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Vitamins in Foods—occurrence,

THE vitamins are organic substances which, although indispensable in nutrition, are required in much smaller quantities than the major food constituents such as carbohydrates, fats, and proteins. Whereas the latter are major components of plant and animal tissues, and important sources of energy, the vitamins are generally minor components and play in many cases a catalytic role. A number of the water-soluble vitamins have been found to be constituents of enzyme systems.

The food technologist must have a broad knowledge of vitamins if he is to ensure that all foods reputed to be important sources of a particular vitamin contain it in adequate concentration. The stability of vitamins under varying conditions should also be studied, so that loss during processing may be reduced to a minimum.

CHEMICAL CONSTITUTION

The known vitamins are listed in the table below. They are divided into two groups: (1) water-soluble and (2) fat-soluble.

Water-soluble Vitamins

The structure of vitamin C (ascorbic acid) is shown in the figure on p. 23. This vitamin

Source, Function, and Daily Requirement of Vitamins

Vitamin	Metabolic Function	Major Source	Daily Requirement (mg)
(1) Water-soluble			
C	—	Fruits, vegetables	75
B_1	Co-carboxylase	Yeast, cereals, legumes, pork	1·5
B_2	Diaphorase, amino acid oxidase	Yeast, cereals, meat, fish, milk, eggs	1·6
Nicotinic acid	Coenzymes I and II	Yeast, meat, fish, cereals, legumes	15
B_6	Transaminase, tryptophan synthesis	Yeast, cereals, meat, fish	1·5
Pantothenic acid	Coenzyme A	Yeast, meat, fish, cereals, green vegetables	5
Choline	Lipids, methylation, acetylcholine	Cereals, meat, fish	500
Inositol	Lipids	Yeast, cereals, fruit, brain	1000
Biotin	—	Egg yolk, liver, kidney, yeast	0·2
Folic acid	Purine and pyrimidine synthesis	Liver, kidney, yeast, leafy veg.	1
B_{12}	Syntheses involving single carbon units	Liver, kidney, oysters	0·001
(2) Fat-soluble			
A	Rhodopsin	Liver oils, fruits, vegetables	1·5
D	—	Liver oils, eggs, fish	0·01*
E	Antioxidant, terminal respiratory chain	Vegetable oils, butter, eggs, green vegetables	20
K	Prothrombin formation	Leafy vegetables	1
Essential fatty acids	Lipids	Vegetable and animal fats	2500

*For children.

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structure, and function

contains the enediol group, —COH = COH—, and is readily oxidized by atmospheric oxygen to the corresponding dicarbonyl compound, —CO—CO—, in the presence of cupric ions or enzymes. The oxidized form (dehydroascorbic acid) is still biologically active, but is rapidly hydrolysed with opening of the lactone ring to give an inactive open chain compound (diketogulonic acid). At high pH further degradation occurs. In the absence of oxygen ascorbic acid undergoes a slow anaerobic decomposition to carbon dioxide and residual products which have not been fully identified.

The 10 vitamins which follow vitamin C in the table belong to the group which was originally called vitamin B (shown subsequently to be a complex mixture). Vitamin B_1 (thiamin, aneurin), as shown in the figure, contains pyrimidine and thiazole rings linked by a methylene bridge. The molecule can be split by heat or thiaminase into the pyrimidine and thiazole portions. Evidence for this degradation is provided by the fact that the products can still be utilized by microorganisms which need only one half of the complete molecule. Vitamin B_2 (riboflavin), as shown in the figure, contains the *iso*alloxazine ring system. Thermal decomposition breaks ring 3, leaving a derivative of quinoxaline, which has only rings 1 and 2.

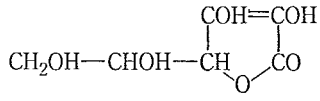
Nicotinic acid (niacin) is pyridine-3-carboxylic acid. Vitamin B_6 (pyridoxin) is 2-methyl-3-hydroxy-4, 5-di (hydroxymethyl)-pyridine. Both these vitamins are relatively stable. Pantothenic acid, $CH_2OH—C(CH_3)_2—CHOH—CO—NH—CH_2—CH_2—COOH$, contains a peptide bond which is split in thermal decomposition to give pantoic acid, $CH_2OH—C(CH_3)_2—CHOH—COOH$, and β-alanine, $NH_2—CH_2—CH_2—COOH$. Other B vitamins are choline, $CH_2OH—CH_2—N(CH_3)_3OH$, inositol, $C_6H_6(OH)_6$ (a derivative of *cyclo*hexane), and biotin, $C_5H_7ON_2S—(CH_2)_4—COOH$. The biotin nucleus contains two condensed rings. This vitamin appears to be fairly readily oxidized, but the nature of the reaction is unknown.

Folic acid (pteroylglutamic acid) has the formula $C_6H_4ON_5—CH_2—NH—C_6H_4—CO—NH—CH(COOH)—CH_2—CH_2—COOH$. It is a peptide of glutamic acid and *p*-aminobenzoic acid linked to a pteridine nucleus through a methylene bridge. It can be split into *p*-aminobenzoylglutamic acid and a number of pteridine derivatives. The most recently characterized vitamin, B_{12} (cyanocobalamin), has the formula $C_{63}H_{88}O_{14}N_{14}PCo$. The central cobalt atom is linked to five heterocyclic rings.

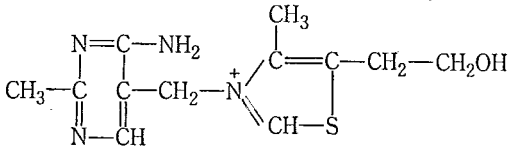
Fat-soluble Vitamins

Vitamin A has the formula $C_{20}H_{30}O$. It is a diterpene alcohol with five conjugated double bonds, and is subject to oxidative

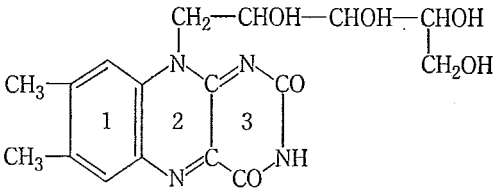
Vitamin C (Ascorbic Acid)



Vitamin B1 (Thiamin, Aneurin)



Vitamin B2 (Riboflavin)



Structure of the vitamins C, B_1, and B_2.

changes which are similar to those of other poly-unsaturated substances. The vitamin A requirement is also met by the carotenes (provitamin A) in which half the molecule corresponds to vitamin A and is converted to it in the intestinal wall.

Vitamin D activity is possessed by at least two closely related substances. One is derived from 7-dehydrocholesterol, $C_{27}H_{44}O$, and the other from ergosterol, $C_{28}H_{44}O$, by irradiation.

The substance with the highest vitamin E activity is known as α-tocopherol, $C_{29}H_{50}O_2$, which has methyl groups in the 5-, 7-, and 8-positions on the chroman nucleus. The other tocopherols have methyl groups in only one or two of these positions, and they are not equal to α-tocopherol in biological activity.

A number of substances with vitamin K activity are known. The natural vitamin from plant sources has the formula $C_{31}H_{46}O_2$ and is 2-methyl 3-phytyl naphthaquinone. The vitamin synthesized by the intestinal bacteria contains the difarnesyl in place of the phytyl group. The synthetic 2-methyl naphthaquinone is just as effective.

Fats are sources not only of energy but also of certain essential fatty acids, for which there is a minimum requirement. These acids all have the general formula $R_1—CH=CH—CH_2—CH=CH—R_2—COOH$, and the requirement is met mainly by linoleic, linolenic, and arachidonic acids. They are subject to atmospheric oxidation with initial formation of hydroperoxides, which interact further to give a variety of decomposition products.

METABOLIC FUNCTION

The metabolic function of the different vitamins, if it is known, is given in the table. The metabolic function of vitamin C is still not understood. Although it can play a part in certain enzyme systems, it is replaceable by other enediol compounds which have no antiscorbutic activity. The next five vitamins in the table are components of coenzymes or prosthetic groups which play an essential role in metabolism. Choline is a component of structural lipids and the acetylcholine liberated by nerve endings, and also functions as a methyl donor. Inositol is a constituent of brain lipids. Views on the metabolic function of folic acid and vitamin B_{12} are at present tentative. They both function in some way in blood formation.

The metabolic functions of vitamin A, particularly in relation to growth, are not generally understood, but it is known to be a component of the pigment rhodopsin, which functions in night vision.

Vitamin E is known to stabilize fats against oxidation, and it is probable that at least one of its functions in the living organism is related to this. Recent evidence indicates that it is a co-factor in the terminal respiratory chain. Vitamin K appears to be essential to the formation of prothrombin, one of the many factors involved in the clotting of blood. The essential fatty acids probably provide essential groups in the structural lipids.

OCCURRENCE

The major sources of each vitamin are given in the table. Yeast is an important source of practically all the B vitamins, and liver oils of vitamins A and D. Wheat germ oil is a particularly rich source of vitamin E.

DAILY REQUIREMENT

The amounts of vitamins required daily by adults is set out in the table. Many of the figures are only approximate, as they cannot be estimated with certainty. Biotin, vitamin B_{12}, and vitamin K are synthesized by the intestinal bacteria, and symptoms of deficiency are comparatively rare. The estimated requirement is based largely on curative doses. No requirement of vitamin D can be estimated for adults, as sufficient for normal maintenance (as distinct from growth) seems to be synthesized in the skin by irradiation. The value for vitamin E is simply based on average intake, as no deficiency symptoms have been observed in man.

The daily requirement varies enormously among the different vitamins, and it is apparent that the division between vitamins and major food constituents is arbitrary. The higher figures are of the same order as those for the essential amino acid constituents of proteins.

CORRIGENDUM

VOLUME 18, NUMBER 1

Page 18, paragraph headed "Determination of Iron", second sentence: *For* glycine *read* glycin.

THE LABORATORY EXAMINATION OF CANNED FOODS—XV*

Dissolved Copper and Lead

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COPPER CONTAMINATION

Copper contamination in canned foods may arise from copper processing equipment or from residues of copper-containing pesticides on the raw materials.

Copper is nutritionally essential in small amounts but in excessive concentrations it may irritate the digestive system (Monier-Williams 1949; Tanner and Tanner 1953). It is not, however, generally regarded as a toxic metal and statutory limits are not commonly laid down. Nevertheless in Britain a statutory limit of 20 p.p.m. on a whole wet basis has been prescribed for the copper content of tomato sauce (Anon. 1957), and a limit of 100 p.p.m. in the dried tomato solids has been recommended for the copper content of tomato juice, paste, and powder (Food Standards Committee 1956). In the Pure Foods Acts of the Australian States, the addition of copper compounds to foods is prohibited but no limits for copper content are prescribed.

Apart from any direct effect on the consumer, the presence of copper may adversely affect the quality of canned foods in a number of ways. Reaction between copper and sulphide ions, derived from proteins, to form copper sulphide has been responsible for black discolorations in a variety of canned foods, e.g. corned beef (Kefford and Murrell 1955), fish (Vesterhus 1949), and vegetables. "First-run black", a grey discoloration of canned sweet corn caused by copper taken up from processing equipment, has long been known to canners (Huelsen 1954). In a recent case investigated in the C.S.I.R.O. laboratories at Homebush, corn showing the characteristic blue-grey discoloration contained 4·8 p.p.m. of copper (wet basis), while normal samples from the same cannery contained 0·7 p.p.m. A similar discoloration has been described in canned peas (Bitting 1937; Adam and Dickinson 1943; Norton 1951). Again, in a case recently encountered, peas discoloured almost black contained 19 p.p.m. of copper while peas normal in colour contained 3·4 p.p.m.

Copper salts were formerly added to canned peas and other vegetables in order to stabilize the green colour by the formation of copper chlorophyllin. This practice is no longer permissible in most countries, but the colour of pickled gherkins (cucumbers) is still commonly "fixed" by boiling in an acid liquor in copper pans. Some deep green gherkins recently analysed showed copper contents of 13–14 p.p.m.

Copper ions catalyse a number of deteriorative reactions in foods, e.g. ascorbic acid destruction (Robinson *et al.* 1947), the oxidation and condensation of phenolic substances in apple juice leading to clouding and sedimentation (Kieser, Pollard, and Timberlake 1957), and the oxidation of fat in dairy products. Commonwealth Food Specifications (1952) prescribe a copper content not greater than 0·15 p.p.m. for canned butter concentrate.

It should be noted that copper in solution in canned foods "plates out" on the can, i.e. it is displaced from solution by tin. Therefore analyses of canned foods after storage do not give a true indication of the initial copper content (Robinson *et al.* 1947).

Lapin and Priev (1957) have reported on the copper content of a number of European canned foods.

*Earlier articles in this series appeared in *C.S.I.R.O. Food Preservation Quarterly*, Vol. 13 (1953), pp. 3–8, 21–31; Vol. 14 (1954), pp. 8–18, 26–31, 46–52, 74–6; Vol. 15 (1955), pp. 28–32, 52–7, 72–7; Vol. 16 (1956), pp. 7–10; Vol. 17 (1957), pp. 11–14, 30–5, 42–7; and Vol. 18 (1958), pp. 15–19.

LEAD CONTAMINATION

Lead metal is present in tinplate cans as a constituent of solder. In a properly made open-top can no solder from the side seam, apart from occasional "splashes", should come in contact with the contents; but in older types of can with soldered end-seams there may be some extrusion of solder within the can. In the beer can a fillet of solder deliberately admitted to protect and strengthen the side-seam is adequately protected by lacquering. However, the amounts of lead picked up by canned foods in contact with solder are minute, even when the solder contains 98 per cent. lead (Emanuele and Ceccherelli 1951; Kawashiro, Fujii, and Harada 1955; Oda and Iwamoto 1956).

Lead is a serious cumulative poison (Monier-Williams 1949, Tanner and Tanner 1953) and low maximum limits for the lead content of foods are laid down. For instance, the N.S.W. Pure Food Act (1908) prescribes 10 p.p.m. as the maximum limit for lead content in canned meats, and 4·2 in other canned foods. In Britain, maximum limits recommended by the Food Standards Committee (1954) are 5 p.p.m. in canned meats and fish, 1 p.p.m. in fruit and vegetable juices, and 2 p.p.m. in other canned foods.

Dick and Pugsley (1950) and Larkin *et al.* (1954) have surveyed the lead content, and also the zinc, copper, tin, iron, and arsenic contents of a range of Canadian canned foods. Cheftel and Panouse-Pigeaud (1938) investigated the lead content of canned sardines.

Like iron and copper, lead forms a black sulphide which may be responsible for discoloration of canned foods. Kefford and Murrell (1955) describe a case of black discoloration in sweet corn which was attributed to lead derived from the can lacquer.

ANALYTICAL PROCEDURES

When it is desired to determine several metals in a canned food, spectrographic analysis offers great advantages, notably in rapidity and economy of sample. Gehrke, Runyon, and Pickett (1954) used a spectrographic method to determine copper, lead, tin, and iron in canned evaporated milk. Kefford and Murrell (1955) have indicated that even semi-quantitative spectrographic analyses may be very useful in investigations of metallic contamination. Spectrographic apparatus, however, is rarely available in canning laboratories and therefore metals must usually be estimated by wet analysis.

Digestion of the sample to destroy organic matter has already been discussed in Part XIV of this series (Kefford 1958). Alternative treatments specifically investigated with reference to the determination of lead and copper in foods are described by Greenblau and Van der Westhuyzen (1956) and Abson and Lipscomb (1957).

Estimation of Copper

Polhill (1956*b*) has reviewed methods for the determination of copper in foods.

In the digests from samples of canned foods, copper may usually be determined colorimetrically without preliminary separation from interfering ions. The chromogenic reagent commonly used is sodium diethyldithiocarbamate, which reacts in neutral or alkaline solution to form a yellow-brown colloidal solution of the copper salt. This reagent is not specific for copper, and interference may be expected from iron, cobalt, nickel, and bismuth. However, interference by iron is avoided by adding pyrophosphate; the other metals are unlikely to be present in canned foods. The precipitation of alkaline earth phosphates is prevented by the addition of citrate. Copper diethyldithiocarbamate is soluble in organic solvents and is extracted from the aqueous solution in carbon tetrachloride for the colorimetric measurement (cf. Association of Official Agricultural Chemists 1955*a*).

In the C.S.I.R.O. laboratories at Homebush the following simple procedure has been used for the estimation of copper in canned foods.

Reagents:

Citric acid: 10 per cent. solution.

Sodium pyrophosphate: 5 per cent. solution.

Ammonium hydroxide: concentrated.

Sodium diethyldithiocarbamate: 1 per cent. solution, filtered.

Copper sulphate, stock solution (1 mg copper per ml): 3·9280 g $CuSO_4.5H_2O$ dissolved in distilled water, 10 ml concentrated sulphuric acid added, and made up to 1 litre.

Carbon tetrachloride: redistilled.

Procedure: Pipette into a small Pyrex separating funnel an aliquot of the digest containing 30–50 μg of copper. Add 10 ml citric acid solution, 5 ml sodium pyrophosphate solution, and concentrated ammonium hydroxide until ammoniacal in odour. Allow to cool and add 1 ml sodium diethyldithiocarbamate solution. Extract three times with 5-ml portions of carbon tetrachloride, running the solvent layers into a 25-ml volumetric flask. Make up to 25 ml with carbon tetrachloride and determine the optical density at 440 mμ in 4-cm cells in a photoelectric colorimeter, using carbon tetrachloride for the "solvent blank". Estimate the copper content from a calibration curve prepared as follows: Take 10 ml of the stock solution of copper sulphate, add 10 ml concentrated sulphuric acid, and make up to 1 litre. Pipette a series of aliquots, in the range 0–10 ml, of the diluted stock solution into separating funnels, add to each 2 ml of concentrated sulphuric acid, and make up to 10 ml with water. These solutions will then contain approximately the same amount of sulphuric acid as a 10-ml aliquot of the digest. Proceed with the method as outlined and plot the optical densities against copper concentrations to obtain the calibration curve.

Finally, determine a "reagent blank" by estimating the copper content of a blank digest and deduct it from the copper content found to obtain the true copper content of the sample. The reagent blank should not exceed 0·25 p.p.m. of copper.

It should be noted that dilute solutions of copper salts lose copper by precipitation on glass surfaces unless free acid is present. Further, solutions of copper diethyldithiocarbamate in organic solvents are bleached by the action of light and therefore the optical densities should be measured promptly.

Other Methods

A considerable number of colorimetric reagents have been suggested for the estimation of copper. Among these, zinc dibenzyldithiocarbamate has the advantage that it may be used to extract copper from acid solutions (Abbott and Polhill 1954; Andrus 1955). With this reagent it is possible to determine copper directly in cider without preliminary destruction of organic matter (Timberlake 1954). Another reagent recently studied is bathocupreine, a substituted phenanthroline (Borchardt and Butler 1957).

A satisfactory polarographic determination of copper in beverages has been claimed by Tanner and Rentschler (1955) using an ethylenediamine electrolyte.

Estimation of Lead

Polhill (1956*a*) has also reviewed methods for the determination of lead in foods.

The most widely used reagent for the estimation of small amounts of lead is dithizone (diphenylthiocarbazone). The lead dithizonate, which is formed in alkaline solution, gives a red solution in organic solvents. Lead may be separated from most other metals by extraction of the dithizonate with chloroform or carbon tetrachloride from ammoniacal solution in the presence of citrate and cyanide. The addition of sodium hexametaphosphate prevents the precipitation of alkaline earth phosphates which might adsorb lead, and permits a straighforward dithizone separation (Johnson and Polhill 1955). Lead is then estimated by colorimetric measurements on the dithizonate solution. In the presence of excess dithizone, a "mixed-colour" procedure may be used (Association of Official Agricultural Chemists 1955*b*) or the reversion technique of Irving and Butler (1953) (cf. Porretta, Capuano, and Cultrera 1956). "One-colour" methods in which excess dithizone is absent are described by Johnson and Polhill (1955) and Gage (1955).

Interference may be expected from bismuth, thallium, and stannous tin; the first two metals are unlikely to be present in canned foods and the tin in the digest may be regarded as being entirely in the stannic form. Gage (1955, 1957) separated lead from interfering metals by extraction as the diethyldithiocarbamate, while Johnson and Polhill (1957) used an anion-exchange resin for this purpose.

Where the apparatus is available, the method of Ferrett, Milner, and Smales (1954), using the square-wave polarograph, permits a rapid determination of lead in foods at concentrations down to less than 1 p.p.m.

Critical comments on the procedures described in this article, and suggestions for modified or alternative methods found to be useful in practice, will be welcomed.

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Rock Melon in Canned Fruit Salads

By D. J. Casimir

Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

Investigations by C.S.I.R.O. have shown that rock melon may be used as a substitute for papaw in canned fruit salads, provided the pH of the pack is sufficiently low.

THE market for rock melons in Australia is at times over-supplied, consequently growers have sought means of disposing of the surplus. Canners, for their part, have been attracted by the possibility of using rock melon as an economical substitute for papaw in fruit salads. The associated technical problems have been investigated by officers of the C.S.I.R.O. Division of Food Preservation and Transport, Homebush. The variety of rock melon used in the tests was the green netted-skin musk melon (*Cucumis melo* L. var. *reticulatus*). The papaw referred to is *Carica papaya* L.

Preliminary investigations showed that mature rock melons have a high pH value. Since canned products can be adequately processed at a temperature of 212°F only if their pH is less than 4 (approximately), it was necessary to blend the rock melon with an acid fruit, or add a suitable acid to the pack. To begin with, pineapple was chosen as the second major component of the fruit salad. It was blended with the rock melon in the proportions shown in Table 1, and the "cut-out" (equilibrium) pH of the various

TABLE 1
pH of Pineapple–Rock Melon Blends

Composition		pH of Blended Sample
Pineapple (%)	Rock Melon (%)	
0	100	6·6
20	80	5·6
40	60	4·9
50	50	4·7
60	40	4·4
80	20	4·2
100	0	3·9

blends determined. The pH values in the table show that the rock melon content cannot exceed 20 per cent. if the fruit salad is to be processed at 212°F. Tasters, however, indicated a preference for blends containing 40 and 50 per cent. The pH of these packs was brought down to 4·1 by adding citric acid in quantities determined by potentiometric titration. Other fruits, including banana and passion fruit, were incorporated in the preliminary tests, but only fruit salads containing pineapple and rock melon, with or without banana, were canned for tasting tests and corrosion studies.

CANNING PROCEDURE

- *Washing.*—The fruits were brush washed under water sprays.
- *Peeling and Trimming.*—The rock melons were peeled and seeded, and the pineapples peeled and cored.
- *Dicing.*—Both rock melons and pineapples were diced by hand into approximately $\frac{1}{2}$-in. cubes.
- *Compounding.*—The fruit was weighed in the proportions shown in Table 2 and mixed in bulk.
- *Filling.*—10 oz of the fruit mixture was filled into 301 × 411 plain cans, and boiling syrup of the composition shown in Table 2 added.

TABLE 2

Fill and Syrup Compositions of Fruit Salad, with Resultant pH, and "Cut-out" Brix

Pack	Fill Composition	Syrup Composition	Equilibration Values	
			pH	Brix
1	40% Pineapple 40% Rock Melon 20% Banana	0·17% Citric acid and 40°B	4·2	24°B
2	40% Pineapple 60% Rock Melon	0·6% Citric acid and 40°B	4·1	27°B
3	60% Pineapple 40% Rock Melon	0·1% Citric acid and 40°B	4·2	26°B

- *Closing and Processing.*—The cans were steamflow closed, processed for 15 min in boiling water, and water-cooled to 98°F.

EVALUATION OF THE PACKS

After standing for 1 week at room temperature for equilibration the three packs were examined by a panel of 45 tasters who rated them on an hedonic (preference) scale. No significant differences were noted but some members of the panel commented that all three packs were too sweet, especially those without banana. This observation was confirmed by the determination of "cut-out" Brix. The values of the latter, and of pH after equilibration, are given in Table 2. The syrup of the pack containing banana was slightly turbid, but in other packs it was clear.

To evaluate the shelf life of the three packs, some of the cans were stored for 20 weeks at room temperature, and others for 20 weeks at 100°F. At the end of the period samples were examined for corrosion, and the amounts of tin and iron in the contents were determined. The results are set out in Table 3.

The interior of cans stored at room temperature showed moderate to light feathering of the tinplate in all packs. Storage at 100°F produced moderate feathering in all packs. Small areas were stripped of tin by Pack 3 (40 per cent. rock melon and 0·1 per cent. citric acid) and large areas by Pack 2 (60 per cent. rock melon and 0·6 per cent. citric acid). The extent of the corrosion was confirmed by the tin content of the two packs at the end of the storage period (see Table 3). The pack containing the higher proportion of rock melon, and consequently the greater percentage of citric acid, had the higher tin content.

Table 3 also summarizes the preferences of the tasting panels for the various packs. The tasting tests were carried out on replicate samples (1) after processing, (2) after 20 weeks at room temperature, and (3) after 20 weeks at 100°F. The hedonic scale used ranged from 1 (dislike extremely) to 9 (like extremely).

CONCLUSIONS

Rock melon is a readily handled and satisfactory component of canned fruit salad,

TABLE 3

Effect of Storage on Tin and Iron Content of Fruit Salad, and on Hedonic Ratings

	Pack		
	1	2	3
Tin Content (p.p.m.)			
20 weeks at room temp.	71	64	37
20 weeks at 100°F	124	158	114
Iron Content (p.p.m.)			
20 weeks at room temp.	4·3	3·8	4·4
20 weeks at 100°F	3·4	4·7	3·2
Hedonic Ratings			
After equilibration	6·6	6·6	7·0
20 weeks at room temp.	6·3	6·7	7·9
20 weeks at 100°F	6·1	5·1	6·7
Tasters' comments on samples stored for 20 weeks at 100°F	Slightly darkened, particularly the banana. Syrup turbid. Flavour of banana dominant.	Dark appearance, slightly burnt flavour. Texture of rock melon considerably softened.	Appearance not distinguishable from sample stored at room temperatures.

provided that the pH of the pack is lowered by the addition of citric or other suitable acid.

Packs which contain a relatively small percentage of rock melon, and which are therefore artificially acidified to a less extent, retain their appearance and flavour better, and cause less corrosion of the tinplate. Nevertheless corrosion is more severe than with most fruit products.

The shelf life of the packs should exceed 2 years under normal conditions, since 20 weeks at 100°F is equivalent to 15–20 months at normal atmospheric temperatures.

ACKNOWLEDGMENT

The tasting tests were carried out in the taste test laboratory of the Division of Food Preservation and Transport, under the direction of Miss E. M. Christie, whose help is gratefully acknowledged.

Ripening of Honeydew Melons

By E. G. Hall
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and
K. J. Scott
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THE honeydew is a dessert melon of the musk melon group (*Cucumis melo* L.). It has been grown for many years in California, U.S.A., and for quite a long time in Australia, but it has never become popular. It is a comparatively large, smooth melon with a nearly white skin and a thick, pale green flesh. When the fruit is ripe the skin is creamy yellow and the flesh sweet, full-flavoured, and very juicy, and, if ripened in the proper manner, of excellent quality. The honeydew is resistant to decay and to damage during transport, and keeps well in storage. Its lack of popularity in America has been mainly due to the fact that most melons left to ripen naturally are unattractive.

H. K. Pratt, working at the University of California, Davis, U.S.A., investigated the ripening of honeydew melons. He showed (personal communication 1956) that those grown in California almost invariably failed to ripen naturally, but ripened well to fine quality when treated with ethylene gas, which has long been known as a stimulator of ripening processes in some fruits. Honeydew melons are grown to a small but decreasing extent in the Murrumbidgee Irrigation Area of New South Wales. It was suspected that the poor acceptance of the melons by consumers was due to their frequent failure to ripen well. An experiment was therefore carried out in 1957 to test the reaction of Australian honeydew melons to ethylene.

ACCOUNT OF TRIALS

In the 1957 experiments melons were picked in the Murrrumbidgee Irrigation Area on April 6 at a stage of maturity customarily chosen for melons destined for the markets in Brisbane (Qld.). According to the grower, this stage is indicated by the development of slight "springiness" at the blossom end, and the start of the disappearance of the green colour from the skin, also at the blossom end. The outer layers of the skin become creamy white and somewhat tranclucent, allowing the green colour below to show through as more or less water-soaked areas. The changes in skin colour during growth and maturation on the vine are small; at all stages the skin is mainly white in colour.

On arrival at the Homebush laboratories groups of 20 melons were placed in an atmosphere containing ethylene (1:1000), and stored at 68°F for varying periods. Both untreated and treated melons were then held at the same temperature for ripening. Other melons were treated with ethylene in a commercial banana-ripening room at 66–68°F. They were removed after 3 days to continue ripening at 68°F. During ripening the skin colour of most of the melons changed to cream or creamy yellow. The melons also softened and became springy all over, and developed a noticeable aroma.

When each melon was judged to have reached this stage of ripeness a small plug was cut out and the actual ripeness checked. Some melons were not fully ripe and others somewhat over-ripe. Thus external appearance and springiness were not always a reliable indication of ripeness.

RESULTS

The rate of ripening of melons varied greatly. The first untreated melon to ripen took 12 days, but the last was not fully ripe after 55 days at 68°F., when the experiment was terminated. Treatment with ethylene for 24 hr had no significant effect on the rate of ripening, but treatment for longer periods hastened the process, and reduced the spread in time to ripen for individual melons (see table on p.33).

Only two treatments—with ethylene for 60 hr after 5 days' delay, and in the banana ripening room—reduced the time to ripen significantly (5 per cent. level). The banana room treatment was also significantly better than the immediate 24 hr treatment. Even with these effective treatments the last melons required 42 and 50 days to ripen, although the first melons ripened in 8 and 9 days instead of 12.

Treatment with ethylene improved the colour of the skin; the majority of the

Times for Honeydew Melons to Ripen at 68°F.
None of the treatments in a group spanned by a line differ significantly at the 5 per cent. level.

Treatment	Time to Ripen* (days)
No ethylene	22·7
Ethylene for 24 hr	21·3
Ethylene for 60 hr	19·2
3 days delay then ethylene for 60 hr	18·9
5 days delay then ethylene for 60 hr	14·7
3 days delay then 3 days in banana room	13·8

*"Time to ripen" is the average time (including the treatment period) for half the melons in the sample to ripen. It is somewhat less than the arithmetic average for all the melons in the sample.

untreated melons remained greenish to whitish cream, whereas those given the most effective treatments nearly all developed an attractive creamy yellow colour. The colour of the ripe flesh varied from almost colourless to distinctly green, and bore no relation to treatment or to eating quality. While the texture of the ripe flesh varied from melting and very juicy to somewhat stringy and only moderately juicy, it was improved by ethylene. There was a similar large variation in flavour between melons in any one treatment, ranging from poor through fair to excellent, and ethylene treatment significantly improved the average flavour of the sample. In addition to the direct ethylene effect there was a general tendency for the melons which ripened earlier to have the better flavour. The flesh first ripened inside and then towards the skin. Ethylene treatment increased the proportion of ripe flesh.

The melons were found to be remarkably resistant to decay at ripening temperature, as Pratt had also found. After full ripeness was reached the melons kept well for a further 4–5 days at a temperature of 68–70°F and for up to 14 days at a temperature of 41°F. The atmospheres in the cavities of three melons after 50 days at 68°F were found to contain 8·7, 8·7, and 5·6 per cent. carbon dioxide and 1·2, 4·3, and 5·9 per cent. oxygen respectively. This indicates considerable resistance within the melon to the diffusion of these respiratory gases. Comparative tasting tests were carried out on six pairs of melons, using a panel of 20 tasters, one melon being untreated and one being from a successful ethylene treatment. Although in two comparisons the melons treated with ethylene were preferred, there were no overall significant differences in texture or flavour. This was apparently due to marked variability between melons from any one treatment.

CONCLUSION

Pratt reported that treatment with ethylene for 48 hr ensured that all melons ripened well. In the work at the C.S.I.R.O. laboratories at Homebush even longer exposures did not cause all melons to ripen evenly, and develop the characteristic melting texture and rich flavour. Nevertheless exposure to ethylene at a concentration of approximately 1:1000 hastened ripening, reduced the large spread in the time to ripen, and improved quality when ripe to a sufficient extent to show clearly the advantage of ethylene treatment. From the consumer's point of view the melon ripened under ethylene is juicier, better flavoured, and has a greater proportion of fully ripe flesh. Ethylene ripening will enable the retailer to speed up his turnover, and offer customers a melon of better and more reliable quality.

The results indicate that 3–4 days treatment with ethylene in a commercial ripening room at a temperature of 65–70°F would cause almost all of a consignment of melons to ripen well and reasonably quickly. This treatment is therefore recommended to the industry. The fact that, even after long exposure to ethylene, the time to ripen still varied greatly, indicates a parallel variation in maturity at picking. Closer attention to time of harvest seems necessary to improve the product further. Because of the good keeping qualities of the honeydew melon, picking at a more advanced stage of maturity should be advantageous.

ACKNOWLEDGMENTS

The authors are indebted to Mr. A. G. L. Elliott, N.S.W. University of Technology (formerly C.S.I.R.O. Division of Mathematical Statistics), for statistical treatment of the data; and to Messrs. J. Hawke, 5 Ultimo Road, Sydney, for the use of a banana ripening room.

Cold Curtain for Refrigerated Trucks

Reprinted from *Agricultural Marketing

THE curtain is installed inside the rear doorway of vans. Vans so equipped average inside temperatures several degrees colder, and do a better job of controlling the temperature of frozen products. This is not the first door curtain that has been tried out. For many years, truck owners and operators have experimented with various types of curtains. The problem has been to keep the frost from melting off the "cold plates" of the trucks and causing soggy packages and ruined labels.

These conditions result largely from the unavoidable opening and closing of the rear door during loading and unloading in hot weather. Even when drivers are careful to close the door immediately after removing each order, they often have the door open as much as 2 hr in an 8-hr delivery day.

To maintain high quality in frozen foods, the truck temperature should be kept at 0°F or lower. Fluctuations in air temperature also mean higher refrigeration costs.

Most of the canvas curtains tried previously have not been satisfactory on at least three counts:

(1) They do not permit entry of light inside the truck.
(2) They become wet and annoying to the driver during deliveries.
(3) The wet canvas freezes stiff during the night chilling process, making it hard for the driver to handle the curtain the next day.

Following a preliminary study of the problem in the summer of 1955, a number of experimental curtains were tested. Researchers sought the right combination of materials and design that would offer the least interference with the driver, yet be durable enough to withstand the stresses and strains of daily use.

These early tests led to the "window" type 2-panel curtain made of 0·0075 in. thick clear polyester film, framed on all edges with 16-oz neoprene-coated nylon to prevent tearing and lend stability.

Each panel is suspended at the top of the doorway with three double-eye harness snaps which provide a strong yet flexible support that allows the curtain to open and close easily. To prevent billowing and flapping as the truck door is opened and closed, researchers put 2 lb of lead shot in the bottom hem of each panel.

The new curtain was tested in actual commercial operation by private companies in Washington, D.C., and Baltimore, Md. Most of the drivers said they liked it, and cooperating truck owners are enthusiastic.

They see four major advantages in the new curtain:

(1) It helps to maintain lower product and air temperatures in refrigerated local delivery trucks during summer months.
(2) Lighting inside the truck is better with the door open than with an artificial light and the rear door partially closed.
(3) It is relatively inexpensive and durable, and installation is easy. It can be readily removed during the winter months.
(4) Elimination of dripping inside trucks more than offsets the minor inconvenience of the curtain.

So far, the curtain has been tried out only on frozen food and meat trucks. But it may also be of benefit when used on refrigerated trucks that deliver milk, ice cream, produce, and other perishable items.

Precise instructions, illustrated by labelled diagrams, on how to make and install the curtain are given in another publication by Guilfoy†. This publication may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (Price is 15 cents.) The illustrated instructions are also available from the Librarian, C.S.I.R.O. Division of Food Preservation and Transport, Private Mail Bag, Homebush Post Office, New South Wales.

*A New Cold Curtain for Refrigerated Trucks. Robert F. Guilfoy, Jr., Agricultural Marketing Service of the United States Department of Agriculture. *Agricultural Marketing* (1957) **2** (7): 7.

†A Curtain to Help Maintain Temperatures in Local Refrigerated Delivery Trucks. Robert F. Guilfoy, Jr., Agricultural Marketing Service, U.S. Department of Agriculture. Marketing Research Report No. 176.

FISH HANDLING AND PRESERVATION—II

Hygiene in Handling Fresh Unfrozen Fish

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ALTHOUGH the temperature at which the fish is held after catching is by far the most important factor influencing spoilage, storage life may also be extended by reducing contamination of the edible flesh by the microorganisms on the fish when caught and by those with which it subsequently comes in contact. For example, the storage life of iced fillets, with initial counts of 100 bacteria (per gram) capable of active growth at 32°F, would be approximately 2 days longer than if the population of similar bacteria were 1000 per gram. The natural slime on the skin, the gills, and the digestive tract of freshly-caught sea fish contain variable numbers of bacteria, depending on the environment in which the fish are found and on the nature and extent of the food in the stomach and intestines. Fish which have not been feeding for a few days generally have very few living bacteria in the digestive tract.

BACTERIAL SPOILAGE

If undamaged fish straight from the water could be held without further infection, bacterial spoilage would develop as the result of the growth of organisms on the skin, gills, and in the digestive tract. Both the skin and the intact walls of the digestive tract offer considerable resistance to the passage of bacteria and there may be very large numbers in these situations while the adjacent flesh remains comparatively free from infection.

The earliest invasion of the flesh of whole fish by bacteria begins in the vicinity of the gills. The mere operation of heading and gutting freshly caught fish will bring about the contamination of exposed surfaces of the flesh by bacteria from the skin and from broken sections of the digestive tract. Further direct infection of the flesh may arise from contact with other sources of contamination. The storage life of headed and gutted fish will therefore be shorter than that of fish in the round. While this is true for bacterial spoilage, the less severe type of deterioration, due to the action of enzymes from the digestive tract on the flesh, will occur only in ungutted fish. Gutting is, however, recommended for fish which have their digestive tracts full of feed, cannot be iced and cooled promptly after catching, or are to be held on ice for longer than 3 or 4 days. When large quantities of small fish are caught at one time it is usually impracticable to gut them. Even when larger fish are taken in great numbers it may be preferable to pack the whole fish in ice without delay and thus avoid undue exposure to relatively warm conditions. In extreme cases where both gutting and icing are impracticable the fish should, if possible, be spread out in single layers protected from direct sunlight and sprinkled with clean cool water to promote cooling by evaporation.

Washing the whole or the gutted fish with water free from bacteria may be expected to reduce the number of bacteria. The effective reduction should be greatest before bacteria have penetrated the skin or the walls of the gut cavity. In theory, washing should be most effective at sea, using clean sea water on freshly caught, gutted fish. Washing should be carried out with flowing water, free from contamination from dirty decks and other sources of infection, and it should drain away freely. As already pointed out a 90 per cent. reduction in bacterial populations is required to bring about a 2-day extension in storage life of fish packed in ice. Even if it

were possible to attain such a reduction the benefits of washing would be almost negligible if the fish become heavily contaminated later from unclean surfaces, dirty ice, bilge water, etc. The advantages of washing would also be lessened if it involved delaying ice-cooling by an hour or more.

On catching vessels the rate of intake of fish is often so high that effective washing is extremely difficult, but simple hosing with sea water should remove some of the mud picked up from the sea floor by trawled fish and the faeces squeezed out from some of the fish.

At land-based plants washing of fish can be carried out more readily, often with mechanical aids. A rotating screen-drum type machine with 3, 4, or 6 sides designed at one of the experimental stations of the Fisheries Research Board of Canada (Tarr and Lantz 1949)* has proved effective in removing a fairly high proportion of the contamination from fillets prepared from perfectly fresh fish, and an even higher percentage from stored fish. The screen's effectiveness as a washer is said to be due to the immersion of the lower part of the rotating drum in a tank of continually changing water. Sprays of water directed at the screen and the fish keep the screen free from slime, wash the fish, and provide a continuous flow of water to the tank. Freely flowing water is essential for bacteriologically effective cleaning. Washing in containers without running water may improve the appearance of the fish through the removal of blood stains and visible dirt, but the water will eventually become so highly contaminated that it will increase bacterial populations on the fish.

CONTAMINATION BY CONTACT

Contamination of fish by infected surfaces can be reduced by avoiding contact or rendering the surfaces bacteriologically clean. In a trawler, contact with floors, walls, and partitions can be reduced by surrounding the fish with more than enough ice to last the trip to port. Contamination of gutted fish by contact with guts during handling on the deck can be prevented by providing receptacles for the guts. In processing plants, contact between freshly cut or skinned fish and dirty tables can sometimes be avoided by placing the fillets immediately on clean conveyor belts or in containers. A skinning machine designed by the Fisheries Research Board of Canada is especially effective in reducing contamination during and immediately after skinning.

TREATMENT OF ICE AND WATER

Under conditions where a good deal of contact between fish and other objects is inevitable, steps can be taken either to eliminate or reduce the bacterial population on these objects.

If ice is made from water containing bacteria, or the surfaces of the blocks are contaminated when it is stored in cold rooms, it may be a prolific source of bacteria. Water used for ice-making in some parts of Australia has been found to carry up to one million bacteria per ml, and a fairly high proportion of these were able to grow actively in the range 32–40°F. During storage in cold rooms very high numbers of low temperature type bacteria may infect the ice surfaces. Ice free from bacteria may be made from water sterilized by chlorination or other means. It should be stored in a clean place, and if the blocks become contaminated they should be washed before crushing. The same treatment could be applied to ice which has already been used for cooling fish. Sea water, or water used for making a 3 per cent. salt solution for cooling and holding fish at 30–31°F, should be bacteriologically clean. Even at these temperatures appreciable growth of low temperature type bacteria derived from the fish may occur after holding for a week or more. The sea water or brine should be renewed for fresh batches of fish, but if this is not practicable its temperature should not be allowed to rise and it should be disinfected before using again. Any batches showing off-odours or other evidence of spoilage should be discarded.

The water used for washing fish and for cleaning tables, benches, and equipment should also be comparatively free from bacteria. Particular care is necessary with the water used for cooling cooked prawns, shrimps, crayfish, and lobsters which have been pasteurized by cooking.

*Tarr H. L. A., and Lanz, A. W. (1949).—*Progr. Rep. Pacif. Biol. Stas.* No. 81: 80–3. also summary in *Food Ind.* **22** : 682 (1950).

Chlorination is one of the cheapest and most easily applied methods for disinfection of water. City water for drinking purposes is commonly chlorinated to provide a residue of about 0·5 p.p.m. available chlorine. Such water would be suitable for ice-making and for general use in fish handling. Water containing as high as 10 p.p.m. available chlorine could safely be used for washing fish, since the chlorine is rapidly destroyed by contact with organic matter. Brines which have previously been used will contain a good deal of organic substances leached out from the fish, and far more chlorine will be required for their disinfection than for ordinary water.

TREATMENT OF SURFACES

The surfaces with which the fish come in contact either on the boats or during unloading, handling, packing, transport, and retailing require special methods for cleaning and disinfection. New surfaces, irrespective of the type of material used, present no special problem, but after being in contact with fish they become contaminated with slime from their skins and with large numbers of bacteria derived from the fish and other sources. The use of relatively impervious surfaces will reduce the extent of impregnation and facilitate cleaning and disinfection. The disadvantages of wood can be overcome in some instances by the use of special coatings such as casein-formalin or suitable plastic materials. Boxes and containers made entirely from plastics are being developed overseas, and aluminium fish containers of various shapes are commonly used in Great Britain. The chief disadvantage of metal containers for transport of fish is that excessive melting of ice will occur unless the atmospheric temperature is kept below 40°F. It is generally unnecessary to use metal surfaces in fishing vessels, and the boards in the bottom of the pen and in shelves will not be sources of contamination if sufficient ice is used to save the fish from contact with the boards. Metal surfaces for the wings and back walls of the hold might have advantages on long voyages, but they would require to be artificially refrigerated or insulated to prevent excessive melting of ice.

The production of bacteriologically clean surfaces is generally accomplished by a combination of cleaning and disinfection. Cleaning is best done by scrubbing, using clean water and suitable detergents applied under pressure. The choice of a detergent is governed to some extent by the kind of water available for washing, although some types are equally effective in soft and hard waters including sea water. Scouring is improved by applying the water or detergent solutions through jets having a pressure of about 20 lb per sq. in., keeping the nozzle close to the surface being cleaned. Hand scrubbing and mechanically operated brushes can also increase the effectiveness of cleaning. After the surfaces have been cleaned and rinsed, disinfection is carried out by heat or by a combination of heat and disinfectants. The bacteria which develop on fish stored in ice have comparatively low resistance to heat, and very short exposure to temperatures as low as 130°F will have pronounced killing effects. Where the organisms have become embedded in wooden surfaces it will be difficult to raise the temperature sufficiently high in their vicinity. Plants with plentiful supplies of steam could readily do so, but in most cases this would not be practicable on vessels at sea. Steam or very hot water should not be applied to surfaces before fish slime and dirt have been removed by washing. The best and cheapest disinfectants are those containing chlorine. They are applied in solutions containing from 50 to about 500 p.p.m. available chlorine, depending on the cleanness of the surfaces to be treated. In these concentrations chlorine does not harm the fish. It is rapidly dissipated through contact with organic matter and it is especially useful in fish-handling factories on account of its properties as a deodorant. Chlorine and some detergent substances are corrosive to metals, and should be thoroughly rinsed off after the desired period of contact.

It is impracticable, if not impossible, to disinfect thoroughly all the wood surfaces in a trawler's hold, but cleaning with detergent solutions under pressure, followed by washing will remove most of the visible contamination. Portable equipment is available by means of which live steam impregnated with detergent substances can be applied through a chisel-shaped nozzle with a slot orifice. In this way steam is emitted in a flat cutting jet. It removes dirt, but is not so effective in removing fish slime from wooden surfaces.

RECOMMENDATIONS

(1) Fish should be gutted:
- If in "feedy" condition.
- When prompt chilling is not possible.
- When they are to be held longer than 3 days in ice or 6 days in brine or other liquid at 30–31°F.

(2) The freshly caught fish should be washed with clean running water to remove mud, faeces, etc.

(3) Fish should be protected from sources of gross contamination by:
- Placing sufficient clean ice between the fish and the surfaces of holds, shelves, boxes, etc., and using protective barriers of materials which are easily cleaned and disinfected.
- Preventing further contact between freshly prepared fillets and the filleting boards contaminated by the skins and slime of the fish.
- Using ice prepared from bacteriologically clean water, and washing the surface of blocks before use.
- Washing and chilling fish in water with a low population of bacteria.
- Cleaning and disinfecting all surfaces with which the fish make contact.

NEWS FROM THE DIVISION OF FOOD PRESERVATION AND TRANSPORT

USE OF RADIOACTIVE TRACERS

As part of its research into the growth and behaviour of plant cells the Division's Plant Physiology Unit is planning to use radioactive tracers to measure the fluxes of ions and sugars into and out of plant tissue. The methods of chemical analysis enable one to measure net flux only, but by measuring the labelled solute passing into initially unlabelled tissue or from labelled tissue into inactive solute one can calculate both influx and efflux.

Conventional Geiger counters are being used, and a scintillation counter is being constructed embodying the relatively new plastic type of scintillator and a highly sensitive photo-electric detector.

The experimental material will include mitochondria from red beet, internodal cells of *Chara australis*, and root and leaf tissue. Particular attention will be paid to trying to locate the site of the ion-exchange system in plant tissue, and to investigating the rate of movement of various ions across plant cell membranes. The effect of temperature and of metabolic inhibitors on movement into the wall, cytoplasm, and vacuole of *Chara* cells will also be studied.

PERSONAL

Mr. S. M. SYKES has been appointed to the Division of Food Preservation and Transport to supervise investigations on the processing of fruit and vegetables at the C.S.I.R.O. Tasmanian Regional Laboratory, Hobart. Mr. Sykes was formerly an officer of the N.S.W. Department of Agriculture, but he has been associated with the Division of Food Preservation since 1940, when he participated in research on the storage of apples. For several years during World War II he was a member of the C.S.I.R. team investigating the dehydration of fruit and vegetables. In 1945 Mr. Sykes accepted a research position in the N.S.W. Department of Agriculture, but he continued to work at Homebush under a cooperative arrangement between his department and C.S.I.R. Initially he worked on the problems of storing fresh fruit and vegetables, but later, after a visit to the United States in 1947, on the freezing of fruit and vegetables.

Mr. E. G. DAVIS, Research Officer, has been granted a Junior Research Fellowship in the Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass., for research on the packaging of foods in non-metallic packaging materials.

Mr. Davis will leave Australia by air towards the end of June 1958, and expects to be away for about one year.

Professor GEORGE STEWART, Chairman of the Department of Poultry Husbandry in the University of California, Davis, U.S.A., who made his headquarters at Homebush on arriving in Australia in July 1957, left Australia by air on March 23, 1958. Professor Stewart returned home via Indonesia, Singapore, Malaya, Thailand, the Philippines, and Japan, so that he might study the poultry industry in those parts, and report to the United Nations on the progress being made with that Organisation's technical assistance programmes to the poultry industry in some of the countries visited.

Miss RUNGTOWAN BUNNAG, a graduate in science, University of Medical Sciences, Bangkok, and an officer of the Department of Science in the Ministry of Industry of the Government of Thailand, spent about five months at the Homebush laboratories, commencing February 1958. The period formed part of Miss Bunnag's sojourn in Australia as a Colombo Plan Fellow, during which she studied food technology and related subjects at Sydney University and the N.S.W. University of Technology, and gained practical experience in the field in the C.S.I.R.O. Dairy Research Section, the Division of Food Preservation and Transport, and several food factories.

PUBLICATIONS BY STAFF

Some Practices of the Pacific Island Peoples in Handling and Storing Foodstuffs. H. S. McKee. *Aust. J. Sci.* **20**: 69–71 (1957).

Dr. McKee was seconded from the Division of Food Preservation to act as Food Technologist with the South Pacific Commission in 1954–56. This paper is a brief summary of his observations on cooking, on methods of removing poisonous constituents from foods, and on storage, fermentation, and drying of foods by the natives of the islands in the South West Pacific.

Electrolytes in Plant Tissue. R. N. Robertson. *Endeavour* **16**: 193–8 (1957).

Storage Tests on Air-dried Mutton Mince. A. R. Prater and A. G. L. Elliott. *C.S.I.R.O. Aust. Div. Food. Pres. Transp., Tech. Pap.* No. 5 (1957).

A study was made of the shelf life of air-dried mutton mince at a temperature of 77°F over a storage period of 2 years. The three different types of pack compared (in increasing order of shelf life) were: air pack, blocks with added fat in air, and nitrogen pack.

Studies on Beef Quality. Part V. Further Observations on Biochemical and Physiological Responses to Pre-slaughter Treatments. A. Howard and R. A. Lawrie*. *C.S.I.R.O. Aust. Div. Food Pres. Transp. Tech. Pap.* No. 4 (1957).

Investigations on various pre-slaughter treatments on the steer have been extended beyond those summarized in *C.S.I.R.O. Food Preservation Quarterly* **17**: 18–19 (1957). Studies were made of their effects on the blood, liver glycogen, and biochemical changes in the psoas, longissimus dorsi, semitendinosus, and semimembranosus muscles of 30 animals.

While post-mortem glycolysis and the changes in creatinephosphate and adenosinetriphosphate, causing the onset of rigor mortis, are similar in all four muscles, they differ from one another in important details such as the amounts of initial glycogen, buffering power, and the pH at which glycolysis ceases. It is suggested that such differences reflect functional specialization.

Unlike its action *in vitro* in slowing adenosinetriphosphate breakdown, pyrophosphate appears to accelerate glycogenolysis in liver, and to cause aerobic production of lactic acid in muscle when injected prior to slaughter, emphasizing that caution is needed in inferring that *in vitro* findings apply to the living animal.

The considerable resistance of steers to the stresses of enforced exercise and fasting was

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confirmed: it again proved most difficult by these methods to deplete muscle glycogen levels sufficiently to raise the ultimate pH. The successful depletion of such reserves in a steer which was forcibly exercised after a long train journey was attributed rather to the nervous effects of the latter than to inanition or muscular activity. The injection of ephedrine failed to produce this manifestation of excitability. On the other hand, the induction of insulin tetany and of shivering (by tuberculin injections), and interference with fatty acid oxidation (by the injection of neopyrithiamin) caused a significant raising of the ultimate pH of the musculature.

Ruminants appear to derive considerable energy from the oxidation of fatty metabolites, but this in no way lessens the fundamental importance of glycogen in muscular activity, especially when it is suddenly increased.

Studies on Beef Quality. Part VI. Effects on Weight Losses and Eating Quality of Further Pre-slaughter Treatments. P. E. Bouton, A. Howard, and R. A. Lawrie. *C.S.I.R.O. Aust. Div. Food Pres. Transp. Tech. Pap.* No. 6 (1957).

The biochemical effects of a number of pre-slaughter treatments on the carcasses of beef steers have been studied. Concomitant effects on weight losses of the meat from before freezing until removal from frozen storage, during thawing (as quarters), and holding (as butchers' cuts), and also the effects on eating quality before and after frozen storage are recorded in this paper.

By a series of treatments designed to modify the glycogen reserves in the animals, muscular tissue was obtained with values of ultimate pH extending fairly evenly from the normal value of about 5·5 to well above 6·0. The earlier suggestion that increased pH was associated with low value of laboratory drip, meat flavour, and acceptability was confirmed, and it was further shown that butchers' drip is similarly reduced. The earlier suggestion that tenderness is at a minimum at a pH around 5·8 received further support, and the development of dark colour at high pH was also confirmed. Losses during cooking also appear to be dependent on pH.

Among treatments designed to modify the physicochemical or biochemical properties of the muscle other than through pH change, the most marked effect was that of pyrophosphate in darkening the meat. Pyrophosphate possibly also increased weight losses during cooking.

The finding that the storage of frozen beef reduces juiciness has been confirmed, and in these experiments frozen storage was also shown to produce darker cooked meat in certain joints.

Biosynthesis of Sucrose. J. F. Turner. *Biochem. J.* **67**: 450–6 (1957).

Sucrose is generally the most abundant sugar in plants, and, until radioactive carbon was available for tracing its formation, biochemists assumed that it was built up from glucose and fructose. This paper describes experiments in which an extract from dried pea seeds formed sucrose from a mixture of glucose-*l*-phosphate and fructose, and presents evidence that uridine diphosphate glucose plays a part in the synthesis.

Studies in the Metabolism of Plant Cells. XII. Ionic Effects on Oxidation of Reduced Diphosphopyridine Nucleotide and Cytochrome *c* by Plant Mitochondria. S. I. Honda, R. N. Robertson, and Jeanette C. Gregory. *Aust. J. Biol. Sci.* **11**: 1–15 (1957).

Copies of papers mentioned above may be obtained from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O., Homebush, N.S.W. (Telephone: UM 8431, UM 6782, UM 8938).