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Preparing samples of peas for tasting.

Food qualities such as flavour are best assessed by tasting. Standard techniques in use at Homebush are described here.

Tasting

THE physical and chemical examination of food, while objective and little affected by personal idiosyncrasies, is not the most effective means of assessing many qualities, such as flavour, in which food scientists and processors are keenly interested. Such qualities can best be assessed by tasting, which is now accepted as a sensitive technique for examining food products.

THE TASTING PROCESS

Tasting involves a complex of nervous responses. *Taste*, in the strict sense, comprises such sensations as sweetness, sourness, saltiness, and bitterness, and is detected by the tongue, but the *flavour* of a food also involves the sense of smell. The reactions of the taster to foods are greatly modified by psychological factors such as his comfort or associations of ideas related to the food. The appearance of the samples, particularly at first sight, is of great importance. It may influence his judgment on other attributes of a sample : the quality of a bright red strawberry is more likely to be rated good than a pale one.

Tasters vary considerably in their reactions to foods. The variation in natural or inherited sensitivity may be illustrated by the following typical values of the thresholds for salt (i.e. the minimum amount of salt that can be detected) reported by Knowles and Johnson (1941). These range from 0·001M through 0·02M (regarded as medium) to 0·08M. Tasters also vary in their familiarity with and preferences for various foods, and in ability to describe their reactions. Their efficiency is affected to some extent by their general health; for example, a taster with a bad cold may have a defective sense of smell. By training and experience tasters can develop greater powers of discrimination and description, so that an experienced panel is more likely to give consistent results than an inexperienced one. Another factor which must be kept in mind is fatigue of the mental powers needed for identification and description of samples, and fatigue of the senses of taste and smell.

FACILITIES AT HOMEBUSH

Tasting tests play such an important part in the researches of the Division of Food Preservation and Transport that they are conducted under the supervision of an officer trained in science and dietetics, in a specially designed and equipped room. The room is divided into three sections : a kitchen and preparation section, the tasting booths, and an office with entrance hall. The plan is shown on p.40.

The kitchen and preparation section, part of which can be seen in the photograph above, is equipped with a stove, an electric dish-

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Tests on Foods

washing machine, a double stainless steel sink, and a food heater for hot servings.

The six tasting booths (see photograph below) are separated from the rest of the room by a partition reaching from floor to ceiling. Food samples are served in individual portions, and each sample is passed through a hatch to the taster in his booth. The paint in the booths is pale grey and white, neutral colours having been chosen to reduce interference with the judgment of the tasters to a minimum. Although most of the tasting is done under natural light, facilities are available for using the light of colour-matching fluorescent tubes, or artificial light of various colours.

In the office section, there is a blackboard on which is posted a timetable of tests, together with instructions and general information for tasters. This section also includes a table around which discussions are held on the planning and results of tests. Unfortunately space is limited and the discussions are sometimes overheard by tasters in the booths. It would be better if all briefing and discussion could take place in a separate ante-room.

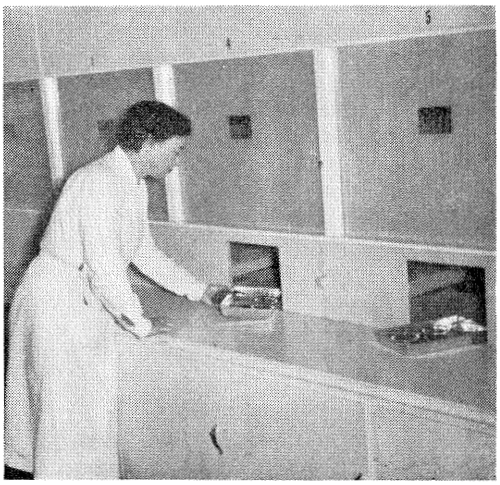
TASTING PANELS

Tasters are members of the staff of the Division of Food Preservation and Transport, most of whom have now gained considerable experience in the tasting of canned, dried, and frozen foods.

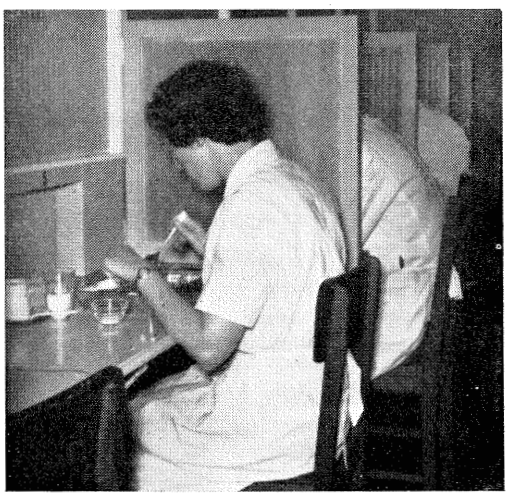
Two types of tests are being made at present:

- A pilot consumer test in which as many tasters as possible, usually 30–40, take part.

Passing samples to tasters.



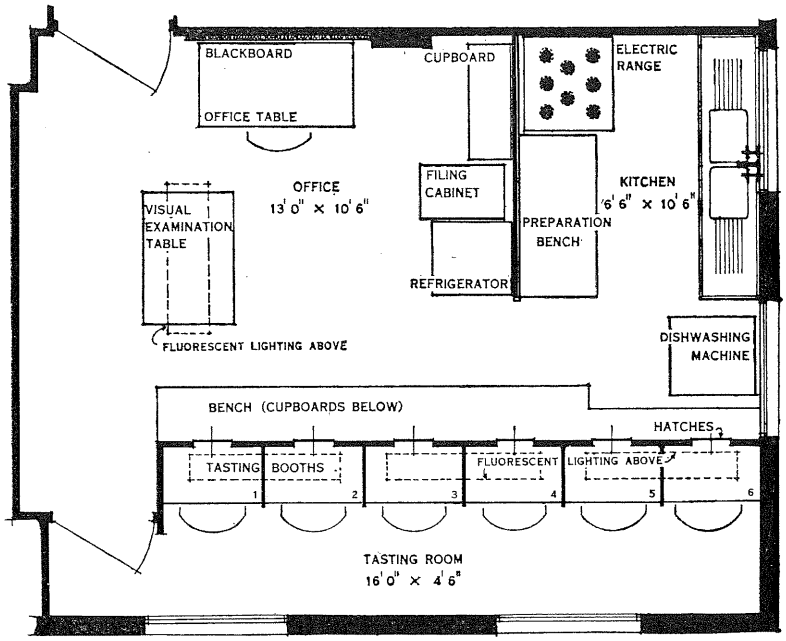
Tasters at work in the booths.



The tasters give their opinions of the various qualities of the food under test, for example, flavour, colour, and general acceptability. People who dislike or do not normally eat the foods under test are not used in these panels.

● Analytical tests for which the panels consist of 8–12 people selected for their ability as tasters of the food under examination. pected, or when an independent assessment of quality characteristics is requested.

Tasting tests are held about 10.15 a.m. and 12 noon, and if necessary at 3 p.m. It is undesirable, for obvious reasons, to arrange tests immediately before or after meals. Each test takes 2–5 minutes, depending on the taster and the number of samples.



Plan of taste test room at C.S.I.R.O., Homebush.

In order to select a suitable panel preliminary runs are made with many more tasters than are needed ; those who obtain consistent results in closest agreement with the panel average are chosen. The method of selection is based on that given by Girardot, Peryam, and Shapiro (1952).

PROGRAMME AND PROCEDURE

The tasting programme continues throughout the greater part of the year. Most of the products tasted are experimental samples prepared in connection with research projects within the Division. Tasting tests are occasionally carried out on behalf of food manufacturers when, for instance, tainting is sus-

At the beginning of each series the tasters are told of its probable duration, which may be from two days to five weeks. They are given a score sheet and instructions on the nature of the test, and, in the case of analytical tests, some preliminary training. Each taster carries out his test independently ; and discussion of results before a series concludes is discouraged.

In certain tests, for example, on bitterness in orange juice, the tasters chew bread between samples to remove the taste from their mouths. If it is necessary to rinse the mouth, a disposable paper carton and a glass of water are placed in the booth.

The number of samples presented per taste session varies from two to eight, depending on the nature of the food and the intensity of

the examination. When food is to be ranked for general quality only, a taster can cope with two sets each of four samples in one session, but when several characteristics (e.g. colour, flavour, and texture) are to be scored on a point scale, he cannot deal with more than three to five samples in a session.

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Financial Support for the Division

SINCE the latter part of 1955, the officers of the Division of Food Preservation and Transport have made special efforts to acquaint industry with the results of their researches, and have invited industrialists to take a more active part in financing the work of the Division (see *C.S.I.R.O. Food Preservation Quarterly* **16**: 55). By June 30, 1956, the campaign had brought in the encouraging amount of £3000. It is now our pleasure to record that by June 30, 1957, this sum had risen to over £5000. During 1956–57 several firms made contributions for the first time and others gave a second donation. The response continues to grow, making it certain that by June 30, 1958, a still broader sector of the food industry will be supporting the work of the Division financially. The money received from private industry has been of great value in making possible the purchase of equipment for which funds from other sources were inadequate. Equipment valued at over £1000 has already been obtained and much more is on order.

Contributors 1956-57

The following companies have contributed to the funds of the Division during the past financial year.

Arthur Yates & Co. Pty. Ltd.
Batlow Packing House Co-operative
Borthwick, Thos., & Sons (Australasia) Ltd.
Committee of Direction of Fruit Marketing.
Gordon Edgell & Sons Ltd.
Harry Peck & Co. (Aust.) Ltd.
Holbrooks' (Australasia) Ltd.
Matthews Thompson (Trading) Co. Pty. Ltd.
R. B. Manufacturing Co. Pty. Ltd.
Rice Growers' Co-operative Mills Ltd.
Riverstone Meat Co. Pty. Ltd.
Swift Australian Co. (Pty.) Ltd.

The Division would also like to acknowledge the substantial grant made by the Commonwealth Canmakers' Association towards the cost of research on electrolytic tinplate.

It is our pleasure also to record the names of a number of Government departments and statutory bodies which support the Division financially. Most of them have been helping to defray the cost of various researches for many years, yet in 1956-57 their contributions together amounted to over £14,000.

Australian Egg Board
Australian Meat Board
Commonwealth Department of Trade
Metropolitan Meat Industry Board, Sydney
New South Wales Department of Agriculture
Queensland Meat Industry Board
United Kingdom Department of Scientific and Industrial Research.

In addition funds have been received through the Commonwealth Department of Primary Industry for investigations on the effect on citrus fruit of methods used to sterilize fruit from fruit fly. These funds have been made up of contributions from the Commonwealth Government, the State Governments in New South Wales, Victoria, and South Australia, and the Federal Citrus Council.

Ascorbic Acid

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; and Vol. 17 (1957), pp. 11-14, 30-5.*

FOLLOWING the discussion of acidity in canned foods, it is appropriate to consider the determination of ascorbic acid. This acid contributes little to the total acidity of foods but it is important nutritionally as vitamin C, the antiscorbutic vitamin. Minimum requirements for ascorbic acid content are laid down in Commonwealth Food Specifications (1952) for canned citrus juices, tomato juice, pineapple juice, cloudy apple juice (fortified), apple and blackcurrant juice, and blackcurrant syrup, and in the Victorian Health Acts (Victorian Health Department 1951) for similar products.

Since ascorbic acid is very soluble in water and sensitive to oxidation, it is readily lost from canned foods during preparation, processing, and storage. The oxidation of ascorbic acid by atmospheric oxygen is catalysed by minute amounts of copper and iron.

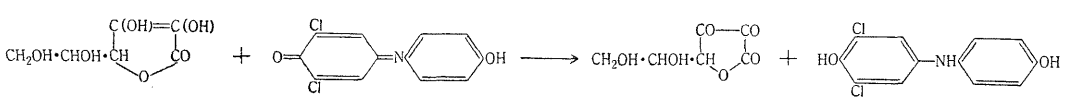
Ascorbic acid has strong reducing properties which form the basis for its quantitative estimation in foods. A number of oxidizing reagents have been suggested for the determination of ascorbic acid, e.g. ferric chloride (Sullivan and Clarke 1955), *N*-bromosuccinimide (Barakat, El-Wahab, and El-Sadr 1955), and sodium 1, 2-naphthoquinone-4-sulphonate (Barakat, Shehab, and El-Sadr 1955), but the favoured reagent is the dyestuff 2,6-dichlorophenolindophenol, first recommended in 1932. This dye, which is blue in alkaline solution and red in acid solution, is reduced by ascorbic acid to a colorless form according to the equation represented below.

The reaction is quantitative and practically specific for ascorbic acid in solutions in the pH range 1–3·5.

Some methods for the estimation of ascorbic acid which do not depend upon its reducing properties are mentioned below.

In the assay of a foodstuff the ascorbic acid is first extracted in an acid medium. Ponting (1943) studied 13 acid extractants but found that only metaphosphoric acid and oxalic acid gave extracts in which ascorbic acid showed satisfactory stability. Oxalic acid is not recommended for canned foods because of the possibility of interference by dissolved tin (see below). Moreover Huelin (1950) has drawn attention to the formation of hydrogen peroxide by photochemical oxidation of oxalic acid solutions exposed to light. Metaphosphoric acid inhibits catalytic oxidation of ascorbic acid by copper and iron and is a good protein precipitant (Horvath 1946). Natural ascorbic acid oxidases are inactivated when the pH of the extract is below 3. Extracts in 3 per cent. metaphosphoric acid usually have a pH value about 1.

The ascorbic acid content of the extract is then determined by titration with a standard solution of the indophenol dye to an endpoint detected visually or electrometrically.



Ascorbic Acid — Dye — Dehydrascorbic Acid — Leuco-dye

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

Content

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An alternative procedure is to measure colorimetrically the amount of dye reduced by the extract in the presence of excess dye (Loeffler and Ponting 1942). Only titrimetric procedures are described here (*cf.* Royal Australian Chemical Institute 1952, Association of Official Agricultural Chemists 1955).

PREPARATION OF EXTRACT

The extractant recommended is 3 per cent. metaphosphoric acid prepared by dissolving glacial metaphosphoric acid (Brown 1942) or phosphorus pentoxide in glass-distilled water cooled to below 15°C and filtering if necessary. The solution is unstable and should be kept in the refrigerator but not for longer than 10 days.

Liquid products such as fruit juices, syrups from canned fruits, and brines from canned vegetables are well mixed and a 10-ml aliquot is taken, diluted to 50 ml with 3 per cent. metaphosphoric acid, and is allowed to settle or is centrifuged or filtered to remove suspended matter particularly pigmented material.

Solid or semi-solid canned foods, such as fruits, vegetables, pulps, and purees, require to be finely subdivided in the acid medium to ensure complete extraction. The following procedure is suggested: Weigh out a representative sample (20–50g) into the bowl of an electric blender, add 150 ml of 3 per cent. metaphosphoric acid and blend for 3 min. Bring the blender to top speed gradually to avoid splashing portions of the sample high on the sides of the bowl where they escape maceration. Decant into a 250-ml volumetric flask, rinse the bowl with metaphosphoric acid, and make up the extract to 250 ml. Lamden (1950) has drawn attention to the danger of copper contamination from exposed brass parts of electric blenders which come in contact with the extract. Stainless steel parts are recommended. In the absence of a blender, grind a 10-g sample with 10 g of acid-washed sand in a mortar containing 15–20 ml of 3 per cent. metaphosphoric acid. Decant into a 100-ml volumetric flask. Repeat the extraction until the volume of extract reaches 100 ml. Clarify the extracts by settling, centrifuging, or filtering, rejecting the first portion of filtrate.

It has been generally observed in this laboratory that an equilibrium is established in canned fruits and vegetables about one week after canning so that ascorbic acid is approximately equally distributed between solid and liquid portions of the pack. For most purposes the liquid portion is then sufficiently representative of the can contents and the preparation of an extract of the drained solids is unnecessary.

STANDARD DYE SOLUTION

An approximately 0·001N solution of 2,6-dichlorophenolindophenol (sodium salt) is prepared by dissolving 0·15–0·25 g (depending on purity) of the dye and 0·32 g borax ($Na_2B_4O_7.10H_2O$) in 1 litre of glass-distilled water. The solution is filtered into an amber bottle and held in the refrigerator, where it may be kept for about two weeks but should be standardized every second day. When an aliquot of the dye solution is added to an equal volume of 3 per cent. metaphosphoric acid containing excess ascorbic acid, the resulting solution should be colourless.

If there is any residual colour the dye solution should be discarded.

The dye solution is standardized against a ferrous ammonium sulphate solution containing 0·250g $FeSO_4.(NH_4)_2SO_4.6H_2O$ (analytical reagent quality) in 250 ml 0·05N sulphuric acid and made up freshly when required. A 2-ml aliquot is diluted with 10 ml of 3 per cent. metaphosphoric acid and titrated immediately with the dye solution from a microburette until the pink colour of excess dye persists for 15 sec. Then the dye factor (mg ascorbic acid per ml) is given by the expression :

$$\text{Dye factor} = \frac{0{\cdot}449}{\text{titre}}$$

ASSAY OF EXTRACT

An aliquot (e.g. 10 ml) of the metaphosphoric acid extract of the sample under test is titrated with the standardized dye solution to a pink end-point which persists for at least 10 sec. The titration should be completed in 1 min, a preliminary titration having been made to determine the approximate titre. The titration flask should be viewed against a white background and an identical flask containing the same volume of extract should be used for comparison of the colour when the end-point is approaching.

The amounts taken for samples and aliquots should be chosen so that the titre is approximately 2 ml. The ascorbic acid content of the sample is then calculated thus :

mg ascorbic acid per 100 g or per 100 ml =

$$t \times f \times \frac{\text{Vol. of ext.}}{\text{aliquot of ext.}} \times \frac{100}{\text{sample (g or ml)}},$$

where t is the titre and f is the dye factor.

COLOURED EXTRACTS

When the foodstuff under test contains soluble pigments, such as the anthocyanin pigments that are present in blackcurrants and other berry fruits, the extract is highly coloured and the visual end-point in the dye titration is obscured. A number of procedures have been suggested for overcoming this difficulty.

Electrometric Method

Harris, Mapson, and Wang (1942) showed that a potentiometric titration of ascorbic acid extracts using a mercury-coated platinum electrode gave a precise and reproducible end-point. Later, Liebmann and Ayres (1945) simplified the method greatly by applying the principle of the "dead-stop" end-point. Special electrodes are not required ; two bright platinum wires fused into glass tubes and cleaned in chromic acid and distilled water are used. Between titrations the electrodes are held in distilled water.

The extract under test is contained in a small wide-mouthed titration vessel closed with a stopper through which are inserted the two electrodes, a tube for the admission of carbon dioxide for stirring, and the tip of a 2-ml burette. From a 2-V accumulator with a 1000-ohm fixed resistance and a 10-ohm potentiometer in series, an e.m.f. of approximately 15 mV is applied across the electrodes. A galvanometer in the circuit indicates the current flowing. Polarization occurs and the external voltage is adjusted to balance the polarization e.m.f. so that the galvanometer shows no deflection. Dye solution is now added from the burette at a rate of one drop per second, and the solution is stirred by a rapid stream of carbon dioxide. When the end-point is approaching, the galvanometer shows movement as each drop of dye is added but returns to zero. Then at the end-point a permanent deflection occurs indicating depolarization of the cathode by excess dye.

Immiscible Solvent Method

Coloured extracts may also be titrated in the presence of a layer of immiscible solvent which selectively dissolves excess indophenol dye but not the natural pigments. The visual end-point is still, however, difficult to detect and results obtained by this method should be regarded as approximate only.

In the procedure of McHenry and Graham (1935), an aliquot of the extract is titrated in a large test tube containing 5 ml of chloroform. In a preliminary titration the dye solution is added 0·1 ml at a time. After each addition carbon dioxide is bubbled through the aqueous layer and then, by lowering the tube, through the chloroform layer also. The end-point is indicated by the appearance

of the pink colour of excess dye in the chloroform layer. The titration is then repeated adding dye rapidly to a point close to the end-point and then dropwise, bubbling carbon dioxide after each addition, until the end-point is reached.

Solvent extraction procedures employing photoelectric colorimetry to determine excess dye are described by Kirkpatrick (1943), and Robinson and Stotz (1945).

In another procedure for titrating coloured extracts, suggested by Lindner (1955), the addition of blue or green dyes, complementary to the original red colours, permits the end-point to be seen.

Somers *et al.* (1951) present evidence that anthocyanin pigments actually react with the indophenol dye although more slowly than ascorbic acid. The extent of interference in a pigmented extract may be determined by applying the formaldehyde condensation method (see below).

INTERFERING SUBSTANCES

Apparent Ascorbic Acid

Canned foods may contain substances other than ascorbic acid capable of reducing 2,6-dichlorophenolindophenol. Interference by some natural reducing agents, such as sulphydryl compounds, is avoided by titrating in solutions more acid than pH 3. It is more difficult, however, to eliminate interference by certain other compounds which have reducing properties very similar to those of ascorbic acid but are not antiscorbutic. These compounds are not well characterized chemically and they are generally referred to as "apparent ascorbic acid" or as "reductones". Substances reacting as apparent ascorbic acid have been detected in greatest amounts in dehydrated foods and appear to be produced from sugars by heat treatment or by prolonged storage. The most satisfactory method for determining ascorbic acid in the presence of interfering substances depends on the fact that ascorbic acid and "apparent ascorbic acid" condense with formaldehyde at different rates at two different pH levels (Lugg 1942 ; Snow and Zilva 1944). The procedure is, however, complicated and it is not recommended for routine determinations.

Tin and Iron

The possibility of interference by stannous and ferrous ions derived from the can is of particular importance in the assay of canned foods for ascorbic acid.

In the experience of this laboratory, tin in concentrations up to 200 p.p.m. does not react with the indophenol dye in metaphosphoric acid extracts but there is appreciable reduction in the presence of oxalic acid (Winter 1952). It is for this reason that oxalic acid is not recommended as an extractant for canned foods.

Ferrous ions are oxidized quantitatively by the dye in metaphosphoric acid and oxalic acid extracts. An iron concentration of 10 p.p.m. introduces a positive error of 1·6 mg per 100 g in terms of ascorbic acid. Iron contents greater than 10 p.p.m. are not often encountered except in canned foods stored for extended periods. When iron contamination is suspected the extract should be titrated with and without the addition of hydrogen peroxide (0·3 per cent.) which oxidizes ferrous ions much more rapidly than ascorbic acid at pH 1 (cf. Winter 1951). If the two titres differ by more than 1 mg per 100 g of ascorbic acid a procedure which avoids iron interference should be applied.

Brown and Adam (1950) eliminated interference by ferrous salts by preparing extracts in a sodium acetate-hydrochloric acid buffer solution of pH 0·65. When Parkinson (1952) applied this method he observed fading end-points, and he devised a procedure involving removal of iron from oxalic acid extracts by passage through a column of an ion-exchange resin ("Zeo Karb 215", Permutit Co. Ltd.). Huelin and Stephens (1947) recommend a method based on the fact that ferrous ions do not react with the dye in extracts containing acetic acid and sulphuric acid at pH 0.4. Solid products are extracted with 10 per cent. acetic acid containing 0·1 per cent. oxalic acid to minimize catalytic oxidation by copper and iron. A fairly stable extract of pH 2·5 is obtained and the pH is reduced to 0·4 immediately before titration by adding 2 ml of 5N sulphuric acid to a 10-ml aliquot. When the sample is a liquid, a juice, syrup, or brine, a very simple technique is possible, thus : Pipette 5 ml of N sulphuric acid into a 20-ml test tube and bubble carbon dioxide through it. Pipette a 1-ml sample from the test can immediately after opening and add to the sulphuric acid. Titrate with the dye

solution, bubbling carbon dioxide continuously to prevent atmospheric oxidation. In this procedure the sample is brought immediately to a pH low enough to avoid iron interference.

Sulphur Dioxide

Sulphur dioxide is not often encountered in canned foods but may be present as a preservative in glass-packed foods such as juices and cordials. Sulphur dioxide reduces the indophenol dye and thus interferes in ascorbic acid analyses. Several procedures have been suggested for avoiding this interference.

The formaldehyde condensation method is effective but unsuitable for routine use. Acetone added to the extract to a concentration of 20 per cent. prevents interference by forming a bisulphite compound with sulphur dioxide (Mapson 1942). The end-point lacks sharpness at pH 1·5 but is better at pH 2·5. The titration should be completed in not less than 40 and not more than 60 sec.

Hydrogen peroxide added immediately before titration to give a concentration of 1·5 per cent. oxidizes sulphur dioxide almost instantaneously but has little effect on ascorbic acid within the period of titration (Levy 1943). This method should not be used, however, in the presence of ferrous ions since they catalyse the oxidation of ascorbic acid by hydrogen peroxide.

Dehydroascorbic Acid

In some processed foods there may be present significant amounts of dehydroascorbic acid which has antiscorbutic properties but does not reduce 2,6-dichlorophenolindophenol. By reduction with hydrogen sulphide at pH 4, dehydroascorbic acid is reduced to ascorbic acid and may then be estimated by dye titration. It is necessary to apply the formaldehyde condensation method since a variety of reducing substances may be formed by the action of hydrogen sulphide on constituents of the extract.

Kohman (1955) found evidence that dehydroascorbic acid is reduced to ascorbic acid during the heat processing of canned foods.

Alternate Methods

Interference by reducing substances may also be avoided by determining ascorbic acid by methods which do not depend upon its reducing properties.

In the Roe method, recently simplified by Schaffert and Kingsley (1955), ascorbic acid is first oxidized by treatment with activated carbon to dehydroascorbic acid which is then converted to the 2,4-dinitrophenylhydrazone of diketogulonic acid, and that derivative is treated with strong sulphuric acid to give a red colour which is suitable for photocolorimetric measurement. Schmall, Pifer, and Wollish (1953) devised a method in which reaction of the ene-diol grouping of ascorbic acid with diazotized 4-methoxy-2-nitroaniline in acid solution is followed by development of a blue colour in alkaline solution.

Both of these methods circumvent interference by reducing substances such as sulphur dioxide and stannous and ferrous ions, but the Roe method is still subject to interference by "reductones". After a careful comparative study of the determination of ascorbic acid in several canned foods by the indophenol and Roe methods and by bioassay, Hewston, Fisher, and Orent-Keiles (1951) concluded that "bioassay remains the only specific measure of vitamin C in the presence of interfering reducing substances since no existing chemical procedure is entirely adequate for this purpose".

In relation to the routine examination of canned foods, the significance of interfering substances may be summed up in this way: ascorbic acid contents estimated by simple indophenol dye titration may have positive errors due to "apparent ascorbic acid" and negative errors due to dehydroascorbic acid. In canned foods errors from these sources are not large and the use of special assay procedures is in general not justified. When examining canned foods which have been stored for long periods or held at elevated temperatures it is, however, desirable to explore the possibility of interference by "apparent ascorbic acid" and ferrous ions.

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Dessert prunes are packed with a high moisture content so that they may be eaten without rehydration. As a result they are very susceptible to microbial spoilage. Investigations on the control of spoilage have been carried out under the aegis of the Dried Fruits Processing Committee,* the members of which have approved the publication of this article.

Control of Spoilage in

EXPERIMENTAL work on the use of epoxides, notably ethylene and propylene oxides, as fungicides was carried out in the United States as early as 1946. Later, numerous reports came from that country of the commercial use of these chemicals for the prevention of microbial growth in such products as high-moisture prunes, dates, and figs. Whelton *et al.* (1946) showed that low concentrations of epoxides were capable of killing yeasts, moulds, and bacteria, and that treated fruit samples could be held for long periods provided reinoculation did not occur.

The most practicable method of using the epoxides was to add them to the fruit in small containers which were sealed immediately. The containers had to be capable of preventing leakage of the volatile material, at least until the contents were sterilized, and care had to be taken to prevent microorganisms from entering the containers subsequently. Whelton *et al.* (1946) showed that there was no residual fungicidal effect, since reinoculated fruit was capable of supporting microbial growth.

Initially, ethylene oxide, which is more lethal to microorganisms than propylene oxide, was used in the United States, but Whelton and his co-workers pointed out that propylene oxide was easier to use and quite effective. Since ethylene oxide (b.p. 51F) is highly volatile, it is impossible to use it alone under most conditions. A mixture of 20 per cent. ethylene oxide in ethylene dichloride, known commercially as "Oxyfume", has been used in the United States, but the dichloride has an unpleasant residual flavour. A mixture of 20 per cent. ethylene oxide in *iso*propyl formate, known commercially as "Fumold", has also been widely used. It has a boiling point of 92°F.

At the request of organizations of prune-growers and processors in Australia, the Dried Fruits Processing Committee arranged for overseas methods to be tested under Australian conditions in the C.S.I.R.O. laboratories at Homebush. C.S.I.R.O. was also asked to devise a method of using the chemicals in a processing line.

MATERIAL AND METHODS

It was not possible to obtain supplies of ethylene oxide in Australia. Thus all work reported deals with propylene oxide, which is available from the United States and Western Germany. Since most prunes are processed in the cooler months succeeding the drying season (March and April) and since propylene oxide boils at 95°F, volatility is not likely to be excessive.

In the trials described in this article the prunes were immersed in boiling water for 8-12 min to raise their moisture content to predetermined levels. The fruit was cooled and packed in bags in 12-oz lots. In line fumigation, the fungicide was placed in the bag which was sealed quickly and stored at ambient or controlled temperatures. In bulk fumigation, the bags were sealed and placed in an air-tight chamber in which the fungicide was volatilized.

*The Dried Fruits Processing Committee is concerned with the coordination of research in Australia on the drying of fruit, and is made up of representatives of C.S.I.R.O. (Commonwealth Research Station, Merbein, Vic.; and the Division of Food Preservation and Transport), Commonwealth Department of Primary Industry, Victorian State Laboratories, and the Departments of Agriculture in Victoria and South Australia.

By D. McBean and A. A. Johnson

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

High-moisture Prunes

RESULTS AND DISCUSSION

Moisture Level

Two moisture levels were used : 29 and 33 per cent. Both are suitable for out-of-package consumption, since the prunes are tender and only slightly sticky. When direct comparisons could be made, mould growth proved more difficult to control at the 33 per cent. level, a higher concentration of epoxide being needed to ensure sterilization. It would be preferable to use a moisture level of about 30 per cent.

Type of Container

Four types of packages, capable of being heat-sealed, were tested. These were made from M.S.A.T. 300 "Cellophane", Saran-coated "Cellophane", polyethylene and "Pliofilm". With the exception of the first, the films were 0·001 in. thick. The selection of these four well-known materials does not exclude the use of others, provided they possess similar characteristics.

The two main points investigated were the incidence of microbial growth and the loss of weight from packages. It was found that sterilization could be accomplished in all four containers as long as they were sealed quickly after adding the fungicide, and that no breakage of the film occurred subsequently.

A large variation was noted in rate of water loss from the different containers. In one storage trial for 11 weeks at ambient temperature (max. 84°F. ; min. 52°F.) and generally high relative humidity, mean weight losses from the containers holding 330 g of fruit with an initial moisture content of 29 per cent. were as follows :

M.S.A.T. "Cellophane"	13 g
Saran-coated "Cellophane"	4 g
Polyethylene	1·5g
"Pliofilm"	5 g

In the "Cellophane" packs, the moisture level was reduced to 26 per cent. and the texture was significantly worse than in fruit from the other packages.

In the tests, bags had to be handled frequently to check microbial growth and this caused some "Cellophane" to split. This happened most often when relative humidity was low. In one trial, polyethylene and "Pliofilm" containers were perforated by insects. Small circular holes were eaten in the bags and larvae of *Plodia interpunctella* were discovered. These observations suggest that, with all four types of packaging material, the fruit should be distributed in master containers.These would protect the films from mechanical damage and facilitate measures to prevent infestation by insects.

Concentration of Propylene Oxide

Six concentrations of epoxide were tested in the range 0–1·0 ml per litre of free space in the container. Only the highest level gave complete protection in all trials. The work of Whelton *et al.* (1946) on inoculated vegetable-agar slants showed that 0·3 ml per litre was needed to destroy yeasts and moulds and 0·6 ml per litre for bacteria, but it was expected that higher concentrations would be needed in practice. An automatic dispenser is recommended, and it should be located immediately before the heat-sealer so that the interval between the addition of fungicide and sealing is as short as possible. An interval of not more than five seconds seems feasible.

Methods of Fumigation

In most trials the propylene oxide was sealed in the containers with the prunes, but bulk fumigation was used in one test. Saran-coated "Cellophane" and polyethylene were

the only two films used in this trial. Propylene oxide was used at concentrations of 1, 1·5, or 2 ml per litre of free space and the chambers were sealed for 20 hr or 68 hr. The treatment was effective in polyethylene bags at all concentrations, but microbial growth occurred in more than 75 per cent. of Saran-coated "Cellophane" containers. Bulk fumigation cannot therefore be recommended in all cases. Differences probably exist in the permeability of films to propylene oxide and these should be investigated before commercial bulk fumigation is attempted. In any case line processes are in general easier to operate in a factory than batch procedures.

Fate of Propylene Oxide

Two days after packing, the characteristic smell of propylene oxide is completely missing from the bags when opened, after which the contents are not resistant to microbial attack. These points raise the question of the fate of the epoxide. It may permeate the container and escape in the gas phase, it may change in the fruit to a substance or substances having no fungicidal properties, or both processes may operate. The bulk fumigation trial suggested that polyethylene was permeable to a considerable extent to propylene oxide while Saran-coated "Cellophane" was at the most only slightly permeable. It seemed likely that the epoxide would be hydrolysed to propylene glycol, which would combine further with acids in the fruit to produce esters. To test this hypothesis, the amount of propylene glycol in selected samples was determined by a modification of the method of Mathers and Pro (1954). Recovery figures of propylene oxide, estimated as the glycol, were in the range 85-90 per cent. These suggest that a little of the epoxide was lost as a gas, but that most of it underwent chemical change in the fruit.

Subsequently a survey was made of the literature on the toxicity of propylene oxide and propylene glycol. Morris, Nelson, and Calvery (1942) found that ethylene oxide was capable of producing stones in the bladder, but that propylene oxide produced no deleterious effects in any of their animal feeding tests. Laug *et al.* (1939), converting the results of animal feeding tests to man, stated that a lethal dose of propylene glycol would be about 1500 ml. Assuming complete conversion of the epoxide to glycol, this quantity would occur in about 1700 lb of prunes. No chronic effects of propylene glycol have been found by either of the above groups of investigators. More recently, propylene glycol has been used as a solvent for food additives. Thus it appears that the use of propylene oxide is not likely to introduce a health hazard for humans. However, the Pure Foods Acts of some Australian States specifically prohibit the use of glycols in foodstuffs, and changes would need to be made before the method could be applied generally.

Fogging of Containers

The disadvantage of "fogging" of transparent packs was raised specifically by representatives of the prune industry. This is due mainly to smears of syrup where the fruit has touched the inner walls. If it is considered a serious deterrent to sales, an attractive completely over-printed bag could be used.

COST FACTORS

The cost of each container would be approximately 2*d.* while that of fungicide would be less than $\frac{1}{10}d.$ per pack. No data are available on equipment and labour costs. However, these would be offset by the 16·6 per cent. increase in weight if the moisture content was raised from 18 to 30 per cent. If should also be borne in mind that the prunes increase in size by one commercial grade, and that the larger prunes command a higher price.

SUMMARY AND RECOMMENDATIONS

The use of propylene oxide in conjunction with a heat-sealed container has been found to prevent microbial growth in prunes packed at high-moisture levels. This is in line with American findings.

The following recommendations are made :

- Raise the moisture content of prunes to 30 per cent.
- Cool, and pack into bags capable of being heat-sealed.
- Add propylene oxide from an automatic dispenser at the rate of 1 ml per litre of free container space.

- Seal promptly. Maximum permissible interval between adding fungicide and sealing bag is 5 sec.
- Pack in master containers for distribution.

It could be desirable, before the recommendations are applied commercially, to conduct a small-scale trial with about 1000 containers.

A survey of the literature showed that propylene oxide is not toxic to animals. The attitude of Australian health authorities to the addition of propylene oxide to foodstuffs has yet to be determined. Some States specifically prohibit the addition of glycols, and propylene glycol may be a product of the above treatment.

ACKNOWLEDGMENTS

Prunes for these tests were donated by the New South Wales Prune Growers' Co-operative through the Hon. T. Steele, M.L.C. Saran-coated "Cellophane" containers were supplied by the South Australian Prune Growers' Association, and the propylene oxide was donated by Robert Bryce & Co. Ltd., Sydney. The authors are indebted to Mr. J. D. Bryden, New South Wales Department of Agriculture, for helpful criticism and advice, and to Mr. J. I. Pitt, Technical Assistant, C.S.I.R.O. Homebush, who helped with the trials.

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Carbon Dioxide Anaesthesia for Pig Slaughter

By A. Howard

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THAT the quality of carcass meat is affected by conditions immediately prior to death is no novel consideration, and it has resulted in the modification of pre-slaughter treatment particularly in the case of pigs. It is only recently, however, that these considerations have had an influence on the method of slaughter.

A slaughter method should be humane, free from danger and other features objectionable to the operatives, and it should not impair the quality of the meat. This last consideration is particularly important in the case of pigs. Struggling should be avoided, since it impairs quality by tending to make curing more difficult, and by accelerating the rate of deterioration. The slaughterman should also ensure that at the moment of sticking the heart is functioning fully. Under these conditions there is slight but not excessive increase in blood pressure and a reflex muscular action. Efficient bleeding then ensues, but, if the blood pressure is excessive, it can burst the capillaries and cause "blood splash". Blood staining can also be caused by the rupture of blood vessels during struggling or shackling.

When electric stunning was introduced it was hoped that it would overcome the impairment of quality associated with slaughter without stunning, and at the same time be more humane. These hopes are realized when the method is properly applied, but unfortunately mishaps occur in applying the

current and timing the sticking. In fact, a recent investigation in Denmark has shown that variation in the acidity of pig meat, which is reflected in quality, was greater in electrically stunned animals than in those slaughtered without stunning. Similar evidence has been obtained in New Zealand. In Denmark, where the electrical method has been compulsory by law, the techniques were modified as late as 1956, but there is now an official recommendation that carbon dioxide anaesthesia be adopted in preference to electric stunning.

CARBON DIOXIDE ANAESTHESIA

The use of carbon dioxide for stunning was suggested by studies on the use of this gas for anaesthesia of human beings. Geo. A. Hormel Co. (1950) was granted a United States patent for its use in slaughtering pigs. The plant used has been described and illustrated by Slater (1952). Later Drewniak, Baush, and Davis (1955), of the United States Department of Agriculture, Agricultural Marketing Branch, showed the process was adaptable to turkeys. Data are also available on its application to the slaughter of cattle and sheep. Its value is rapidly being realized, and already it has been introduced into Denmark and there are reports of its use in Sweden.

When pigs are placed in an atmosphere containing 65-70 per cent. carbon dioxide they show no effects for about 15 sec. They then show signs of excitement and within 5 sec of the beginning of this reaction they fall on their sides unconscious, and are insensitive to pain. Voluntary and involuntary muscular movements disappear without seriously affecting circulation of the blood or other vital functions. When the pigs are again brought into the air about 80 sec elapses without any signs of consciousness, and if left lying undisturbed they awake calmly in 1½–2 min. They recover completely in 10–15 min, and are apparently willing to undergo the treatment repeatedly. A human volunteer who underwent the treatment did not recollect any pain or report any discomfort.

When the pigs are taken from the atmosphere of carbon dioxide they are calm, completely relaxed, and have a reduced respiration rate. If shackled and bled in this condition they show no violent reactions. Bleeding occurs with a strong spurt, and a few strong reflex movements of the front legs and the back are observed.

In an investigation carried out by the Danish Meat Research Laboratory an examination of carcasses disclosed no blood splash, and blood stain from torn blood vessels was less than with electric stunning. Variation in the acidity of the meat was lessened distinctly, and the quality ratings of the carcasses after storage and transport were higher than for animals stunned electrically or not at all.

PRACTICAL DETAILS

In practice, the method is applied by arranging for the pigs to enter a race through a control gate, and to proceed down an incline onto a moving belt in a covered pit. The atmosphere in the pit contains 65 per cent. carbon dioxide, which is fed in from cylinders of the compressed gas or from generators containing solid carbon dioxide. The percentage of carbon dioxide is automatically controlled, and provision is often made for automatically venting the pit if the concentration rises above the maximum permissible level of 75 per cent., or if the belt mechanism fails. The pigs remain in the chamber for about 1 min, and are unconscious when they emerge on the conveyor. Being at table height, they are easily shackled onto a bleeding rail, where they are stuck and bled. The whole operation is carried out without struggling or splashing of blood, and there is none of the noise so typical of pig slaughter under other conditions. This feature, which strikes all who have observed the method in operation, appeals strongly to the slaughtermen and others taking part in the slaughter of pigs.

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NEWS from the Division of Food Preservation and Transport

25TH ANNIVERSARY

It is 25 years since the Section (now the Division) of Food Preservation was established in 1932. Early in that year the Council for Scientific and Industrial Research (the forerunner of C.S.I.R.O.) adopted a limited scheme of organized investigations on food preservation and established the Section of Food Preservation and Transport. Dr. J. R. Vickery was appointed Officer-in-Charge and initially the other officers were Mr. E. W. Hicks, Mr. W. A. Empey, Mr. N. E. Holmes (now of the Food and Agriculture Organization of the United Nations), and Dr. S. A. Trout (now Director of Horticulture, Department of Agriculture and Stock, Queensland). On account of the difficult economic conditions at the time, the Council did not have sufficient funds to build laboratories for the projected investigations on meat preservation and the storage of deciduous fruits. However, the Queensland Meat Industry Board generously met most of the cost of two laboratories and four cold rooms for meat investigations at its abattoir at Cannon Hill, Brisbane, and in Melbourne the Victorian Department of Agriculture provided accommodation for the fruit storage investigations.

PERSONAL

Professor George Stewart, Chairman of the Department of Poultry Husbandry in the University of California, Davis, U.S.A., has made his headquarters at Homebush during a nine months sojourn in Australia as a Fulbright scholar. Professor Stewart is a world authority on eggs, egg products, and the preparation and handling of poultry meat. In Australia Professor Stewart will conduct investigations aimed at improving the functional properties and stability of egg yolk products. He intends also to visit egg production centres in several States of the Commonwealth to meet egg producers and discuss technical problems with them.

Miss Annada Gohain, a science graduate from Gauhabi University, Assam (India), is a guest worker in the Divisional laboratories at Homebush. Miss Gohain, who holds a junior Fellowship under the Colombo Plan, has completed a 2-year course in food technology at the New South Wales University of Technology. She is now engaged on research into the storage of orange juice concentrate. Miss Gohain came to Homebush in March 1957 and plans to remain for one year from that date.

Mr. H. L. Evans, a Research Officer of the Division, left Australia on S.S. *Orontes* early in September 1957. Mr. Evans has been awarded a C.S.I.R.O. Overseas Studentship which he is taking up at the Imperial College of Science and Technology in the University of London. He intends to study problems in the transfer of heat and moisture, under Dr. D. B. Spalding, Senior Lecturer in the Section of Applied Heat, Department of Mechanical Engineering.

PUBLICATIONS BY STAFF

WATER RELATIONS OF FOOD SPOILAGE MICROORGANISMS. *W. J. Scott. Adv. Food Res. 7: 83-127 (1956).*

This review discusses the water relations of food spoilage organisms under the following headings : some basic concepts ; methods of study of water requirements ; water requirements for growth of moulds, yeasts and bacteria and the factors that affect them ; microorganisms with high tolerance of concentrated substrates, halophilic bacteria, osmophilic yeasts, and xerophilic moulds. Finally the review demonstrates how a knowledge of water relations may be applied in food preservation, and suggests aspects of the subject which call for further research.

STUDIES IN THE PHYSIOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E. *D. F. Ohye and W. J. Scott. Aust. J. Biol. Sci. 10: 85-94 (1957).*

Overseas a number of cases of botulism in human beings have been caused by *Clostridium botulinum* type E from preserved marine

products. This paper reports some physiological studies made on 10 type E strains at 12 temperatures between 2·5 and 45°C. Growth proceeded consistently from spore inocula at temperatures between 5 and 37·5°C, but some strains developed slightly at temperatures up to 45°C. Maximum rates of growth occurred at 35°C. The upper and lower temperature limits were several degrees lower than for type A and B strains.

The heat resistance of the spores was about one-thousandth that of spores of some type A and B strains. Type E toxin was found in greatest amount in cultures grown at 25°C. The toxin was most stable at pH 4·5–5 but more heat labile than type A toxin.

Two of 22 samples of marine mud yielded cultures containing botulinum toxin. The possible marine origin of type E strains is discussed.

HEAT RESISTANCE OF BACTERIAL SPORES AT VARIOUS WATER ACTIVITIES. *W. G. Murrell and W. J. Scott. Nature* ***179*** *: 481-2 (1957).*

Partial drying markedly increased the heat resistance of spores of several organisms, but further drying over phosphorus pentoxide caused some loss of this increased resistance. Differences up to 30,000-fold in the heat resistance of spores of different organisms in dilute buffer were reduced to about 10-fold after controlled drying.

DETERMINATION OF ETHYLENE DIBROMIDE IN FUMIGATED FRUIT. *B. H. Kennett and F. E. Huelin. J. Agric. Fd. Chem.* ***5*** *: 201-3 (1957).*

Ethylene dibromide is being used to fumigate oranges infested with the larvae and eggs of the Queensland fruit fly, and it is important to have a means of estimating the chemical in the fruit. The authors describe a method of recovering the ethylene dibromide from the fruit by distilling with steam and extracting with benzene. It may then be estimated by decomposing with sodium hydroxide in ethyl alcohol–benzene solution, oxidizing the liberated bromide to bromate, and determining the latter iodometrically.

HANDLING AND BRUISING OF APPLES. *E. G. Hall. Fruit World Aust.* ***56*** *(4): 9-11, 13 (1955). Also published in other Australian horticultural journals.*

This summary of American and some Australian investigations reveals the main causes of the bruising of apples and shows what may be done to eliminate them.

RAPID METHOD FOR THE ESTIMATION OF VOLATILE BASES IN FISH MUSCLE. *W. A. Montgomery. FAO. Fish Processing Technologists Meeting, Rotterdam, June 1956. Symp. Pap. No. 20. Mimeo, 12 pp.*

This method, suitable for measuring fish spoilage in the field, is a modification of Conway's microdiffusion method for the estimation of ammonia, trimethylamine, and other volatile bases.

Using a suitably prepared fish muscle extract the analyst measures the time needed for a definite proportion of the base (usually 7–35 per cent.) to be absorbed by a fixed amount of standard acid. The acid is in a conventional Conway unit which is continuously rocked by hand. The concentration of a particular base is determined by reference to a logarithmic absorption graph.

By this method, determinations of the concentration of trimethylamine and ammonia in prepared muscle extracts can be completed within a few minutes with an error of $\pm$ 0·25 mg N per cent. for trimethylamine and $\pm$ 0·4 mg N per cent. for ammonia.

EFFECT OF COATING WITH STARCH AND STARCH FRACTIONS ON STORAGE OF DEHYDRATED CARROT. *S. Kuppuswamy* and D. McG. McBean. Food Tech., Champaign* ***11*** *: 262-5 (1957).*

When dehydrated carrot is stored in air it develops off-flavours and odours, and becomes discoloured. Overseas workers have shown that the carrot retains its colour and flavour better when it is dipped in 2·5 per cent. starch solution or sprayed with the solution before drying. The experiments described in this paper were designed to show which of the two components of potato

*Colombo Plan Junior Fellow from the Central Food Technological Research Institute, Mysore, India.

starch (amylose or amylopectin) had this effect.

A panel of tasters examined dried carrots which had been treated with one or both of the starch fractions, and stored for 0, 2, 4, or 6 months at temperatures of 0, 77, 86, or 98 °F. No significant differences were observed in flavour, but chemical analysis showed that the amylopectin fraction of the starch improved the retention of carotene. Although starch coating retards deterioration, possibly doubling the storage life of dehydrated carrots under certain conditions, it is not as effective in this respect as packing in inert gas.

A POSSIBLE MECHANISM FOR THE MORPHOGENESIS OF LAMELLAR SYSTEMS IN PLANT CELLS. *A. J. Hodge,* J. D. McLean, and F. V. Mercer†. J. Biophys. Biochem. Cytol. 2 : 597-608 (1956).*

*C.S.I.R.O. Division of Industrial Chemistry.

†University of Sydney.

WHAT CAN METABOLIC STUDIES CONTRIBUTE TO STORAGE PROBLEMS? *F. E. Huelin, Papers Conf. Fruit Storage Investigators, 2nd., pp. 41-45 (1957).*

STATISTICAL DESIGN AND ANALYSIS OF FRUIT STORAGE AND RELATED EXPERIMENTS. *G. G. Coote. Papers Conf. Fruit Storage Investigators, 2nd., pp. 45-66 (1957).*

RAIL TRANSPORT VEHICLES USED FOR PERISHABLE PRODUCE IN AUSTRALIA. *E. W. Hicks. Papers Conf. Fruit Storage Investigators, 2nd., pp. 72-74 (1957).*

Copies of the 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).

ANSWERS TO INQUIRIES

SALTING AND CURING ANCHOVIES

Are anchovies found in Australian waters, and what is the usual method of processing them for commerce?

Anchovies are obtained commercially in two localities on the coast of Victoria, namely, Lakes Entrance and Port Phillip Bay. They are found in all Australian waters south of the tropics, and there are three subspecies—in the east, south, and west respectively.

At present the catch is largely used for making fish paste. A method for doing this is described by Tressler and Lemon on page 462 of their well-known book.*

Anchovies may be packed in Spanish or Italian style. This method depends on fermentation to give the product the desired flavour. The details vary among packers, but the following is a typical procedure. The fresh anchovies are headed and gutted by twisting the head. The visceral material comes away with the head. The fish are salted down in large hogsheads or vats using 40–50 lb of salt to 100 lb of fish. The containers are let stand in the sun or subjected to a temperature of 80–90 °F for several hours each day. After 3–4 months, fermentation will have progressed and the flesh will have assumed a red colour and acquired the flavour desired. At this stage the fish are removed from the brine and pressed to remove excess moisture and oil. They are then packed in cans with oil.

Another method is to cure the anchovies in tanks using 50 lb of salt to 100 lb of fish. After about 3 months the fish are removed from the heavy brine and resalted in hogsheads using 25 lb of salt to 100 lb of fish. The hogsheads are left in the sun until the anchovies have acquired the colour and flavour sought.

*TRESSLER, DONALD K. and LEMON, JAMES McW. (1951).—"Marine Products of Commerce." 2nd Ed. (Reinhold Publishing Corporation: New York.)

Conference on Refrigeration

THE Experimental Station for Refrigeration (Centro Experimental del Frio) at Madrid will hold its Second conference from November 4 to 9, 1957, at Vigo on the north-western coast of Spain. Overseas delegates will be welcome. The technical programme will consist of sessions on production of cold, application of refrigeration to animal products, cold stores, and refrigerated transport. Discussions at the conference will include packing and wrapping of animal products for storage.

Applications to attend or submit papers should be sent to Centro Experimental del Frio, Serrano 150, Madrid, as soon as possible. They should state whether the applicant is representing an organization or not, if he is a member of the International Institute of Refrigeration, and if accommodation in Vigo is to be reserved.

FOOD SCIENCE ABSTRACTS

THE THERMAL DESTRUCTION OF VITAMIN B_1 IN FOODS. *K. T. H. Farrer. Advanc. Food Res. 6 : 257-311 (1955).*

This review surveys the data available on factors influencing the thermal destruction of vitamin B_1 in foodstuffs, e.g. temperature, duration of heating, pH, presence and concentration of electrolytes, presence of heavy metals, presence of non-electrolytes, form and concentration of the vitamin, presence of oxygen, and moisture content. Details are given of losses of vitamin B_1 caused by various forms of heating in cereals, meats, poultry, fish, vegetables, dairy products, peanuts, etc., and in canned and dehydrated products. The most reliable and satisfactory method of following the destruction of vitamin B_1 is through simple reaction kinetics. By means of the kinetic approach it is shown that, of the data available, much is worthless and the remainder can be correlated and simplified, and that information available can be used through the first order reaction and the Arrhenius equation to predict the behaviour of vitamin B_1 in specified conditions. A study is being made of the products obtained from vitamin B_1 on thermal destruction, and from this, and from further studies on foods, specifically designed to yield kinetic data, the rapid solution of outstanding problems may be expected.

EFFECT OF PROCESSING ON THE VITAMIN CONTENT OF FOODS. *L. W. Mapson. Brit. Med. Bull. 12 : 73-7 (1956).*

A review dealing with: losses of ascorbic acid and carotene from vegetables during preparation, scalding, cooling, freezing, drying, and canning ; losses of B-vitamins from meat, and of vitamin A from herring ; losses of vitamins from dried egg, and dried and pasteurized milk ; and further losses during storage of processed foods. It is concluded that some loss of nutritive value during processing is inevitable, but that with care this need not be great, even in the case of ascorbic acid. Losses may be unimportant if the food is not consumed as a source of the particular nutrient (e.g. loss of ascorbic acid from meat or eggs), but loss of ascorbic acid from fruits and vegetables may be serious, since it is one of their chief nutritive properties. The same factors that diminish nutritive value during commercial processing also operate during domestic cooking. A common error is the overcooking of foods already processed.

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