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Quality of Australian honeys

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This paper presents in more general terms a summary of the Division of Food Research Technical Paper No. 38 (Chandler *et al.* 1974)

With an annual honey production of about 20 000 000 kg, which exceeds local consumption by about 8 000 000 kg, Australia not only ranks as one of the four leading honey-producing countries of the world, but also as one of the three leading exporters of honey. Its honey markets overseas, principally in the United Kingdom, South-East Asia and Japan, return about $A15 000 000 annually. However, the honeys produced in Australia vary widely in flavour, colour, texture and other quality characteristics because its vast hardwood forests and extensive pastoral areas provide literally hundreds of floral sources, each with the potential for producing its individual characteristic honey. Although this variety can be an asset in the marketing of uniquely Australian honeys, the range of characteristics may also present problems in meeting the rigid standards set by the importing countries. Moreover, since most is sold as blended honey, blenders need to know which honeys, if any, to avoid in blending because of their unfavourable quality characteristics. Besides, the apiarists themselves would often like to be able to apply the same principles in order to exclude their bees from harvesting nectar from undesirable floral sources.

Nevertheless, apart from work on the diastase activity, colour, pH and amino-acid contents of some Victorian honeys (Langridge 1966; Petrov 1971) and the sucrose contents of some Western Australian honeys (Smith 1965), there was until recently a dearth of published information on the composition of Australian straightline honeys, i.e. honeys of identified floral source. Some studies had been made on the composition of commercial blended honeys (Langridge 1971) in relation to European standards set by the Codex Alimentarius Commission (FAO/WHO 1969) but, while defining those quality factors in which our honeys could be improved, the information obtained did not indicate those straightline honeys or nectar sources whose avoidance could lead to such improvements.

Accordingly, at the request of and with financial support from the Australian Honey Research Advisory Committee, a program to study the composition of Australian honeys was undertaken in this Division under the supervision of Dr T. M. Reynolds. Chemical analyses were carried out on almost 100 straightline honeys from all six honey-producing States and representing over 60 different floral sources. The program, which was based on a similar study made of American honeys by White *et al.* (1962), led to the publication of a technical bulletin on this subject (Chandler *et al.* 1974). This article summarizes that bulletin. It will discuss the results recorded for each quality characteristic for each of the three honey types into which Australian honeys may be divided according to their floral source: eucalypt honeys, honeys from non-eucalypt Australian flora and honeys from exotic floral sources.

The discussion will also relate these results to the three main sets of standards operating for Australian honeys: those of the Codex Alimentarius Commission (FAO/WHO 1969), the Australian Defence Force Food Specifications (1972), and the Australian Export Standards (Australian Statutory Rules 1964, 1966). These comparisons are summarized in Table 1. Attention will be given to circumstances where these standards, though developed in good faith to reject adulterated or maltreated honeys, appear to be unfairly penalizing an Australian honey whose natural composition is such that the standards could not be met by pure samples

Table 1. Summary of analytical results for Australian honeys

Compositional criteria[1]	Range	Eucalypt	Other Aust. flora (Number of samples)	Non Aust. flora
Granulation				
0 = no crystals	0	19	1	1
2 = very few crystals	1–3	5	2	3
6 = semi-crystalline	4–6	7	3	5
9 = completely crystalline	7–9	29	12	12
Colour (Pfund value in mm)				
AES*: Extra white	0–17	2	0	7
White	18–34	20	0	5
Extra light amber	35–50	16	5	4
Light amber	51–65	10	1	1
Pale amber	66–75	7	2	0
Medium amber	76–90	4	7	2
Dark amber	91–114	1	3	1
Manufacturing	> 114	0	0	1
Moisture (%)				
CAC†: Max. 21%	< 14·5	10	2	4
AES: Max. 18·5%	14·5–15·9	32	9	8
ADFFS‡: Max. 20%	16·0–17·4	16	5	8
	⩾ 17·5	2	2	1
Ash (%)				
AES: Max. 0·5%	<0·20	38	5	21
CAC: Max. 0·6%	0·21–0·50	21	13	0
ADFFS: Max. 0·75%	> 0·50	1	0	0
Free acid (m-equiv/kg)				
CAC: Max. 40	6·0–9·0	19	1	0
	9·1–20·0	35	7	13
	20·1–40·0	9	10	7
	> 40·0	0	0	1
Reducing sugars (%)				
CAC: Min. 65%	54·0–59·9	0	1	0
AES: Min. 60%	60·0–64·9	0	3	0
ADFFS: Min. 60%	65·0–71·9	15	0	0
	72·0–79·0	45	14	22
Apparent sucrose (%)				
CAC: Max. 5%	0·0–1·5	37	9	8
ADFFS: Max. 5%	1·6–5·0	18	5	11
	5·1–10·0	4	0	2
	10·1–19·3	1	4	0
Diastase number				
CAC: Min. 3 if HMF < 15·0	9–15	24	10	1
Min. 8 if HMF > 15·0	16–20	11	6	4
	21–30	21	2	10
	31–44	7	0	6
HMF (mg/kg)				
CAC: Max. 40;	0·0–10	51	16	18
Max. 15 if DN < 8	10·1–15·0	3	0	0
	15·1–24·0	5	0	0
	24·1–40·0	1	0	2
	40·1–90·0	0	2	1

*AES, Australian Export Standards (Australian Statutory Rules 1964).
†CAC, Codex Alimentarius Commission (FAO/WHO 1959).
‡ADFFS, Australian Defence Force Food Specifications (CFS-8-3-10).

of the honey which had been subjected only to the best possible processing and storage conditions. Finally, a comparison will be made of the results from these authentic straightline honeys and from 28 commercial straightline honeys, 30 commercial blended honeys and 32 imported honeys.

Moisture content

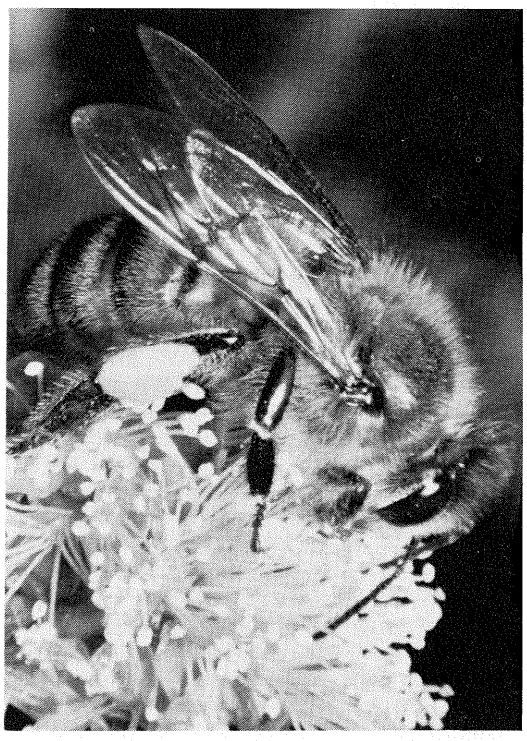
Dilution of honey was sometimes practised in earlier times, either to overcome granulation problems or to assist in the recovery of honeys during transfer and processing, and a maximum value for the moisture content of honey is set in all honey standards, e.g. 21% by the Codex Alimentarius Commission (CAC), 20% by the Australian Defence Force Food Specification (ADFFS) and 18·5% by the Australian Export Standards (AES); honeys with moisture contents less than 18·5% are very unlikely to ferment under normal circumstances.

Australian honeys should have little difficulty meeting these standards since only three of the 99 examined failed these specifications: two honeys (a mulga eucalypt and a natural banksia blend) exceeded the AES maximum, the lowest of the limits, and a broad-leaved tea-tree honey exceeded the CAC maximum, the highest of the limits. The generally low moisture content of Australian honeys is shown by the fact that these three honeys plus four other eucalypt honeys (South Australian blue gum, mallee, dusky-leaved iron bark, long-leaved box) were the only ones to exceed the *average* moisture content of 17·2% recorded by White *et al.* (1962) for U.S. honeys. Particularly low moisture contents (< 14·5%) were recorded for three eucalypt honeys (yorrell, sugar gum, yellow box), two non-eucalypt Australian flora honeys (loudonia, red bell) and two exotic honeys (Lincoln weed, Paterson's curse).

The results from the commercial honeys confirm these findings, with mean moisture contents of 17·8% and 16·1% in foreign and Australian honeys respectively and at least 30% of the foreign honeys would have failed the AES specifications. Moreover, although there was statistically a very highly significant difference between the mean moisture contents of commercial blended and non-blended honeys (16·6 and 15·8%, respectively), only one of the 30 blended samples tested would have failed the AES specification.

Ash content

Although most honeys are derived from blossom nectar, bees will forage nectar excreted by plants elsewhere than in the flower, and there is no basic difference between the compositions of floral and extra-floral nectars or between the compositions of the honeys derived therefrom. However, when bees forage on honeydew, the syrup excreted by certain plant-sucking insects, the product obtained, though similar to blossom honey, is inferior to it in quality, being darker in colour, lower in glucose and fructose contents and higher in polysaccharide, acid and ash contents. Such foraging, though rare in Australia, can be prolific overseas, especially in pine, cedar and oak forests, and the honeydew honeys produced have different properties according to the plant and insect that provide the excretions. Standards for honeydew honey are laid down by the CAC which allow, for example, a maximum ash content of 1·0%, compared with 0·6% for blossom honey. Honeys containing more than 0·6% ash



A honey bee foraging for floral nectar which it packs mixed with pollen into 'baskets' on its hind legs for transport back to the hive where the bees 'process' it into honey.

could therefore be labelled and sold as honeydew honey, finding their own value in the market place for commercial use in manufactured honey products.

Since contamination by metal corrosion, particularly of iron-based containers, leads to darker honeys and since dark honeys have a higher ash content than light honeys, it may be thought that a limit set to the ash content provides a barrier to metal-contaminated honeys. However, the principal difference between the metal content of average U.S. light and dark honeys lies in their potassium content (205 and 1676 ppm respectively) and not in their iron content (1·4 and 9·4 ppm respectively), and ash contents bear no direct relation to metal contamination. Similarly, the addition of alkali to reduce the titrable acidity of a honey (see below) would not be detectable by its ash content because of the low amounts of alkali required.

With ash contents of $0 \cdot 18 \pm 0 \cdot 12$, $0 \cdot 22 \pm 0 \cdot 07$ and $0 \cdot 08 \pm 0 \cdot 05$ for honeys from eucalypt, non-eucalypt and exotic flora respectively, current standards are unlikely to offer any undue restriction to Australian honeys. Only one sample exceeded the CAC and CES maxima (a spotted gum honey with 0·67% ash) and only two other honeys exceeded 0·36% ash. Consideration of other quality characteristics of these honeys does not indicate contamination by honeydew honey, and it seems unlikely that insect exudates constitute an important source of food for bees in this country. Australian commercial honeys and imported honeys also all gave ash values well below the level set by local and overseas standards.

Acidity and pH

Though the acidity and pH of a honey will affect its flavour characteristics to some extent, the wide range of flavours exhibited by honeys do not make these factors important in the definition of honey quality. Nevertheless, natural enzymic processes occurring in stored honeys lead to the production of free acids and extremely high acid contents may indicate excessive storage. However, only the CAC specifications set a limit on the free acid content of honey with a maximum permitted level of 40 m-equiv./kg. Of the 99 straightline honeys studied, one Paterson's curse sample (and not five others from this floral source) gave an acidity above the CAC maximum. Eucalypt honeys, in particular, had very low acid contents, with a mean value of 12·2 m-equiv./kg compared with 20·0 m-equiv./kg for honeys from other sources.

Though the total acidity (free acid plus lactone contents), lactone:acid ratio and pH value of honeys are sometimes measured, these parameters are not used in honey specifications because of their complicated relation to honey quality. The pH is related not so much to free acidity as to ash content which determines the buffering capacity of the product, while the pH itself determines the degree of natural hydrolysis of gluconolactone to gluconic acid that has occurred and hence the lactone:acid ratio. For the reasons given above, all these parameters will change with storage, but the changes are not always in the same direction, hence their absence from honey specifications.

Carbohydrates

Until regulations defining honey quality were established, one of the commonest methods of adulterating honey was by the addition of sugar syrups containing glucose, sucrose and particularly invert sugar. Such adulterations, when carried out at a commercially profitable level, can be detected by analysis of the carbohydrate content of the honey and hence the setting of permissible sugar contents by all honey standards: the minimum apparent reducing sugar content as 60% by both the ADFFS and AES and the higher figure of 65% by the CAC, while the CAC and the ADFFS set 5% as the maximum sucrose content.

All eucalypt honey and honeys from exotic floral sources had reducing sugar contents above the minimum values set by all three standards, but honeys from blackboy (54·2%), grand banksia (60%), Menzies banksia (63·3%), and red bell (63·2%) would have failed two or more of the specifications as well as the sucrose standard, with contents of 19·3, 15·3, 13·8 and 10·1% respectively. White stringybark honeys with reducing sugar contents of 66–68% were well below the average in this respect, and would have failed all sucrose specifications because of their high sucrose contents of 6–12%. One yellow box (5·1%) and one yellow gum (5·7%) among the samples of eucalypt honeys, and one Paterson's curse (6·0%) sample among the honeys from exotic floral sources also failed the standards for maximum sucrose content, but other samples of these honey types did not.

The CAC standards make a special allowance for the high natural sucrose

contents of Menzies banksia honeys by accepting 10% as the maximum sucrose content for such honeys. The present work indicates that such a dispensation should be extended to other honeys, in particular to white stringybark honeys which have potential economic value as non-candying honeys. Other honeys with high sucrose contents listed above, especially blackboy honeys, should be avoided by both apiarists and honey processors. None of the commercial honeys tested, either from local or overseas sources, failed any of the specifications relating to the carbohydrate content of honeys.

Diastase number and hydroxymethylfurfural content

The diastase number is a measure of the activity of starch-hydrolysing enzymes naturally present in honeys and is used in honey specifications to exclude honeys that have been damaged by overheating during processing or by overlong storage at unfavourable temperatures. Under these conditions, enzymic activity is reduced and, as a guard against such abuse, honeys with a low diastase number are rejected by the European market. Heat and prolonged storage also initiate discoloration reactions involving sugars and amino acids by promoting the formation of hydroxymethylfurfural (HMF), and a high level of this compound is also the basis for the exclusion of a honey from the EEC.

It is recognized, nevertheless, that some honeys have a naturally low diastase number, and a system with a triple standard is therefore followed by the EEC. This system effectively places an embargo on:

- all honeys with HMF content greater than 40 mg/kg;
- all honeys with HMF content greater than 15 mg/kg and a diastase activity of less than 8 on the Gothe scale; and
- all honeys with a diastase activity of less than 3 on the Gothe scale.

Eucalypt honeys easily met those criteria: no honeys had an HMF content greater than 40 mg/kg or a diastase number of less than 3, and although six samples, including three blue gum honeys, exceeded the 15 mg HMF/kg level, their diastase numbers were well above 8, enabling them to pass the standards. The honeys from all other sources gave diastase numbers well above 8 and HMF contents well below 15 with the exception of two natural broad-leaved tea-tree blends and one natural blue heliotrope blend, all of which had exceptionally high HMF contents (over 40 mg/kg), although their diastase numbers (over 13) demonstrated they had not been grossly heat-abused. These three honeys came from the same general area of Queensland where blue heliotrope presents a serious weed problem. Authentic blue heliotrope honey is unique in having a distinctly bluish cast in its pale amber colour and it has an HMF value (6·5) above average even when fresh, while storage for a few months, even of natural blue heliotrope blends, leads to an HMF value approaching 15. The three samples mentioned above had been stored for over 12 months and while there is no certainty that in each case the bees foraged on pastures contaminated by blue heliotrope, the evidence suggests that apiarists should avoid areas where this weed is prevalent if they want their honeys to meet CAC specifications.

Generally speaking, although they give much the same diastase numbers, Australian commercial honeys have an HMF content higher by about 6 mg/kg than the test honeys, but this is to be expected as a result of the additional handling and processing the commercial honeys would have received. However, despite their higher HMF contents, they would all pass the CAC specifications because their diastase numbers were high enough, though just high enough in a couple of samples. On the other hand, of the 32 foreign-produced honeys examined, six would have been rejected outright by the CAC for their high HMF content and two outright for their low diastase number. A further three would have been rejected for having an HMF content greater than 15 mg/kg *and* a diastase number less than 8 on the Gothe scale. Nevertheless, Australian honey processors should not become complacent on this matter and should take care to prevent over-heating in their operations, especially where blending is involved, and to ensure that temperatures above 50°C (preferably 45°) are avoided during processing, transport and storage.

Colour

Freshly extracted honeys vary in colour from nearly colourless to dark amber according to floral source, and with abuse during processing and storage they will darken at a rate which also varies with the

floral source. Since HMF is the precursor to the pigments formed under these conditions, the HMF content provides a basis for the rejection of such discoloured honeys under CAC specifications, and honeys passing this standard are allowed to find their own market value. However, because consumer demand for honey is largely dependent on colour, lighter coloured honeys being preferred, this quality characteristic is a prime determinant of the price paid for honey at each marketing level. Consequently, the AES specifications incorporate a grading system which separates honeys into seven groups according to their colour as determined by the Pfund Colour Grader: Pfund readings 0–17, extra white; 18–34 white; 35–50 extra light amber; 51–65, light amber; 66–75, pale amber; 76–90, medium amber; and 91–114, dark amber.

Compared with the 490 American honeys examined by White *et al.* (1962), Australian honeys are darker, but the differences are not related to geographical differences directly but to the available floral sources. Honeys from the same floral source fall into the same colour grade irrespective of the country of origin, and the major difference in the colour of honey from the two countries originates in the particularly darker colour of honeys from non-eucalypt Australian flora (Table 2). Because of the commercial importance of colour grading, the lightest and darkest honeys within each classification of floral source have been listed in Table 3. Particularly notable are honeys from wireweed, messmate, blackbutt and blue heliotrope; the presence of the latter in pastures foraged by bees led to natural blends that were medium to dark amber in colour, and the two Queensland honeys mentioned above as possibly naturally contaminated with blue heliotrope honey were also medium to dark amber.

Because a premium price is paid for lighter honeys, most commercial Australian straightline honeys are lightly coloured (< light amber) while blended honeys are light amber to medium amber. Generally speaking, Australian honeys would be disadvantaged by colour comparison with foreign honeys. Except for four extremely dark samples from Mexico and China, all the foreign honeys tested fell into the white to extra light amber range.

It is recognized, as indicated above, that the colour of honey gradually deteriorates on storage and the discolouration process can be regarded superficially as another example of non-enzymic browning since both the reactants, reducing sugars and amino acids, are present in honey, the former in very high concentration. Because of the higher pH of Australian honeys and the higher temperatures at which they are frequently stored, the deterioration in colour would be expected to be a bigger problem in Australia than in Europe or the United States.

In these studies, of all the chemical criteria that could be associated with colour development (acidity, pH, ash content,

Table 3. Australian honeys notable for their colour

Lightest	Darkest
Eucalypt honeys	
pink gum	messmate
dusky-leaved ironbark	blackbutt
green mallee	bloodwood
yellow box	river red gum
yorrell	jarrah
napunyah	mallee
Honeys from exotic floral sources	
Paterson's curse	wireweed
orange blossom	blue heliotrope
Honeys from other floral sources	
Menzies banksia	blackboy
grey mangrove	tea-tree
leatherwood	wallum oak

Table 2. Colour ranges for Australian and foreign honeys

Source of honey	Standard deviation in colour of test samples	Standard deviation in colour of commercial samples
Australian eucalypt honeys	White–light amber	White–light amber
Australian honeys from exotic flora	Extra white–pale amber	White–light amber
Other Australian honeys	Light amber–medium amber	Extra light–light amber
American honeys	Extra white–extra light amber	—
Foreign commercial honeys	—	White–medium amber

reducing sugar content), the closest relationship was between colour and pH. This association can be expressed best by a simple empirical relation: the Pfund reading of a honey will always be greater than 30 times its pH less 107. This relationship would mean that a honey less than 6 months old must have a pH of 4·13 or less before it can fall into the 'extra white' grade, and that for other colour grades the maximum pH would be: white, 4·70; extra light amber, 5·23; etc. Of course, not all honeys with a pH less than 4·13, for example, would be graded extra white, and there is a storage factor operating such that the above pH values would be reduced by 0·3–0·4 pH units for honeys stored for a year.

The above formula held for all but 10% of the honeys studied in this work and to all but 2% of the honeys examined by White *et al.* (1962). (The better correlation in the American studies may have been due to the fact that their storage conditions could be controlled better than was possible in this work.) Moreover, the general light colour of U.S. honeys would be expected from the above relation since only 3% had pH values higher than 4·70 and only 1% had values higher than 4·13.

Finally, on the colour question, the ability of certain flower pigments to pass through into the honey, as indicated by our experience with blue heliotrope honeys, suggests that flavonoids and other phenolic constituents of flowers may do likewise. Such compounds have the ability to form coloured complexes with many of the metals that can become incorporated into the honey as a result of corrosion of the container. (Corrosion is partly related to the acidity of the honey and to the duration and temperature of storage.) Clearly, honey colour is a complicated question, and more than one mechanism is likely to be involved in colour changes as indicated by the apparent anomaly that, in these results, both high pH and high acidity are associated with high Pfund readings, although normally a high pH means a low acidity and a high acidity means a low pH.

Granulation

Although honey granulation is not covered by any regulatory standards, it is an important factor in determining the acceptability of honeys on both a personal and a regional basis. Such granulation occurs on storage because fresh honey, predominantly a mixture of fructose, glucose and water, is frequently supersaturated at normal temperatures with respect to glucose, the least soluble of its major sugar constituents. In simplest terms, whether a honey will granulate or not depends on the proportion of glucose to other components of the mixture. Three formulae have been suggested (White *et al.* 1962) for predicting the susceptibility of honey to granulation:

- the ratio of glucose to water contents (G/W)
- the ratio of fructose to glucose contents (F/G)
- the ratio of the difference between glucose and water contents to the fructose content [(G-W)/F].

Of these formulae, White *et al.* (1962) found G/W the simplest to determine and the most reliable in use. They associated a G/W of 1·7 or less with non-granulating honeys and a value of 2·1 or more with rapidly granulating honeys.

These three formulae can be assessed for their usefulness in classifying honeys according to their susceptibility to granulation on storage by comparing the number of samples of liquid (or solid) honeys after storage with the number of such samples indicated by the formula to be liquid (or solid), or by comparing the number of samples predicted to be liquid (or solid) by the formula with the number of such samples that actually were liquid (or solid) after storage. The application of such comparisons to the honeys examined in the present work gave the results recorded in Table 4.

The formulae (G-W)/F appears to be the most satisfactory of the three for predicting honey granulation, though only marginally more satisfactory than F/G, and its application would have predicted the continued liquidity of about half the honeys that remained liquid after 6 months' storage at 20°C. To obtain more successful formulae for the prediction of honey granulation, further work would be needed on the compositional factors controlling the tendency of honeys to granulate, e.g. on the importance of high molecular weight components in the stability of the supersaturated system.

The question of granulation is, of course, of major importance in those markets where consumers display a preference for fully liquid honeys, and Table 5 shows how

Table 4. Effectiveness of formulae for predicting granulation in honeys

	Predictor		
	G/W	F/G	(G-W)/F
Range of values for liquid honeys[A]	1·36–2·17	1·64–2·88	0·12–0·37
Range of values for solid honeys[B]	1·70–2·46	0·92–1·56	0·28–0·70
Most suitable limit for predicting liquidity	$\leqslant$ 1·70	$\geqslant$ 1·64	$\leqslant$ 0·27
Most suitable limit for predicting solidity	$\geqslant$ 2·20	$\leqslant$ 1·25	$\geqslant$ 0·42
Number of liquid honeys[A] predicted to be liquid	10/31	13/13	14/31
Number of solid honeys[B] predicted to be solid	8/42	11/42	12/42
Number of successful predictions of liquidity	10/11	13/14	14/14
Number of successful predictions of solidity	8/10	11/17	12/14

[A] Honeys showing no or extremely few crystals; [B] honeys completely or almost completely crystalline.

Table 5. Extent of granulation in Australian and foreign honeys

Source of honey	Standard deviation in granulation of test samples
Australian eucalypt honeys	extremely few crystals–completely solid
Australian honeys from exotic flora	moderate crystallization–completely solid
Other Australian honeys	moderate crystallization–completely solid
American honeys	no crystals–sample semi-crystalline
Foreign commercial honeys	extremely few crystals–moderate crystallization

Australian honeys, especially those from non-eucalypt sources, would be at a disadvantage on such markets overseas. Eucalypt honeys varied greatly in their tendency to granulate, with an abnormal distribution showing population peaks corresponding to both completely liquid and completely solid honeys. Regional factors, rarely important in honey quality apart from defining floral source, also come into play. Thus none of the five Queensland honeys examined showed more than very few crystals, while all but six of the 24 Western Australian honeys were at least semi-crystalline. Australian honeys notable for their liquidity or solidity are listed in Table 6.

Table 6. Australian honeys notable for their liquidity or solidity

Liquid	Solid
Eucalypt honeys	
messmate	comet vale mallee
white stringybark	swamp yate
jarrah	napunyah
coastal blackbutt	river red gum
grey box	S.A. blue gum
dusky-leaved ironbark	long-leaved box
stoney mallee	yorrell
spotted gum	karri
pink gum	marri
	forest blackbutt
Honeys from exotic floral sources	
blue heliotrope	most other sources
Honeys from other floral sources	
blackboy	most other sources
grand banksia	

Conclusions

Most Australian honey should be able to pass the standards for quality demanded by overseas markets providing they are properly processed, stored and transported. A strong case could be made for the introduction into the AES of specifications based on HMF content and diastase number and designed to reject honeys that have been maltreated. Since Australian honeys apparently do not present problems of naturally low diastase content as encountered in foreign honeys, scrupulous honey processors would have little to fear from the introduction of such specifications.

However, in addition to Menzies banksia honey, which is already allowed a special dispensation by the CAC, certain Australian

honeys could face rejection under CAC specifications for their unusual natural carbohydrate composition, particularly white stringybark honey, noted for its light colour and limited granulation. Acceptance of such honeys on the European market could partially compensate for the disadvantage Australian honeys generally suffer on account of their natural dark colour and strong granulating tendency.

Although there is still a market for granulated and dark coloured honeys, apiarists and processors at present attempt to eliminate or reduce these potential quality defects by avoiding honeys from certain identifiable floral sources. This recent work will assist in such selective activities along the lines indicated in Tables 3 and 6. Such selections could also extend to the avoidance of honeys from the following sources: broad-leaved tea-tree (high in moisture), spotted gum (high in ash), white stringybark (high in sucrose), blackboy, grand banksia and red bell (low in reducing sugars), and blue heliotrope (with high HMF values). In blending operations, consideration can now also be given to the incorporation of honeys specifically selected to boost the properties of the blend with respect to one or more of the important quality characteristics.

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Book notice

'Guide to Refrigerated Storage.'

International Institute of Refrigeration, 177 bd. Malesherbes, 75017, Paris; 1976; pp. 190, 50 F (hard cover).

This book is an up-to-date and enlarged version of the publication 'Practical Guide to Refrigerated Storage' which appeared in 1965. The new book, which is bilingual (English and French), has been compiled by an international team of qualified experts on refrigerated storage.

Summary of contents:

- design and construction of cold stores;
- handling of merchandise;
- the merchandise in the refrigerated warehouse;
- the cold store and its customer;
- safety precautions; and
- personnel working in cold stores.

The book collates and reviews many documents on refrigerated storage. It will assist and guide professionals concerned with the design, construction and operation of cold stores.

Device for measuring small weight changes in carcasses during chilling and chilled storage

By J. Anderson and R. R. Weste

CSIRO Division of Food Research, Cannon Hill, Qld.

Introduction

Chilling in batch chiller rooms, where cold air is blown over carcasses or sides hanging on elevated rails, is an important step in the hygenic production of meat. As the carcass cools, water evaporates from its surface and the resultant weight loss is a direct monetary loss to the industry. Efforts are being made to ascertain the conditions permitting satisfactory rates of cooling in the chiller while causing minimum losses of weight.

Fifty devices for measuring weight loss were required for an investigation of chiller performance by the Physics and Engineering Section of the CSIRO Meat Research Laboratory. Commercially available load cells and experimental weight loss devices (Lovett 1973) were not suitable because of their high cost, instability or inability to withstand conditions in an abattoir. A new device was therefore developed which was:

- Compatible with rail systems of abattoirs, easy to clean and sterilize, and able to withstand rough handling and adverse conditions.
- Portable, simple in mechanical and electronic design, and cheap to manufacture.
- Capable of measuring weight changes of ± 7 g in carcasses weighing about 30 kg, and of ± 25 g in carcasses up to 200 kg, stable with time, preferably unaffected by temperature variations, and with an electrical output suitable for an existing data logger.

Design and construction

The final form of the device is shown in Fig. 1 and diagramatically in Fig. 2. Basically, the device is a spring balance, with a hook for carrying the carcass attached to a lower, moving plate. This plate is

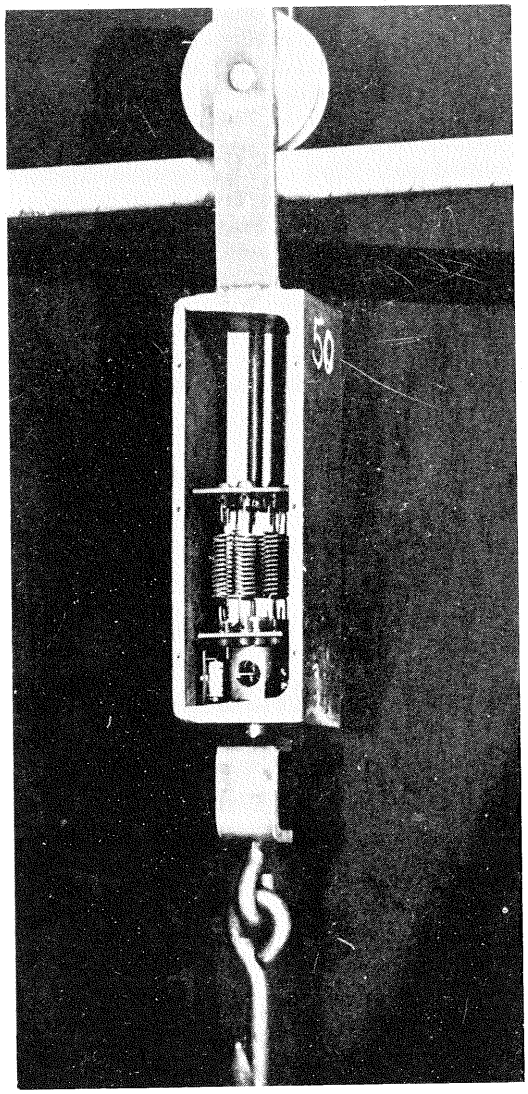

Fig. 1. Photographic illustration of the weighing device

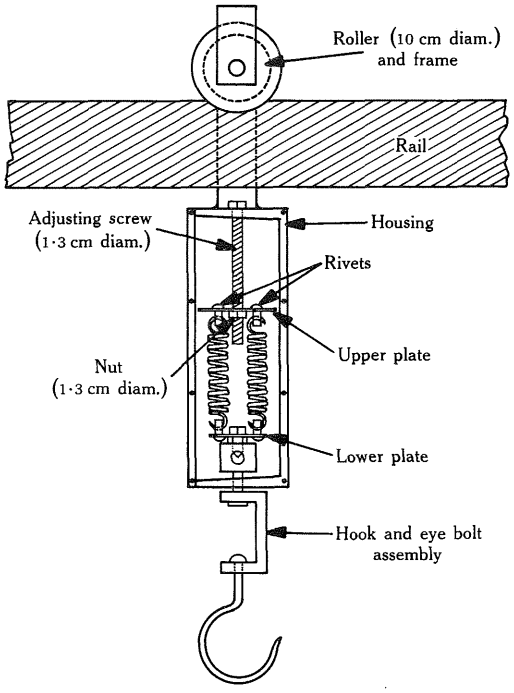

Fig. 2. Weighing device shown diagramatically.

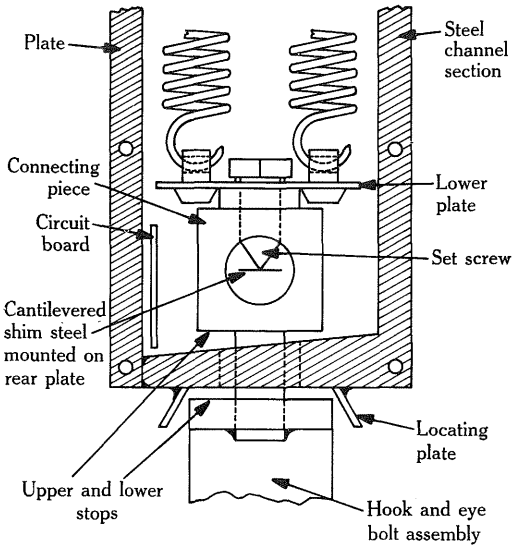

Fig. 3. Detailed view of displacement transducer.

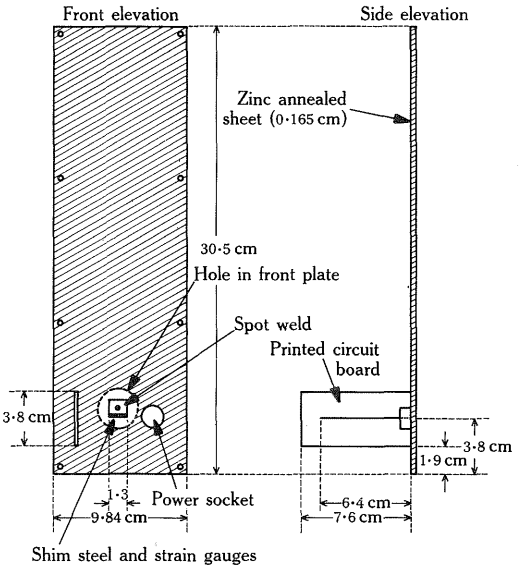

Fig. 4. Front and side elevation of rear plate.

suspended by six springs from an upper plate connected by a vertical adjusting screw to the housing and to the roller on the meat rail. The position of the upper plate is adjusted to vary the tension in the springs so that measurements may be made on carcasses that differ widely in weight.

Two sets of tension springs are used. Light springs for small stock (10–40 kg) are made from galvanized spring wire (wire diam. 1·6 mm, mean coil diam. 15·8 mm, 13 coils in each spring and slightly enlarged hooks). The heavier springs used for beef sides (50–160 kg) are similar but the diameter of the wire is 2·8 mm, the mean coil diameter is 19 mm and there are 20 coils. All other materials and components used in the device are readily obtainable or easily fabricated in a small workshop.

Loss of carcass weight causes the lower plate to rise (Fig. 3) and this in turn changes the shape of a strip of shim steel which is fixed to the electronic panel (Fig. 4) and makes contact with the lower plate through the specially machined set screw. Changes in shape of the shim steel are detected by changes in output of two strain gauges cemented to the shim. One gauge is in compression on the lower surface and the other in tension on the upper surface; their combined output is double that of a single gauge. The strain gauges and two resistors forming a bridge circuit (Fig. 5) are carefully selected to have very similar values of resistance and temperature coefficients, with the result that the bridge output is virtually unaffected by temperature changes.

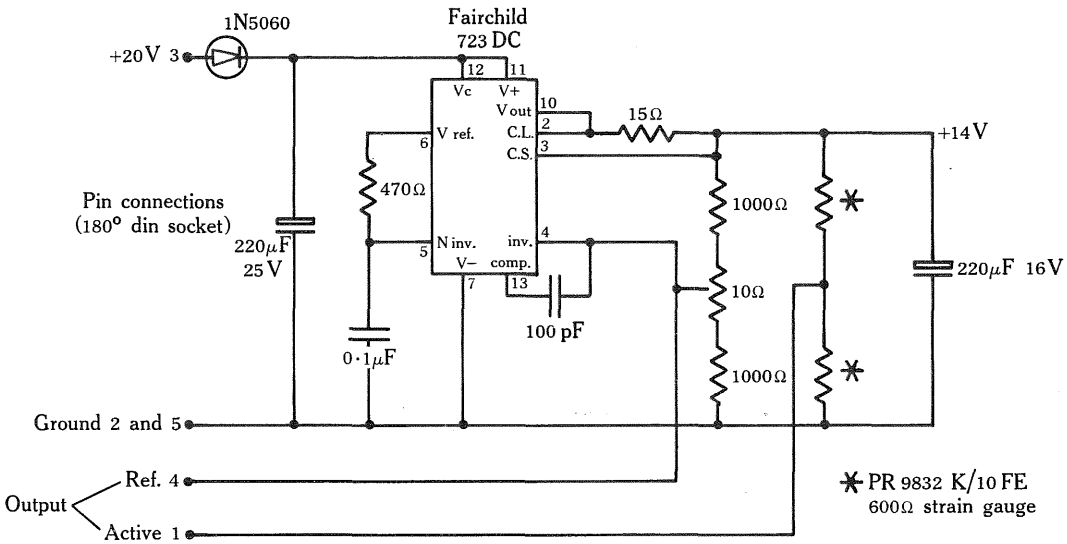

Fig. 5. The electronic circuit.

With the carcass hanging on the hook, the position of the upper fixed plate is altered with the adjusting screw (Fig. 2) until the bottom plate is 'floating' approximately half way between the upper and lower stop positions (Fig. 3). Changes in output from the bridge circuit resulting from changes in the weight of the carcass are then recorded by means of a scanner and data logger.

Calibration and performance

The instruments were calibrated with a base load of 24 kg when fitted with small springs, and 135 kg when fitted with springs for measuring weight changes in beef. The change in electrical output with change in weight was linear being about 0·7 g/μV for small springs and 2 g/μV for the heavy springs (Fig. 6). The instruments were calibrated at 0°C and 10°C and temperature coefficients were found to be reproducible and in the range 0–2 μV per Celsius degree. Corrections can therefore be made for changes in ambient air temperature. Drift of output with time was negligible over the calibration period of 2 to 3 days and there was negligible change in sensitivity or temperature coefficients when the instruments were calibrated at intervals during a period of several months.

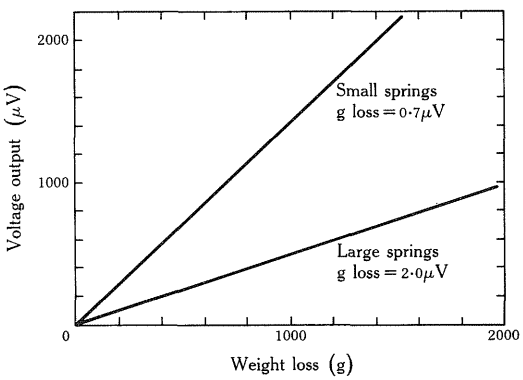

Fig. 6. Calibration of the weighing device.

The devices have been used for 16 investigations of weight loss in two mutton, one pork and four beef chillers. Electrical outputs, as well as other electrical signals from thermocouples, relative humidity and air velocity instruments, were measured and recorded at regular intervals throughout the chilling cycle by a 100-point data logger. Measurement discrimination in the logger was ±10 μV, so that weight losses could be measured with an accuracy of about ±7 g for small stock, and ±20 g for beef. Useful results were obtained in all investigations and typical curves of weight loss *v.* time of chilling are shown in Fig. 7. Any unsatisfactory results could generally be attributed to extraneous factors such as the presence of water on plug connections or contact between the test carcass and adjacent carcasses. Poor results were obtained when the bottom plate was not adjusted to be approximately midway between the upper and lower stop positions at the beginning of a measurement. This adjustment was

particularly difficult in beef chillers where it must be done from the top of a ladder three metres above the floor of the chiller. Regular inspections and calibrations showed that some errors of measurement resulted from the breakdown of the strain gauge. Twenty sets of strain gauges have been replaced during the 18 months that the 50 devices have been in use.

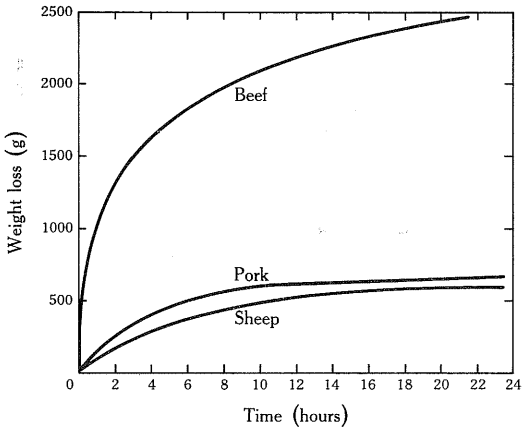

Fig. 7. Typical curves of weight loss *v.* time of chilling.

Reference

Lovett, D. A. (1973). Load cell for measuring small weight changes in carcasses. *CSIRO Food Res. Q.* **33,** 40–3.

Tropical and subtropical crops in Hawaii

By E. K. Akamine

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A review of postharvest problems and handling methods. Professor Akamine recently spent 6 months as a guest worker at the Food Research Laboratory, North Ryde

Because crops are grown under much the same environmental conditions in Hawaii as in tropical and subtropical Australia, they are similarly subjected to attacks from insects and diseases that influence the quality of shelf life of the stored commodity. There are three species of fruit fly in Hawaii, the Mediterranean fruit fly, the melon fly and the Oriental fruit fly. Nearly all fresh commodities must be disinfested before shipping to continental United States or wherever fruit flies do not exist. The Queensland fruit fly poses a similar problem in Australia, whilst the problem of control of storage diseases is universal. In addition, there is a need to extend shelf life by regulation of ripening and senescence, and this is basically associated with respiration and the production of ethylene by the crop.

The primary aim in proper postharvest handling is to maintain the original quality of the commodity as long as possible. A diseased or insect-damaged fruit or fruit physically damaged in the harvesting or handling process cannot be expected to have much shelf life even under optimum storage conditions; it will only deteriorate. Since cultural practices including sanitation (disease and insect control, weed control, disposal of diseased and insect-infested plant materials, etc.) are the main factors determining the quality of the commodity at harvest, it is apparent that the best practices must be maintained in the field in

order to obtain a high quality commodity which will benefit most from proper postharvest handling.

The purpose of this article is to present some aspects of postharvest handling of some Hawaiian crops that may be of interest to growers and processors in Australia. The discussion of different fruits, vegetables and ornamentals is based on the results of research conducted at the College of Tropical Agriculture, University of Hawaii, and on observations in the field and in commercial packing facilities.

Papaw

Disinfestation methods for papaw and other fresh commodities intended for export from Hawaii are developed in a cooperative effort between the College of Tropical Agriculture, University of Hawaii, and the Hawaii Fruit Fly Investigations Laboratory of the United States Department of Agriculture (USDA). The University is responsible for determining the tolerance of commodities subjected to the disinfesting treatments prescribed by the USDA, which also determines the toxic residues of the treatments in the commodities. Three requirements must be met before any treatment is certified for a commodity. They are:

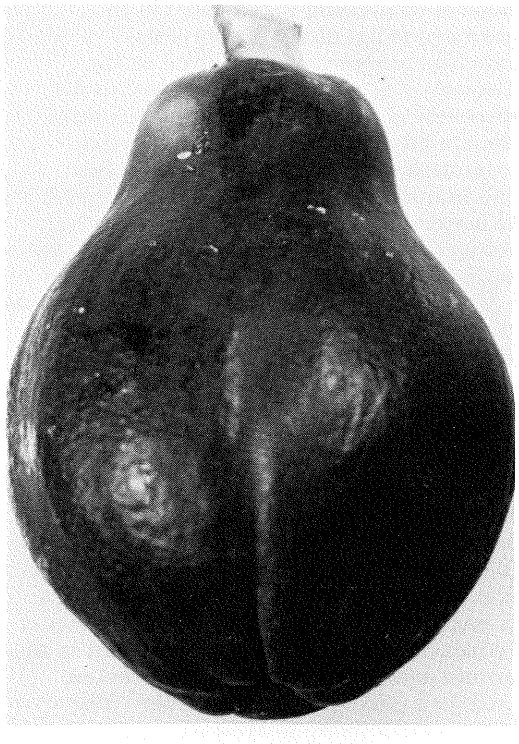
- the treatment must destroy the fruit flies or other insects involved,
- the commodity concerned must exhibit a reasonable degree of tolerance to the treatment, and
- toxic residues of the treatment must be within the safe levels prescribed by health regulations.

Two disinfestation methods are currently approved for export papaws—vapor heat and fumigation. In the vapor heat method, the fruits are initially subjected to dry heat at 43°C and about 40% R.H. for 6–8 h ('conditioning') to improve tolerance. They are then subjected to a saturated atmosphere (100% R.H.) and manipulation of the temperature for 4 h or more until they reach 47°C. The fruit is then cooled with circulating air for several hours before being packed for shipping. In the fumigation treatment, ethylene dibromide is used at the rate of 225 g per 28 m^3 of fumigation chamber space for 2 h followed by airing for 1 h before being packed. The fruit temperature during fumigation should not be below 21°C.

The vapor heat treatment reduces the typical papaw aroma without affecting the taste, but this is not objectionable. In fact, some people prefer fruit with reduced aroma. The treatment also controls storage decay. On the other hand, the fumigation treatment does not affect the aroma or flavour, but since it does not control storage decay, other means have had to be developed to overcome this problem. Primarily because of the shorter period and fewer risks of this treatment (for unless it is properly controlled, papaws can readily be damaged by vapor heat), more fruits for the export trade are fumigated than are treated with vapor heat. However, because the method leaves a relatively high bromide residue in the treated papaws, even though it is within the presently required tolerance limits, some concern has been expressed by growers and shippers over the possibility of ethylene dibromide being eliminated as a disinfestation treatment. If this happens, the industry must use the vapor heat treatment until such time as a substitute fumigant is found. Although research has shown that low dose gamma irradiation (about 25 krad) is also effective for disinfesting papaws, it is not as yet an approved treatment for export fruit, presumably because it may produce carcinogens.

In order to control storage decay in fumigated papaws, a simple hot water treatment was developed at the University of Hawaii in 1952. This was designed initially to control anthracnose, the major storage disease at the time, and the recommended method consisted of dipping the fruit in water maintained at 43–49°C for 20 min. The value of this treatment was proved in extensive trial shipments conducted by the University of Hawaii in projects supported jointly by the then Hawaii Territorial Government, the USDA and the papaw industry. It also proved effective for controlling other diseases which eventually attacked the fruit as the industry expanded. Nevertheless, until recently shippers were reluctant to use the treatment because it was not required by regulation for export fruit and it entailed additional cost. Moreover, in certain periods of dry weather as in the summer months, the incidence of storage decay was low. So the hot water treatment was used only sporadically by the industry.

In 1963, growers were obliged to stop applying certain fungicides in the field because their use on papaws had not been



Solo papaw. Photo: M. Awada.

cleared by the U.S. Food and Drug Administration. Consequently, the degree of field infection increased tremendously. Since the hot water treatment was practically forgotten by this time, the percentage of decay in papaws shipped to the West Coast of the United States was very high, sometimes reaching 75%. Upon the recommendation of the University of Hawaii, the shippers in desperation again began using the hot water treatment in 1964.

The hot water treatment was made an integral part of the disinfestation process in 1972 and since then all papaws for export have been subjected to a combination of both the hot water and fumigation treatments. The hot water treatment enhances the effect of the fumigant in killing fruit fly to such an extent that the standard dose of fumigant could be reduced. This in fact has not been done as the heated papaws can tolerate the treatment. The fruit is first dipped in hot water maintained at 49°C for 20 min (complete immersion), then cooled in a shower of tap water for *c.* 20 min before being fumigated. As the hot water treatment has always been considered an insurance against storage decay when the field infection rate is high, the required combination treatment now affords protection against storage decay at all times in addition to protection against emergence of fruit fly.

Papaws are harvested commercially when slightly yellow, i.e. as much as one-third of the fruit surface showing yellow. After disinfestation treatment (vapor heat or hot water plus fumigation), the fruits are packed in fibreboard cartons with shredded paper to prevent bruising in transit. At present, nearly all papaws are shipped by air. Those shipped by sea are carried in refrigerated containers at *c.* 10°C.

In addition to cold storage and hot water treatment, controlled atmosphere storage (C.A.) was investigated as a means of extending the shelf life of papaws. Fruits that were successively treated by hot water, fumigated and stored under C.A. (1–2% oxygen and 99–98% nitrogen at *c.* 10°C) had their shelf life extended by 1–2 days over that of fruits similarly treated but stored in air. Although trial shipments showed that transport by sea under C.A. conditions was feasible, the industry has opted for air shipment which does not require any special method of storage because of its short duration.

Application of gamma irradiation with a dose of *c.* 75 krad (higher doses are detrimental) delays ripening and senescence, but it does not control storage decay. The hot water treatment used for controlling storage decay in fumigated fruit is also effective for irradiated fruit. Hence if irradiation is approved for export papaws, the recommended treatment would consist of pasteurizing in hot water plus irradiation as this would simultaneously control fruit fly and storage decay while extending the shelf life of the fruit.

Pineapple

At present, pineapples for export do not receive a disinfestation treatment. Although formerly required this precaution was discontinued after it was discovered that while fruit fly may attack pineapples the flies do not survive in this fruit. Pineapples are harvested commercially when the surface of the fruit is up to one-quarter yellow if shipment is to be by sea, and when the surface is one-third to nearly full yellow for shipment by air. The base of each fruit is treated with a fungicide, Dowicide A (7·2 g/l water), to control a storage decay caused by *Thielaviopsis paradoxa*. After being

sorted for size, the fruits are placed in single layers on their sides in fibreboard cartons, each designed to hold 5–8 fruits depending on their size. The packed cartons are loaded directly onto the aircraft, but for shipment by sea they are carried in a refrigerated container at *c.* 7°C.

C.A. storage was found experimentally to be effective for extending the shelf life of pineapples, but the economic feasibility of its use for refrigerated fruit has not been fully established and the industry is not using it routinely. The effect of gamma irradiation on shelf life has not been established.

Probably the only serious obstacle to the expansion of the market in fresh pineapples is the physiological malady, Endogenous Brown Spot, which in its worst form is known as Black Heart in other areas of the world where pineapples are cultivated. In Hawaii, the disease occurs after refrigerated fruits are stored under ordinary conditions; it is rare in unrefrigerated fruit. Hence it is a problem only in pineapples shipped by sea, but as most are shipped by this means, it is a major concern for shippers. The disease can cause 75–100% loss in a single shipment. There are no visible symptoms in the intact fruit and hence roguing as a means of removing whole diseased fruits cannot be used.

Except for low temperatures in the field, no other known factors cause Endogenous Brown Spot. Until preventive measures applicable in the field are found, the only hope of controlling the disease lies in postharvest handling. Laboratory experiments recently conducted at the University of Hawaii have resulted in the discovery of a practical method to control the malady in shipped pineapples. The treatment entails application of dry heat (no humidity control) at 32–38°C for 24 h either just before or immediately after refrigeration; the latter method of application is slightly more effective.

Commercial line in Hawaii: an airgun is used to insert a tag with a brand name into the crown leaves of the pineapple before the fruit is packed and shipped.

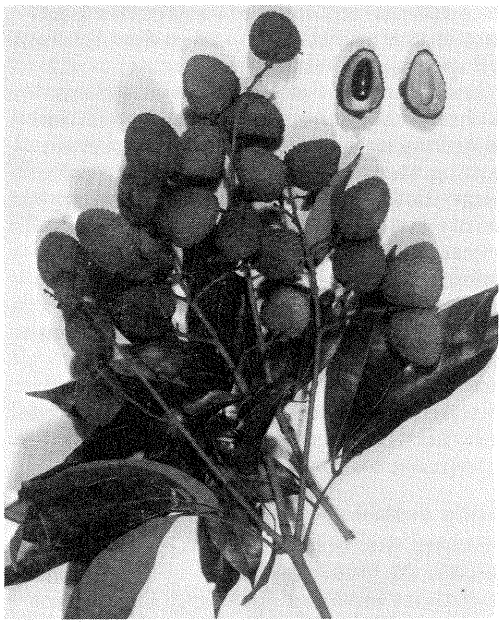
In actual shipment, heat can be applied on the first day of the transit period in the shipping container or on the last day of the transit period, with refrigeration applied during the balance of the shipping period. The control of Endogenous Brown Spot in heated fruits after storage under ordinary conditions is 90–100% effective depending on the degree of incidence of the disease; the lower the incidence the better is the control. The only detrimental effect of the treatment is increased weight loss in the fruit, but this is more than offset by the beneficial effect of reduction of disease and improvement in the appearance (golden yellow) and flavour (reduced astringency) of the pulp. The pineapple industry in Hawaii is currently testing the feasibility of this treatment on a pilot scale.

Avocado

Fumigation by ethylene dibromide used to be the required treatment for avocados intended for export but it was subsequently declared ineffective for disinfestation unless administered at such high doses as to cause injury to the fruit. Gamma irradiation is also detrimental as it produces severe injury even at doses below the levels required for disinfestation (about 25 krad). Currently, fumigation with methyl bromide (1 kg per 28 m^3 for 4 h at a minimum fruit temperature of 21°C) is the approved treatment for export. However, only a few varieties can tolerate this treatment, which accelerates ripening. Hence shipment of avocados is very limited and is by air only. Some untreated fruit is also shipped to Canada and Alaska where fruit fly cannot survive because of the low temperatures prevailing. For extended storage, Hawaiian avocado varieties, in general, keep well at 7–13°C.

Lychee

The approved disinfestation treatment for export lychee is fumigation with ethylene dibromide (225 g per 28 m^3 for 2 h at a



Lychee. Photo: W. Yee.

minimum fruit temperature of 21°C). The fruit also tolerates disinfestation doses of gamma irradiation, but this treatment has not been certified for export fruit. Because of the erratic fruiting habit of the species in Hawaii, shipments of fresh fruit are limited and are all by air. Since lychees keep well under refrigeration (4–6 weeks at *c.* 7°C), shipment by sea is feasible when the volume to be exported justifies it.

The only major problem in postharvest handling is darkening of the pericarp (skin) of the fruit. Research has shown that injury to the cells as a result of surface desiccation is the cause of the darkening, and the solution lies in preventing this desiccation. In practice, this is done by packaging the fumigated fruit in a moisture-proof material such as polyethylene or a similar plastic membrane that retains high relative humidity. The package should allow adequate entry of air to prevent fermentation of the lychees. For shipping, the package is then placed in a cardboard carton. (Fresh whole lychees can readily be frozen and stored for as long as one year and retain their quality. This is one of only a few fruits in which freezing and subsequent thawing does not soften the pulp.)

Banana

The approved treatment for bananas intended for export is fumigation with ethylene dibromide (225 g per 28 m^3 for 2 h at a minimum fruit temperature of 21°C). Bananas used to be shipped from Hawaii to the United States mainland, but they are now imported from Central America via California to supplement the short supply on the Hawaiian market.

Research has unearthed varietal difference in the behaviour of bananas when subjected to fumigation. Thus the Cavendish varieties must be prevented from accumulating excessive concentrations of chlorophyll in the peel if the bananas are to tolerate the fumigation treatment, whereas the other varieties—Gros Michel, Apple and Cooking—do not have such a requirement. The Cavendish varieties may be readily safeguarded by covering the bunch in the field for the 2 months preceding harvest with an opaque paper or some similar material. Such shading reduces the accumulation of chlorophyll and prevents darkening of the fruit surface on fumigation. Apparently, fumigation interferes with the breakdown of chlorophyll in the ripening process if it is present in excessive amounts. For extended storage of both green and ripe, fumigated and untreated bananas, 13°C is the optimum temperature (this seems to be the only instance where green and ripe fruits have a similar storage requirement), and the optimum ripening requirement is a temperature of 21°C with *c.* 90% R.H.

Ripening in bananas is accelerated by the required ethylene dibromide fumigation, especially when they are stored under prevailing atmospheric conditions. Consequently, the possibility of using the fumigant as a ripening agent was investigated. Doses of the fumigant at levels below those required for killing insects were found to be just as effective for ripening as pure ethylene. Thus a substitute ripening agent is available when ethylene is unavailable.

Mango

Although mangoes grow well in Hawaii, shipment of the fresh fruit is not allowed because there is no approved treatment for destroying the mango seed weevil without injuring the fruit. Fumigation by ethylene dibromide eliminates any fruit-fly infestation but it is ineffective for killing the seed weevil. Gamma irradiation is effective but has not been approved as a treatment for export fruit. For extended storage, 7–13°C is the optimum temperature range; lower temperatures cause chilling injury.

Anthracnose is the most common cause of poor fruit set in mangoes. Different varieties are more or less tolerant to this disease. In Hawaii, the variety Haden, which is the major commercial variety, is very resistant and is probably more resistant to attack from fruit fly than are other varieties. In general, therefore, fruit set in this variety is heavy. Nevertheless, fruits produced in cloudy or rainy areas invariably succumb to anthracnose decay after the fruit is harvested and stored. The hot water dip treatment (at *c.* 47°C for 20 min) is effective for controlling this storage decay.

Tangerine

Hawaii does not produce tangerines in quantities sufficient for shipment and hence no disinfestation treatment has been developed for this fruit. Since the harvest season is very short (about 2 months in late fall and early winter), there is a tendency for growers to glut the market, with a consequent reduction in price. Moreover, Hawaiian tangerines are very perishable. Under ordinary storage conditions at room temperature their shelf life is only about 1 week. A storage method that would prolong the marketable life of the fruit was therefore needed. From the results of research, storage at *c.* 7°C and 92% R.H. was recommended. This permits tangerines to be stored for *c.* 6 weeks without excessive weight loss, decay or development of off-flavours—the main causes of deterioration in fruit during storage. Dowicide A dip at the same concentration as for pineapple is used routinely by growers immediately after harvest to control storage decay.

Ginger root

No disinfestation treatment is required for the shipment of fresh ginger root (rhizome). Before the advent of competition from Fijian ginger on the mainland market of the United States' West Coast, Hawaii was the major source of this crop for the Oriental population on the mainland. Currently, fresh ginger is shipped only in limited quantities from Hawaii, partly because of price competition and partly on account of decreased production resulting from field diseases and other factors. Today it is not uncommon to see foreign ginger, including some from Australia, on the shelves of supermarkets in Honolulu.

Ginger roots must be dug when they mature. If left in the ground for any extended period, they are subject to attack from insects and disease, and to discoloration and sprouting. When the shipment of this crop was substantial, growers wanted a method to keep the roots in good condition for as long as 6 months in order to prevent glutting the market and lowering the price. Ginger deteriorates in ordinary storage mainly as a result of weight loss caused by desiccation, decay, sprouting, discoloration and senescence. It was discovered at the University of Hawaii that at 13°C and 65% R.H. the rhizomes can be stored for 6 months. This condition minimizes the factors responsible for deterioration. The Hawaii State Department of Agriculture concurred with this finding after an extensive pilot experiment on conditions of storage.

Vanda orchid

Among the orchid blossoms exported from Hawaii, the Vanda orchid (*Vanda Joaquim*) contributes most to total sales. The blooms are shipped by air. Fruit fly are unable to survive on the tiny blossoms and so fumigation, which reduces the life of the blossoms, is unnecessary.

Fading is the major problem in the shipment of Vanda blossoms. It normally occurs at senescence but may happen prematurely as a consequence of pollination, disturbance of the pollinia or exposure to noxious gases such as domestic heating gases, automobile and aircraft exhaust fumes, or industrial and tobacco smoke, all of which may contain ethylene, acetylene and other related gases. Whatever the cause, as the flowers fade they produce ethylene. The Vanda flowers are among the greatest biological producers of ethylene (over 3000 ml/kg/h). If one flower in a package begins to fade, it will produce ethylene which will cause normal flowers to fade also in a few hours. Therefore the utmost care should be exercised during packing in order to avoid including in the package damaged flowers or blooms beginning to fade from other causes. In spite of the care being taken, human errors are unavoidable and shipments may be lost because of fading. An insurance against such losses is necessary.

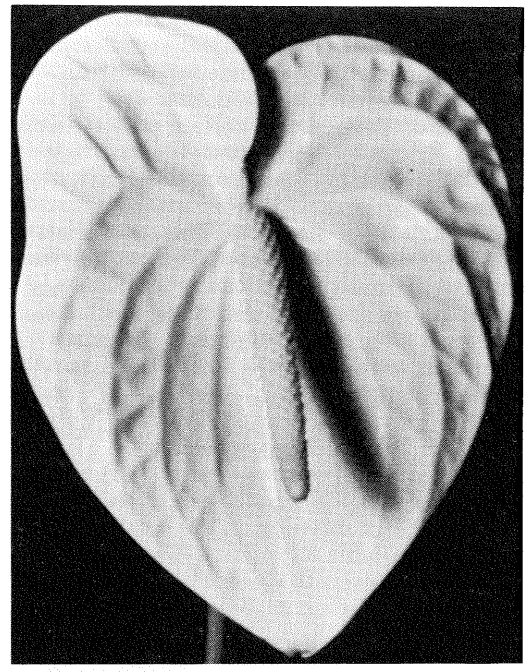
In laboratory experiments brominated charcoal, potassium permanganate and carbon dioxide were found to be effective as ethylene inactivators and therefore controlled fading. Hypobaric storage also seemed effective. The brominated charcoal method has not been adopted by the industry

because of practical difficulties including the need for very close control of the amount of bromine. Potassium permanganate incorporated in a commercial preparation called Purafil was found to be very effective for inactivating ethylene and appears to have commercial application for preventing premature fading. The other methods found effective as ethylene inactivators in the laboratory also need further experiment if they are to become of practical value. In the meantime, care in the packing operation to prevent the inclusion of damaged or fading flowers is the only commercial control measure available for preventing premature fading in Vanda orchid blossoms during shipping.

Anthurium

Flowers of anthurium (*Anthurium andraeanum*) are free from fruit-fly attack and therefore there are no restrictions on shipping them. These flowers constitute the major portion of the Hawaiian export trade in ornamentals. They are packaged in fibreboard cartons with moistened shredded newspaper and shipped by air mostly to the U.S. mainland, but some also go to foreign countries.

The vase life of cut anthurium flowers is long compared with that of other cut flowers. Provided they are packaged so that physical injury and excessive wilting are minimized during transit, anthuriums withstand shipping well. In general, the current demand for these flowers is such that almost immediately after harvest they are packaged and shipped, thereby eliminating the necessity of holding them in storage. However, with increased production from increased plantings, it is speculated that eventually the flowers will have to be held in storage for varying periods before shipment.



Anthurium (*Anthurium andraeanum*).
Photo: H. Kamemoto.

A method for maintaining the life of the flowers during this holding period was therefore desirable.

As with most cut flowers premature wilting is mainly responsible for shortening the vase life of cut anthuriums. Wilting follows when water transport is interrupted by vascular blockage of the conducting system. Such an occlusion may be caused by bacterial organisms or by accumulation of products disintegrated by enzymatic or bacterial activities in the exposed (cut) ends of the flower stems. Eliminating the blockage by cutting off a short segment of the stem tip

Production and cash value of Hawaii's main fruit and ornamental crops*

	Total production (tonnes)				Value (US$1000)				Export to U.S. mainland (tonnes)			
	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Avocados	461	344	516	460	120	113	187	184	Export very limited			
Bananas	2727	3316	3000	2812	720	773	865	856	Not exported			
Ginger root	227	234	160	360	209	354	218	481	111	139	49	209
Papaws	11 698	14 920	16 920	18 093	3423	4180	4788	5668	5118	7908	9760	10 322
Pineapples	858 929	734 670	638 528	616 760	43 900	39 600	41 100	38 500	27 256	46 735	39 246	42 793
Tangerines	252	132	159	76	83	42	58	34	Not exported			
	Total production (1000 doz.)				Value (US$1000)				Export to U.S. mainland (1000 doz.)			
	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Anthuriums	542	556	560	NA	1789	2036	NA	NA	542	556	550	519
Vandas	NA	NA	NA	NA	290	273	NA	NA	NA	NA	NA	NA

* From Department of Agriculture, Hawaii, Statistics of Hawaiian Agriculture 1975.
NA, not available.

every other day or so will maintain normal conduction of water, and the flower does not wilt until natural senescence occurs. This method, of course, is labour intensive.

Research showed that certain preservatives may be added to the water in the vase to prevent vascular blockage and forestall premature wilting without resorting to cutting the tip of the stem. These materials not only extended the vase life of cut flowers held continuously at prevailing ambient temperatures, but they also exerted beneficial carryover effects after shipment. Effective chemicals were benzoic acid (500 ppm) and sodium hypochlorite (7·3 ppm). Vase life after shipping may be extended from 1·4 to 2·7 times by placing flower stems in solutions of the recommended preparation for 5–7 days at ambient temperatures before packaging and shipping. Thus treatments are now available for holding Hawaiian anthurium flowers in storage before shipping if and when holding becomes necessary.

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Physical data on uncooked prawns

This note summarizes the physical data required by Australian fishermen and processors to calculate, for instance, freezing rates or to determine the quantity of prawns which will fill tanks of chilled sea water.

The data were obtained from measurements on four commercial species of prawns, but the results probably apply to other species as well. The species tested were: tiger prawns, *Penaeus esculentus*; eastern king prawns, *P. plebejus*; school prawns, *Metapenaeus macleayi* and greentail prawns, *M. bennettae.* (Colour illustrations of three of these species—king, tiger and greentail, the latter being formerly known as *M. mastersii*, appeared in *Food Preservation Quarterly*, Vol. 30(2), June 1970, p.23.)

Freshly caught uncooked school, king and greentail prawns were collected from Tuggerah Lakes (N.S.W.) and from the Sydney Fish Centre, Pyrmont. The prawns were packed in ice and transported to the Food Research Laboratory at Ryde. Uncooked tiger prawns and large eastern king prawns were collected in Brisbane, packed in ice and air freighted to Sydney.

Size grades

The prawns were divided into three size grades according to their count per kilogram. Large prawns were those that numbered less than 40 to the kilogram, medium prawns were those that numbered between 40 and

90 to the kilogram and small prawns were those that numbered more than 90 to the kilogram.

Measurements

Samples of at least 50 prawns of each size grade and species were used to determine: the percentage recovery on heading and shelling to 'tail', 'cutlet' and 'meat'; percentage of adhering water; the true density and the load density. Before each determination the prawns were rinsed in water and drained for 20 min on an inclined (30°) No. 16 sieve. There were no samples of the large grade from the school or greentail species.

Percentage recovery after heading and shelling

Prawn 'tails' were prepared by removing the 'head' (cephalothorax) from the 'tail' (abdomen) with scissors. Prawn 'cutlets' were made by removing the shell of the first five abdominal segments by hand from the prawn 'tail' and prawn 'meat' was prepared by removing all the shell from the prawn 'cutlet'. The prawns were weighed before and after being headed and shelled and the recovery was calculated as a percentage of the initial weight.

Percentage of adhering water

Adhering water is defined as the water which fails to drain from freshly immersed prawns after 2 min on an inclined (30°) No. 16 sieve.

The prawns were drained for 20 min and then weighed (W_1). The drained prawns were then immersed in water and tipped onto a previously weighed No. 16 sieve (W_2); the prawns were drained for 2 min. The prawns and sieve were then weighed (W_3) and the percentage of adhering water was calculated as:

$$[(W_3 - W_2 - W_1)/W_1] \times 100$$

True density

The density of each whole, uncooked prawn was calculated by dividing its weight by its volume. The weight was measured after the prawns had drained for 20 min on an inclined (30°) No. 16 sieve. The volume was measured as the difference between the weight of a cylinder of water and the weight of the same cylinder of water containing a fully immersed, freely suspended prawn. If the weight of the drained prawn is W_1, the weight of the cylinder of water is W_2, and the weight of the cylinder of water and prawn is W_3,

the density of prawn $= W_1/(W_3 - W_2)$ g/ml.

Load density

The load density is defined as the weight

Physical data of uncooked prawns

Property	Prawns		
	Large (< 40/kg)	Medium (40–90/kg)	Small (> 90/kg)
Average percentage recovery on heading and shelling to:			
'tail'	57 (2·4)[A]	60 (2·4)	64 (2·7)
'cutlet'	50 (2·5)	52 (2·3)	54 (2·5)
'meat'	46 (2·5)	48 (2·5)	50 (2·6)
Average percentage of adhering water	5·5 (0·02)	7·5 (0·04)	10 (0·14)
Average density (g/ml)		1·08 (0·011)	
Load density in water (kg/m^3)		600	
Water content[B] (%)		70	
Average freezing point[B] (°C)		−2·2	
Specific heat above freezing[B] (J/kg °K)		$3·6 \times 10^3$	
Specific heat below freezing[B] (J/kg °K)		$1·9 \times 10^3$	
Latent heat[B] (J/kg)		$2·8 \times 10^5$	

[A] Values in parentheses are the standard deviations.

[B] 'ASHRAE Handbook of Fundamentals' (1972), page 573. (American Society of Heating, Refrigerating and Air-Conditioning Engineers: New York.)

of prawns which may be randomly packed into a water-filled container so that the water may move freely among the prawns. The load density was measured by means of a perforated plastic box with dimensions $0{\cdot}6\,m \times 0{\cdot}4\,m \times 0{\cdot}3\,m$ ($0{\cdot}072\,m^3$). The box was immersed in water, and then removed and allowed to drain for 20 min and weighed (W_1). It was then filled with drained prawns and immersed in water to ensure that the prawns were packed so that water could just move freely past them. The box and prawns were removed and drained for 20 min and weighed (W_2). The load density = $(W_2 - W_1)/0{\cdot}072\,kg/m^3$.

Results

The results of these measurements and other appropriate data on the physical properties of uncooked prawns are given in the accompanying table. No differences were noted between the species for any of the properties measured, but differences were found for the different grades of prawn for percentage recovery on heading and shelling and percentage of adhering water.

Acknowledgment

This research was financed by a grant from the Fishing Industry Research Trust Account.

JUDITH H. RUELLO

News from the Division

Obituary

Edward Felix Lucien John Anet, 1925–1976

Dr E. F. L. J. Anet was born in Doulcon, France, in 1925 and died suddenly at his home in Lindfield, N.S.W., on 27 December 1976.

Ted Anet joined CSIRO in June 1950 when he was awarded a post-graduate studentship to work for his Ph.D. degree in Lord Todd's laboratory at Cambridge. His scholastic and academic career had been brilliant, first at Sydney Boys' High and then at Sydney University, and he obtained his Ph.D. degree in the shortest time possible, returning to Sydney in October 1952 to join the Division as a Research Officer. Here his interest in the chemistry of natural products, built up at Sydney University in the Hughes-Ritchie school, was maintained by his location in Dr Thelma Reynold's team to work on the chemistry of the non-enzymic browning reaction.

On this project, after initial work on the identification of natural fruit acids, Ted was assigned the task of isolating and identifying the degradation products of carbohydrates believed to be intermediates in the development of brown pigments when sugars are heated with amino acids. In this difficult sphere of carbohydrate chemistry, his experimental work was of an exceptionally high order and, coupled with an acute appreciation of its theoretical aspects, led to significant advances in our understanding of the browning reaction. This work yielded 34 papers in 16 years which, together with four 'outside' papers in this period and eight papers from his university studies, gave Ted an enviable record of 46 research papers in less than 20 years. At the same time, he built up an international reputation as a carbohydrate chemist, resulting in invitations to give talks overseas, prepare reviews, and act as Australian representative on the Editorial Board of the journal *Carbohydrate Research*.

When it was decided to cease the Division's work on the browning reaction, Ted was assigned to take over the late Dr F. E. Hueln's work on the involvement of farnesene in the superficial scald of apples, together with Ili Coggiola, whose sudden death at the early age of 37 preceded Ted's by only four years. This collaboration produced six papers over the period 1969–1972 inclusive until it became apparent that a greater understanding of the physiology of this storage disorder would be required before chemical studies could make a further significant contribution.

With the cessation of the farnesene work, Ted was called upon to investigate the possible usefulness of antioxidants in foodstuffs, the presence of ascorbic acid sulphate in foods, the development of off-flavours in cooked 'polyunsaturated' mutton, and most recently the occurrence in foods of certain amines implicated in migraine. These studies resulted in two publications before Ted's untimely death.

Though regarded as something of a 'loner' in his own research work, Ted was always ready, willing and able to assist his colleagues on the staff with any problems in organic chemistry they might encounter. Thus, though he preferred to work in a narrow, well-defined field, his chemical interests were very broad, and many of his colleagues will remember his willingness to discuss a hypothesis with them and to suggest a new path through their difficulties. His acute brain allowed him to sum up an argument rapidly and to give considered advice that was short and to the point—propounders of unsound or illogical hypotheses found him a severe critic. As a result of such discussions, many of his co-workers were saved the trouble of needless experimentation.

Ted was always willing to employ the latest developments in techniques and instrumentation, his recent interest in electronics allowing him to modify equipment to suit his purposes. In the complex modern fields of conformational analysis and n.m.r. spectroscopy he was a reservoir of information, and his passionate interest in chemical nomenclature and journalistic style was of great assistance to authors compiling manuscripts.

Ted was very much 'a family man'; he met his wife Jennifer when she was employed by the Division at Homebush, and he left one son and three daughters, aged between 13 and 18. His spare time was devoted to fishing and electronics, two activities which greatly broadened his circle of friends within the Division. He will be sadly missed by his family and colleagues; his published work stands as his memorial.

B.V.C.

Congresses

The Fifth International Congress of Food Science and Technology, hosted by the Union of International Food Science and Technology of Japan and sponsored by the Union of International Food Science and Technology, will be held at the Kyoto International Conference Hall, Kyoto, Japan, from 17 to 22 September 1978. The Congress will be a major meeting of professionals for the international exchange of ideas and experience in those scientific disciplines and technology relating to the production, processing, distribution conservation, and utilization of food for adequate nutrition, and related concerns. The steering committee and the program committee are already actively working on plans for the Congress to encompass and call public attention to major progress made in the field of food science and technology since the previous Congress, and to provide opportunity to meet, exchange ideas, obtain stimulation for further work and promote world-wide collaboration on topics of great importance.

For further information and preliminary registration blanks, please write to: Secretariat, Fifth International Congress of Food Science and Technology, c/o Nippon Italy Kyoto-Kaikan, Sakyo-ku, Kyoto, 606 Japan.

The 20th International Horticultural Congress will be held in Sydney from 15 to 23 August 1978, under the direction of the International Society for Horticultural Science. It will also have the support of the Commonwealth and State Governments of Australia, and of the Australian horticultural industries.

The main purpose of the Congress is to facilitate exchange of information in all spheres of horticulture. The Congress is open to all. It will cater for technologists, scientists, practising horticulturists, extension specialists and research workers.

Further information may be obtained from the Secretary, 20th International Horticultural Congress, 157 Liverpool Street, Sydney, 2000, who will also enter names on a mailing list for subsequent information on the Congress.

Visiting workers

Associate Professor E. C. Tigchelaar of the Department of Horticulture, Purdue University, Lafayette, Indiana, is spending the period from October 1976 to May 1977 at FRL, as a Visiting Scientist in PPU. He and Dr W. B. McGlasson are collaborating in a study of the physiology of ripening mutants of tomatoes.

Dr Christa Critchley, formerly of the

Botany Institute of the University of Düsseldorf, Germany, joined PPU for eight months from October 1976 as a Visiting Scientist. Her interests are in temperature regulation and plant growth and development, and in plant growth and chloroplast development.

Professor T. A. Nickerson, Department of Food Science and Technology, University of California, Davis, spent three months from November 1976 at DRL. Professor Nickerson, who is well known for his work on lactose, participated in current studies of lactose crystallization in the whey utilization research program.

Jubilee year seminar

As part of the activities to celebrate the 50th Anniversary of CSIRO, the Division held a seminar entitled 'Science and Technology of Food Preservation by Cold', in September 1976 at North Ryde. Among those invited was a number of distinguished overseas scientists who had come to Australia to attend a joint meeting in Melbourne of the Food Sciences, Refrigeration and Air Conditioning Commissions of the International Institute of Refrigeration.

Appointments

Dr B. A. Cornell was appointed Research Scientist and commenced work in FRL's Physics Section in November 1976. He is studying the physical properties of simple lipid–water–protein systems to elucidate the structure of natural lipid–protein complexes. The project aims at an understanding of the fundamental processes that cause irreversible changes during freezing, drying and heat treatments of foods. Dr Cornell holds B.Sc. and Ph.D. degrees from Monash University and recently spent a year at the University of London under a CSIRO Postdoctoral Studentship.

Miss P. L. Conway, B.Sc., was appointed as an Experimental Officer to work in FRL's Microbiology Section on spore morphology and on the microflora of the human gut. Miss Conway had previously completed an assignment at MRL concerned with the use of microbes from ruminant paunches as inocula for fermentation systems.

Dr C. R. Timms has joined DRL to undertake a research program on the physical and chemical structure of butterfat and of blends of butterfat with other edible fats and oils. After completing his M.A. and Ph.D. degrees at Cambridge, Dr Timms worked for several years on lipid research in industry in Britain.

Miss Helen Dornom has been appointed Information and Liaison Officer at DRL. Miss Dornom graduated in Agricultural Science from the University of Melbourne and has recently completed studies for a Master's degree.

Mr D. T. Kerr, Experimental Officer, was appointed to the Process Development Group, MRL in December 1976, to work on the investigation and practical implementation of new meat processing techniques. Mr Kerr has a degree in Mechanical Engineering from Caulfield Technical College. He was previously employed by M.W.M. Diesel Pty Ltd.

Mr P. Pisansarakit, Experimental Officer, was appointed by the CSIRO Division of Animal Production to the Muscle Growth and Development Section, MRL in December 1976, to work on the preparation of histological sections of muscle and to operate image analysis equipment. He has the degree of Bachelor of Rural Science and was previously a lecturer at Khon Kaen University in Thailand.

Mrs V. Miller, Experimental Officer, resigned from her position with the Biochemistry Section, MRL.

Mr R. D. Redford, Experimental Officer, resigned from his position with the Process Investigation Section, MRL.

General

A joint AIFST/ASM/CSIRO Symposium on 'Food-borne microorganisms and public health' was held at FRL on 13 August 1976. The guest of honour was Miss Betty Hobbs, recently retired Director of the Central Public Health Laboratory, Colindale, London.

AIFST/ASDT/AIP sponsored a seminar on 'Aseptic packaging' at North Ryde on 24 November 1976. More than 100 persons from the three institutes attended.

FRL welcomed a number of high school students for brief periods of 'job experience' late in 1976, under a scheme devised by the New South Wales Department of Education.

Because News from the Division in this issue covers the period since Vol. 36, No. 2 of the *Quarterly*, details of overseas travel and some other items have been omitted to conserve space.