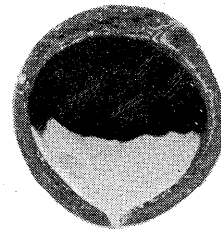
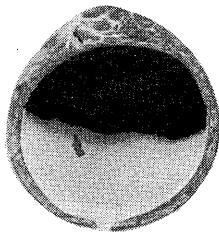
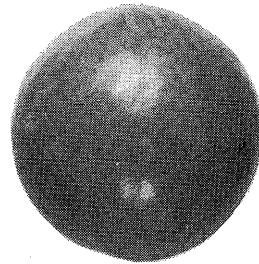
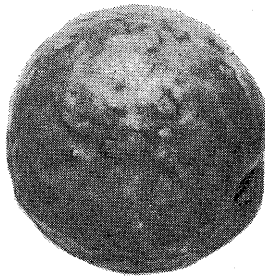
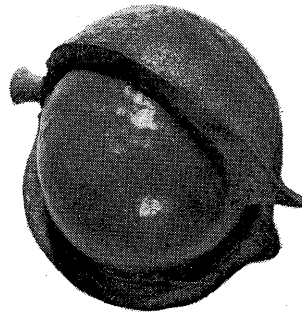
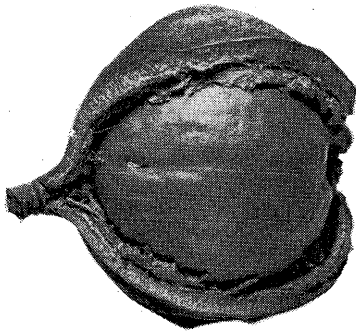
Macadamias are usually grown on fertile coastal well-drained soils in areas protected from wind and frosts. Consideration is now being given to growing macadamias in drier inland areas under irrigation. Accessibility for harvesting and cultural operations is essential and requires that the land be level and clear of weeds.

Soil nutrition, cultivation, water supply, and pruning are important and the grower must control pests, three of which are particularly troublesome. The fruit-spotting bug attacks the young developing nuts soon after setting and causes immediate shedding of many nuts. Its worst effect, however, is malformation of the kernels. The macadamia nut flower-eating caterpillar attacks blossom and may cause almost total loss of the crop. The macadamia nut borer attacks the developing nut, and by the time the nut is mature the kernel is completely ruined.

### Evaluation of Selections

When commercial processing of macadamias began in Hawaii in the 1930s, the great variation in yield, recovery, and quality of kernels from seedling trees became obvious. Ripper-ton, Moltzau, and Edwards (1938) set out to establish methods of evaluating macadamia nuts for commercial use, and made a study of the variability in quality between nuts from seedling plantings in Hawaii. They found that when kernels of high specific gravity and low oil content were roasted they acquired a dark brown colour, a strong scorched taste, and a hard tough consistency. At the other extreme, kernels of low specific gravity and high oil content developed a light golden colour, a mild nutty flavour, and a crisp texture. Specific gravity was therefore recommended as a basis for the assessment of macadamia nuts for suitability for roasting, first-grade nuts having a specific gravity of less than 1. Selection of macadamias for the Hawaiian industry was based on the results of this work (Hamilton and Fukunaga 1970).

Up to 1950, commercial orchards of macadamia nuts in Australia had developed from seedling plantings, after some selection of parent trees had been made, but even from the best orchards the nuts were extremely variable in size, shape, thickness of shell, percentage of kernel, and general quality. With a view to establishing grafted trees of known quality, Ross and Wills (unpublished



Typical macadamia nuts.

*M. tetraphylla* in husk.

*M. tetraphylla*.

Good *M. tetraphylla* shell.

*M. tetraphylla* kernel.

*M. integrifolia* in husk.

*M. integrifolia*.

Good *M. integrifolia* shell.

*M. integrifolia* kernel.

data, 1952) surveyed orchards, assessing trees as sources of scion wood on their cropping habit and yield, and assessing rootstocks mainly on their vigour. In 1954, the Queensland Department of Primary Industries evaluated the suitability for processing of nuts from these trees, and from similar selections by the N.S.W. Department of Agriculture (Leverington 1958, 1962*a,b*). The best types were later propagated on Departmental research stations to provide scion wood for commercial production.

### Assessing Nut Quality

Criteria for the evaluation of the quality of macadamia nuts have been defined by several authors including Ripperton, Moltzau, and Edwards (1938), Storey *et al.* (1960), and Leverington (1962*a*).

#### Shape

Nuts should be spherical or nearly so. Ellipsoidal or spindle-shaped nuts present difficulties in mechanical handling, including machine sizing and cracking.

#### Size

The range in size of the nuts from a selection should be small. Average diameter should be not less than 0.75 in. Smaller nuts are uneconomic to handle owing to excessive costs in sorting and grading the kernels. In addition, kernels of small diameter tend to shatter readily during cracking as the air gap between the kernel and shell is too small. On the other hand, kernels from excessively large nuts, more than 1.1 in. in diameter, pose heat penetration problems during roasting, and yield too few kernels to the packet for satisfactory retail marketing in transparent bags. The ideal size corresponds to not less than about 45 nuts to the pound.

#### Thickness of Shell

Moderately thick shells shatter easily with little damage to the kernels. Thin shells do not appear to be as brittle and the kernels of these nuts are easily damaged during cracking. Thick-shelled nuts crack well but give low recoveries of nut meat.

Nuts that have a very thin shell at the apical end are readily attacked by ants and by fruit-spotting bugs, and may germinate while still on the tree. When germinating kernels are roasted, a dark brown band develops at the growing surface. It is interesting to note that Stephenson, a selection which gives nuts

of this type (Leverington *et al.* 1961), has nevertheless proved successful in California, where it matures during the dry season so that germination is not usually a problem (Schroeder and Frolich 1960).

#### Cracking

After dehydration, nuts should crack cleanly so that there is minimum damage to the kernels which should not adhere to the shell.

#### Kernel Recovery

The lowest acceptable kernel recovery is 33% provided the tree has a high yield, but recoveries of 38–42% are possible and, of course, desirable. Some selections give even higher recoveries, but unless the shells are of uniform thickness the nuts may be more suitable for table use.

Kernel recoveries from samples examined in Queensland varied from 25% to 50%, the averages being 37% for *M. tetraphylla* and 30% for *M. integrifolia*. This variability exemplifies the difficulties that beset a manufacturer who buys nuts in shell from seedling orchards.

#### Kernel Size

The most desirable size is 2.5–3 g; average weights should not lie outside the limits 2–4 g.

Breaking of the kernels, particularly the larger ones, into halves during cracking is not considered to be a disadvantage.

#### Kernel Colour

Freshly cracked kernels should be white to cream in colour. Very light greying on the rounded portion is not objectionable as it is generally masked by roasting. Dark brown discoloration on kernels usually results from the absorption of tannin-like substances from the shell and disqualifies a nut from selection.

*M. integrifolia* kernels are usually a light even colour before and after cooking, but *M. tetraphylla* kernels are frequently variable in colour, particularly after roasting.

#### Kernel Quality

Kernels having a specific gravity less than 1.0 are preferred. *M. integrifolia* nuts examined in Queensland show consistent high quality with 90–100% first-grade kernels, but *M. tetraphylla* nuts are variable with first-grade kernels ranging from 7% to 100%.

#### Kernel Flavour and Texture

The kernel flavour should be delicate, mild, and uniform, and the texture tender, but

crisp. However, there is again a distinct difference between species, *M. tetraphylla* kernels being characterized by a firm, hard texture and a sweet but variable flavour, while the *M. integrifolia* kernels are crisper and more tender, with a more delicate, mild, and uniform flavour. These differences are more pronounced in the processed kernels.

The fact that the original introductions into Hawaii were *M. integrifolia* no doubt determined that the industry there is based on that variety. Nevertheless organoleptic tests conducted both there and in Queensland demonstrated a preference for that species. Californian interests are making a detailed study of *M. tetraphylla* because its comparatively short cropping characteristics might lower production costs.

### Harvesting and Curing

Macadamia nuts usually fall from the tree when mature and are then picked up by hand and bagged. As it is impracticable on a commercial scale to distinguish mature nuts from immature nuts on the tree, it has not been the practice for nuts to be harvested directly from the tree. However, workers from the University of Hawaii showed that the variations in maturity of nuts harvested from the tree have no significant effect on the quality of the processed nuts whereas quality was reduced if the nuts were allowed to lie on the ground (Cavaletto and Monroe 1970).

Earlier, Leverington (1962a) showed the need for frequent harvesting when he found that carefully selected mature nuts picked from the tree at fortnightly intervals were of higher quality than those harvested from under the tree on the same basis; this is particularly so with *M. tetraphylla*.

When harvesting is delayed, especially in wet weather, kernels may become mouldy or germinate. Extended periods between harvests also result in the development of rancidity, and the nuts are more prone to attack by ants or rodents.

The area under the trees must be kept free of grass, weeds, and fallen leaves during the harvesting season. In Hawaii, two methods are used for mechanical harvesting of macadamia nuts that fall from the tree (Anon. 1957; Erskine 1968; Nakamura 1968; Ooka 1968). One method uses nylon nets suspended under the trees so that the fallen nuts collect in one place. Another system uses two

machines, one which sweeps the nuts from under the trees into piles along the rows and another which gathers up the piles. In Hawaiian practice the harvesters move through the groves every 3–4 weeks.

Because of the different characteristics of the nuts of the two macadamia species they should always be kept separate for processing.

The fact that the mature nuts are enclosed in a fibrous green husk or pericarp at least  $\frac{1}{8}$  in. thick also causes problems in determining the frequency of harvesting. In most cases the husks dry, split, and discharge the nut, but many fallen nuts remain enclosed in the green pericarp. These nuts must be husked as soon as possible, preferably within 24 hours, to prevent the nuts from heating and spoiling. Husking machines operate by shearing the nuts either between two serrated plates set about 1 in. apart, one revolving and one fixed, or between a stationary cylinder and a rotating cylinder with a spiral scroll (Shigeura 1968).

When the nut falls from the tree the kernel may contain up to 30% moisture and fill the entire shell cavity, but as it dries shrinkage occurs, the texture becomes crisper, and a characteristic nutty flavour develops. Nuts from *M. integrifolia* normally have a higher oil content and a lower moisture content when harvested than nuts from *M. tetraphylla*.

Australian growers allow the de-husked nuts to dry slowly in a shed or in the sun for several weeks to reduce the moisture content of the kernel to about 10% or less before marketing.

To ensure the success of the infant macadamia processing industry in Queensland, and at the same time to encourage growers to maintain the best orchard practices, very stringent conditions of acceptance have been imposed by processors. The nuts must be at least  $\frac{3}{4}$  in. in diameter and free of blemish and insect damage. In addition, nuts were originally purchased on a 'sound kernel recovered' basis. This system required much extra handling by the processor to keep consignments separate, but it has proved its worth in maintaining nut quality. As production has increased and growers have learnt the importance of proper orchard maintenance and harvesting, the processor has become more selective in purchasing raw material.

## Processing Techniques

Moltzau and Ripperton (1939) were the first to describe methods for processing macadamia nuts and most subsequent work has been based on their findings.

### Dehydration

The first operation in processing macadamia nuts is to reduce the moisture content of the kernels to 1.5% or lower. As a result of this treatment the shell becomes hard and brittle, the kernel shrinks leaving an air gap, and the point of attachment between the shell and the kernel is weakened.

Vertical-stack driers are frequently used. In some cases they are operated in two stages, the first with circulation of ambient air and the second with heated air. Drying times may extend to 3–4 weeks, but the minimum time required is 4–5 days when a forced-draught dehydrator is used at a temperature of 100–120°F.

Depending upon climatic conditions and factory procedures, it is sometimes advantageous to dry the kernels in two stages: to 4–5% moisture in the shell, then to 1.5% moisture after removal from the shell. In the latter stage, temperatures as high as 170°F may be used, thereby reducing the moisture content from 4.5% to 1.5% in less than 8 hours. With this procedure a centrifugal machine to loosen the kernels from the shells may be necessary.

### Size Grading

Size grading must precede cracking for efficient operation of the cracking machines. Up to 10 sizes may be separated on tapered roller graders or perforated screens.

### Cracking

Cracking machines are of several types. One machine is designed on the rock crusher principle and consists of two serrated jaws, one of which moves in a gyratory motion. Between the cracker jaws, the nut is gently crushed until the shell shatters and the kernel and the shell fragments fall into a separator. Another type of cracker uses splined rollers which nip and crack the nuts, while a third machine has a split anvil with tapered holes. Because of the noise and dust produced, the cracking and mechanical sorting operations are normally carried out in a sound- and dust-proof room.

### Separating

Kernels are separated from shells on vibrating screens, with or without blowers, and the nut meat is segregated into whole or half kernels, broken kernels, and chips. Some hand-sorting is required to complete the separation and to remove mouldy or insect-damaged kernels.

Electronic sorters are used in Hawaii to separate kernels from shell fragments on the basis of colour. The stream of kernels and shells passes between a light source and a sensor. The sensor activates an air jet to divert pieces darker than the selected standard.

Quality grading based on specific gravity has been advocated and may be carried out in pneumatic separators or by flotation in water (Cruess 1963).

### Roasting

Although raw macadamia nuts are very palatable, cooking enhances the flavour and increases stability; consequently, almost all the Hawaiian nuts are marketed in the cooked state, with or without salt.

The kernels are usually cooked by deep frying in a highly refined hydrogenated coconut oil for 12–15 minutes at a temperature of 275°F for *M. integrifolia* and 260°F for *M. tetraphylla*, the latter requiring the lower temperature because the higher sugar content may result in charring at the higher temperature. Both batch and continuous fryers are used. During deep frying there is considerable exchange of fat between the cooking oil and the nuts (Cavaletto and Yamamoto 1971).

When the kernels reach the desired golden brown colour, they are removed from the oil bath, drained or centrifuged, and cooled with a draught of cool air as quickly as possible to avoid overcooking.

During the early years of development, the Australian macadamia processing industry encountered rancidity problems in stored processed nuts. Trout and Leverington (1962) reported that if the cooking time was reduced to less than 12 minutes by using higher oil temperatures, premature rancidity was induced. When rancidity continued to be encountered in commercial processing, Leverington and Winterton (1963) concluded that deep frying with a limited throughput resulted in rapid rancidity development in the cooking oil with subsequent deterioration in

the product. Batch-type oven roasting was investigated and a rotary roaster developed. Based on ideas reported by Miller (1960), it consisted of a rotating perforated drum heated by an infrared heater thermostatically controlled by a thermocouple in the kernels. Using the normal roasting temperatures, cooking times of about 25 minutes were necessary. A small infrared dry rotary roaster is in commercial use in Honolulu.

#### Grading

After roasting, sorting is again necessary to grade the kernels according to colour, which is a practical index of quality. Light-coloured kernels are used for retail packs, darker kernels are used for confectionery or chopped nuts, and the darkest kernels are rejected.

#### Salting and Packing

To bring out their piquant flavour it is desirable for the kernels to be dusted with salt. The deep-fried kernels are partially cooled under a forced draught and before the oil coating solidifies, salt is sprinkled on the product and thoroughly mixed. Some Hawaiian manufacturers have used adhesives such as acetylated monoglycerides to hold the salt on the surface of the nut but the necessity for this treatment has never been demonstrated in Australia.

As soon as the salted nuts are cooled they are packed in jars, cans, or flexible film pouches, under vacuum or with nitrogen flushing.

#### Factors Affecting Quality

The quality and storage life of macadamia nuts depend on the raw material quality, and also on the manner in which the nuts or kernels are stored, dried, processed, and packaged. They are highly susceptible to enzymic rancidity and the enzymes must be inhibited by heat treatment. During storage the flavour of the nuts changes in characteristic sequence from the freshly cooked flavour to bland and neutral, then slightly bitter, and eventually stale.

Drying high-moisture macadamia nuts at elevated temperatures results in high reducing sugar concentrations and dark-coloured kernel centres after roasting, probably as a result of enzymic reactions (Prichayudhi and Yamamoto 1965). Cavaletto *et al.* (1966) and Dela Cruz *et al.* (1966) demonstrated the

importance of drying the kernels since the presence of moisture above a level of 1% encouraged production of reducing sugars and free fatty acids by enzymic reactions in raw nuts and hydrolytic reactions in roasted nuts.

Rancidity following too rapid processing of macadamia kernels was attributed by Winterton (1966) to the survival of enzymes in the centre of the kernel.

Anti-oxidants have been used by some Hawaiian processors in the cooking oil, and Cavaletto and Yamamoto (1971) demonstrated favourable effects on storage life when anti-oxidants were directly applied to the kernels. Winterton (1966), however, found that provided recommended processing and packaging procedures were followed, there was no advantage in using anti-oxidants. Macadamia nut oil appeared to contain substantial amounts of natural anti-oxidants (Winterton 1968).

#### Nutritive Value of Macadamia Nuts

Early work at the Hawaii Agricultural Experiment Station (Ripperton, Moltzau, and Edwards 1938; Moltzau and Ripperton 1939) showed that first-grade kernels with a moisture content of 1.5% had an oil content of at least 71%. The total sugar contents were high, 10–16%, in immature nuts, but declined in normal, mature kernels to 3–5%.

Miller and Louis (1941) analysed two samples, five months apart, representative of factory-run Grade 1 unsalted nuts, cooked in hot oil at 275°F for 12–15 minutes. Their data (Table 1) indicate that macadamia nuts

Table 1  
Composition of Cooked, Unsalted, Macadamia Nuts  
(From Miller and Louis 1941)

Constituent	Sample 1 (%)	Sample 2 (%)
Water	1.2	1.4
Protein (N × 6.25)	9.3	9.2
Ether extract	78.7	77.6
Crude fibre	1.8	—
Carbohydrate (by difference)	7.6	8.6
Total ash	1.4	1.4
Calcium	0.06	0.05
Phosphorus	0.24	0.24
Iron	0.002	0.002



Table 2  
Fatty Acid Composition of Macadamia Nuts  
(From Cavaletto *et al.* 1966)

Fatty Acid	Percentage of Total (As Methyl Esters)
Lauric	Trace
Myristic	0.75
Palmitic	7.37
Palmitoleic	18.46
Stearic	2.78
Oleic	64.96
Linoleic	1.51
Arachidic	1.85
Eicosenoic	2.33

are similar to pecans in fat and protein contents. Most other nuts contain more protein and carbohydrate and less fat than macadamias. The fatty acid composition of macadamia fat is shown in Table 2; oleic acid is dominant. Macadamia nuts yield 707 kilocalories/100 g.

Vitamin values determined by chemical and microbiological methods on raw and cooked nuts by Miller *et al.* (1956) are shown in

Table 3  
Vitamins in Hawaiian Macadamia Nuts  
(per 100 g edible portion)  
(From Miller *et al.* 1956)

	Raw	Cooked
Moisture (g)	1.9	1.8
Vitamin A	0	0
Thiamine ( $\mu$ g)	340	215
Riboflavin ( $\mu$ g)	93	118
Niacin (mg)	0.96	1.59
Ascorbic acid	0	0

Table 3. There was approximately 46% loss of thiamine as a result of cooking. However, cooking appeared to increase the contents of riboflavin and niacin to a considerable extent (27% and 66% respectively), perhaps by increasing the extractability of these vitamins by the solvents used in the assays.

Macadamia nuts contain no carotenoid pigments, no vitamin A, and, like most nuts, no ascorbic acid.

## By-products

A ready market is available for broken kernels and chips in the manufacture of confectionery, such as macadamia nut brittle and chocolate-coated nuts, and in macadamia ice cream.

In Hawaii, the waste shells have been used as a fuel. Investigations in Australia indicate that macadamia shell flour (300 mesh) makes a very good substitute for coconut shell flour as a filler in the plastics and adhesives industry.

## Future Prospects

If the remarkable growth of the macadamia industry in Hawaii is a guide, Australia may expect a major expansion in macadamia production over the next two or three decades.

Up to 1936, the industry in Hawaii was based on seedling trees and developed very slowly. By the mid forties grafted trees were coming into bearing and 200–300 tons of nuts were being processed annually; production reached 500 tons in the mid fifties (Hamilton and Storey 1956). During the following years, production has continued to expand. Precise statistics are difficult to obtain, but projections based on Smith (1968) and other sources indicate that by 1980 production will exceed 12,000 tons.

The success of the macadamia industry in Hawaii has stimulated production in other parts of the world, including California, Florida, Israel, Guatemala, Mexico, New Zealand, and South Africa.

The establishment of a macadamia processing industry in Australia in the mid fifties, by creating a demand for this nut in a processed form, stimulated existing growers to improve cultural practices and plant new areas, and attracted new growers into the industry. Then in the early sixties, the Colonial Sugar Refining Co. indicated an interest in macadamia production (Anon. 1964; Borrell 1971). This large organization had the resources to support specialized horticultural skills and to provide the expensive equipment required for efficient insect control, mechanical harvesting, and efficient handling and treatment of nuts. They were prepared to acquire the many horticultural and processing techniques involved, to invest large sums, and to wait many years before receiving returns on their investments.

In June 1964, the C.S.R. Co. announced that it had purchased over 1000 acres in the Baffle Creek area north of Bundaberg and Maleny for macadamia production. Some of this area is now carrying grafted trees approaching the age of 5 to 7 years at which they may be expected to bear nuts, although it requires about 14 years for a tree to reach maturity. The Company is beginning to plan the establishment of processing facilities.

The limited, almost static, supplies of nuts (about 50 tons per year) that have been available in the past 15 years have been processed almost exclusively by one organization, Macadamia Nuts Pty. Ltd., under the management of Mr S. Angus. This operation was initially established in Murwillumbah, N.S.W., but moved to Slacks Creek on the southern boundary of Brisbane in 1964, closer to the major producing areas.

Now after many years of neglect Australia's unique nut is achieving adequate commercial attention in its native country. The macadamia nut industry may look forward to continued expansion, firstly to fill the Australian demand, estimated at 300 tons per year, and subsequently to supply export markets.

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# Take-away Foods

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This paper was presented at the Fifth Convention of the Australian Institute of Food Science and Technology, Sydney, June 1971, and was one of several papers in a symposium entitled 'Technological Challenges from Changing Food Markets'.

This article deals with hot, take-away, ready-to-eat foods which are becoming more and more a part of the Australian scene. Their increasing importance undoubtedly stems from the advent of the take-away food chains of mainly American origin. These organizations now occupy a very important place in the take-away food business but are only a part of the story.

The range of hot take-away foods available is increasing rapidly and varies from traditional items such as fish and chips and Chinese food to the ubiquitous fried chicken and the salads associated with it. Somewhere in between come hamburgers, the more aesthetically packaged seafoods, Italian-style food including the whole range of largely farinaceous products, rotisserie chicken, and the meat and gravy dishes often vended through the same outlets. The more common of these are curries, goulashes, stroganoff, and chicken with mushrooms.

Take-away foods are by no means new to Australia although the fast service offered by the majority of the big chain operators, and the increasing number of smaller merchants, is. The technological problems associated with this fast service warrant some comment from the viewpoint of quality in its widest sense.

## Changing Food Habits

Food markets, and by inference food habits, are in a state of transition. Selling food is a profit-oriented business as is any other merchandising, and until a few months ago Australia was going through a period of free spending unseen before in its history. Take-away food has thrived on the fact that people have more cars, more leisure time to spend away from home, and more money to spend on food. When people buy take-away foods, and in particular hot, ready-to-eat, take-away foods, they are buying time and not neces-

sarily taste and quality, and the package is certainly costing them money. The major attraction of these take-away foods is, then, with the exception of hamburgers which appeal mainly to teenagers and travellers, that they preserve the family meal tradition without requiring the same kind of effort for preparation or serving.

## Effect on Manufacture, Marketing, and Consumption of Food

Because the take-away food vendor is involved so much in the preparation of food for the table, he replaces, in part, the food processor and in so doing must assume some of the technological responsibilities assumed, to a greater or lesser degree, by food processors. This applies particularly to take-away food processors who prepare so-called convenience foods which are held chilled or frozen in their own store-rooms or by retailers prior to sale. At the same time, take-away food processors must also assume the retailer's responsibility of keeping foods correctly stored before they are purchased. The fact that not all manufacturers and retailers have faced up to these responsibilities does not excuse the take-away food operator for not doing so.

The large take-away chains, because of their special role as processor-retailer, are in a position, at least theoretically, to exercise maximum quality control over the product they sell. Their limited product range, consisting of three or four basic items, further simplifies the problems of quality control.

In addition, food merchandising on the scale practised by the larger companies has special significance to the purchasing and selling agent. He can specify size, quality, nature, and all other essential characteristics of the few items he must purchase to meet production needs. He can also purchase in large enough quantity for his order to be important to the supplier whether that be for

chicken, fish, chips, flour, vinegar, tomato sauce, or garlic. He should therefore be able to obtain the quality he specifies, within reason, as in most instances there will be willing alternative suppliers. In these circumstances, or any other for that matter, there is no excuse for sacrificing quality for operational economy. In the big take-away food areas, there seems to be a trend towards standardized mediocrity. There is little doubt that this starts at the beginning of the chain with the suppliers of raw materials to the take-away chains. It is hoped that whatever buying pressure the bigger take-away food firms possess is used to raise the quality of the raw materials rather than to lower the price without due regard to quality.

### Quality of Take-away Foods

Two aspects of quality are linked closely to food handling methods and should be of prime concern to consumers and people in the industry: nutritive value and microbiological safety.

#### *Nutritive Value*

Australians are becoming increasingly concerned about the nutritive value of their foods although they still basically eat what they like, particularly in the snack food or quick-meal line. This concern about the nutritive value of take-away foods may be somewhat irrational in view of the other meals consumed during the day, but it is a real concern and some companies at least are well aware that it exists.

For the purpose of this article, take-away foods are classified on the basis of the type of service offered. When this is done, four main groups emerge:

- A—Cooked on order, with a subsequent waiting time for service: Chinese food, fish and chips, some new-style seafoods, some pizzas, old-style hamburgers.
- B—Held at elevated temperatures for what can be long periods, usually in servery trays: rotisserie chicken, curries, stroganoff, goulash, some Italian-style farinaceous products, fish cakes, crumbed cutlets.
- C—Fast-food service: deep-fried chicken, new-style hamburgers.
- D—Fast-food chains and delicatessens: salads—cole slaw, bean salad, potato salad, other mixed salads, fruit salads.

If group D foods are not included in the

meal, then in the strictest sense, such meals are not well balanced nutritionally. The other meals, unless supplemented by additional dishes at home, contain either protein or carbohydrate alone, or the two together usually with some fat.

Provided other meals during the day have supplied vitamins, minerals, and bulk missing from the take-away meal, the absence of these elements from the take-away meal is not a real cause for concern. The inclusion of vegetable and fruit salads in the menus of some of the major chains is, however, a realization on their part that the average housewife is a lot happier when her family receives a balanced meal, irrespective of who prepares it.

These salads when properly formulated and stored will provide a valuable nutritional supplement to the meal as well as adding taste and colour appeal. Correct storage of these salads is also necessary to maintain consumer appeal and the pre-production storage and retail storage facilities of the big chains are very good. Low temperatures (34–40°F) are essential if a storage life of four to five days is to be achieved and this is the aim of most manufacturers. In a well-run operation where salads are prepared in a properly organized kitchen, held in cool storage till required, and delivered in a vehicle capable of maintaining the store-room temperature, no serious fluctuations of product temperature should be encountered. It is then the responsibility of the retailer to ensure that these salads are promptly refrigerated, either in the chilled display cabinet or chilled store-room. When this is done the loss of vitamins in four days of storage is minimal.

Group B foods in particular, and to a lesser extent group A and C foods, are subjected to prolonged exposure to warm to high temperatures. This probably does not significantly affect the protein value of the food though it is possible a certain proportion of the protein in group B foods is not nutritionally available due to heat damage of the lysine fraction (Eldred and Rodney 1946; Carpenter 1960). The holding period is, however, very significant for microbiological safety.

#### *Microbiological Safety*

The responsibility for the safety of foods ultimately rests on the person preparing the food for consumption. The complete eradication of salmonellae from raw meats and

poultry is not yet possible, though efforts to this end are being maintained. However, the not infrequent presence of these organisms in flesh foods in particular means that prevention of illness depends on the use of correct handling practices in the kitchen, and the bigger the kitchen the greater is the responsibility. In addition, staphylococcal food poisoning and illness due to *Clostridium perfringens* are usually a result of poor practices and temperature abuse in the kitchen and not at the processing stage.

In theory, microbiological safety should be built into a take-away food system, as it should be in any food service system. Food is purchased fresh or frozen for each production run so that the need to store it unprocessed for any length of time is eliminated. When prepared, the food should be cooked to a temperature that is high enough to ensure bacterial safety, after which it should be stored at the correct temperature before any final heating before serving. Most important of all, the food should always be on premises that are under the control of a manager who is well trained in food service operations.

How often this sequence of events is followed is debatable, but from the public health point of view, the fast service chains, whether using their own store managers or franchisees, have many potential advantages. These chains handle mainly group C foods, and some group A foods, and the franchise system means that people with limited knowledge of such foods, and more particularly food storage and its inherent problems, are brought into the food service industry. The initial training of the franchisee or manager is of prime importance to the success of such organizations. The franchiser must specify all operating procedures to ensure that safe quality products are produced by franchisees of varying backgrounds and attitudes. This is achieved by mechanizing the operation as much as possible, operating the whole system virtually by numbers, inculcating established practice thoroughly during the initial training period, and maintaining centralized quality control through area supervisors and food technologists based on the head office. In other words, the big chains are aware of potential problems and have the staff to handle these before they arise. It is hoped that those trained in food technology do not become spread too sparsely over a vast,

largely untrained network of retailers.

Strict control over the microbiological quality of these products is extremely important because of the very nature of the food being handled. Group D foods, with the possible exception of potato salad, do not present food-poisoning problems because of their high acid content. A combination of low-temperature storage and short holding time should also ensure the safety of potato salad which is often low in acid content. The acidity of the salad products is not sufficient to prevent yeast spoilage but temperature and time of storage should prevent yeast growth from being a problem. In fact chemical breakdown of ingredients is a major limiting factor with storage of salads containing oil and vinegar.

Batters are a well-known source of staphylococcal food poisoning because, although the final cooking may destroy the bacterial cells, it may not destroy the heat-stable toxin produced by staphylococci. If batters are prepared a long time in advance of use, the temperature of storage should be below 40°F.

Protein foods are a potential source of salmonella and *C. perfringens* food poisoning. An internal temperature of 190°F in the flesh of chicken is necessary to give a desirable degree of finished cooking (Hoke 1968); similar temperatures are necessary for fish and red meat. Salmonellae are destroyed at this temperature so they should then be a problem only if the product is recontaminated and held at the wrong temperature. Pressure frying in oil permits uniform cooking and quality control, and a centre flesh temperature of 190°F is easily attainable during normal cooking from the chilled state. Longer cooking times are needed if the product has a lower initial temperature and especially if it is frozen.

*C. perfringens* food poisoning is caused by the ingestion of large numbers of its vegetative cells, and the spores of this organism are capable of surviving the common cooking and roasting processes (Hauschild 1970). Storage of pre-cooked food below 40°F or above 140°F is essential to minimize the risk of food poisoning from this and other organisms. No dependence should be placed on the final cooking at whatever temperature or by whatever method to eliminate the hazard associated with the survival of spores

of *C. perfringens* and subsequent outgrowth of vegetative cells.

Microbiological safety of take-away foods can be achieved by the application of well-known principles, so the problem requires an educational rather than a technological solution. The technological principles are known to the technical staff of the bigger organizations and these members of staff must ensure that their companies implement these principles.

Operators of take-away food services which handle group A and B foods face very similar problems because they are storing partially or wholly cooked foods including protein foods. Few of them have the knowledge or the facilities to provide a reliable, safe food service. Rotisserie chicken and the mixed meat dishes are frequently held at temperatures which permit growth of microorganisms and these foods are ideal vehicles for *C. perfringens* poisoning. If these foods are contaminated after cooking they could also be sources of salmonella and staphylococcal food poisoning. Sometimes, for instance, rotisserie chicken is recontaminated when it is cut up on the same board as was used to prepare the raw bird. There is, of course, a time factor involved and this does provide some safeguard because a minimum amount of microbial activity is necessary before the food becomes a health hazard. This, however, is not a sufficient safety measure for a type of food service which is becoming so widespread.

There is no doubt that rotisserie chicken, which has become unsuitable for sale in this form, is used in many of the chicken combination dishes offered by some take-away food stores. The meat in these products could well have been held at suitable growth temperatures for contaminating microorganisms for many hours. Since these mixed meat dishes are nearly ideal anaerobic bacteriological media, it is small wonder their contribution to food-poisoning outbreaks from food service operators is a major one.

### Conclusion

The technological problems associated with food service have been largely overcome and it is the application of the solutions of these problems that has made take-away food the big business it is. The main technological challenge rests with the supplier of raw

materials; he must try to ensure that food-stuffs of the highest possible quality from all aspects, flavour, microbiology, and nutrition, reach the take-away vendors, and buying pressures must not be allowed to alter this aim.

The challenge facing the take-away food industry is largely one of educating the vendors. The Australian public has accepted this form of food retailing even though it cannot reasonably be expected to serve food of the best flavour and highest nutritive value in a matter of moments. The public has shown it wants fast service and that is what it is getting. It retains the right, however, to be served food which is perfectly safe microbiologically. This is why take-away food vendors must either familiarize themselves with the facts and costs of proper food service or employ somebody to do the job for them. In the case of franchisers, they must ensure that their employment of qualified technical staff does not lag behind in any expansion programme.

For too many years now anybody in this country who wanted to call himself a food processor could set up a factory and start business. This is a stupid, dangerous state of affairs, and should be stopped. We now have another form of food processor, the take-away food vendor, doing exactly the same thing. If people want to prepare and serve food to the public, they should have to satisfy a public health authority that they or their staff know how to look after that food. This requirement should apply to processors and to take-away food vendors. The properly run, properly staffed, and properly equipped establishments have nothing to fear. If inefficient and, by inference, potentially dangerous establishments go out of business it will be a good thing.

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# Handling Pears for Export

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This article outlines good handling practices before shipping which, with careful sizing and packing and with good carriage conditions in the ships, should ensure that pears arrive on overseas markets in the best possible condition. The helpful advice of officers of State Departments of Agriculture is gratefully acknowledged.

The condition of pears on arrival at overseas markets, their subsequent shelf life, and their quality when ripe, depend primarily on the stage of maturity at which they are picked, on prompt and rapid cooling, and on storage at a steady low temperature and keeping well within the storage life of the variety in so far as this is known for the growing area.

Not only forward condition on arrival but also low net weights and excessive blemishes, mainly due to rough handling, are frequent causes of complaint by overseas buyers of Australian pears.

## When to Pick

For satisfactory storage or export, pears should be picked as soon as well sized and fully developed and while still hard and green. The best practical guide to maturity is firmness of the flesh, provided that the fruit is mature, at which stage there will also be a slight exudation of juice on the cut surface. The colour of the skin and the calendar date are also useful practical guides to maturity. If the fruit is picked when the cut surface of the flesh remains dry, the flesh is still very hard, and the skin is still deep green and dull, it is immature, will shrivel excessively in storage, and will not ripen with good flavour and juiciness. Pears picked too late will have only a short life and will not ripen to maximum quality. For most varieties the optimum picking period extends over only about a week or 10 days and two pickings should generally be made from each tree, taking the larger top and outer fruit at the first picking.

## Firmness of the Flesh

This is most conveniently measured on the thinly peeled flesh with a pressure tester (penetrometer), e.g. the Standard U.S. (Magness Taylor) pressure tester, fitted with a  $\frac{5}{16}$ -in.-diameter plunger. For Williams pears the pressure by this method should not be

less than 17 lb, for Packham's Triumph, Bosc, Winter Nelis, and Glou Morceau not less than 15 lb, for Josephine and Comice not less than 14 lb, and for Winter Cole not less than 13 lb. Evidence over several years in Tasmania indicates that usually the firmness of pears grown in that State can safely be 2 lb less than the above values at the time of harvest. Pressures more than 4 lb greater than these would indicate immaturity. Other types of pressure testers which are easier to use, such as the 'Effi-gi', are becoming available.

## Skin Colour

This is measured by comparison with standard colours in a specially prepared colour chart (e.g. the Victorian Department of Agriculture's colour chart for Victorian pears). If the skin is russeted, the russet can often be removed by gentle scraping with a knife to expose the true skin colour beneath. It must be recognized that the colour of the skin of a hard, unripe, but mature, pear on the tree is affected by climate. In dry, inland areas the skin will be paler at an equivalent stage of maturity than on fruit grown in cooler, highland or maritime climates. Inland fruit should not be less green than plate 2 and pears from southern Victoria, Tableland areas, Tasmania, and similar areas should be picked when the skin colour is nearer plate 1 on the colour chart for Victorian pears. However, skin colour, particularly of Packham's Triumph, is often variable in any one district so that it is a less reliable guide than pressure. Similarly the Josephine is often relatively pale in colour at correct pressures.

## Picking Date

In Victoria optimum picking dates are generally as shown in Table 1. In normal seasons, the dates in the other States would be generally similar. For early or late seasons

Table 1  
When to Pick the Main Varieties

Variety	Firmness at Correct Maturity* (lb)	Usual Optimum Picking Period
Williams Bon Chrétien	17-22	1st-2nd wk Feb.
Comice	14-18	Early Mar.
Beurre Bosc	15-19	2nd wk Mar.
Packham's Triumph	15-19	1st-2nd wk Mar.
Winter Cole	13-17	3rd-4th wk Mar.
Josephine	14-18	4th wk Mar.- 1st wk Apr.
Winter Nelis	16-19	4th wk Mar.- 1st wk Apr.
Glou Morceau	15-18	4th wk Mar.- 1st wk Apr.

\*May be 2-3 lb less in Tasmania but not less than 11 lb for Winter Cole and 13 lb for Packham's and probably other varieties.

these dates may be earlier or later by up to 10 days, but special care must be taken in a 'late' season, as picking time 'may not be as late as you think'. It is always wise to check maturity with a pressure tester as the firmness of the flesh is probably the most reliable of the criteria of maturity.

Particularly in northern Victoria, it is necessary to start picking Bosc and Packham's and often also Josephine earlier than the optimum dates so that the crop can be handled. This early start of picking for export also enables shipping to start early in March and pears to arrive in Britain and Europe in April, when the market is usually more buoyant. However, it must be realized that fruit picked early, and therefore often rather immature, although desirably harder and greener, is very prone to shrivelling and will not ripen to best quality. Shrivelling and weight loss can be prevented by packing in polyethylene, but such fruit, especially in polyethylene, can be quite difficult to ripen after discharge.

### Cooling

Pears should be cooled to storage temperature as soon as possible after picking. Delay between picking and placing in the cool store, or slow cooling in the store or ship, can seriously reduce storage life. Every effort should be made to have the flesh temperature

of the fruit down to 45°F within 24 hr from placing the fruit in the cool store and down to 35°F within 72 hr; completion of cooling to an equilibrium fruit temperature of 31°F will probably require another two days, even under good cooling conditions.

It is a big advantage to pick the fruit as early in the day as possible, when it is cool, and to get it into the store without delay. If fruit must be picked in the afternoon when it is hot, it is better to cool it overnight in the orchard and to put it into the cool store next morning. In hot weather, overnight cooling can be improved by wetting the fruit in the bins. This will also reduce the shrinkage of the fruit that occurs during cooling. For best overnight cooling the bins of wetted fruit should be left out in the open, in a single layer, so that they are fully exposed to the radiation effect of the clear night skies which are usual in March, at least in inland areas. It is also an advantage for warm fruit to be wet when it is put into the cool store.

### Storage Conditions

Every effort should be made to hold the air temperature in the store at 29·5-30°F so that, after initial cooling, the flesh temperature of the fruit in the bins or boxes is not more than 31°F. Higher temperatures will shorten the life of the fruit. In early work with Williams pears the storage life at an air temperature of 34°F was only half that of fruit stored at 30°F. In recent work at the CSIRO Division of Food Research (Beattie *et al.* 1971) with Packham's from northern Victoria the storage life at different temperatures was as shown in Table 2. Reducing the temperature from

Table 2  
Storage Life of Packham Pears at Different  
Temperatures

Storage Temperature* (°F)	Storage Life (days)
38	95
36	120
34	150
32	180
31	220
30	240

\*Flesh temperatures of the fruit were about 1 degF higher.



Table 3  
Time for Packham Pears to Soften at Different Temperatures

Storage Temperature (°F)	Time to soften to 10 lb in Cool Storage (days)
38	70
36	95
34	125
32	175
31	220
30	250

32°F to 30°F increased the life of the fruit by about 50%.

Pears not only have a shorter life but soften more rapidly in storage at the higher temperatures. The times for the Packham's pears in the CSIRO experiment to soften from an initial value of 15 lb to 10 lb, measured with the  $\frac{5}{16}$ -in. plunger, are shown in Table 3. On arrival overseas the firmness of pears should not be less than 10 lb if the fruit is to have not less than the minimum acceptable shelf life.

Although the gains in increased life and better condition of the fruit obtained by maintaining the air temperature at 29·5–30°F are considerable, much more care in operating the store is required to avoid freezing some fruit. Thermometers should be tested for accuracy and fruit flesh temperatures in different parts of the room should be regularly checked. The accuracy of thermometers may be checked by immersing them in a slurry of melting ice and water, either in a vacuum flask or in a can in the cool room, allowing them to stand for several minutes with occasional stirring, and then reading the thermometers. As the temperature of melting ice is 32°F, the necessary corrections can then be written on a permanent label and attached to the thermometer, e.g. +1 means *add* 1 deg to the thermometer reading, –0·5 means *subtract* 0·5 deg from the reading, to get the true temperature.

### Packing

The pears should be packed for export and shipped with as little delay as possible, as longer storage before packing and shipping may increase weight loss and shrivel, reduces the firmness and greenness of the fruit at discharge, and shortens its market life. Holding

in cool storage before shipment has much less effect on fruit packed in polyethylene film bags and it is a decided advantage, both in reducing weight loss and in improving out-turn condition, to pack into polyethylene as soon as possible after initial cooling of the fruit. The fruit is then held in the cool store, fully packed in polyethylene, awaiting shipment.

Only small quantities of fruit should be brought out of the cool store at a time for packing so that warming up and 'sweating' (with consequent pick-up of dust) are minimized, and the fruit should be returned to the cool store as soon as possible after packing.

### Packages

The wooden, one-bushel, long-pear box with full wrap-around liners and some similar protection between the fruit and the ends of the compartments, and the standard wooden,  $\frac{4}{5}$ -bushel, pear box (standard pear case), with a similar complete liner, are satisfactory packages. Neither introduces any serious cooling problems, although the full lining does make cooling somewhat slower. If these wooden boxes are packed correctly and not over-filled, bruising need not be serious, although they are basically pressure packs.

A telescopic,  $\frac{4}{5}$ -bushel, twin-cushion, fibre-board container, preferably with a waxed inner section for greater stacking strength in refrigerated spaces, and packed with fruit as a non-pressure pack, is overall a better package and is now the main one for export pears. However, being a *flat-sided package*, it *must* be stacked in the cool store and stowed in the ship, or large ISO container, so as to provide the air gaps between individual cartons essential for satisfactory cooling. This requires the use of spacing dunnage between the cartons to provide continuous gaps *parallel to the direction of air flow*. As air flow is usually vertical,  $1\frac{1}{2} \times \frac{3}{8}$  in. laths are placed against the ends of all cartons in every second row so that every carton has one end exposed. With the shorter-keeping Williams pears, either one side or both ends must be so exposed.

Smaller half-bushel packages, packed without pressure with two or three layers of fruit, with a small air gap between the top of the fruit and the lid, and stowed with adequate air gaps, have, *when carried in strapped pallet units*, delivered fruit in excellent condition.

### Liners

In wooden boxes, full wrap-around, light, corrugated, smooth-faced, fibreboard liners, with strawboards or similar pads covering the ends of the boxes, should be used to give maximum protection to the fruit, reduce case rubs and bruising, and protect polyethylene bag liners (if used) from damage. When polyethylene bags are not used it is a distinct advantage to use sheet polyethylene or similar film, to further minimize rubbing in the case and to reduce shrinkage. For similar reasons, it is also good practice to use polyethylene bags or sheet liners in cartons.

### Wraps

Copperized oiled wraps are recommended for all varieties, especially when in polyethylene liners, to prevent contact spread of fruit rots (mainly grey mould), and consequent 'nesting', and to control superficial scald on the Packham's variety. The copperized pear wraps now available in Australia contain 1.5–1.6% copper and 10–12% oil. Such wraps have been widely used on pears in both the U.S.A. and New Zealand for some years. In trials by CSIRO, contrary to some reports, oiled wraps have not noticeably increased yellowing of the fruit when compared with fruit in plain wraps at the same core temperature. If oiled wraps are not used, Packham's pears should be protected against superficial storage scald by pre-storage treatment of the fruit with either of the scald-inhibiting chemicals, ethoxyquin or diphenylamine, or using wraps impregnated with one of these compounds, *provided that the importing country permits its use on pears*.

While scald rarely occurs on fruit marketed soon after discharge, unless it is a very late shipment out of cool storage, it can be a problem in fruit put into cool storage in the importing country.

### Polyethylene Film Bag Liners

As discussed, the basic requirements for the successful storage of pears are picking the fruit at the correct stage of maturity, cooling it promptly, and thereafter maintaining its flesh temperature as close to 31°F as possible. The composition of the atmosphere in which the fruit is stored is also a critical factor. Early investigations have shown that moderate levels of carbon dioxide and fairly low levels of oxygen usefully extend the safe

storage period for most pears and certain varieties of apples, and considerably increase their subsequent shelf life. This has led to the development of controlled-atmosphere (C.A.) storage, which, however, is not yet much used for pears. Somewhat similar principles apply when sealed polyethylene film bags are used as box liners for pears in cool storage since the polythene bag maintains an individual atmosphere within each case. The advantages of this method are firstly, greatly reduced weight loss and prevention of shrivelling, and secondly, better quality and increased shelf life after storage. However, if proper precautions are not taken there is a risk of carbon dioxide injury to the fruit (brown heart) and of increased waste from mould growth.

If storage life and out-turn conditions are to be significantly improved there must be some build-up of carbon dioxide and a considerable reduction in the level of oxygen within the bag. This is best achieved by sealing the bag after packing by tightly tying the top, e.g. with tape, string, or a rubber band. To avoid excessive carbon dioxide and consequent brown heart the fruit should be pre-cooled before packing and the bag should be made of low-density film, 0.0015 in. thick (150 gauge). Under these conditions very successful results are being obtained with Packham's Triumph and with other varieties more tolerant of carbon dioxide.

Certain varieties, such as Winter Cole, Winter Nelis, and Beurre Bosc, are less tolerant of carbon dioxide and, to avoid brown heart, must not be stored (or shipped) in sealed bags unless an absorbent of carbon dioxide is included in the pack. These varieties should be packed in sealed bags in which a small sachet of fresh hydrated lime is included to absorb the carbon dioxide. They may also be packed in perforated bags or in boxes or cartons lined with polyethylene sheets. The latter will effectively prevent shrivelling of the fruit but, as there is no atmosphere control, will not increase storage life or shelf life.

The bags may also be closed by carefully and neatly folding the tops over the fruit. While this does not seal the bag as effectively as a tight tie, some modification of the atmosphere and some increase in storage life and shelf life are generally obtained. A suitable method of folding is to flatten and fold

the top of the bag in and over the fruit from each end of the carton or case and then to fold over the tails from each side. If perforated bags are used the tops should be similarly folded.

The effects of packing Packham's Triumph pears in polyethylene film bags have been studied in the CSIRO Division of Food Research under simulated export conditions, which included local storage for up to 8 weeks before packing and simulated slow shipboard cooling of the fruit. The polyethylene bag liners, whether tightly tied or carefully folded, greatly improved the out-turn condition of the fruit, which was firmer and greener and had a longer shelf life than the fruit not in polyethylene. In this trial the inclusion of hydrated lime in the bags to reduce carbon dioxide levels, and so to safeguard against brown heart injury by excess carbon dioxide, proved to be unnecessary with the Packham's variety. Cool storage for several weeks before packing and shipping gave softer and more yellow fruit at discharge, which effect was largely reduced by packing in polyethylene before storage. However, the best-quality fruit was that which was pre-cooled and packed in sealed polyethylene and shipped without delay.

Packing in polyethylene bag liners has so improved the condition of the fruit overseas that almost all exported pears are now packed in packages lined with polyethylene film bags.

#### *Recommendations for Use of Polyethylene Bags*

**Bags.**—The bags should be made of *low-density* polyethylene film 0.0015 in. thick (150 gauge or  $1\frac{1}{2}$  mil). For the standard pear case or carton ( $\frac{1}{8}$ -bushel) the bag should be 32 in. wide and 30 in. deep but the 32 in.  $\times$  32 in. bag, in common use for the bushel box, may be used instead. A gusseted bag is a better fit and dimensions of 32 in.  $\times$  18 in.  $\times$  14 in. are suggested for the carton and 32 in.  $\times$  20 in.  $\times$  14 in. for the standard pear case.

Film made from *high-density* polyethylene, which is now in wide use for general packaging, should *not* be used for polyethylene bags for the storage of fruit. This film has a higher resistance to permeation by carbon dioxide and oxygen and its use could lead to brown heart or other breakdown in the fruit. The early work was done with film of density 0.920 and, until more is known about the characteristics of film of different densities

and thicknesses, only film of density approximately 0.920 (0.917–0.923) and thickness 0.0015 in. should be used.

**Fruit.**—As the polyethylene pack is a premium pack, only high-quality, fancy-grade fruit should be used. It should be picked at the correct stage and handled with particular care. Because of the very high humidities in the bags, conditions are more favourable for mould growth; only sound fruit, free from skin damage, should be packed.

**Packing.**—To minimize the risk of puncturing the bag, wooden boxes should be completely lined (sides, top, bottom, and ends) with a full wrap-around corrugated or light smooth cardboard liner, strawboards, or similar pads.

Use copperized wraps to prevent contact spread of blue or grey mould and the development of nests of rotted fruit.

As polyethylene bags or sheet liners greatly reduce shrinkage, high packs (which increase bruising and rubbing in the case) are not necessary to ensure correct net weights on arrival overseas.

Avoid packing fruit when it is wet, e.g. from condensation (sweating) following removal from cool storage. If fruit is graded and handled wet it picks up dust, which becomes unsightly when the fruit dries, and excessive moisture in the bag encourages mould wastage.

Do not pack fruit in sealed polyethylene film bags when flesh temperatures are above 50°F.

After packing, the bag should be a close fit over the fruit with no bellying at the edges. Half way through packing the box or carton and again when packing is finished, pull the bag firmly up and around the fruit. Finally, draw the top tightly over the fruit and tie it tightly with tape, string, or a rubber band, or carefully and closely fold over the top.

Every care should be taken during packing, and especially during lidding, to avoid tearing the bag or puncturing it with nails. When the bags are closed by folding be careful not to disturb the fold during lidding.

**Cooling.**—Pre-cool the fruit to a flesh temperature of 40°F or lower before packing in sealed polyethylene film bags. Pack quickly and return the packed cases or cartons to the cool store without delay, open-stacking them so that they can quickly cool to the correct storage temperature (air, 30°F; fruit, 31–32°F).

**Cool Storage before Packing.**—Cool storage for longer than necessary to remove field heat from the fruit before packing in polyethylene should be kept to a minimum as it results in poorer out-turn condition. Pack in polyethylene as soon as possible after picking and cooling, and hold packed fruit for later shipments. In any event do not cool store for longer than 4 weeks before packing.

**After Discharge.**—The bags should be opened, slit, or punctured, within 4–5 days of discharge when ambient temperatures are higher than about 60°F.

Once the fruit itself has warmed up to about 60°F, holding it in sealed or closely folded bags may lead to flesh breakdown of the brown heart type and to increased rotting. If the fruit is to be placed in cool storage after discharge from the ship this must be done without delay and re-cooling must be rapid.

#### *Varieties.*—

● **Packham's Triumph:** Use sealed bags and diphenylamine or ethoxyquin to control superficial scald if long storage is anticipated, *but only if the importing country permits the use of these chemicals on pears*; otherwise use oiled wraps, preferably copperized oiled wraps.

● **Williams (Bartlett):** Use sealed bags and do not hold in cool storage more than a week before packing.

● **Beurre Bosc:** Use sealed bags with lime inserts or folded bags; do not cool store for longer than 3 weeks before packing. The lime insert is a sachet of *fresh* hydrated lime in a glassine bag within a paper bag, or in a strong paper bag. One pound of lime is used for each bushel. The sachets are most conveniently large and flat and are placed either below or on top of the fruit. As the fruit is not stored for a long time  $\frac{1}{2}$  lb lime is normally enough for the standard pear box or carton.

● **Josephine:** Use sealed bags.

● **Winter Cole:** Very susceptible to brown heart and to shrivel; use sealed bags with lime inserts, or perforated bags or sheets. Do not cool store for more than three weeks before packing.

● **Winter Nelis:** Very susceptible to brown heart; use sealed bags with lime inserts or perforated bags or sheets.

● **Comice:** Use sealed bags; do not cool store more than a week before packing.

● **Glou Morceau:** Use sealed bags.

**Labelling.**—As packing in *sealed* polyethylene bags is a specialty high-quality pack of fancy-grade fruit, the packages should be distinctively and exclusively marked. It is suggested that the brand should be SEALED POLYPACK. This would be a guarantee to the buyer that the pack has been properly prepared and that it will contain premium-quality fruit with a good market life. It will also be a warning that it must be handled correctly after discharge.

#### **Loading Temperature**

Whatever the cooling capacity of a particular ship, the higher the temperature of the pears when loaded, the longer will it take to cool them to carrying temperature. In any event cooling in ships is unavoidably slower than in land stores, with average first half-cooling times of as long as 120 hr.

Not only do packages loaded warm have a higher average temperature for the voyage, but also there is evidence that boxes which are loaded at a higher temperature tend to have a higher equilibrium temperature and so be more advanced at discharge.

Therefore the gains from loading pears at a temperature close to carrying temperature, which should be actual fruit temperatures of 30–32°F, are considerable, and all pears should be loaded with a flesh temperature of not more than 40°F.

At present the export regulations require a maximum fruit temperature at loading of 40°F for all Williams and Josephine pears, all pears in cartons, and all pears exported in ISO containers; otherwise the maximum permitted temperature at loading is 45°F.

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# Frozen Concentrated Apple Segments

By M. J. Powers and W. J. Miller

M. J. Powers, Associate Professor in Food Science, Washington State University, U.S.A., spent a sabbatical year (September 1970–August 1971) in the Division of Food Research; W. J. Miller is Plant and Research Division Manager, Valley Evaporating Company, Chelan Falls, Washington, and both authors have had a long association with apple processing in the U.S.A. The pressing need to develop new marketing outlets for apples makes this account of recent work on dehydrofrozen apples especially relevant.

In 1946, Howard and Campbell, working at the Western Regional Research Laboratory of the U.S. Department of Agriculture, introduced a new combination method of food preservation which they called 'dehydro-freezing', and which was subsequently patented (Howard, Ramage, and Rasmussen 1949).

Dehydrofrozen fruits and vegetables combine the advantages of dehydrated foods, savings in weight, space, and packaging, with the higher quality of frozen foods. Rapid removal of water to intermediate moisture contents minimizes heat damage in drying, and frozen storage ensures good retention of initial quality.

Apples were among the first foods to be successfully dehydrofrozen and they have achieved the highest commercial production (about 20 million pounds per year) of the dehydrofrozen foods in the U.S.A. (Lazar 1968). Apple segments, or dice, are especially

suitable for dehydration as they are porous, are easily dried, and will readily rehydrate when properly handled.

In the early work on dehydrofreezing (Talbert, Walker, and Powers 1950; Kaufman 1951; Rockwell *et al.* 1954) the apples were dehydrated to about 50% of the original weight, i.e. to a solids content of about twice the original level. Subsequently twofold ( $2\times$ ) came to be the accepted level of concentration of dehydrofrozen foods, but this was certainly not the intent of the original workers (Howard and Campbell 1946). No dried apple products are manufactured in the U.S.A. with concentration levels between  $2\times$  dehydrofrozen and  $5\times$  evaporated apples (Table 1). Yet the natural porosity of apples makes them very suitable for the preparation of dehydrofrozen products at higher concentrations than  $2\times$ .

Accordingly, laboratory and commercial

Table 1. Types of Concentrated and Frozen Apple Products

Common Designation	Usual Concentration	Approx. Solids Content (%)	Approx. Sugar Content (%)	Approx. Water Content (%)	Approx. Percent Orig. Wt. (%)	Approx. Temp. to Freeze (°F)
Frozen	$1\times$	15	13	85	100	27
Dehydrofrozen	$2\times$	30	26	70	50	15
Proposed concentrated apple segments	$3\times$	45	39	55	33	5
	$3\frac{1}{2}\times$	52	45	47	29	0
	$4\times$	60	52	40	25	-10
Dried, or evaporated	$5\times$	75	65	24	20	—
"Overdried"	$5\frac{1}{2}$ – $6\times$	82–90	71–78	10–17	16–18	—
(not presently commercial)						
Low-moisture	$6\frac{1}{2}\times$	97 $\frac{1}{2}$	84	2	15 $\frac{1}{2}$	Indef.

Table 2. Results of Pilot-plant Concentration, Freezing, and Rehydration of Apple Segments

Concentration of Frozen, Thawed Segments	Time of Rehydration (hr)	Extent of Rehydration (as % original wet wt.)					
		Winesap Apples				Golden Delicious Apples	
		Radial Cuts 1/20		Radial Cuts 1/8		Radial Cuts 1/20	
		Water	20% Syrup	Water	20% Syrup	Water	20% Syrup
2 ×	4	90.5	88.0	85.0	81.0	88.2	72.0
	24	94.5	97.5	90.5	95.5	92.5	89.2
3 ×	4	84.3	71.8	77.3	60.7	77.8	64.7
	24	89.3	84.5	91.3	84.0	91.5	70.7
3½ ×	4	81.7	73.1	68.6	56.4	85.8	65.8
	24	89.3	87.1	85.1	76.0	94.0	87.3
4 ×	4	81.5	70.8	64.4	51.1	72.1	71.1
	24	89.2	83.8	80.3	67.4	86.4	77.1

trials were undertaken with Winesap and Golden Delicious apples, two varieties commonly grown in the State of Washington, to investigate the rehydration properties of apples dehydrated to several concentration levels and then frozen.

#### Pilot Trial

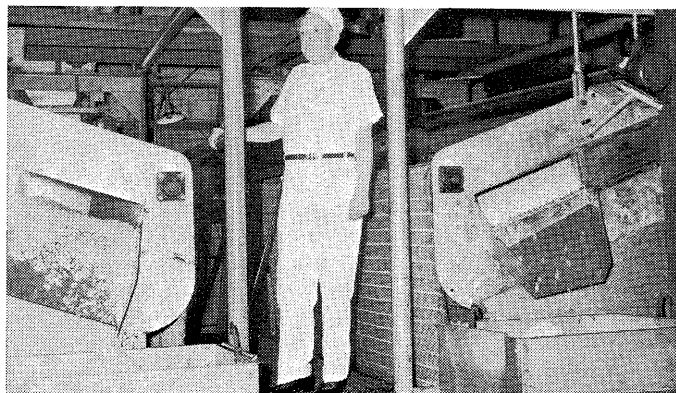
Winesap and Golden Delicious apples were peeled, cored, radially sliced, and sulphited as for dehydrofreezing (Walker, Powers, and Taylor 1955) and dried in a tray-type laboratory drier. The extent of concentration was determined by following weight losses during drying, and samples were taken at concentrations of 2×, 3×, 3½×, and 4×. All samples were packaged in small polyethylene bags and held at -10°F. Samples to be tested for rehydration were thawed and were separately immersed in either hot water or 20% sucrose syrup. The rehydration temperature was held close to 185°F by repeated

warming and stirring. The extent of rehydration after soaking for 4 and 24 hours was determined by weighing the apple after draining for 2 minutes on an 8-mesh screen. The percentage rehydration in relation to the original wet weight was then calculated.

The results in Table 2 show that both varieties of apples gave satisfactory dehydro-frozen products. However, in comparing the two sizes of cuts of the Winesap apples, which were medium-sized fruit (125 fruit/42 lb box), rehydration was more complete for the small radial cuts (1/20ths) than for the larger cuts (1/8ths). Rehydration was more rapid and more complete in water than in syrup, as might be expected from osmotic considerations.

#### Commercial Trial

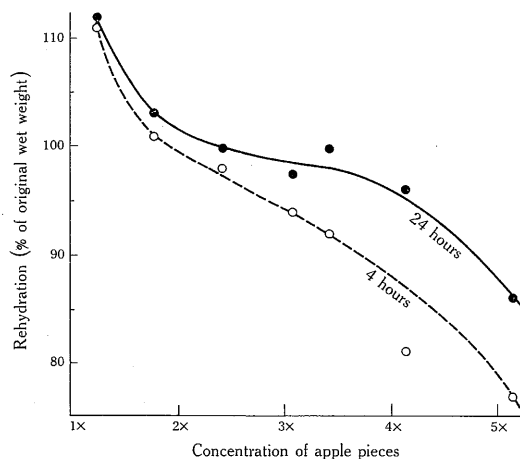
A larger pack was prepared using a commercial belt trough dryer (Lowe *et al.* 1955) at the Valley Evaporating Company, as shown



Belt-trough drying of apple pieces.

in the photograph. Winesap apples were peeled, cored, and cut into pieces ( $\frac{3}{4}$  in.  $\times$   $\frac{1}{2}$  in.  $\times$   $\frac{1}{2}$  in.). They were sprayed with 0.1% sodium bisulphite solution and dehydrated at 270°F dry-bulb temperature. Samples were taken before and at intervals during the dehydration process and were separately packaged and frozen. The moisture content of each sample was calculated from the loss in weight on drying.

Rehydration was performed as before at an average temperature of 185°F but in hot water only. The percentage rehydration after 4 and 24 hours is shown in the diagram. Substantially complete rehydration of the samples concentrated up to  $3\frac{1}{2}\times$  was achieved in 24 hours.



Extent of rehydration of frozen concentrated apple pieces soaked for 4 and 12 hours in water at 185°F.

### Conclusions

The possible range of frozen and dehydrated apple products is shown in Table 1. The results indicate that 3 to  $3\frac{1}{2}\times$  frozen concentrated apple segments represent an optimum product, combining useful weight saving with satisfactory rehydration and quality retention. This product has a lower unit cost than dehydrofrozen apples at  $2\times$  concentration, but is superior in quality to dried apples at  $5\times$  concentration; the concentration of solids (45–52%) minimizes freezing damage.

Frozen concentrated apple segments ( $3\frac{1}{2}\times$ ) rehydrate readily for bakery use.

Conditions for most rapid and complete rehydration are:

- small-sized pieces;
- hot liquor (160–200°F);
- water or low-sugar liquor;
- extended soaking time.

In bakery operations, mixes are often prepared in the late afternoon for use in production the following morning. One major baker has indicated a preference for dehydrofrozen apples over other forms of processed apple because of greater convenience in the bakery and especially because of freedom from excessive drip after thawing.

Frozen concentrated apple segments ( $3\times$ – $4\times$ ) are recommended as convenient, economical, and high in quality for desserts, pies, and other bakery products.

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# News from the Division

FRL, Food Research Laboratory; MRL, Meat Research Laboratory; DRL, Dairy Research Laboratory

## Tenth Anniversary

About 140 members and former members of the Division gathered at Ryde during the afternoon and evening of Friday, September 3, to celebrate the tenth anniversary of the move from Homebush to the new laboratories in September 1961.

Among those who attended the function were Dr J. R. Vickery, former Chief of the Division of Food Preservation, and Mr M. V. Tracey, the present Chief. In a short speech, Mr Tracey contrasted the size of the Division and scope of its activities now and 10 years ago. Staff numbers had almost doubled, and with the additions of extended meat research facilities at Cannon Hill and, early in 1971, those of the Dairy Research Laboratory at Highett, the new Division carries out research on a much wider range of foods.

Members of staff also wished to commemorate the tenth anniversary by instituting a series of specialist courses for the food industry. The first of these, on instrumental techniques, was held in July, and the second, on flame sterilization, in November 1971, as reported elsewhere. Courses on other topics are being planned.

## New Appointments

Dr M. P. Sparrow, formerly a National Heart Foundation Fellow in the Department of Physiology of the University of Western Australia, has been appointed to the research staff of MRL, to work on a programme of research in developmental and adaptive changes in mammalian muscle. Dr Sparrow graduated B.Sc. with honours from the University of Western Australia in 1963 and Ph.D. from the same university in 1966.

Mr B. F. McKeon has transferred from the position of Assistant Secretary in CSIRO's Agricultural and Biological Sciences Branch to that of Industry Liaison Officer at the

Dairy Research Laboratory, Highett. His extensive knowledge of the dairy industry and his services on a number of industry committees, as well as his previous experience with the Department of Agriculture in Victoria, will be of value not only to DRL but to the Division as a whole.



Mr D. W. Roberts.

Mr D. W. Roberts joined MRL at the end of August, and will take up duties as Extension Officer in Perth after a period of training at Cannon Hill. His main function will be to develop and maintain liaison with meat processing firms in Western Australia and the Northern Territory. Mr Roberts graduated B.Sc.(Agr.) from the University of Western Australia in 1964. For the past several years he has been stock manager for the Benedictine Community Inc. of New Norcia, Western Australia.

MRL hopes to appoint an additional extension officer in the near future, to be located in Melbourne.



### Awards

Dr G. R. Jago, DRL, has been awarded the Silver Medal of the Australian Society of Dairy Technology for his work on enzymology and bitterness in cheese.

### Visiting Workers

Two Colombo Plan Fellows from the National Atomic Energy Agency of Indonesia are currently attached to FRL for approximately six months. Miss Soertina Gandanegare is working on post-harvest physiology, and Miss Warsijati Martojoedo is investigating the radiation and pressure resistance of spores isolated from milk.

### General

Mr L. L. Muller, DRL, recently accompanied a study mission to Japan in the role of technical consultant. The mission was sponsored by the Victorian Whey Utilization Association.

On a visit to New Zealand in July 1971, Mr D. J. Casimir, FRL, called at Massey

University and DSIR, Palmerston North, as well as a number of food processing plants in the South Island.

Dr June Olley of the Tasmanian Regional Laboratory, Hobart, also visited Massey University after taking part in a seminar on the quality of fish products held in Wellington in August.

Dr Olley, Mr Tracey (Chief of the Division), and Dr R. A. Buchanan (DRL) attended the Twelfth Pacific Science Congress in Canberra, at which Mr Tracey chaired the symposium on 'Protein nutrition in the Pacific area'.

Dr R. A. Buchanan and Mr L. L. Muller of DRL attended the biennial conference of the N.S.W. Division of the Australian Society of Dairy Technology at Lismore and the twenty-seventh annual conference of the Society at Surfers' Paradise in July.

Dr Buchanan presented a paper, 'Scope for increasing usage of dairy products in other foods', at the Lismore meeting, which was also attended by Mr K. C. Richardson of FRL.

## Financial Contributions, 1970/71

In the year ended June 30, 1971, the Division had a total budget of \$2,818,902. Of this the Australian Meat Research Committee contributed \$405,000 in support of the Meat Research Laboratory at Cannon Hill, Dairy Research Grants of \$205,100 were made available for work at the Dairy Research Laboratory at Highett, \$15,500 was contributed by the CSIRO Executive for development projects, and \$109,800 was contributed by other statutory bodies and by State Government departments. In addition the Food Industries Equipment Fund received donations from a number of firms connected with the food industry as support for the Division's activities.

The Division of Food Research wishes to thank these organizations for their generosity.

### Government Departments and Statutory Bodies

#### Australian Apple and Pear Board

Apple and pear storage investigations

#### Australian Dried Fruits Association

Investigations on dried tree fruits

#### Australian Meat Research Committee

Research on the quality, processing, storage, and

transport of meat; also on the mechanical skinning of sheep.

#### Department of Primary Industry

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

#### N.S.W. Department of Agriculture

Fruit storage investigations

#### National Packaging Association of Australia

Investigations on food packaging

#### Queensland Fish Board

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

#### Australian Honey Board

Research on honey quality

### Contributors to Food Industries Equipment Account, 1970/71

Abattoir Construction & Engineering Co. Pty. Ltd.

Australian Fibreboard Container Manufacturers' Association

Citrus Products Co.

K.9 Pet Foods

Pict Limited

Schweppes (Aust.) Ltd.

Tarax Ltd.

Winn Food Products