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Trends in Citrus Products in the U.S.A.

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In June 1962 Mr. Kefford was invited to address the annual meeting of the Institute of Food Technologists in Miami, Florida, on citrus products research in Australia. Following that meeting he spent several weeks surveying the citrus products industry in Florida and California.

THE 1962 season was an interesting and fortunate season to visit Florida, since for the first time the orange crop exceeded 100 million boxes (each of 90 lb). This crop record is likely to stand for several years to come, because the disastrous freeze in December 1962 caused widespread damage to citrus trees and has reduced current crops. Because of the large crop in 1962, orange juice and concentrate plants were still running in mid June of that year, when they would normally have closed down.

The citrus industry in Florida is tightly controlled through a State agency, the Florida Citrus Commission. This control operates in many directions, some of which are technically interesting. The industry is levied at the rate of 5 cents per box to provide funds for promotion and research, and its present prosperity can be attributed very directly to results of research that the citrus-growers themselves have sponsored. Officers of the Commission administer the system of fruit analysis in citrus products plants, involving sampling at the rate of approximately 0·1% of each load, determining the yield of juice, the soluble solids content, and the acidity, and calculating the pounds solids per box, which is the basis of payment for oranges (for lemons, pounds acid per box). Twice a month, samples of finished products are taken at every plant for quality examination, and reports on these samples are sent to all processors with only their own samples identified. In spite of keen competition between individual processors there is frequent exchange of samples between plants and there are regular meetings of quality control technologists to discuss mutual problems.

At present the principal product of the American industry is frozen orange juice concentrate, and the ensuing discussion is concerned mainly with the manufacture of this product.

PRODUCTION METHODS

Fruit Handling

American methods of handling large volumes of citrus fruits, involving bulk cartage, bin storage, washing, and size grading, have been frequently described. Fruit from different bins is blended to obtain juice of the desired composition, and the best bins are kept for cut-back juice.

Juice Extraction

Modern mechanical juice extractors have increased the yield of juice from oranges by about 20% when compared with yields in the early days of the industry. Two machines dominate this field: the Food Machinery Corporation extractor, which subjects whole fruit to the action of pressure fingers and permits simultaneous recovery of juice and peel oil; and the Brown Citrus Machinery Corporation extractor, which halves and reams citrus fruits but requires a separate operation for peel oil recovery. A juice yield from oranges of at least 50% by weight is expected from these machines.

Finishing

Screw finishers, paddle finishers, and continuous centrifuges, in various combinations, are used to obtain the desired type and amount of suspended solids in citrus juices. Juice for cut-back is given a light finish with a screen size not less than 0·04 in. to keep down the pectin content and the pectin esterase activity. Juice for evaporator feed was formerly given a double finish with a tight adjustment, but the present practice is to finish with a light adjustment (screen size 0·02–0·03 in.) and then to wash the pulp. Screening centrifuges are receiving attention for finishing citrus juices, and Californian processors claim that the bitterness of Navel orange juices can be significantly decreased by centrifugal finishing rather than screw finishing.

Pulp Washing

To recover more solids from the fruit then available, a procedure of pulp washing was devised in a previous "freeze" year (1957–58). This practice has now become general in the Florida industry. Because of the competitive position all operators have been forced to wash pulp, but it is widely admitted that it is not good for the quality of the juice, because of the increased content of peel extractives. The pulp washing lines differ in detail from plant to plant, e.g. from three-stage to six-stage countercurrent washing, with paddle finishers or brush finishers between each stage and with or without mixing between finishers. The final washed pulp has a soluble solids content less than 1° Brix and is used for by-products. The final liquor is taken off at 6° Brix, which represents about 50% added water in the original juice. This liquor is centrifuged in self-cleaning centrifuges to reduce the suspended solids content to about 2% wet pulp by volume, and is then added to the evaporator feed and pasteurized.

Only recently, and after protracted hearings, had the U.S. Food and Drug Administration accepted the pulp washing procedure without label declaration.

De-aeration

Opinions differ in the industry on the importance of oxidative changes in orange juice and the need for de-aeration. One plant practises nitrogen sparging in the juice lines and nitrogen blanketing of the cut-back juice and blended concentrate up to the time of filling. Formerly the cans were flushed with nitrogen at the filler, but this proved to be too expensive in relation to any benefit derived. Most plants, however, do not use nitrogen but try to avoid aeration by keeping juice lines full, filling tanks from the bottom, and taking similar precautions.

Pasteurization

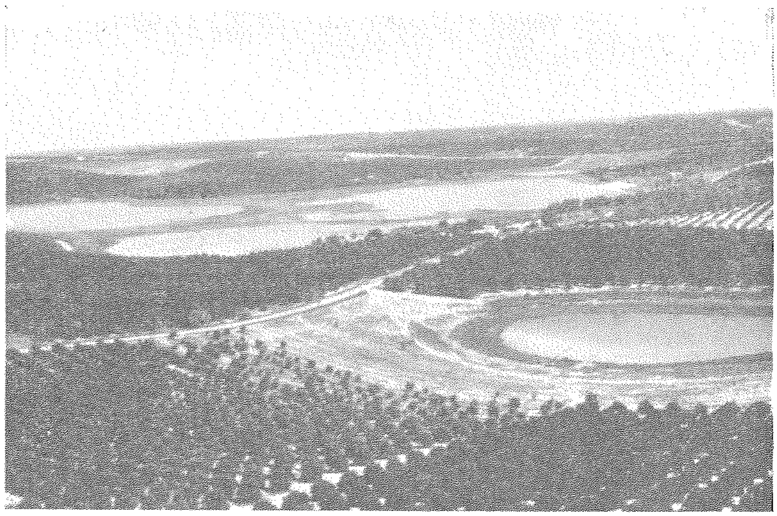
At the time when the industry was satisfied with moderate yields of juice containing low amounts of pulp extractives, enzymic clarification and gelation were not serious hazards in frozen concentrates. When higher juice yields were sought, the pectin and pectin esterase contents in the juice also increased, and pasteurization became necessary to ensure stability during storage. It is now general practice to flash-pasteurize evaporator feeds and pulp washings. The heat treatment necessary for pectin esterase inactivation increases with increasing pH of the juice. In some plants, the pasteurization treatment is applied to a partial concentrate rather than to the single-strength juice (Moore, Rouse, and Atkins 1962).

Some coarse pulp containing whole juice cells is usually added to the cut-back juice, and this pulp is pasteurized for pectin esterase inactivation using either swept-surface heat exchangers or direct steam injection. The juice for cut-back is not pasteurized and therefore is not sterile and retains pectin esterase activity.

Evaporation

Most American plants are still using low temperature–high vacuum evaporators similar to those with which the industry was launched; these are falling-film evaporators, some steam heated and some based on an ammonia heat-pump cycle. There has been a trend towards the building of larger units, and the largest existing evaporators are double-effect units with three stages in each effect, having a capacity of 60,000 lb of water evaporated per hour; but these are admitted to be above the optimum size for convenient operation and quality of the product. The maximum product temperature is about 100° F and the retention time is probably about 90 minutes. Some operators claim that the maximum product temperature in their evaporators does not exceed 80° F.

Considerable interest is being shown in high-temperature, short-time evaporators because they are cheaper, more compact, and more efficient in steam usage than low-temperature evaporators; but opinions are sharply divided about their suitability for citrus juices. Some believe that high-temperature, short-time evaporation must cause heat damage and some loss of quality as compared with low-temperature evaporation, but others take the view that insistence on low temperatures is pointless when the juice is subjected to high temperatures during pasteurization.



Typical Florida citrus country.

Concentration by Freezing

In spite of the generally satisfactory quality of Florida frozen orange juice concentrate, processors are still chasing the elusive fresh flavour of orange juice. One company has approached this problem by using, for cutback, a concentrate at 26° Brix prepared by freezing. This means that the blended 42° Brix concentrate contains a higher equivalent proportion of juice that has not been subjected to an evaporation process than a concentrate cut back with single-strength juice. To prepare the freeze concentrate, orange juice is slush frozen, then transferred to a centrifuge in which three fractions are separated, namely, the concentrate fraction drawn off at 26° Brix; a fraction at 16° Brix, obtained by washing the ice, and which is passed to the evaporators; and finally the residual ice at 0·2° Brix, which is used for regenerative cooling and then goes to pulp washing.

Tasting of orange juice concentrate which had been prepared entirely by freezing revealed outstanding retention of a fresh note that was missing from all evaporator concentrates tasted.

Essence Recovery

Another approach to the problem of fresh flavour is the recovery and adding back of volatile flavouring materials. This was formerly considered not worth while with orange juice, since the recovered volatiles were said to introduce a foreign note. One Florida company, however, is pioneering with the use of an essence recovery unit attached to a low-temperature evaporator. The evaporator feed is not pasteurized, and the volatiles are taken off the first stage of the evaporator and fractionated. A particular terpene fraction which oxidizes to an unpleasant aroma is removed, and a concentrate of the remaining volatiles is added back to the concentrated juice. Workers at the University of Florida Citrus Experiment Station are using gas chromatography to examine the composition of the volatile fractions recovered in this plant and have found more than 40 components (Wolford, Alberding, and Attaway 1962).

Containers

Currently the frozen concentrate industry is using 6-oz cans made from tinplate, aluminium, or paper. The tinplate cans are made from 55-lb tinplate with 65-lb ends, are internally lacquered, and have cemented side seams to permit lithography all round. They are preferred for easy handling on lines and closers. Aluminium and paper cans do not run and slide easily, and aluminium clogs up closers, dents readily, and is subject to leakage. Two types of paper cans, flat wound and spiral wound, lined with aluminium foil inside and out, are promising but still in the course of development. Another container trend is the use of aluminium easy-opening ends.

United States Department of Agriculture Fruit and Vegetable Products Laboratories at Winterhaven, Florida.

Blending

Orange juice concentrate at 42° Brix, intended for reconstitution by the addition of 3 volumes of water, may be prepared by blending in various ways a selection of the following ingredients:

- 58° Brix concentrate from immediate production.
- 58° Brix concentrate from previous production held in frozen storage.
- Cut-back juice with added pulp.
- Cold-pressed peel oil. The typical range for oil content in concentrate is 0·025–0·052 ml/100 g.
- Freeze concentrate at 26° Brix.
- Volatile flavour fraction.

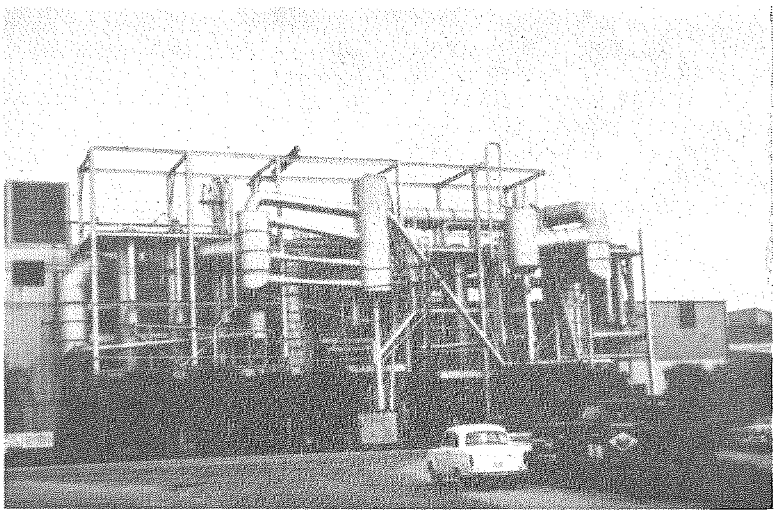
The blend is cooled to about 20° F in swept-surface heat exchangers and filled into cans of 6, 12, 32, or 46 oz capacity.

Preservation

Filled cans are frozen in air-blast tunnels to a product temperature of 0° F, then cartoned, palleted, and stored at −5° to −15° F. A few plants are using methanol spray freezers or direct immersion freezers.

Higher concentrates (58° or 65° Brix) are packaged in bulk in steel, wood, or fibre drums with polythene liners, and are held at −5° to −15° F, or sometimes at 40° F, for subsequent blending or for beverage manufacture.

Some concentrate is flash-pasteurized, filled into No. 10 cans at around 185°F, inverted to sterilize the lid, cooled to 90–100°F by rolling under water sprays, cartoned, palleted, and stored at 40°F. At higher temperatures browning and swelling are likely to occur.



Two citrus juice evaporators. Each evaporates 60,000 lb of water per hour. Pasco Packing Co., Dade City, Florida.

DRYING OF ORANGE JUICE

The ultimate goal of any concentration process must be a product from which all water has been removed. For some years one plant in Florida has been producing orange juice "crystals" by vacuum belt drying. The likelihood of more widespread production of citrus juice powders has been greatly increased since research workers in the U.S. Department of Agriculture discovered that citrus concentrates can be dried in air at atmospheric pressure without damage to flavour by the technique known as foam-mat drying (Bissett *et al.* 1963). The starting product for the process is 58°Brix concentrate to which is added 1%, on a solids basis, of a stabilizer consisting of 1 part of methyl cellulose and 4 parts of an enzyme-modified soy protein. These additives amount to less than 0·1% in the reconstituted juice. The mixture is whipped into a foam which, in the original form of pilot plant, is extruded on a fibreglass and "Teflon" belt in the form of continuous rods that resemble spaghetti (Morgan *et al.* 1959). In a later design of drier, known as the crater drier, the foam is spread on perforated flat trays and craters are blown through the layer of foam by passage of air through the holes (Morgan *et al.* 1961; Rockwell *et al.* 1962). The foam is dried in 15–20 minutes at atmospheric pressure in recirculated air at temperatures ranging from 260°F down to 150°F, giving foam temperatures of 160–180°F. At a final moisture content of 2·5–3·5% the product is brittle and can be ground to a friable powder in a room at low humidity. After grinding, volatile flavour is restored by the addition of "locked-in" peel oil preparations and the powder is packaged with a calcium oxide desiccant. The desiccant is necessary because it is not feasible to dry to a lower moisture content than 2·25% and at this level the powder has a limited storage life. It is hoped to dry to lower moistures, and hence eliminate the in-package desiccant, by a technique called "extractive drying" which involves wetting the powder with about 10% ethanol or methanol, then removing the solvent together with most of the residual moisture. Storage trials at 70°F and 85°F are in progress to determine the shelf life of the powder at several moisture levels.

The foam-mat process has not yet been applied commercially to orange juice but one canner in California has installed a crater drier for tomato paste (Stark 1962).

OTHER CITRUS PRODUCTS

Juices and Beverages

Although frozen orange juice concentrate is the dominant product in the American industry, single-strength orange and grapefruit juices are still being canned on orthodox canning lines, comprising de-aerator–deoilers, tubular pasteurizers, fillers, closers, and spin coolers.

The shipment of chilled citrus juices from Florida to distribution points all over the U.S.A. has also become big business. The juice is handled essentially as for canning up to the de-aerator–deoiler, and is then chilled continuously, filled into wax cartons, packed into board cartons, and stacked in cold-rooms until despatch in refrigerated trucks. A shelf life of 14 days is expected. Juice chilled to the point of formation of some slush ice is also shipped in bulk in insulated road or rail tankers. During a 5-day journey the temperature rise does not exceed 5°F.

The most significant recent trend in the beverage market in the U.S. is the rapidly increasing popularity of canned fruit drinks, punches, and -ades (Anon. 1960). Orange, pineapple–orange, and pineapple–grapefruit are among the most popular varieties. At present there are no Federal definitions or standards for juice content in these products and they are widely variable in composition; the fruit juice content is said to vary from 5 to 55%. These beverages appear on the market in various forms:

- Frozen concentrated drinks, consisting of fruit juices or fruit juice concentrates with added sugar and with or without added acid, ascorbic acid, colouring, and flavouring. They are reconstituted with $4\frac{1}{3}$ volumes of water, i.e. one 6-oz can makes one U.S. quart.
- Hot-pack concentrated drinks, which are similar products, flash-pasteurized and held at 40°F until distributed.
- Hot-pack single-strength drinks, which are flash-pasteurized, ready-to-drink products, similar in composition to the concentrated drinks as reconstituted.

Citrus Segments

For many years Florida has successfully produced large packs of canned grapefruit segments. This industry is about to achieve automation of the hand operations of peeling and sectioning the grapefruit. A highly ingenious automatic peeling machine has already performed successfully in full-scale production trials, and an even more ingenious sectioning machine has been designed but has yet to be completely proved in commercial operation. In addition to the heat-processed canned segments, there is a large production of glass-packed segments which are syruped cold with a syrup containing benzoate, and are closed with steam flow, chilled in a spray chiller, and held in chiller storage (Anon. 1958). A storage life of at least a year is claimed. Not only grapefruit segments, but mixed packs of grapefruit and orange segments, together with pineapple, canteloupe, or honey-dew melon are also prepared.

By-products

Dried peel for cattle feed is still the main by-product from the American citrus industry. Some peel, particularly lemon peel, is used for pectin manufacture, which returns approximately 2·5 dollars per ton of fruit, whereas cattle feed returns only 1·5 dollars. Small amounts of peel are candied or specially prepared for use in cake mixes (Swisher 1962).

A novel by-product under investigation is a polypectate preparation added to bushfire retardants to provide adhesion to foliage. Some bioflavonoids are recovered from citrus residues for pharmaceutical use. Peel oils are prepared by orthodox procedures involving successive centrifuging of aqueous emulsions, and are being offered to users in the form of "locked-in" preparations consisting of an oil emulsion in a solid matrix of supercooled sugars (Swisher 1963).

HORTICULTURAL ASPECTS

Opinions were sought in both Florida and California on two problems that concern the citrus products industry in Australia—bitterness and low soluble solids content in orange juices. Bitterness is a continuing problem in processed Navel orange juices in California just as it is in Australia. Extensive new plantings of Navel oranges have been made in California, and it is expected that larger volumes of Navels will have to be handled by processing plants. The U.S. Department of Agriculture has resumed basic studies on limonin and the bitterness problem in Navel juice in the Fruit and Vegetable Products Laboratory at Pasadena. An immediate need is a convenient chemical assay of limonin in orange juice so that batches of juices may be diverted to various end uses according to limonin content.

Bitterness in Valencia juices, however, has never been encountered in Florida or California. It is suggested that the bitterness that does appear in Australian Valencia juices may be genetic in origin, i.e. 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.

Low soluble solids content in orange juices is not a general problem in the American industry. The Brix may range between 10° and 13·5°, with the usual range 11° to 12·5° and the average about 11·75°. The Brix : acid ratio usually ranges from 12 to 16·5. Factors stated to have an influence on soluble solids content were those that are already well known. Thus rough lemon rootstocks, oil sprays, and excessive or poorly timed watering can all reduce solids content. It is very difficult to demonstrate significant effects of tree nutrients on solids, and in Florida only magnesium appears to have a slight effect. The age of the tree influences solids content and the optimum age is 10–20 years. There is some evidence from Florida studies of genetic effects on solids, but critical tests on Valencia strains are just beginning.

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Use of the Maturometer for Quality Grading of Peas

By B. K. Nortje,* C. J. B. Smit,† and K. J. Kotze*

Last year, the March issue of *Food Preservation Quarterly* (Vol. 22, pp. 18–19, 1962) contained a description of the maturometer developed by Mitchell and Lynch of the C.S.I.R.O. Division of Food Preservation, and outlined recent improvements to the instrument. The following paper, contributed from South Africa, emphasizes the importance of taking into account the method of shelling the peas when the instrument is used for quality control purposes.

THE alcohol-insoluble solids content (A.I.S.) has been shown to be a reliable indication of the tenderness and quality of green, canned, and frozen peas (Kertesz 1935), but since this method is not particularly suitable for the routine grading of peas for canning and freezing, various physical instruments such as the maturometer (Lynch and Mitchell 1950) have been designed for the rapid judgement of the raw material when received at the factory.

During exhaustive tests with the maturometer by Lynch and Mitchell (1950) on commercially vined peas it was shown that maturometer readings correlated well with the A.I.S. content and that this machine could therefore be used for the rapid determination of the quality of peas as received at the factory. In a subsequent publication (Moyer, Lynch, and Mitchell 1954) it was shown that, owing to bruising, the beater speed of the viner or huller used for shelling the peas has a marked influence on the maturometer readings obtained, and that careful control of viner or huller speeds is therefore necessary for reliable results. Two years later, Mitchell and Lynch (1956) published a formula by means of which it is possible to calculate the maturometer index before vining from the maturometer index of peas vined at a known speed. They indicated that maturity is of importance when this formula is used, but that the formula gives a reasonable approximation for peas having a maturometer index in the range 150–300.

In South Africa different makes of viners and hullers are used. These machines are operated at different beater speeds and settings considered suitable for obtaining a good yield without excessive damage to the peas. The maturity of peas received at factories varies markedly from one load to another. The present study was undertaken to establish whether comparable results could be expected with different machines running at satisfactory speeds, and secondly, whether maturity could influence the extent of damage to the peas when different machines are used under such conditions. Because of difficulties in sampling peas for viners, no data on viners were collected.

EXPERIMENTAL METHODS

During the 1960 season Greenfeast peas were sampled at a commercial pea processing factory. From a particular load of peas approximately 100 lb of pods were collected in small quantities of about 2 lb at a time as the peas were being fed into a factory huller operating

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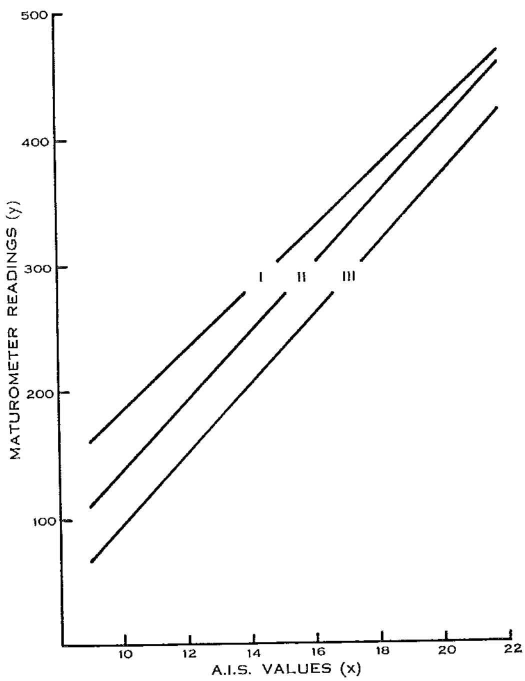
at a beater speed of approximately 200 r.p.m. At the same time about 20 lb of shelled peas were collected from the huller.

The sample of pods was divided into two lots and the first lot was shelled by hand, while the second was shelled with a laboratory huller operating at a beater speed of approximately 400 r.p.m. The peas obtained by this method of shelling showed milder signs of bruising compared with the commercial huller. In all, five loads of commercially grown Greenfeast peas were sampled and shelled in this manner.

After shelling, the peas obtained with each method of shelling were size graded separately. Five size grades were chosen to represent a range of maturities within each sample for the comparison of A.I.S. values with maturometer readings. The peas from each lot were first screened to remove those smaller than 9/32 in. and the remaining peas were graded into sizes: 9/32–10/32 in., 10/32–11/32 in., 11/32–12/32 in., 12/32–13/32 in., and 13/32 in. by means of 8-in. sieves.

The A.I.S. content was determined on each size grade by the procedure of Lynch and Mitchell (1950) except that the method of sampling was slightly modified to improve its accuracy. An aliquot of peas weighing 100 g was blended with an equal weight of 80% ethanol for two minutes in a Waring blender and 40 g of the macerate was then used to determine the A.I.S. The maturometer readings were carried out according to the instructions of the manufacturers* of the instrument. In this way, 25 pairs of observations were made of A.I.S. values and corresponding maturometer readings for each method of shelling.



Relationship between A.I.S. values and maturometer readings of Greenfeast peas obtained by three different methods of shelling.

I, *Hand shelling:*

$$y = 23{\cdot}60x - 53{\cdot}04,\ 0{\cdot}951 \leqslant r \leqslant 0{\cdot}994$$

II, *Laboratory huller:*

$$y = 26{\cdot}84x - 132{\cdot}90,\ 0{\cdot}969 \leqslant r \leqslant 0{\cdot}997$$

III, *Factory huller:*

$$y = 27{\cdot}17x - 178{\cdot}11,\ 0{\cdot}985 \leqslant r \leqslant 0{\cdot}998$$

RESULTS AND DISCUSSION

The experimental results obtained are given in the table on page 54 and the statistical data are presented in the diagram at left.

Further statistical tests (Bennett and Franklin 1954) were then carried out to determine whether differences exist:

(1) With respect to the regression coefficients (slopes) of the regression lines;

(2) With respect to intercepts of the regression lines.

By using this method it was found that highly significant differences existed between the regression coefficients (slopes) of the hand shelling and factory huller regression lines, and also between the hand shelling and laboratory huller regression lines. However, no significant differences were established between the regression coefficients of the factory huller and laboratory huller regression lines.

In the same manner it was established that highly significant differences existed between the intercepts of the hand shelling and factory huller regression lines and also between those of the regression lines of the factory huller and the laboratory huller. Between the hand shelling and the laboratory huller regression lines, however, significant differences only existed at average and lower A.I.S. values.

* Edwards and Associates, Sydney, N.S.W.

A.I.S. and Maturometer Readings of Peas obtained by Three Methods of Shelling

Observation	Size Class (in.)	Sample No.	A.I.S.	Maturometer Reading		
				Hand Shelling	Laboratory Huller	Factory Huller
1	9/32–10/32	1	10·37	180·0	163·0	107·0
2	9/32–10/32	2	10·00	161·0	131·0	85·0
3	9/32–10/32	3	9·10	142·0	96·0	75·0
4	9/32–10/32	4	9·45	142·6	116·4	87·3
5	9/32–10/32	5	10·00	180·8	138·4	102·6
6	10/32–11/32	1	11·43	234·0	179·0	119·0
7	10/32–11/32	2	11·50	224·0	182·0	117·0
8	10/32–11/32	3	10·80	203·0	142·0	103·0
9	10/32–11/32	4	11·12	204·6	159·2	134·2
10	10/32–11/32	5	11·87	250·0	212·2	149·0
11	11/32–12/32	1	13·90	299·0	243·0	190·0
12	11/32–12/32	2	14·10	291·0	246·0	177·0
13	11/32–12/32	3	12·30	254·0	185·0	155·0
14	11/32–12/32	4	13·56	274·0	210·0	185·0
15	11/32–12/32	5	14·05	287·3	252·3	218·4
16	12/32–13/32	1	17·60	353·0	324·0	278·0
17	12/32–13/32	2	16·90	335·0	327·0	261·0
18	12/32–13/32	3	14·60	306·0	252·0	228·0
19	12/32–13/32	4	16·10	318·0	289·4	279·2
20	12/32–13/32	5	16·41	333·2	330·2	274·8
21	13/32	1	21·14	425·0	411·0	372·0
22	13/32	2	19·60	405·0	409·0	255·0
23	13/32	3	18·10	352·0	311·0	323·0
24	13/32	4	19·40	400·2	391·0	349·0
25	13/32	5	19·62	439·0	414·0	338·6

Since hand shelling causes practically no bruising or tenderization of the peas it is evident from the data that bruising due to mechanical shelling was responsible for the lower maturometer readings obtained with the laboratory huller and the factory huller. As could be expected, damage was more severe at low and medium A.I.S. values. It is further important that, although both the laboratory huller and the factory huller were running at satisfactory speeds, the extent of damage in the factory huller was more severe but the same throughout the range of maturities tested. This observation should, however, be substantiated with further data on machines used under commercial conditions at factories. The data furthei indicate that unless hand shelling is used to obtain a sample for measurement on the maturometer, it is advisable to check or standardize the mechanical shelling before samples from such a machine are used in the maturometer for grading purposes.

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Experimental Shipments of Apples and Pears

By E. G. Hall

Division of Food Preservation, C.S.I.R.O., North Ryde, N.S.W.

Australia exports annually as fresh fruit some 8,000,000 bushels of apples and pears, mostly to the United Kingdom and other countries in the northern hemisphere.

AS a result of research carried out before the war, with which this Division was associated, the refrigerated shipment of apples and pears in standard wooden bushel boxes has been developed to a very satisfactory level of efficiency. Modern refrigerated ships catering for this trade enable the fruit to be readily cooled within a reasonable time and to be held at the desired temperature for the duration of the voyage.

New Containers

Largely because of the amount of bruising which occurs in the customary wooden boxes, the fibreboard carton (either as a cell or tray pack, but chiefly the former) has gained rapidly in importance as an export container for apples. Also, to reduce bruising—but mainly to reduce costs—significant quantities of both apples and pears have recently been shipped in special non-returnable export bulk bins holding about 1000 lb of fruit. High cost and other difficulties associated with the manual handling of small containers of fruit have also stimulated interest in the handling of fruit cargoes in pallet units.

Technical Problems

These developments are posing a number of technical problems by creating a very different set of conditions in the ships' holds. Before the war a large land-based ship's hold existing at the Ditton Laboratory in England enabled investigators to determine the best methods of stowing cases and also to develop efficient designs for refrigeration and air distribution systems, these techniques being subsequently perfected in ships. Unfortunately the experimental hold no longer exists, and present-day investigators are faced with the many difficulties associated with experimentation in ships carrying cargoes of fresh fruit.

From the knowledge (Hall and Mellor 1962*) of cooling rates gained in cool stores on land, it was evident that fruit in large stows of cartons in ships may not cool at a sufficiently fast rate, and also that the equilibrium temperatures reached may be considerably higher than desirable. Additional problems arise with the use of pallet units and with the deep stowage of cartons.

Joint Action

After discussions on these various problems, the C.S.I.R.O., the Oversea Shipping Representatives' Association, and the Shipowners' Refrigerated Cargo Research Association in England (S.R.C.R.A.) decided to collaborate in making a number of experimental shipments of fruit from Australia during the 1962 export season. These shipments have been made in cooperation with the State Departments of Agriculture, shipping companies and fruit exporters concerned, the Australian Fibreboard Development Council, the Australian Apple and Pear Board, and the Commonwealth Department of Primary Industry.

* HALL, E. G., and MELLOR, J. D. (1962).—Bulk bins for fruit storage. *C.S.I.R.O. Food Pres. Quart.* **22**: 49.

Shipments

Experimental shipments were made in four ships which, for convenience, will be designated *A*, *B*, *C*, and *D*.

Ship A

From Fremantle, W.A.—Apples shipped in cell and tray pack cartons without precooling were compared with similar fruit packed in standard Australian apple boxes (bushel dump cases). Both shipments were placed in lockers.

Experimental pallet unit of cell pack cartons of apples for export.

Ship B

From Hobart, Tas.—Comparisons were made among apples shipped without precooling, in bulk bins, in wooden cases in strapped pallets, in special pallet units consisting of both cell and tray pack cartons, and in loose wooden cases and cartons. All were placed in a lower hold.

From Hobart, Tas.—Apples shipped in wooden cases as a full locker of warm fruit were compared with fruit precooled in cell pack cartons and shipped in a similar locker.

From Melbourne, Vic.—An investigation was made of pears shipped in long bushel boxes. Some boxes were block stowed, and others vertically dunnaged. The fruit was placed in lockers having the normal vertical air flow.

Ship C

From Melbourne, Vic.—This consignment represented a comparison of pears shipped in bulk bins and long bushel boxes. All were placed in a large 'tween-deck space.

Ship D

This contained a large-scale trial shipment of apples packed in cell pack cartons and stowed to the full height of a deep lower hold.

Arrangements for Inspection

A member of the research staff of the S.R.C.R.A., after spending some time studying the fruit-handling techniques employed in Australia, helped to organize the experiments and returned to England on Ship *B* to make the very detailed temperature measurements required.

After the last shipment the author flew to England to join the other persons concerned in studying the result of the experimental shipments. The reports which follow were prepared jointly with the officers of the S.R.C.R.A. responsible for the temperature analyses and for other data. These officers have prepared their own more specialized technical reports.

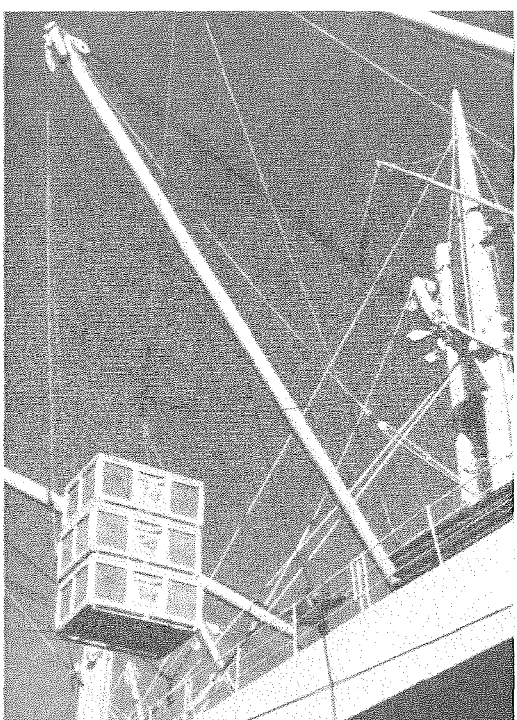
Reports

Ship A

The experimental conditions for this shipment were not entirely satisfactory, in so far as the voyage was comparatively short and the temperature of the fruit at loading was around 63° F, or some 10° F below that which had been anticipated. Although the cell pack cartons varied in size, a dunnaged stow would have been preferred to the block stow actually employed. Because of a shortage of fruit, the storage spaces were not completely filled.

The experimental shipment was stowed in the port and starboard lockers of No. 4 U.T.D. hold. One of these shallow lockers was loaded with "dump" cases of Granny Smith apples, stacked seven high without the use of dunnage. The companion locker was loaded with similar apples packed in cartons stacked six high, half of these being of the cell pack type and half being tray packs. A few cell packs of fruit were precooled and placed with the other precooled fruit in cartons in another space. Loading at Fremantle took place at the end of April and its discharge at Hull, England, was at the beginning of June.

Air temperature reached an equilibrium of 33°F in 9 days with the dump cases and in 11 days with the cartons. Cooling was slow, and it was found that fruit in the centre of the dump cases took as long as 16 days to reach 35°F. Cooling of fruit in the cartons was even slower, and barely reached equilibrium by the end of the voyage. On discharge, the fruit temperatures from the dump case stow ranged from 33·5° to 34·5°F, which was regarded as satisfactory. Somewhat higher temperatures of 34° to 37°F were recorded from the cell pack stow, and a similar range was recorded for the tray packs, except that where the cartons had been stowed exceptionally tightly, readings of 38° to 40°F were not uncommon. Weight losses ranged from an average of 1·1% in dump cases to 1·7% in carton cell packs. The fruit from the experimental stows, in common with other commercial shipments from Western Australia, was somewhat on the "forward" side on discharge, but it was not sufficiently so to warrant adverse comment from the importers. The precooled fruit in the cell packs was in better condition on discharge than that which had been packed warm.



Loading bulk bins of apples for export to the United Kingdom.

Ship B

The experimental shipments were loaded in Hobart towards the end of April and in Melbourne during the second week of May. The apples were discharged in the middle of June in London and the pears in late June in a Scandinavian port.

Bulk Units.—The bulk bins used were of the standard export type, lined with hardboard. They were filled mostly with apples of the Democrat variety, although in some instances mesh bags containing Sturmers were placed among the rest of the experimental fruit to provide samples for comparison with the same variety in other containers. The pallet units, all containing Sturmers, consisted of regular 44-case strapped units (60 by 44 in.) and specially formed 44-carton units of cell and tray packs in the standard-sized pallets (66 by 47 in.) used in Tasmania. The cartons were stacked four high to give a stable load and, wherever possible, air gaps were left between individual cartons. The cell packs, which had a light wooden top cover, were strapped; the tray packs also had 4 by 1 in. uprights to take the stacking load. The stow in No. 2 L.H. consisted of bins stacked four high and pallet units two high; a number of loose boxes and cartons of fruit were used to fill the rise and taper of the side of the ship.

On loading the fruit the temperatures of the precooled units were: bulk bins 39–42° F; cell pallets 36–40° F; and tray pallets 45° F. On closing the holds, five days after loading commenced, the following temperatures were recorded: bulk bins 47–48° F; cell pallets 45–46° F; tray pallets 47° F; wooden case pallets 56–57° F; single cases 51–53° F; and single cartons 48–49° F. In general the subsequent cooling was slow, the rates achieved in the various bulk units being only about half those for the loose cases and cartons. The case pallets were exceptional, however, in having a cooling rate comparable with the loose cases. The average space temperature was 34° F after completion of cooling and the average fruit temperature for all units was 36·9° F. The average equilibrium temperatures were higher in the bulk units (bins 37·4°, tray pallets 36·9°, cell pallets 37·0°, and case pallets 37·9° F) than with the loose cases (35·9° F) and loose cartons (35·6° F).

Though the rates of cooling in bin and pallet units could not be regarded as really satisfactory, the fruit as a whole turned out well. The samples of Sturmers placed in mesh bags in the bins were rather more forward than was the fruit of the same variety in the other packs. The fruit in the cartons tended to be rather more forward than in the cases, but the difference was not such as to cause concern.

Bruising in the case pallets was less severe than in the cases handled and stowed singly, in which the fruit was sometimes quite badly bruised. Apart from damage to cartons caused on taking the first few pallets out of the hold, the fruit in pallets of cell and tray pack cartons was virtually free from bruising. The sampling and weighing of fruit, done under difficult conditions, showed an average weight loss of 0·5% from bulk bins and 2·6% from cartons.

Full Stow of Cell Pack Cartons.—6900 precooled cell packs of apples, mainly of the Sturmer variety, were block stowed nine cartons high in the port locker, while 7600 standard bushel cases were placed in the starboard locker. The varying size of the cartons (which were not dunnaged) proved useful, since it allowed some air gaps for ventilation. At loading, the fruit temperatures were 37–42° F for cartons and 55–62° F for cases, but when the holds were closed on April 25 temperatures averaged 40·5° F and 50·6° respectively.

With the cartons the cooling rates varied considerably, the bottom cartons cooling the more slowly. The time taken to reach equilibrium conditions ranged from 6 to 20 days. The cooling rates varied also within the case stow, the time required to reach the equilibrium temperature of 34° F being 10 to 30 days.

When discharged, the fruit in cartons was somewhat more forward in spite of its having been precooled prior to loading.

Pears in Long Bushel Boxes.—On occasion the out-turn of pears packed in long bushel cases has caused some concern. Unsatisfactory out-turns have been attributed to this type of case, which is usually free from bulges, stacking more tightly than apple boxes.

Although previous trials had not shown any particular advantage to be derived from dunnaging, the opportunity was taken of comparing a block stow of pear cases with a dunnaged stow in a similar locker. In both instances the cases were stowed flat and 11 high. The dunnaging, which was the best that could be arranged, consisted of a moderate amount of vertical 1 by $\frac{3}{8}$ in. slats, and could not be regarded as very satisfactory. Neither storage space was completely full; this was partly because of rejection of some fruit owing to the presence of San José scale. Apart from showing some evidence of stem-end shrivel, the fruit on loading in Melbourne was generally in good condition. With initial fruit temperatures of 35·5° F in the dunnaged stow and 36·8° F in the block stow, equilibrium temperatures of 32·5° and 32·8° F respectively were reached quite quickly. On discharging the dunnaged-stowed fruit in Stockholm, Sweden, the fruit temperature averaged 34·2° F; while that of the block-stowed fruit unloaded at Helsinki, Finland, was 31·9° F. The fruit was reported in both instances to be in quite good condition. For the reasons stated already the conditions under which this trial was conducted cannot be regarded as satisfactory.

Ship C

The cooling rates, equilibrium temperatures, and weight losses of pears of the Beurre

Bosc variety packed in bins and cases were compared in this shipment. Some cases were also stowed in bins. Flesh temperatures prior to loading were in the range 35–38° F. While the majority of the cases reached equilibrium temperatures after 10 days, and the bins after 16 days, some were considerably slower. The out-turn of the fruit in London, though variable, was on the whole satisfactory, especially when it was taken into account that the journey was long and it was the end of the season for shipping this variety. The fruit in the bins tended to be rather more forward than in the cases but was much less shrivelled, as reflected by its losing much less weight.

In a subsidiary test on this ship, it was found that when pear bins were lined with polythene bags and the precooled fruit (32° F) was sealed in them, the accumulation of carbon dioxide caused the development of brown heart. The use of loose polythene liners, by raising humidity without building up carbon dioxide, caused considerable wastage from mould attack.

Ship D

The object of the trial on this ship was to study the effects on the containers, and on their contents, of deep stowing to a full height of 19 tiers (the present maximum stowage height being 11 for cell pack and 7 for tray pack cartons). The cartons, which were not dunnaged, occupied only a small section of the largest hold, the remainder being filled with cases. The temperature of the fruit on loading was in the range 40–45° F. Thermographs placed in different parts of the trial stow indicated that hardly any cooling took place during the first 10 days of the voyage. At discharge in Liverpool fruit temperatures ranged from 38° F to as high as 84° F in one hot spot, low down, where many cartons of the same size had been stowed very tightly. As would be expected under these conditions, the fruit varied from good to overripe and "wasty". No marked increase in bruising could be correlated with the depth of stow. While there was some slight and occasional bruising resulting from stack pressure, the severe bruising which occurred in some cartons was attributable to rough treatment on discharge. This bruising was noticeable only when the cartons had been walked upon or roughly dumped.

Discussion

Use of Bins.—Because of a great reduction in bruising and the somewhat lower cost, the export of apples in bins holding 20–25 bushels has gained in popularity. Also, until a satisfactory pack and container equivalent to the cell pack carton for apples can be developed, the present use of bulk bins for the shipment of pears is likely to continue.

Though apples exported in bins must be precooled so as to be at least 45° F when delivered to the ship, it appears from the trials that fruit in bins takes longer than in boxes to cool to equilibrium temperature on the ship. Cooling in bins is likely to be considerably improved by venting the bottom of the bins adequately, in addition to raising the lids off the sides, to facilitate a through flow of air.

The effective control of temperature in bulk bins is much more important with pears than with apples. The present common practice of lining the bulk bins of pears with a bituminized paper, in an effort to minimize rubbing and weight loss, is undoubtedly detrimental to cooling. There should be no objection to lining the sides, but the floor of the bin should not be covered and should be well vented to ensure more movement of cooling air through the fruit.

The square Victorian pear bin, like the Tasmanian apple bin, is strong, well made, and handles well. Apple bins from other parts of Australia, often made of soft wood, are sometimes too flimsy and depend on strapping to hold them together. It was noticed that some bins had insufficient clearance (less than 3 in.) for the ready insertion of fork lift equipment—this caused trouble in both Australian and British ports. For convenience the bins should be square, or nearly so, with four-way fork entrance.

Use of Cartons.—The results of these experimental shipments have shown that cartons when of uniform size can be stowed so closely as to interfere very seriously with cooling. For cartons to be loaded without very good precooling ample dunnaging would appear essential. Even with precooled cartons, the provision of dunnaging and of air gaps by suitable arrangement of pallet units seems to be necessary.

Pallets.—As dunnaging is expensive and there is an active interest in mechanical handling of fruit cargoes it seems there is a strong case for the palletizing of cartons. Since there is some loss of stowage space with pallet units, the economics of the system for the long voyage to the northern hemisphere must be carefully studied. The saving in handling costs by the use of pallets may not suffice to compensate for the resulting loss of stowage space. Because of the difficulties observed, every endeavour should be made to load cartons at a temperature within 5° F of the desired carrying temperature. The present maximum allowed temperature of 45° F appears to be high.

The earlier remarks on bins, relating to clearance for fork lift equipment and floor dimensions, apply equally to pallets, whether for boxes or cartons. The Australian standard pallet of 46 by 46 in. does not correspond to any of the three sizes of pallet accepted by the International Standards Organization or to the size (40 by 48 in.) recommended by the British Standards Institute (Standard Specification BS2629).

The Long Pear Box.—The use of the long bushel box has over the years become associated with the high reputation of Victorian pears. Nevertheless, this container is virtually flat-sided and is capable of being too closely stowed. Since the use of dunnaging is both cumbersome and expensive, there appears to be good reason for changing the design of the box sufficiently to ensure vertical air gaps in an undunnaged block stow. It has been suggested that the ends of the lids should be cleated; another suggestion is that the height of the centre partition should be raised by ½ in. so as to build a bulge into the box. The value of such modifications still needs to be tested.

Examination in the United Kingdom of boxes of apples from an experimental shipment from Australia.

Future Developments

The view was expressed in London that the present demand for fruit in bulk bins is not likely to persist indefinitely. For one thing, it is costly to regrade and repack fruit from bins. The trade would like to see all apples in cartons, with a preference for the use of cell packs. As regards pears, the use of 40-lb cartons or even smaller units has been suggested. There seems to be a need to develop a carton or other pack for pears which will eliminate the present pressure-bruising which occurs in the wooden box.

Condition prior to shipment is of greater importance with pears than with apples. It was observed on unloading the trial shipments that fruit coming from two Tasmanian growers who are known to pick their fruit at the optimum stage and to cool quickly to 32° F in their own cool stores was outstandingly good, being substantially in tree-fresh condition. The present maximum temperatures at loading for pears (45° F in boxes and 40° F in bins) appear to be too high. Lower carrying temperatures would be of benefit to pears, and a steady temperature of 31° F for the fruit appears desirable, although, to avoid the risk of freezing, the minimum air delivery temperature after the initial cooling should be 29° F. For apples, also, there seems to be a case for a lower carrying temperature, and it is suggested the aim should be to obtain an equilibrium air temperature of 32° F. Except in the variety Cox's Orange Pippin, low-temperature breakdown is much less of a risk than it used to be with cold-sensitive varieties when voyages were longer and control of ship temperatures was less accurate.

While it is difficult to get the same rate of cooling in ships as in land-based stores (ships being designed primarily as carriers of pre-cooled fruit and not as coolers) the experience gained from the experimental shipments in the 1962 trials stresses the importance of bringing air delivery temperatures down rapidly. To achieve this the brine temperature may be made as low as 26° F initially, the fans could with advantage be run at full speed, and, of course, cooling should not be limited by a lack of air gaps in the stow.

The trials reported above do not in themselves provide a complete answer to current problems relating to the export shipment of apples and pears, and further investigations are being carried out during the present (1963) season along similar lines.

Food Technology Exhibition

A display of novel processing equipment at the Division's research laboratories at North Ryde on July 4 attracted great interest among food technologists, of whom about 125 were present.

After a welcome by Dr. J. R. Vickery, Chief of the Division, the visitors were given short talks on the exhibits, which they later examined at leisure in the Food Processing Building.

One of the most novel pieces of equipment was a pea-sheller, for which C.S.I.R.O. has sought a patent. This device removes peas from their pods with great rapidity and with much less damage than does the conventional pea viner. The effect on the quality of frozen peas was strikingly demonstrated by inviting the visitors to compare the taste of peas frozen after preparation by the two methods. The effect on canned peas is equally dramatic.

A second striking illustration of the marked effect which processing equipment can have on the quality of the product was given with the spin cooker. This machine, which has been greatly improved by the food technologists in the Division, rotates the cans as they are being heat processed. By this means the time for processing is reduced and the quality of heat-sensitive products, for example fruit juices, is not adversely affected. The fine natural flavour of pineapple and passion-fruit juice processed in the spin cooker was the subject of much favourable comment.

A demonstration was given of a recently installed belt-trough drier, which is capable of drying foods at a very rapid rate. A new blast-freezer was on display, and a talk on a fluidized-bed freezer was given. Considerable interest was shown in the finding that loss of crispness by peanut kernels may be overcome by packaging in flexible films with suitable physical properties.

The day concluded with a dinner with members of the Institute of Food Technologists (Australia Northern Region), which held its annual meeting in the Hicks Meeting Room at night.

Publication

VOLATILE FRUIT FLAVOURS*

One of the most rapidly developing fields of activity in food science and technology at the present time is the identification and recovery of volatile flavours from foods. Identification of the elusive individual constituents of the complex mixtures that make up food flavours has become feasible by application of the techniques of gas chromatography, while the recovery, concentration, and restoration of volatile flavours to processed foods have become a commercial procedure following the design and manufacture of "packaged" fractional distillation equipment. So far these procedures have been applied mainly in the fruit juice industry for the restoration of volatile flavours to concentrated fruit juices.

In May 1962 the International Federation of Fruit Juice Producers organized a symposium in Berne, Switzerland, on the chemistry and technology of volatile fruit flavours and the papers presented there have been reproduced in the present volume.

The first 10 papers are general reports reviewing the state of knowledge in various aspects of the field: the volatile flavouring substances in citrus fruits, apples, pears, and black currants; gas chromatographic techniques; and the design and operation of essence recovery equipment. Then follow 21 original papers presented at the symposium by workers from nine countries. There is much valuable material here relating to laboratory and production experience, and the symposium as a whole presents a comprehensive panorama of research and development on the volatile flavouring constituents of fruits.

This volume is paper-bound and photolithographed but both text and figures are highly legible. The papers are reproduced in the languages in which they were presented (English, French, or German) but there are also summaries to each paper in these three languages.

J. F. K.

* "Volatile Fruit Flavours". A symposium. 449 pp. (Juno Verlag: Zurich, 1962.) (Price: 40 Swiss francs, from International Federation of Fruit Juice Producers, Eschenz, TG, Switzerland.)

Retirement of Mr. Ottley Barr

The recent retirement of Mr. Ottley Barr, Senior Test Engineer in the New South Wales Railways Department, brings to a close a long and fruitful period of cooperation with the Division of Food Preservation.

As long ago as 1928 Mr. Barr was responsible for conducting investigations, in cooperation with the late Professors Bagster and Young and the late Mr. E. W. Hicks, on the appropriate conditions for the safe transport of bananas from Queensland to the southern States. This cooperation on banana transport continued for some years until the techniques were firmly established.

After World War II, Mr. Barr and Mr. Hicks again resumed close collaboration in detailed studies of the design and performance of refrigerated rail cars for the carriage of meat, fruit, and vegetables, and of ventilated rail cars for fruits and vegetables. A series of papers published by these two men firmly established the principles governing design, and enabled firm predictions to be made of performances under a variety of conditions. For ventilated cars such analyses had not been attempted elsewhere. Further collaborative studies with officers of this Division continued almost to the day of Mr. Barr's retirement.

C.S.I.R.O. is deeply indebted to Mr. Barr for his unstinted cooperation over many years, which enabled many long and difficult investigations to be successfully completed. In his retirement, it will be a major source of gratification to him that he has contributed so comprehensively to research and technology in the field of rail transport.

NEWS FROM THE DIVISION OF FOOD PRESERVATION

BEEF RESEARCH

Considerable development in beef research in Australia is expected to follow the disbursement of funds by the Australian Cattle and Beef Research Committee, a statutory committee constituted under the Cattle and Beef Research Act 1960–61. The Division of Food Preservation has been granted £26,000 for 1963–64, and this will be used to finance investigations in muscle biochemistry, animal physiology, and the physics of meat preservation by cold. It is expected that the grant will be greatly increased in future years, and that capital funds will be made available for the erection of new buildings for the Division's Meat Research Laboratory at Cannon Hill.

NEW APPOINTMENTS

Dr. R. M. Smillie, a graduate of Sydney University and of Queen's University, Ontario, Canada, has been appointed leader of the Plant Physiology Unit which is operated jointly by the Division of Food Preservation and the Botany School, Sydney University. He succeeds Dr. D. D. Davies. Dr. Smillie, who arrived in Sydney with his wife and family in September, comes from the Biology Department of Brookhaven National Laboratory, N.Y., where he led a group studying a number of aspects of metabolism in plants.

The first research appointment made from funds provided by the Australian Cattle and Beef Research Committee has been taken up by Dr. W. R. Shorthose, a graduate of the University of Nottingham and formerly Assistant Lecturer in the Department of Physiology, Royal Veterinary College, London. Dr. Shorthose will be investigating the influence of the physiology of meat animals on the meat derived from them.

Mr. D. G. James joined the Division's research team at the Tasmanian Regional Laboratory, Hobart, as an Experimental Officer in August 1963. Mr. James, who is a graduate in chemistry and physiology from the University of Liverpool, will participate in investigations on the processing of fruits, vegetables, and fish.

OVERSEAS TRAVEL

Dr. F. E. Huelin, Principal Research Officer, one of the Division's senior chemists, left Sydney on August 17 on an overseas visit of four months' duration. Dr. Huelin attended the 11th International Congress of Refrigeration at Munich and the Conference of European Meat Research Workers at Budapest. At the latter he delivered, on behalf of his colleagues, a paper on freezer burn, and another on the disinfection of chilling rooms with lactic acid. Dr. Huelin will visit many laboratories in Europe and North America, and spend a few days at the Central Food Technological Research Institute, India. His tour is being undertaken to study a wide range of problems in the chemistry and biochemistry of food.

Mr. J. F. Kefford attended, as technical adviser to the Australian delegation, the first meeting of the Codex Alimentarius Commission in Rome, from June 24 to July 3. The Codex Alimentarius Commission is an international body set up jointly by the Food and Agriculture Organization and the World Health Organization of the United Nations. The task of the Commission is to coordinate and rationalize the activities of a large number of bodies that are at present concerned with drawing up food standards, and eventually to publish in the Codex Alimentarius a collection of internationally adopted food standards presented in unified form. The publication of the Codex is expected to protect the health of consumers, to ensure fair practices in food marketing, to raise the level of food standards in underdeveloped countries, and to promote international trading in foods.

Mr. M. K. Shaw left Sydney for California in September. Mr. Shaw, an Experimental Officer at the Meat Research Laboratory, Brisbane, has been granted an overseas postgraduate traineeship from funds provided by the Australian Cattle and Beef Research Committee. Mr. Shaw will spend two years in the Department of Bacteriology at the University of California, Davis.

Sources of Finance, 1962-63

EXPENDITURE by the Division of Food Preservation in 1962–63 amounted to £422,100, of which 94%, i.e. £396,100, came from the Commonwealth Treasury. The balance came from the following sources:

	£
Australian Meat Board	
Meat investigations at Cannon Hill, Qld.	500
Metropolitan Meat Industry Board, Sydney	
Muscle biochemistry investigations	500
Queensland Meat Industry Board, Brisbane	
Investigations at Meat Research Laboratory, Cannon Hill, Qld.	1275
Department of Primary Industry	
Fruit fly sterilization investigations on citrus fruits and on pears*	6657
Spray residue investigations	700
N.S.W. Department of Agriculture	
Fruit storage investigations	2200
Australian Apple and Pear Board	
Apple and pear storage investigations	1100
Australian Egg Board	
Investigations on egg storage	750
Peanut Marketing Board	
Investigations on the storage and packaging of peanut kernels	550
Broken Hill Pty. Co. Ltd.	
Tinplate corrosion investigations	5000
Food industry	
General donations for purchase of equipment for food research	6827
Total	£26,059

In the course of the year an officer of the Division spent eight weeks in U.S.A. studying the problem of pink whites in stored eggs, and other problems associated with the quality of eggs and egg products. The major part of the cost was met by contributions from the National Cottonseed Council of America, Hunt Foods and Industries Inc., Swift and Co., the U.S. Department of Agriculture, and the Australian Egg Board, to all of whom the Division is deeply grateful.

The private section of the food industry has continued to support the work of the Division by making facilities available for research in food processing plants and by gifts of raw materials. Financial contributions for support of general research continue to be received. These contributions, first sought in 1956, now total £33,000, of which the sum of nearly £8000 was donated in 1962–63. It is pleasing to note that a record number of donations (55) were obtained from July 1, 1962, to June 30, 1963, and a considerable number have been received since. It is with a deep sense of gratitude that the Division places on record the support afforded it in the financial year 1962–63 by the following donors:

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

Abattoir Construction & Engineering Co. Pty. Ltd.
Arthur Yates & Co. Pty. Ltd.
Australian Consolidated Industries Ltd.
Australian Fibreboard Container Manufacturers' Association
Australian Paper Manufacturers Ltd.
Australian Sisalkraft Pty. Ltd.
Batlow Packing House Co-operative Ltd.
Blue Moon Fruit Co-operative Ltd.
Campbell's Soups (Aust.) Pty. Ltd.
Coca-Cola Export Corporation
Corona Essence Pty. Ltd.
Cottee's Ltd.
Craig Mostyn & Co. Pty. Ltd.
Crosse & Blackwell (Aust.) Pty. Ltd.
Crystal Engineering Service Pty. Ltd.
Cygnet Co-operative Canning Society Ltd.
Dark's Ice & Cold Storage Ltd.
Dewey & Almy Pty. Ltd.
F. J. Walker Ltd.
Fremantle Cold Storage Co. Pty. Ltd.
Gordon Brothers Pty. Ltd.
Gordon Edgell Pty. Ltd.
Griffith Producers' Co-operative Ltd.
Harry Peck & Co. (Aust.) Pty. Ltd.
Helix Electrical Products Pty. Ltd.
Henry Lewis & Sons Pty. Ltd.
Intercontinental Packers Ltd.
James Barnes Pty. Ltd.
J. Gadsden Pty. Ltd.
John Heine & Son Pty. Ltd.
Leeton Co-operative Cannery Ltd.
Lewis Berger & Sons (Aust.) Pty. Ltd.
Mount Barker Co-operative Ltd.
Northern Pear Growers Ltd.
Nugan (Griffith) Pty. Ltd.
Peanut Marketing Board
Pick-Me-Up Food Products Pty. Ltd.
Pict Pty. Ltd.
P. Methven & Sons Pty. Ltd.
Port Huon Fruitgrowers' Co-operative Association
Producers Cold Storage Ltd.
Prune Growers' Co-operative Ltd.
Queensland Cold Storage Co-operative Federation
Reckitt & Colman Pty. Ltd.
Riverland Fruit Products Co-operative Ltd.
Roche Products Pty. Ltd.
Schweppes (Australia) Ltd.
Shepparton Preserving Co. Ltd.
Sou'West Frozen Food Packers Ltd.
Sunshine Wrappings Pty. Ltd.
Unilever Australia Pty. Ltd.
W. Angliss & Co. (Aust.) Pty. Ltd.
Western Australian Ice & Cold Storage Association
W. G. Goetz & Sons Ltd.
Winn's Food Products Pty. Ltd.