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Citrus Fruits and Apples for Processing

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The quality of fruit products is greatly affected by the attributes of the fruit from which they are made. In the following address, which he delivered to the Fourth Australian Fruit and Vegetable Storage Conference in June 1964, Mr. Kefford, leader of the Food Technology Section in the Division of Food Preservation, discusses the characteristics of citrus fruits and apples for processing, especially for making juice.

CITRUS FRUITS

More citrus fruits are consumed directly as human food than any other kind of fruit. The world crop approaches 20 million tons per year, and this huge annual harvest is a comparatively recent phenomenon. Indeed, it has doubled in the last 20 years, and most of the increased production has been in oranges. The United States of America produces more than 40% of the world crop of citrus fruits, and consumes more citrus—especially oranges—than any other country. American consumption of oranges ranges from 50 to 60 lb per head per year, while Australian consumption is only about half this quantity. But in America only 20% of the total consumption of oranges is in the form of fresh fruit; the remainder is consumed in the processed form.

A notable feature of citrus fruits is the extent to which the whole fruit can be utilized in a variety of ways for human food. The flavedo carries the carotenoid pigments responsible for the bright colours of citrus fruits, and also oil sacs containing aromatic essential oils to which the fruits owe their characteristic aromas and flavours, and which are extracted for use as flavourings in many foods. The albedo is rich in pectin, which is extracted and used as a gelling agent in foods. The whole peel enters human diets as candied peel, and also in marmalades.

Marmalade was one of the earliest processed foods to be made from citrus fruits. This essential component of the British breakfast was traditionally made from Spanish bitter oranges, the Seville oranges. More recently marmalades have been made from many citrus fruits—sweet oranges, grapefruit, lemons, and limes, in various combinations.

The principal edible portion of citrus fruits is the endocarp, or pulp, which usually amounts to 65–75% of the weight of the whole fruit. Frequently the pulp is consumed in the form of juice, comprising the cell contents from the juice vesicles expressed by means of hand or mechanical juice extractors and usually screened. In addition to soluble constituents, the juice contains suspended material, often called "cloud", which consists of chromoplasts and fine fragments of various fruit tissues. The yield of screened juice may be 30–50% of the weight of the fruit.

Although juices are the principal processed foods made from citrus fruits, there are also a number of highly acceptable products prepared from the segments of the endocarp—notably from grapefruit, sweet oranges, and mandarin-oranges. Processing of grapefruit and orange segments, or sections, originated in Florida and this State continues to provide most of the world production. After the peel is removed by highly ingenious machines, skilled women operators cut out the segments with trowel-shaped knives. This operation also is expected to be automated very soon. The prepared segments are preserved in various ways—as canned, frozen, or chilled products. Another distinctive canned citrus product is canned mandarin-orange segments from Japan. The mandarin-orange, *Citrus unshiu*, called Mikan in Japan and generally called the Satsuma mandarin in English-speaking countries, is uniquely suitable for preparation of canned segments because it is virtually seedless, and it may be peeled and separated readily to provide firm segments that retain wholeness and shape during processing.

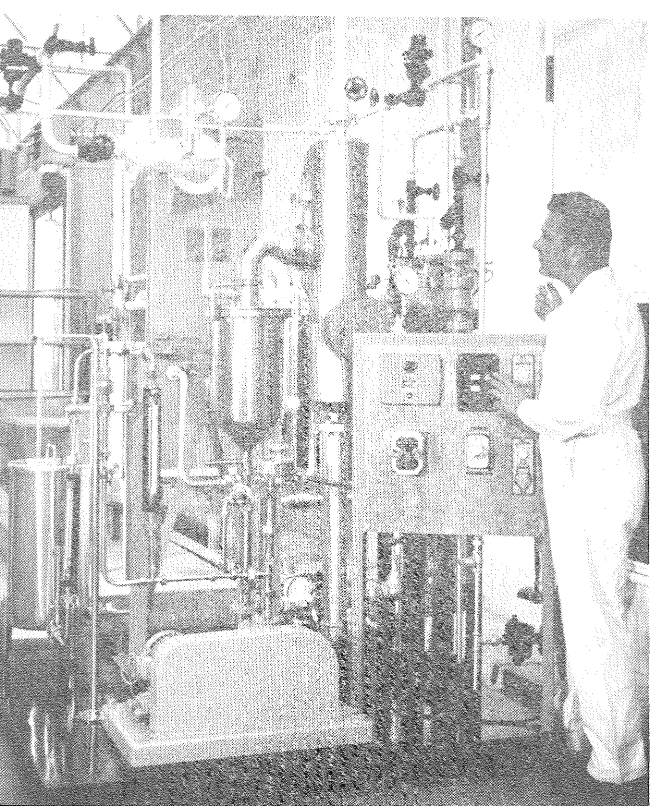
Citrus Products in Australia

Citrus production in Australia topped 10,000,000 bushels for the first time in the 1961 season, i.e. about 200,000 tons and about 1% of the world crop. The Australian citrus crop is made up of about 82% oranges and this proportion is increasing; there are about 8% lemons and about 5% each of mandarins and grapefruit, but the production of these fruits appears to be declining.

The domestic fruit market takes about 75% of Australian citrus fruits, and 5% are exported, leaving 20% to be consumed in the processed form. This is about 100,000,000 pounds, which represent about 5,000,000 gallons of juice. The proportion of the lemon crop processed is considerably greater and may amount to 80%.

The citrus juice industry in Australia might be described as a microcosm of the industry in the U.S.A., reproducing American developments after a lag of 10 to 15 years. Prior to 1940, processing of citrus juices was restricted to the manufacture of soft drinks and cordials, and even today these products remain major outlets. Cordials are required to contain at least 25% by volume of citrus juice; they have a total sugar content of about 50%, they are preservatized, artificially coloured, flavoured, and they are intended to be diluted with 4 or 5 volumes of water for consumption. Soft drinks are, of course, ready-to-drink beverages, and they contain 5% by volume of citrus juice.

An A.P.V. plate evaporator that may be used for concentrating fruit juices.



Canning of citrus juices was pioneered in Australia by the CSIRO Division of Food Preservation when a pilot plant was set up in 1940. Demands for citrus juices by the U.S. Armed Forces during World War II encouraged the establishment of an orange juice canning industry in Australia, and eventually about two million gallons of single-strength juice were canned in a season, in about 20 plants. At the end of the war, however, production of canned orange juice fell away, and only two of the original plants have continued to can single-strength juice since that time.

From about 1946, the citrus products industry in the United States showed extremely rapid development, away from canned juice and towards frozen concentrates. Frozen orange juice concentrate became one of the most successful products in the history of food manufacture—overnight, almost, it became the best-selling frozen food, and it has maintained that position.

The manufacture of frozen concentrates commenced in Australia about 1958. There has been a steady growth in the market, but not the spectacular expansion that occurred in the United States. There are now perhaps seven or eight processors in Australia equipped to produce frozen concentrates, although only two of these so far have placed products on the retail market.

It was a very simple concept that launched frozen orange juice concentrate—the concentration of orange juice at low temperatures, and the restoration of the volatile flavouring materials by cutting back with a certain amount of fresh juice. Then, because the product is frozen for microbial stability, it retains its fresh character during long storage periods. The concentrate is highly convenient to use, and the reconstituted juice reproduces faithfully the quality and nutritive value of fresh orange juice. I happened to visit Florida in 1947 when the industry was getting under way, and then again in 1962, when it was extremely interesting to see how the industry had evolved after 15 years (Kefford 1963).

CHARACTERISTICS REQUIRED IN CITRUS FRUITS FOR PROCESSING

The three quality attributes commonly specified in foods are colour, flavour, and texture or consistency, and to these we might add nutritive value. Let us look at citrus fruits for processing in the light of these attributes, together with two others, yield of solids and length of season, that are related to the commercial utilization of citrus fruits. I shall speak mainly about oranges: in fact, what I have to say will refer to oranges unless I specifically mention other kinds of fruit.

Colour

The colour of citrus juices is due to carotenoid pigments carried in chromoplasts which form part of the suspended cloud. Requirements for colour in citrus juices are often expressed only in descriptive terms, but recently the U.S. Department of Agriculture (1964) introduced plastic colour standards made in the shape of a test-tube so that they may be compared in a simple comparator with orange juices contained in test-tubes 1 in. in diameter. The CSIRO Division of Food Preservation has a set of these standards.

Flavour

Several attributes of flavour may be distinguished:

Sugar–Acid Balance.—The attractiveness of citrus fruits and juices to the palate depends greatly upon the balance between sweetness and acidity. This balance is customarily expressed in terms of the Brix : acid ratio, which is the ratio of the soluble solids content (in degrees Brix) to the acidity (as anhydrous citric acid per cent). A low ratio means that a fruit or juice is relatively sour, while a high ratio means that it is relatively sweet. In oranges the ratio increases with maturity. Some American studies indicated that orange juice was most acceptable when the Brix : acid ratio was in the range 14 to 20. American tastes are notoriously sweet, and we should expect the Australian preference to lie perhaps in the range 12 to 14, but there has never been a systematic survey of the preferences of Australian consumers for citrus fruits or juices.

Characteristic Flavour.—In addition to an acceptable sugar–acid balance, citrus juices must have distinctive aromatic character, which is provided by volatile flavouring materials. These are mainly terpene derivatives derived from the essential oil in the peel, small amounts of which find their way into the juice during extraction. Citrus fruits are unique among fruits in that they can have too much volatile flavouring material when the amount of peel oil in the juice is excessive. Quantitative limits for peel oil content are often specified, but the amount of peel oil depends more upon the method of juice extraction than upon the raw material.

While some of the terpene derivatives in the peel oil are desirable flavour constituents, it is fairly certain that some are undesirable, either because of initial flavour or because of chemical changes that they undergo during processing and storage. Gas chromatography has shown that there are some 40–50 individual constituents in citrus essential oils, and further application of this technique may permit us to sort out which are the good ones and which are the bad. Some sorting out is already being applied by one Florida producer of frozen concentrate, who adds back a fractionated orange essence to his product.

Bitterness.—An important requirement in orange juice is freedom from bitterness. Bitterness in orange juice is generally due to limonoid bitter principles, so called because the compound present in greatest amount is limonin.

We now know the chemical constitution of this complicated organic molecule, but this has not advanced very far the solution of the practical problem of bitterness in orange juice. The mechanism of bitterness development is still obscure in many respects; for instance, it is not clear why bitterness is delayed. Navel orange juice when freshly expressed is completely palatable and free from bitterness, but after standing for a few hours at room temperature, or immediately upon heating, it develops marked bitterness. Californian workers sought to explain delayed bitterness in terms of a non-bitter precursor substance, which was thought to be stable at the pH of the albedo tissues but was converted to limonin at the pH of the juice. Nobody, however, has yet isolated this precursor substance. On the other hand, we in Australia incline to the view that the phenomenon of delayed bitterness can be explained on physical grounds. Initially, limonin is present in the tissue fragments that make up the suspended solids in the juice. Limonin is extremely insoluble, and it takes an appreciable time for it to diffuse from these particles and to reach a concentration at which it can be tasted, say 5–10 parts per million. This process is accelerated by heating.

Limonoid bitter principles appear to be generally present in citrus seeds and structural tissues, but they disappear from the endocarp of most citrus fruits at normal maturity. Some varieties of oranges, however, retain significant amounts of limonoids in the edible portion at maturity and these oranges are unsuitable for the manufacture of processed juices.

This Division recognized some time ago that there was a need for a chemical assay of limonin, since the only way in which a processor could distinguish bitter from non-bitter juices was to taste a sample of heated juice. An analytical procedure based on thin-layer chromatography has now been developed for determination of limonin in juices and whole fruits. When sufficient information has been accumulated about Navel and Valencia orange juices, it should be possible to recommend maximum limits for limonin content for incorporation in specifications of oranges for processing. In this connection it is desirable to emphasize that the differences in bitterness between orange varieties are relative rather than absolute. The bitter principle, limonin, is probably present in all orange juices, but bitterness is apparent to the consumer only when the limonin concentration is above a certain level, which, however, is very low, about 5 parts per million.

Although it would be extremely useful to have a reliable method of chemical assay, the original problem remains unsolved. Fundamental studies have not yet revealed a commercial method by which bitterness can be removed from processed orange juice. Processors are still in the position of having to select oranges that will not give bitter juice.

In other citrus fruits, notably grapefruit and Seville oranges, bitterness is accepted as a normal taste characteristic. Bitterness in grapefruit juice is regarded as refreshing, and is accepted and liked by consumers provided it is not excessive. Quantitative limits are desirable for the amount of bitter principle, which in this case is a flavonoid, naringin. Seville oranges, which impart desirable bitterness to marmalades, also contain naringin together with another related flavonoid, neohesperidin, which also contributes to bitterness.

Consistency or Texture

Consistency in citrus juices depends mainly upon the presence of pectic substances which help to suspend the cloud of chromoplasts and tissue fragments. Also present in the freshly extracted juice are pectic enzymes which may de-esterify the pectin and lead to two quality defects, clarification and gelation. Clarification refers to settling of the cloud to a sludge in the bottom of the container with a clear serum above it. This is unsightly and unattractive to consumers. Gelation refers to formation of gelled aggregates in juices and concentrates by reaction between de-esterified pectins and calcium ions. The amounts of pectin and pectic enzymes in extracted juices do differ among different varieties and maturities of citrus fruits, but they are influenced rather more by methods of juice extraction than by inherent natural differences.

Texture as a quality attribute becomes relevant in considering processed citrus segments. A firm but tender texture is desirable here so that the segments retain their wholeness and shape during processing and distribution.

Nutritive Value

Since citrus fruits contain 85–92% water they cannot be important sources of major nutrients. Their importance in the diet depends upon the presence of minor nutrients, especially vitamin C, or upon considerations other than nutritive value in the strict sense. Ascorbic acid content is therefore an important attribute of citrus juices for processing. It may be mentioned in passing that ascorbic acid is usually very well retained in processed citrus products.

Yield of Solids

The soluble solids content of the juice influences the Brix : acid ratio which has already been mentioned, and in addition the yield of solids from citrus fruit is important to the manufacturer of citrus concentrates because it determines the yield of concentrate. The yield of solids is calculated from the soluble solids content of the juice and the yield of juice from the fruit, and is expressed in pounds of solids per box or per ton (or pounds of acid per ton of lemons). In America, citrus fruits for processing are bought on this basis—pounds of solids or pounds of acid per ton.

The American procedure is to sample loads of fruit at the rate of 0·1%, i.e. a 45-lb sample from a load of 45,000 lb. The fruit sample is put through an automatic extractor and the juice obtained is weighed; then the soluble solids content of the juice is determined by refractometer or hydrometer, and from this figure together with the juice yield the "pounds of solids per ton" is calculated. At the same time the acidity of the juice is also determined, and the Brix: acid ratio is calculated.

The reason why yield of solids is so important is that the solids content of the final concentrate is standardized at 42° Brix, while commercial concentrates are commonly standardized at 65° Brix. Obviously, to produce a product of standardized solids content, the manufacturer wants to buy solids and not water.

The common consumer product, frozen orange juice concentrate, was standardized at 42° Brix because when it is broken down, 1 part plus 3 parts of water, it gives a reconstituted juice at 11·8° Brix. In the early days of the Florida industry, 11·8° Brix was selected as a reasonable average value for Florida orange juice. Even Florida processors are now inclined to think that this value is a little high as an average for Florida single-strength juice. As I shall indicate shortly, it is certainly high as an average for Australian juice, but if Australian producers wish to compete with American concentrates in export markets they must conform to the American standard. Even within Australia present production conforms to this standard, but processors are permitted to add up to 5% sugar to single-strength juice and still call it pure orange juice.

Length of Season

Another important consideration for citrus processors is the season in which citrus fruit is available for processing; for smooth production and minimum overheads, the longer the season the better from the processor's point of view.

SPECIFICATIONS

In the light of the characteristics that we have discussed, we might envisage drawing up specifications for citrus fruits for processing. For instance, the following is a typical American specification for fruit for the preparation of frozen orange juice concentrate:

Minimum Brix	10·5°
Maximum acidity	1·3%
Minimum acidity	0·75%
Minimum Brix : acid ratio	10

To this specification we would add "freedom from bitterness", and eventually, as I have mentioned, it may be possible to specify a maximum limonin content.

This specification expresses the high standards that are necessary to ensure satisfactory quality in frozen orange juice concentrate, which is the premium product in the line of processed citrus juices. For certain other products it may be possible to accept fruit giving a juice that fails to meet this specification. For canned single-strength juice, a high-quality raw juice is necessary if the product from the can is to be highly acceptable. However, some Australian processors have evidently been able to market a canned juice that shows appreciable bitterness.

In cordials and soft drinks, the quality of the citrus juice ingredient is considerably masked by other ingredients—by the addition of sugar, acid, and flavourings based on peel oil. Thus in the past the processing industry has been supplied mainly with so-called "factory fruit", for which specifications of composition and quality were generally not laid down, and which was generally cull fruit from packing houses. Often, of course, this fruit is satisfactory in juice quality when it is rejected only for defects in external appearance. Our citrus industry has been oriented towards the fresh market and external appearance has been the primary criterion of quality.

We may now ask ourselves the question, "How well do Australian citrus fruits line up to the requirements that have been laid down for processing?", and the short answer is, "Not too well". We do not have well-organized and comprehensive information about the composition of Australian citrus fruit but we may look at what is available under a number of headings.

Varieties

The Australian orange crop consists mainly of Valencias and Navels, with rather more Valencias than Navels. There is a small and declining production of common oranges. The Valencia Late is the preferred orange for juice production throughout the world because of good colour, good sugar–acid balance, good yield of solids, high flavour, and freedom from bitterness. Australian Valencias, however, tend to be low in solids and to be subject to bitterness.

During the 1961–62 season, a survey was made of the quality of Valencias grown in New South Wales. About 250 samples of oranges were analysed, and the canned juices were tasted for bitterness. Among these juices, approximately 60% failed to reach the minimum Brix of 10·5° and approximately 25% were unacceptable because of bitterness.

We also have some data for Queensland Valencias in the 1963 season. Some 46 samples were analysed from 12 growers, and the overall range for Brix was 6·6–11·8°: in other words, the Florida average was in this case the maximum Brix recorded; the corresponding range of acidity was 0·70–1·75% (Paroz, private communication, March 1964).

Another comparison might be made between the yield of solids from Australian and Florida Valencias. In the period from 1946 to 1960, the average yield of solids in frozen orange juice production in Florida increased from 124·5 lb per long ton to 156·5 lb. A large part of this increase is due to changes in methods of mechanical juice extraction (Dall 1962). Kefford and Chandler (1961) reported yields of solids from Australian Valencias, extracted by hand reaming, ranging from 101 to 141 lb per ton. Again, some Queensland data are available (Summerville, private communication, August 1963) showing that Valencias on trifoliate orange, sweet orange, and rough lemon stocks yielded respectively 160, 143, and 127 lb of solids per long ton.

Bitterness is sometimes encountered in early Valencia juices in Florida or California. One American worker suggested to me that the bitterness in Australian Valencia juices may be genetic in origin. There may be bitter and non-bitter strains of Valencias, and a bitter strain may have been widely propagated at some time in the history of the Australian industry.

Florida workers reported some evidence of genetic effects on solids in Valencias, but they are just beginning to test Valencia strains critically.

In Australia, Valencias are available in reasonable quality for processing for only about three months (October to December). In fact, one might say that one thing wrong with the Valencia Late variety is the fact that it is late, i.e. it has a restricted season. Since it blossoms in September and takes about 12 months to mature, it is approaching maturity in the following September and reaches its peak about November. After Christmas, Valencias generally show a marked decline in quality. In California, they seem to be able to extend their Valencia season to about 6 months.

It is difficult to extend the orange processing season significantly in Australia by the use of other varieties. The Washington Navel is an outstanding variety for the fresh market, but generally speaking Navels are not suitable for juice because of bitterness, due to limonoid bitter principles. The Shamouti orange in Palestine and loose-skinned oranges in India are also subject to this bitterness. In Florida, the orange processing season is made to last for about 9 months by the use of early and mid-season varieties such as Hamlin and Pineapple that are not commonly grown in other parts of the world. The common oranges grown in Australia, such as Parramattas, Joppas, and Sillettas, are only moderately satisfactory for the production of juice.

Rootstocks

The general effects of rootstocks on the quality and composition of oranges are well known, and they have been well exemplified in Australian experience. Only three rootstocks are used in commercial citrus plantings in Australia—rough lemon, sweet orange, and trifoliate orange. Rough lemon is the stock used most widely. It grows quickly, resists drought, and crops early, but has adverse effects on fruit appearance and juice quality, and it is susceptible to phytophthora root rot. Sweet orange stock, which produces fruit and juice of better quality, is being increasingly used as a rootstock for oranges on the deeper sandy soils of the Murray Valley. Trifoliate orange rootstock has very favourable effects on fruit and juice quality, and is resistant to phytophthora root rot and citrus nematode.

It is, however, sensitive to the scaly butt virus and requires special propagation methods using only buds from vigorous parents that have themselves been grown on trifoliate stock. Trifoliate orange stock has been used extensively in New South Wales, both on the coast and in the Murrumbidgee Irrigation Area, where a series of wet seasons caused large losses of trees on rough lemon stock.

As stocks for Navel and Valencia oranges, rough lemon and trifoliate orange represent opposite extremes. Trifoliate orange stock gives high yields of juice, high in acidity and soluble solids but low in ascorbic acid and low in bitterness. Rough lemon stock gives low yields of juice, low in acidity and soluble solids but high in ascorbic acid and high in bitterness. Sweet orange stock occupies an intermediate position in its influence on juice composition and bitterness. Processed juices free from bitterness have been prepared from both Navel and Valencia oranges on trifoliate orange stock. In the survey of New South Wales Valencias already mentioned, all of the bitter juices came from Valencias on rough lemon stock, but not all the juices from this rootstock were bitter—only about 40% of them. None of the Valencias on trifoliate stock gave bitter juices. As a result of this survey and previous observations, Australian producers of canned single-strength juice and frozen orange concentrate are specifying Valencias on trifoliate stock for processing purposes. I have already mentioned Queensland data showing higher yields of solids from Valencias on trifoliate stock than on sweet orange or rough lemon stocks.

Regional Aspects

There is a great deal of rumour in the citrus industry regarding differences in the quality of citrus fruits from different regions within Australia. Persons interested in particular regions are usually enthusiastic advocates for the quality of citrus grown in these regions. There may be some basis for some of the opinions expressed, but the evidence at present is scanty. In the survey of N.S.W. Valencias, only 10% of the juices from rough lemon stock in the Murrumbidgee Irrigation Area were bitter, whereas 60% of the juices from this stock on the central coast were bitter. Some earlier studies (Kefford and Chandler 1961) suggested that bitterness levels were generally lower in the Murray Valley than in the M.I.A. or the central coast of New South Wales.

We might raise at this point the general question as to whether we are growing citrus in Australia in the right areas. In the past, the location of citrus plantings has been determined hardly at all by considerations of fruit quality, but mainly by the need to make use of irrigated land and by proximity to major metropolitan markets for fresh fruit.

Barnard (1946), in an interesting analysis of this question, pointed out that since the minimum temperature required for citrus growth is about 55°F, the suitability of areas for citrus crops may be compared in terms of heat units received by summing the mean daily temperatures above 55°F. Such calculations indicate that the lower Murray area compares favourably with California, which has proved to be eminently suitable for the growth of Navel oranges. If we regard Florida as a successful environment for the growth of Valencia oranges, the Australian climatic equivalent is near Gladstone in Queensland.

These general thoughts are supported by observations on the comparative quality of Australian and American Valencias. Australian Valencias resemble Californian Valencias in having generally good skin colour and juice colour. Florida Valencias tend to be pale in the skin and give a yellow rather than an orange-yellow juice. Phytotron experiments have shown that low soil temperatures and low night temperatures are necessary for maximum colour development in Valencias. For processing purposes, however, high solids content is rather more important than high colour, so therefore perhaps we should look for areas with high heat units. From this point of view, however, the values quoted for Queensland Valencias are disappointing.

Grapefruit also require high heat units for good quality. Our southern grapefruit areas receive only about half the heat units of good grapefruit areas overseas (Barnard 1946), and our grapefruit tend to be excessively bitter and sour in comparison with the mild flavour of American grapefruit.

Californian workers have made some preliminary studies on heat unit effects on oranges (Jones, Embleton, and Cree 1962). They suggest that high heat units at critical periods during the development of the fruit favour high Brix : acid ratios and early maturity in terms of acidity standards. The critical periods in California were April–May, the time of flowering and fruit set, and August, the time of acid formation in the fruit.

Cultural Practices and Tree Nutrition

Many studies have been made throughout the world and in Australia of the effects of orchard practices and the nutritional status of the tree on the composition and quality of the fruit. Some effects are well known, for instance oil sprays will reduce soluble solids content by about 1° Brix, and watering, if excessive or poorly timed, will also reduce solids. It is very difficult to demonstrate significant or consistent effects of tree nutrients on juice yield and composition. In Florida, only magnesium appeared to have a slight effect on juice solids.

With regard to the major nutrients, published experience throughout the world is very difficult to sort out. In general it may be said that there are evidently optimal levels for the nutritional status of the tree to produce fruit with desired chemical characteristics, but these levels are not yet clearly defined.

A committee has been formed in New South Wales for investigations of citrus juice quality with representatives of the N.S.W. Department of Agriculture, N.S.W. Citrus Growers' Council, and CSIRO. It is hoped that cooperative studies in progress will elucidate some of the effects of orchard factors on the quality of orange juices.

APPLES

About 20% of the Australian apple crop is processed, and the principal product is solid-pack apple in No. 10 cans. Other products are apple pulp, dried apple, frozen apple, apple juice, and apple concentrate. The characteristics required in apples for processing are of two kinds: some are important in the economics of the industry, and others are important in relation to the quality of the final product.

Solid-pack Apple

First let us review briefly the steps in the preparation of canned solid-pack apple (Gallop and Board 1956). The apples are peeled and cored mechanically, and then may be passed to a seed celling machine which is designed to remove any remaining seed and core tissue. The apples are trimmed by hand, and up to four trimmers may be required per peeling machine according to the quality of the fruit. The trimmed apple is then cut into smaller units, either in dicers or chippers, which give pieces of somewhat random size and shape, or in slicers, which cut the apples symmetrically by means of radial blades. After cutting, the apple falls into a dilute brine and is then elevated to a blancher where it is heated in steam for 3–6 minutes. The blanched apple is filled into No. 10 cans, tamped down, and sealed immediately. The sealed cans are processed in boiling water and cooled.

In order to ensure good yields of prepared apple after peeling, coring, and trimming, apples for processing should fall within a narrow size range and should have a smooth spherical shape with the core symmetrically placed. Desirable qualities in solid-pack apple are bright colour, i.e. white or creamy without grey discoloration, distinctive flavour, and a firm not floury texture so that the integrity of the apple pieces is well maintained during blanching and cooking. On the other hand, for apple sauce, apples should break up readily with a good consistency. A high specific gravity is desirable in apples for processing since it is often difficult to achieve the required filled weight of about 6 lb 6 oz in a No. 10 can.

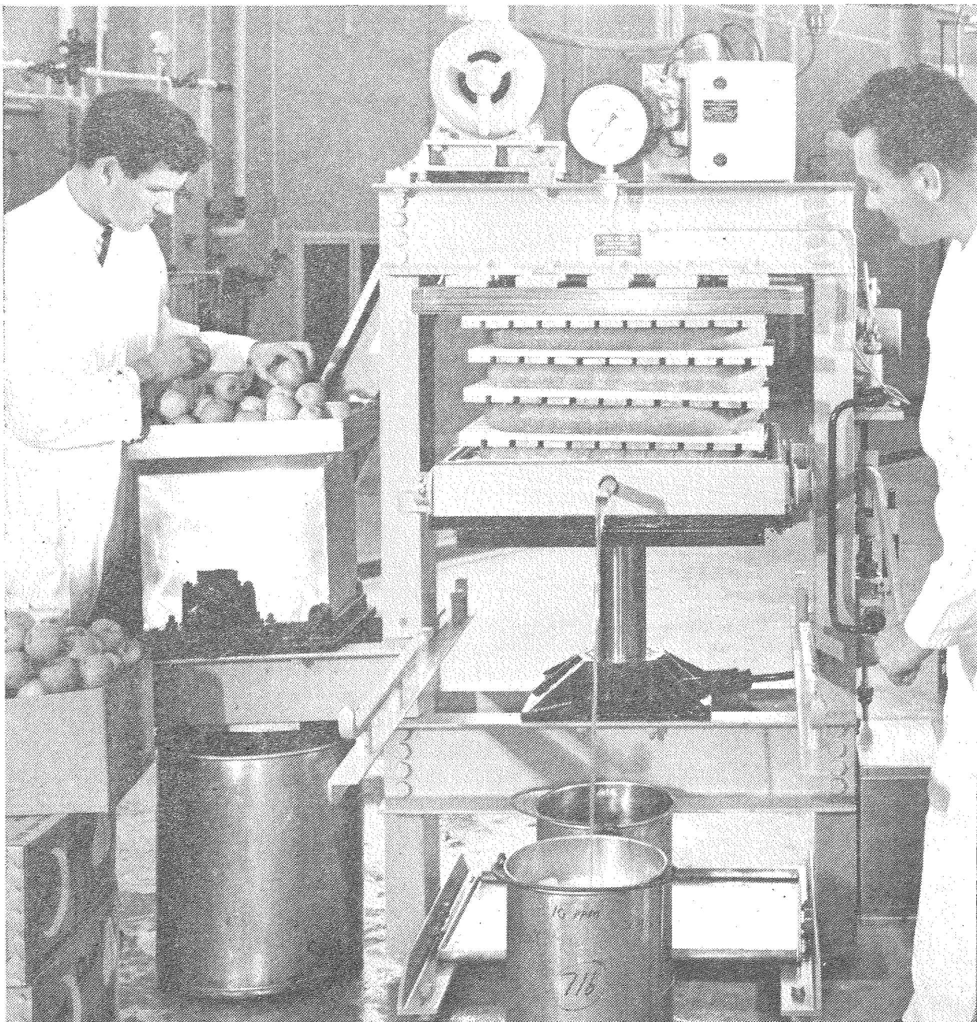
Sturmer is the best variety for canning. Jonathan, Granny Smith, Stone Pippin, Statesman, Geeveston Fanny, Duke of Clarence, and Rome Beauty varieties are satisfactory if not over-mature. Democrat, Cleopatra, French Crab, Scarlet Alfriston, and the Delicious group of varieties are not regarded highly by the industry. Apples not favoured for canning tend to be diverted to drying.

Apple Juice

For the manufacture of apple juice the apples are first crushed, usually in a stainless steel hammer mill or grater mill. The traditional method of extraction of juice from apples is the hydraulic rack-and-cloth press. A press cloth is laid over the bed of the press, the crushed apple is run on top of it, and the corners of the cloth are folded in. A wooden rack is placed on this cloth, and another cloth is filled and folded. This procedure, alternate racks and cloths, is continued until a press load, called a "cheese", is completed. The load is then pushed under the press and hydraulic pressure applied. This is a tedious and laborious procedure, but it has proved to be the best method to obtain an acceptable juice from apples. Recently, however, there have been many attempts to make the process continuous and more in line with modern industrial practice. Considerable success has been achieved by the use of continuous presses and centrifuges.

The yield of juice from apples ranges from 130 to 180 gallons per ton according to the raw material and the method of extraction. The expressed juice contains variable amounts of suspended matter and it can be processed as either cloudy or clarified juice. Canned juices are usually cloudy, while bottled juices are usually clarified. For preservation, apple juice must be subjected to a pasteurization operation either before or after filling into the container. Canned and bottled apple juices are very widely consumed in Europe and America, but they have a somewhat restricted sale in Australia.

Recently the apple juice industry has experienced a revival because of the production of apple juice concentrate for incorporation into soft drinks. This activity is based on the fact that soft drinks containing 5% of Australian fruit juice are exempt from sales tax. Although this regulation was probably originally designed to assist citrus growers by encouraging incorporation of citrus juices in citrus drinks, it is now being more widely interpreted and apple juice is being added to many soft drinks in order to qualify them for sales tax exemption. For this purpose a concentrate from which all apple character has been removed is desired, i.e. a water-white product with practically no volatile flavouring materials. It is not easy to achieve the "water-white" characteristic, but most of the volatile flavouring materials are lost during concentration. In Europe and America, apple juice concentrators seek to recover these volatile flavouring materials for



A mill for crushing apples (left) and a hand-operated hydraulic apple press.

adding back to the concentrate, but in Australia, because of our peculiar usage of the product, these volatiles are not recovered.

This present production of apple juice concentrate makes little demand on the quality of the raw materials. Since a pale colour is the most important characteristic of the concentrate, the red-skinned varieties and those which brown excessively on crushing are less favoured.

Speaking more generally, however, about quality in apples for juice, the processor looks for crisp, firm texture which permits ready pressing and good yield of a juice with a good sugar–acid balance, and a distinctive flavour and aroma. Few varieties alone produce well-balanced juices, and generally best results are obtained by blending. Varieties such as Sturmer, Cleopatra, and French Crab produce satisfactory basic juices to which aromatic character can be imparted by blending with Jonathan, Granny Smith, or Delicious juices. In New South Wales, Jonathan, Granny Smith, and Delicious are in any case the predominant varieties, and processors generally blend Jonathan or Delicious with Granny Smith in proportions such as 1 : 1 or 1:2. It is generally not possible to schedule deliveries of apples to maintain an optimum or uniform blend.

Apples are stored to extend the processing season, often in common storage. In general, it may be said that storage of apples does not make them any better for juice production, but they can be held in cold storage for periods of the order of three months without significant deterioration in juicing quality. Over-stored or over-mature apples tend to give low juice yields because of difficulties in pressing and in clarifying.

Apart from a few straightforward variety trials, we have made no systematic studies of factors affecting the quality of apples for processing. The views stated are rather those that have grown up in the industry as a result of accumulated experience.

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Determination of Thermal Processes for Canned Foods

The CSIRO Division of Food Preservation has published a booklet* to instruct food technologists on the experimental determination of safe thermal processes for canned foods.

The Division has been advising Australian canners on safe processes for a number of years, and it has often determined processes experimentally. Many canners, however, have sought details of the methods used, and the booklet reviewed here has been written in response to their requests.

In a short introduction the author explains, in simple but scientifically sound terms, the physical and microbiological principles on which the evaluation of a process is based. Selected references are included for those who seek a more complete knowledge of the subject. In the second half of the publication the author describes the experimental procedure for evaluating a process. He explains how to construct and calibrate thermocouples, and how to use them to measure temperatures in cans and processing equipment during the heating and cooling phases of a process. The circular, which contains many useful diagrams, graphs, and tables, concludes with a section on the interpretation of results.

* P. W. BOARD.—Determination of thermal processes for canned foods. Commonwealth Scientific and Industrial Research Organization, Division of Food Preservation, Circular 7-P (1965). 11 pp. (Obtainable from the Librarian, CSIRO Division of Food Preservation, Box 43, P.O., Ryde, N.S.W.)

Northern Bluefin—
A New Tuna Potential?

By W. A. Montgomery

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

It has recently been established that, contrary to a widely held belief, the canning quality of northern bluefin tuna is at least equal to that of the southern bluefin, the species being predominantly exploited by the Australian tuna industry at present. In this article Mr. Montgomery outlines how evidence on this point was obtained by the CSIRO Division of Food Preservation.

FOR canning purposes the most important fish within the large mackerel group is the tuna, but the industrial importance of various tuna species varies from one part of the world to another.

In Australia, the tuna industry is based almost entirely on the southern bluefin. Two major Australian fisheries, located respectively in South Australia and New South Wales, use this species almost exclusively, the fish caught being 3–4 years of age, with an average live weight of 40–50 lb. Catches made during the months of January to May are mostly canned at Port Lincoln in South Australia. The fishery based at Eden, on Twofold Bay in southern New South Wales, operates from October to January. Some tuna are also processed and canned in Sydney.

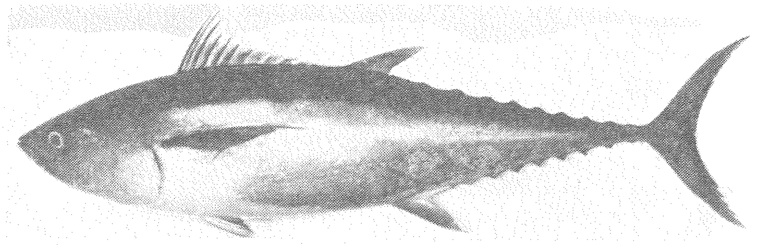
Tuna production in Australia increased dramatically after about 1950, in which year the liveweight catch was 320,000 lb. In 1961 the year's catch had increased to about 9·7 million pounds, and by 1964 it had attained 17·9 million pounds; in these two years the production of canned tuna was 3·0 million pounds and 4·7 million pounds, respectively. There are indications that there is room for yet greater expansion of the Australian market.

With an expanding market for canned tuna it would clearly be advantageous to the industry if in addition to southern bluefin, more of other locally available species of tuna could be utilized. For, provided this did not lower the acceptability of the canned product and thus adversely affect the market, existing fisheries would be able to extend seasonal operations, and also exploit resources more fully. In addition, the feasibility of establishing new fisheries based on other species occurring further northwards would be enhanced. For the tuna canneries, too, an extension of the canning season should be beneficial, since significant improvements in operational efficiency and in the economics of production might be expected to result.

AUSTRALIAN TUNA RESOURCES

Little is yet known of the total tuna resources in Australian waters. Thirteen species of tuna are known to frequent the area, and MacInnes (1950) has listed nine that might be considered to have commercial potential. These are the albacore, yellowfin, striped tuna (skipjack), dogtooth tuna, mackerel tuna, and the Australian bonito and Oriental bonito, in addition to the southern bluefin and a closely similar species, the northern bluefin.

The bonitos, which belong to the family Sardidae, are relatively small, and on account of their flavour and texture are inferior for canning: many countries have enacted legislation disallowing the labelling of canned bonito as "tuna". The striped tuna or skipjack, *Katsuwonis pelamis*, is another relatively small species, although adults may attain 3 ft in length. Its flesh is good, and it constitutes a large proportion of the canned tuna trade in North America. Since the recent introduction of monofilament nets it has been caught in moderate quantities off the Australian coast, where in deep waters this species often occurs in large schools. However, striped tuna is not favoured by Australian canners, because the small size of the fish caught (normally 5–10 lb) necessitates a greater expenditure of labour in the "picking" operation.



Northern bluefin tuna.

Australian tunas with the greatest potential for canning are those of the family Thunnidae. This family comprises albacore, yellowfin, big-eye tuna, and southern and northern bluefin.

Albacore (*Thunnus alalunga germo*) is much prized for canning because of its delicate flavour and firm, white flesh; but it is doubtful whether this or other local species (except southern bluefin) are canned in sufficient quantities for the Australian market to warrant distinctive labelling of the canned fish, as is done with albacore in the U.S.A. Some yellowfin (*Neothunnus macropterus*) caught at the newly established long-line fishery at Ulladulla in southern New South Wales have been frozen and shipped to other centres for canning.

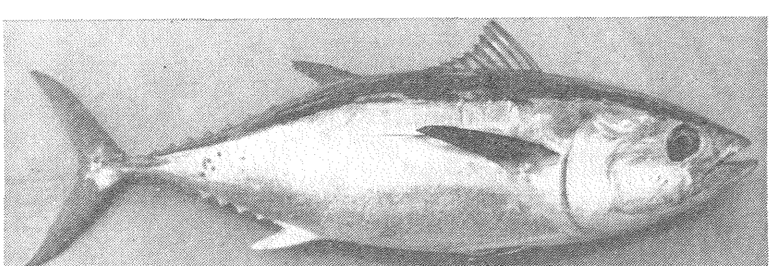
BLUEFIN TUNAS

According to Serventy (1941), the southern bluefin (*Thunnus thynnus maccoyi*) and the northern bluefin (*Kishinoella tonggol*) were not differentiated in Australia prior to 1941. Earlier references to the occurrence of the former in more northerly waters are likely, therefore, to relate to the northern bluefin, to which the southern species has a marked resemblance.

Fish of both species (see illustrations) are robust in appearance and have the torpedo-like body, tapering markedly towards the tail, that is characteristic of all tunas. The southern bluefin appears more chunky because the body tapers off abruptly as compared with the more attenuated taper of the northern bluefin. Other distinguishing features (Department of Primary Industry, Fisheries Division 1961) are that the southern species has the insert of the second dorsal fin well behind the mid point of the fork length, whereas in the northern bluefin the insert is approximately at the mid point. (The fork length is the distance between the nose and fork of the tail or caudal fin.) Also, although both species are blue to blue-grey above and silver underneath, the northern species has a series of pale, elongate blotches running longitudinally along the belly. In the northern species the fins are dark grey, except the anal fin, which is yellow. In the southern bluefin, although the tail finlets and tail keel are tinged with some yellow, the anal fin is never yellow.

Distribution

Because of the importance of the southern bluefin to the Australian tuna industry an extensive survey of its distribution and migratory habits was recently undertaken by the CSIRO Division of Fisheries and Oceanography, and the data are now being collated. Juveniles of the species are found in open coastal waters around the southern half of the Australian continent and around the coast of New Zealand, which are the main fishing



Southern bluefin tuna.

grounds for this species. Adults, up to 800 lb or more, range to the deeper oceanic waters of the South Pacific.

The northern bluefin occurs widely in Asian waters. It is found in tropical and subtropical areas from Australia, New Guinea, and Papua to the Philippines, Japan, and westwards to Ceylon and the Gulf of Aden. On the eastern Australian littoral, shoals are encountered northwards from Twofold Bay; along the west coast they are found from Fremantle northwards. The fish are said to be plentiful off the north Queensland coast and along the Barrier Reef, but as no sustained exploratory programme has as yet been carried out, basic information on the occurrence and extent of the resource is not available.

Northern bluefin shoals are quiet, and pass along beaches and enter estuaries, where they are usually taken by beach seine nets. The weight of the fish when taken usually lies between 11 and 42 lb, but it may reach 60 lb. In general, the 20–30 lb size predominates, so that in commercial catches the size would be somewhat smaller than found in commercial catches of the southern bluefin (40–50 lb). The mean weight of the fish used in the canning experiments described later was 18 lb.

Canning Quality of Bluefin Tunas

The Australian southern bluefin was formerly thought to be identical with the Californian bluefin (*Thunnus thynnus*), but is now recognized as a distinct subspecies, as it has several important points of difference from its Californian counterpart. However, for canning purposes it may be considered identical, as tasting tests on comparable packs of the two species carried out by the CSIRO Division of Food Preservation disclosed strikingly slight differences in flavour, colour, and texture ratings: both types were judged equally as "very acceptable".

The northern bluefin gives a lower percentage yield of flesh for canning than the yellowfin or the southern bluefin, because the long, thin taper towards its tail gives a high ratio of skin, bone, and subcutaneous fat to flesh. "Picking" is more difficult and therefore more costly. Although not entirely new to some packers of tuna for the Australian market (see illustration), the species has never attained importance as a tuna canning variety, principally because of a widely held belief that canned northern bluefin is mushy in texture and suffers from colour and other defects.

Northern bluefin tuna was probably first canned on a commercial scale around 1954, when the tuna canning industry was still in its infancy, and it seems likely that the prejudice against the species arose at about this time when the soft texture of the canned fish was observed. It was found that the texture was not improved by prolonging the precooking times.

In more recent times, evidence from a cannery that has canned many tons of northern bluefin has indicated that there is little to support the earlier prejudice against this species: no difficulties have been encountered during the pre-cooking stage, nor have the canned products shown any indication of being oversoft. For this reason it was considered worth while to investigate the question more fully (Prater and Montgomery 1964). The following is an account of some of this work.

Packing northern bluefin tuna in cans.

EXPERIMENTAL COMPARISONS OF CANNED TUNAS

To ascertain relative acceptabilities of the three species of tuna used in the tests (southern bluefin, northern bluefin, and yellowfin), comparable packs prepared from each species were judged by an analytical taste panel. Volatile constituents of similar packs were also compared by gas–liquid chromatography. This was done on vapours from packs that had been aged six months at room temperature.

Preparation of Material.—Nine fish from each of the foregoing species, their weight ranges 16–24 lb, 13–25 lb, and 24–33 lb respectively, were used for the tests. Fish of each species were held at −5°F for 11, 4, and 1 wk, respectively, before processing.

The northern bluefin came from the Hervey Bay and Moreton Bay areas in Queensland, and the southern bluefin and yellowfin from the south coast of New South Wales. Adequate icing and freezing were employed, following the best practices, to ensure that the fish were in prime condition when processed.

Processing.—Processing followed standard procedures for tuna, consisting of thawing, pre-cooking, cooling, and dressing. To ensure that the packs were truly representative of each fish assigned to them, each fish was cut into slices 1¼ in. thick and these were broken into chunks and thoroughly mixed before they were filled into 7-oz cans, to which salt and deodorized peanut oil were also added. After a heat exhaust, the cans were sealed, retorted, and pressure cooled with water.

Results of Tasting Tests

The canned samples were aged for 1 month and 6 months before being tasted. On each of these occasions the nine replications of each of the three species were presented to an analytical panel consisting of 15 judges. The tasters were asked to allocate scores from 1 to 5 for colour (5, most attractive); from 0 to 10 for flavour (10, best flavour); from 0 to 10 for off-flavour (10, absence of off-flavour); and from 0 to 10 for texture (10, best texture).

The results of two series of tasting tests are summarized in the table. There were small but significant differences in texture and colour among the three species after one month's ageing in the cans, but these were certainly not due to inferiority of the northern bluefin, as compared with the southern bluefin. For the samples aged for six months the differences among the species were not significant.

Palatability Ratings for Three Species of Canned Tuna: Mean Scores

Sample Size	Months in Can	Type of Fish	Colour	Flavour	Off-flavour	Texture
135 cans	1	Yellowfin	4·02	7·88	8·87	7·96
		Southern bluefin	3·62	7·47	8·56	7·32
		Northern bluefin	3·70	7·91	8·94	7·86
		S.E. of mean (16 d.f.)	±0·090	±0·13	±0·12	±0·11
		Significance of overall test	$P < 0{\cdot}05$	$P \nless 0{\cdot}05$	$P \nless 0{\cdot}05$	$P < 0{\cdot}01$
		5% L.S.D.	0·27	0·40	0·37	0·34
144 cans	6	Yellowfin	3·76	7·58	8·63	7·35
		Southern bluefin	3·37	7·41	8·37	6·98
		Northern bluefin	3·58	7·94	8·89	7·54
		S.E. of mean (16 d.f.)	±0·14	±0·14	±0·14	±0·16
		Significance of overall test	$P \nless 0{\cdot}05$	$P \nless 0{\cdot}05$	$P \nless 0{\cdot}05$	$P \nless 0{\cdot}05$
		5% L.S.D.	0·41	0·41	0·42	0·47

In both series there was a tendency for the southern bluefin to rank lowest in overall rating, but here again the effect was not statistically significant at the 5% probability level.

It is also interesting to note that the quality of the packs was not improved by storage for six months. This inference was not tested statistically, but the table shows that scores for samples aged six months are either similar in magnitude or very slightly lower than those for cans aged one month. Where differences do occur, it is doubtful whether they are real.

Gas Chromatograms

The conclusions from the tasting tests are supported by the results of gas–liquid chromatography of vapours in the headspace of the cans that had been aged for six months after sealing. These chromatograms were reproducible, and a similar pattern of 12 peaks was obtained for each of the nine fish of each species. Separate statistical comparisons for each of the 12 peaks, appropriately numbered, were made of the three species (nine replicates), but no significant difference was found. Thus the aroma profile data support the conclusion that the canned products were equal in tasting quality.

CONCLUSION

The experimental results reported, and commercial experience in at least one cannery, have provided no support for the view that the northern bluefin tuna is inferior to the southern bluefin, the species comprising the bulk of Australian packs of canned tuna.

Since recent evidence suggests that the northern bluefin, along with the yellowfin, may be caught in Australian waters during the summer months, it would seem desirable that a detailed biological survey and assessment of its fishing potential should be commenced as soon as possible. Should the results of such a survey confirm earlier sporadic studies, a valuable source of good-quality fish would be available to Australian canneries.

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Retirement of Mr. L. J. Lynch

MR. L. J. LYNCH retired as head of the Canned Foods Section of the CSIRO Division of Food Preservation on June 11, 1965, after 30 years in the Organization. Mr. Lynch was born in Maitland, N.S.W., in 1900 and began his professional career as a pharmacist. Pharmacy did not hold him long, however, and in 1935, the year after he graduated with first-class honours in Agricultural Science from the University of Queensland, he took up an appointment with CSIR, the forerunner of CSIRO. For the next five years he applied himself to the problems of wastage in citrus fruits and the preservation of orange juice, much of this work being carried out in cooperation with officers of the Departments of Agriculture of New South Wales, Victoria, and South Australia. He was placed in charge of the Fruit Products and Canning Section of the CSIRO Division of Food Preservation in 1940 and retained this position until his retirement this year.

As the dynamic leader of the Canned Foods Section, Mr. Lynch has had a considerable influence on the development of the Australian canning industry since the early days of World War II. Among his first wartime projects were investigations on the ascorbic acid content of canned foods, modifications of processing procedures to reduce loss of vitamin, and means of fortifying foods with synthetic vitamin. The commercial canning of fruit juices in Australia was largely due to his achievements in this field and to his enthusiasm and persuasiveness. Canned citrus juices and vitamin-fortified apple juice soon became important antiscorbutics in the Army diet.

During World War II Mr. Lynch made other notable contributions to the war effort of the canning industry, which was then rapidly expanding to meet the needs of the Allied Forces in the South Pacific. In 1942, as Technical Adviser to the Commonwealth Controller of Defence Foodstuffs, he made a short visit to the U.S.A. The knowledge he gained of the American canning industry was immensely helpful to Australian canners, particularly those undertaking the canning of vegetables for the first time.

Until the end of the war the Canning Section, under his leadership, was called on to solve numerous production problems and to advise military and civil authorities on technical aspects of canned foods. Mr. Lynch personally assisted in the formulation of food standards and specifications, and for a time his Section carried out laboratory examinations of canned foods for the whole of the Australian Commonwealth. From 1944 onwards, as a contribution to the post-war development of the Australian canned foods industry, he encouraged his Section to give special emphasis to investigations on quality improvement, and valuable work was done on tomatoes, sweet corn, peas, and peaches.

During a highly productive career Mr. Lynch's most outstanding contribution has perhaps been his work on the chemistry and technology of green peas.

The invention of the maturometer with which his name is linked revolutionized the harvesting and processing of green peas in this country and elsewhere. It provided a reliable and objective means of determining the maturity of peas, and thus enabled growers and processors to predict accurately when optimum maturity would be reached. He has recently also invented a pea sheller which, used in conjunction with a pea pod picker, should eliminate the problem of "viner off-flavours" in processed green peas.

An important aspect of Mr. Lynch's services to the food industry has been the part he has played in furthering technological education. It was largely due to his enthusiasm that the Food Technology Diploma course at the Hawkesbury Agricultural College, Richmond, N.S.W., was established, and he always showed a considerable and sympathetic interest in the training of overseas students who visited Australia under the Colombo Plan and other technical assistance schemes. No less than twenty such students trained under his supervision, and many others spent short study periods in the Canned Foods Section. He was for six months Professor of Vegetable Crops at the New York Agricultural Experiment Station at Geneva, N.Y., this temporary appointment having been offered him in 1954 following the success of the maturometer overseas. In 1957 he accepted an invitation to act as Director of the Food Processing Laboratory in the College of Agriculture, University of Hawaii, and occupied this post with distinction for a period of nine months. He has advised the Colombo Plan Supplies Directorate on the supply of food machinery to Indonesia and Pakistan, and has been for many years Australian liaison officer for the Comité International Permanent de la Conserve.

In 1962, Mr. Lynch's contributions to the international exchange of information in food technology were recognized by his receiving the International Award of the Institute of Food Technologists. In 1965 he was the recipient of the Australian Award of the Institute of Food Technologists, an award made for meritorious contributions to the advancement of food technology in Australia. Mr. Lynch is the only Australian to receive both awards.

When he retired, Mr. Lynch was a Senior Principal Research Scientist in the Division of Food Preservation. At a farewell tendered him by his colleagues on June 9, 1965, tribute was paid to his notable contributions to the work of the Division of Food Preservation and to food technology generally. In retiring this year, he joins two noted food technologists from sister institutions whose activities have been closely linked with those of the CSIRO Division of Food Preservation, namely, Mr. W. B. Adam, Director of the Fruit and Vegetable Canning and Quick Freezing Research Association at Chipping Campden in England, and Mr. F. E. Atkinson, of the Canada Department of Agriculture Research Station at Summerland, B.C.

R. B. WITHERS

NEWS FROM THE DIVISION OF FOOD PRESERVATION

FOOD TECHNOLOGY

Groups in the Division of Food Preservation engaged on investigations on canned, frozen, and dried foods, together with the Taste Test Unit, have been formed into a Food Technology Section under the direction of Mr. J. F. Kefford, Senior Principal Research Scientist. Mr Kefford, who joined the Division in 1938, succeeded Mr. L. J. Lynch when he retired as leader of the Canned Foods Section in June 1965.

NEW PILOT-PLANT FACILITIES

Although there has been increasing interest, particularly in recent years, in the commercial application of heat concentration to a wide range of liquid foods, the Division of Food Preservation has lacked facilities for pilot-plant work in this field. This position has recently been rectified by the purchase of an A.P.V. Junior plate evaporator and Alfa–Laval Pty. Ltd. are donating two pilot-scale Centritherm evaporators.

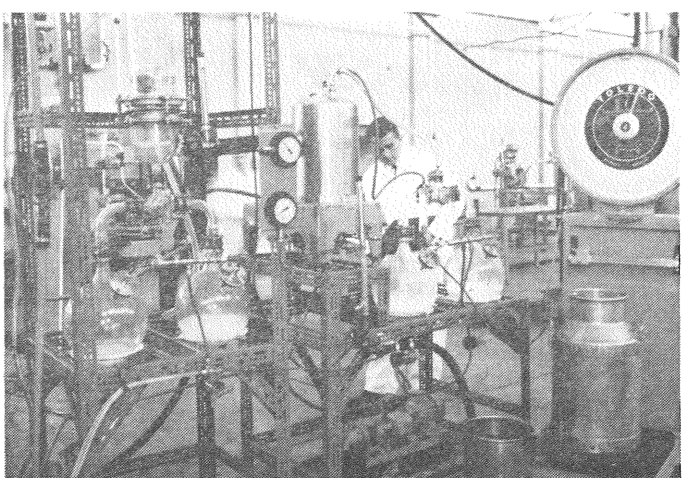
The Centritherm evaporator has a very low hold-up volume and extremely short contact time. The liquid film from which the evaporation takes place is produced centrifugally on a rotating, steam-heated conical surface. The heat transfer surface has an area of approximately 1 sq ft and other cones may be substituted to reduce this area. A number of products, including passion-fruit juice, have already been successfully concentrated on the unit.

The A.P.V. plate evaporator operates on the well-known rising-falling film principle and has a heat transfer surface approximately 7·5 sq ft in area. The plates are located in a similar manner to the plates of a plate heat exchanger, the product and steam being passed between alternate sets of plates. The wall through which heat transfer takes place is stationary in this type of evaporator.

The addition of these units to the pilot-plant equipment will allow the Division to undertake investigations related to the heat concentration of liquid food products.

APPOINTMENTS

Mr. N. S. Scott has been appointed a Research Scientist on the staff of the Division's Plant Physiology Unit at the University of Sydney. Mr. Scott graduated in Agricultural



Alfa–Laval pilot-scale Centritherm concentrator used to evaporate fruit juices and other liquid food products.

Science from the University of Adelaide in 1961, and subsequently carried out research at the Waite Agricultural Research Institute, Adelaide, on aspects of respiration and metabolism in plant cells. He joined the Division on July 6, 1965.

Dr. J. K. Palmer, formerly Senior Biochemist in the Central Research Laboratory of the United Fruit Company, Norwood, Mass., U.S.A., joined the Division as a Senior Research Scientist on August 9, in the United States. Accompanied by his wife and family, Dr. Palmer reached Sydney on August 28, having visited en route a number of centres engaged in research in plant physiology. Dr. Palmer is located at the Division's headquarters at Ryde, where he is pursuing research into the biochemistry and physiology of ripening and senescence in fruits.

OVERSEAS TRAVEL

Dr. R. P. Newbold, a Principal Research Scientist in the Division's Muscle Biochemistry group at Ryde, delivered a paper at a symposium convened by the University of Wisconsin and held at Madison, Wisconsin, U.S.A., on July 11–14, 1965. The symposium was on the physiology and biochemistry of muscle as a food, and Dr. Newbold's paper was concerned with some post-mortem changes in muscle that are associated with the onset of rigor mortis. Dr. Newbold was absent from Australia for most of the month of July and took the opportunity to visit a number of research centres in the United States and Canada.

Mr. J. Middlehurst, leader of the Physics Section in the Division of Food Preservation, left Sydney on July 18 on a three-month official visit to Great Britain, Sweden, Germany, France, the United States, and New Zealand. Mr. Middlehurst examined the outturn at British ports of two experimental shipments of canned fruit that had been shipped from Australia at the request of the Australian Canned Fruits Board. The experimental shipments were made in order to investigate factors influencing condensation of water on the exterior of the cans during their transport by sea from Australia.

Mr. Middlehurst visited a number of laboratories engaged on research on the physics of foods and food preservation, and delivered two papers to the International Congress of Refrigeration held at Stockholm in September. These papers dealt with the measurement of shipboard conditions affecting condensation, and with dewpoint control of ventilation in ships.

Mr. A. D. Warth, an Experimental Officer in the Microbiology Section of the Division's laboratories at Ryde, has been awarded a CSIRO Overseas Post-graduate Studentship. He left Sydney with his wife and family on August 14, 1965, on his way to the University of Wisconsin, Madison, U.S.A., where he will carry out research under Professor J. L. Strominger in the Department of Pharmacology and Toxicology. In the Division of Food Preservation, Mr. Warth has been a member of a group studying the heat resistance of bacterial spores, and has contributed greatly to knowledge of the chemical composition of these spores.

Dr. J. Giovanelli, a Senior Research Scientist in the Division's Plant Physiology Unit, has been appointed Visiting Scientist in the National Institutes of Health, Bethesda, Maryland, U.S.A. He will spend one year with Dr. S. Harvey Mudd in the laboratory of cellular pharmacology at the above Institute, where he will carry out research on the metabolism of 1- and 2-carbon compounds in plants. Dr. Giovanelli, accompanied by his wife, left Sydney by air on August 26. He will visit a number of research laboratories in the United States on his way to Bethesda, where he will take up duties near the end of September 1965. Dr. Giovanelli will return to Australia via Great Britain, Italy, and Japan.

Mr. J. I. Pitt, Experimental Officer in the Dried Foods Section in the Division of Food Preservation, has been awarded a CSIRO Overseas Studentship. Accompanied by his wife, he left Sydney for the University of California, Davis, Calif., U.S.A., at the end of August. Mr. Pitt is attached to the Department of Food Science and Technology at Davis where he will undertake mycological investigations under the guidance of Professor M. W. Miller, who was a guest worker in the Division of Food Preservation in the first half of 1965. In electing to work in the field of mycology, Mr. Pitt is continuing his interest in a subject which, in March 1965, earned him the degree of M.Sc. (University of New South Wales) for a thesis on microbiological problems in prune preservation.

Financial Contributions, 1964-65

The Division of Food Preservation has pleasure in once again placing on record its deep appreciation of the generous support accorded its work by a growing number of contributors in the Australian food industry and by Government departments and statutory bodies.

In the financial year ending June 30, 1965, the total budget for the Division was £554,317 of which £493,200 came from the Commonwealth Treasury and the balance of £61,117 from contributory sources.

Financial support for specific researches was given by the following organizations in Australia:

Australian Canned Fruits Board
Investigations on external water damage to cans of fruit

Australian Cattle and Beef Research Committee
Research on beef quality, processing, storage, and transport

Australian Apple and Pear Board
Apple and pear storage investigations

Australian Dried Fruits Association
Investigations on dried tree fruits

Australian Egg Board
Investigations on packaging of egg pulp

Banana Research Advisory Committee
Research on storage, transport, packaging, and ripening of bananas

Department of Primary Industry
Fruit fly sterilization investigations*

Metropolitan Meat Industry Board, Sydney
Muscle biochemistry investigations

New South Wales Department of Agriculture
Fruit storage investigations

The Rice Marketing Board for the State of New South Wales
Investigations on the drying of rice grain

The Division has continued to receive financial support from the United States Department of Agriculture for researches on cyclopropenoid compounds and the chemical structure of ovalbumin and S-ovalbumin.

The Australian food manufacturing industry and many associated firms such as canmakers contributed a record amount of nearly £10,000 in 1964–65. These generous donations, which were mostly unconditional, will be used for the purchase of scientific equipment.

During 1964–65 a number of companies and organizations provided facilities for experiments, made gifts of raw materials or equipment, or financially supported the work of individuals in the Division.

The Division gratefully acknowledges its appreciation of the generous financial and other assistance afforded by its supporters, including the 78 contributors listed below.

* Central funds made up of contributions from several States and the citrus and pear industries.

Contributors to General Donations Account, 1964-65

Abattoir Construction & Engineering Co. Pty. Ltd.
Ardmona Fruit Products Co-operative Co. Ltd.
Arthur Yates & Co. Pty. Ltd.
Australian Consolidated Industries Ltd.
Australian Fibreboard Container Manufacturers' Association
Australian Paper Manufacturers Ltd.
Australian Sisalkraft Pty. Ltd.
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Kyabram Preserving Co. Ltd.
Leeton Co-operative Cannery Ltd.
Lewis Berger & Sons (Aust.) Pty. Ltd.
Marrickville Margarine Pty. Ltd.
Northern Peargrowers Ltd.
Nugan (Griffith) Pty. Ltd.
Orange Fruitgrowers' Co-operative Cool Stores Ltd.
Pick-Me-Up Food Products Ltd.
Pict Limited
Plaistowe & Co. Ltd.
P. Methven & Sons Pty. Ltd.
Producers' Cold Storage Ltd.
Queensland Cold Storage Co-operative Federation
Reckitt & Coleman Pty. Ltd.
Riverland Fruit Products Co-operative Ltd.
Roche Products Pty. Ltd.
Schweppes (Australia) Ltd.
Shepparton Preserving Co. Ltd.
Sidac (Aust.) Ltd.
Sidney Cooke Pty. Ltd.
Smak Products Co.
Sou'West Frozen Food Packers Ltd.
Swift Australian Co. (Pty.) Ltd.
Tasmanian Breweries Pty. Ltd.
Taubmans Industrial Coatings Pty. Ltd.
The Batlow Packing House Co-operative Ltd.
The Committee of Direction of Fruit Marketing
The Golden Circle Cannery
The Nestlé Company (Aust.) Ltd.
Thomas Borthwick & Sons Ltd.
Thomas Playfair Pty. Ltd.
Tooheys Ltd.
Unilever Australia Pty. Ltd.
W.A. Ice & Cold Storage Association
W. Gregg & Co. Ltd., New Zealand
White Wings Pty. Ltd.
Winn's Food Products Pty. Ltd.
W. G. Goetz & Sons
Young District Producers' Co-operative Ltd.

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