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Food Technology in Western Samoa

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For a period in 1967 the author of this article managed a food processing laboratory at Alafua, four miles from Apia, Western Samoa. The laboratory was built by the Government of Western Samoa to encourage the processing of local products.

WESTERN SAMOA is a group of islands in the Pacific Ocean between 13° and 15° south latitude, and 171° and 173° west longitude. There are two large and several small islands, formed mainly of volcanic rocks, and surrounded for the greater part by coral reefs. The most fertile island is the second largest, Upolu, on which is the greatest proportion of the nation's population (135,000) as well as its seat of government and commercial capital, Apia. Formerly a trust territory administered by New Zealand for the United Nations, Western Samoa was declared an independent State on January 1, 1962.

Western Samoa faces similar problems to other developing countries. The population is increasing at the rate of 3·3% per year, and is expected to reach 159,100 by 1971 and 267,000 by 1986. Its income depends on copra, cocoa, and bananas and this dependence has put Western Samoa's economic stability in a precarious position during the last few years. World market prices of these products have fluctuated greatly, and production has been hampered by insects and disease and by a severe hurricane that struck in 1966. The need for economic diversification is urgent.

One of the greatest impediments to development is Samoa's geographic isolation. Western Samoa is 80 miles from American Samoa, 750 miles from Tonga, 790 miles from Fiji, 1800 miles from New Zealand, 2600 miles from Hawaii, and 2700 miles from Australia. These great distances from potential buyers drastically reduce Western Samoa's comparative trade advantage in some areas.

Fig. 1.—Taro plants (*foreground*) and cocoa tree (*right*) in the garden of a fale (native house without walls) in Western Samoa.

Food and Nutrition

The diet of the Western Samoans consists largely of taro root (boiled), together with bread-fruit (roasted), bananas (boiled green), and fish. Taro (Fig. 1), of which there is more than one species, is essentially a starchy food: although the tubers contain some protein they provide an unbalanced diet unless supplemented by foods richer in proteins, fats, and vitamins. Young taro leaves are edible after cooking, and could be a useful source of protein, vitamins A and C, iron, and calcium, but they are seldom eaten. Other starchy foods in the Samoan diet are bread-fruit and bananas. Starchy foods are often rendered palatable by the addition of small quantities of tastier foods, which also serve as sources of dietary essentials not in the staple diet. Animal products are important in this respect: most of the villages in Western Samoa are by the sea, from which fish is obtained, though it is sometimes in short supply. Some of the village natives keep pigs and fowls, and there are a few poultry farms. Palolo (*Eunice viridis*), a marine worm, is a traditional dish. It appears in enormous swarms at dawn on the day preceding and on the actual day of the moon's third quarter in October and November. The phenomenon is well known to the natives, who collect large quantities of the worm for food. A suitable method of preservation would guarantee availability for a greater proportion of the year than at present.

Papaws, mangoes, and occasionally pineapples are used for variety, and some vegetables are grown in the mountain gardens. The coconut plays an appreciable part in the diet on the coastal lowlands, but less on the highlands. A high proportion of the crop is made into copra and sold, and much of the proceeds is spent on importing foods for the Europeans and Samoans in the towns. The coconut provides fat, and some protein. At various stages of its development it is the source of ingredients for traditional dishes, one of which (palusami) is made by baking a creamy extract from the coconut. Palusami wrapped in taro leaves is served with hot meals. The coconut is also an important source of food for pigs and hens. Another source of dietary fat for the Samoans is cocoa, which is an important cash crop and is used as a beverage in the villages. The principal exports from Western Samoa are copra, cocoa, and bananas. Most of the trade is with New Zealand, from which there is a considerable import of flour, sugar, rice, canned meat, and canned fish. The native people earn money from selling garden products, and some work on plantations or for business organizations or the Government. As a result, some are able to buy imported foods, but the amount is relatively small. It is estimated that in the villages about 80% of the family effort is devoted to gathering or producing food. In all cases the Western Samoan diet is deficient in protein, especially animal protein, and with this goes a deficiency in iron and vitamin A.

In the towns there are extremely primitive marketing facilities. The surrounding villages could supply adequate amounts of bananas, papaws, coconuts, and other fruits in season, but it is doubtful if supplies of vegetables other than roots could be found easily. Better markets would help to improve the nutritional value of food for Western Samoans and also Europeans, for the latter are greatly dependent on expensive fresh food imports.

Development Programme

The Government of Western Samoa is endeavouring to educate its people in nutrition. In this it is being aided by United Nations agencies and the South Pacific Commission, which were jointly responsible for a training course in applied nutrition held in Apia in August–September 1967. The participants were teachers, nurses, and students of agriculture.

Western Samoa is dependent almost entirely on its production of coconuts, cocoa, and bananas for its domestic needs and for earning the foreign exchange essential for its economic well-being and development. The Government is accordingly putting considerable effort into growing and marketing these crops more efficiently, introducing other crops, and developing livestock production.

Some new export markets have been started in efforts by the Government to increase production for the domestic market. The Department of Agriculture is encouraging individual villagers to grow crops such as papaw, green beans, and green peppers for export, primarily to New Zealand. Western Samoa eventually hopes to be able to supply New Zealand with

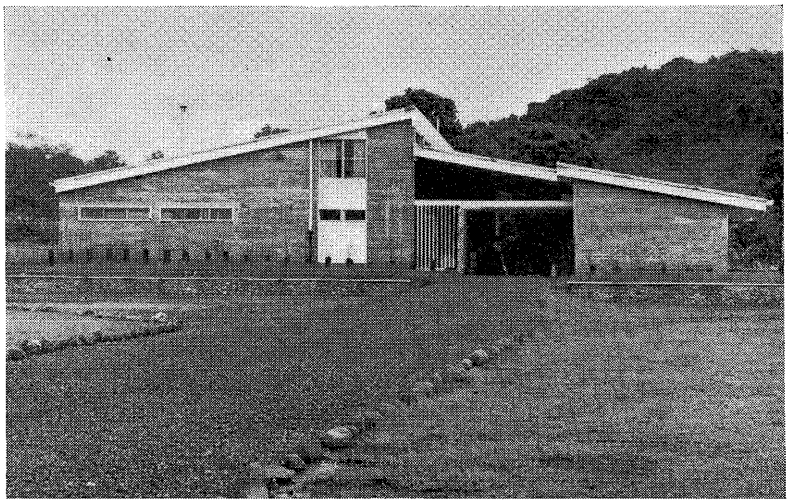

Fig. 2.—The Government Food Processing Laboratory at Alafua, in Western Samoa. The factory space (*left*) is separated from laboratory and office block (*right*) by a breezeway.

most of its fresh fruit and vegetables during its winter season. Although this will be a seasonal market at first, it is hoped that eventually it will become a regular export trade throughout the year.

Already, canned papaw and canned tropical fruit cocktail (bananas, pineapple, papaw, and mangoes) are in the initial stages of production. Other products such as guava, passion-fruit, and papaw juices are forecast. The manufacture of jams and jellies from tropical fruits, the canning of bananas and mangoes, the processing of coffee, macadamia nuts, coconut chips, and syrup, have been investigated, and all have great potential. Food processing when fully under way will be a great boon to the local market as well as the export market.

The local Government in conjunction with the New Zealand Government has established a substantial agricultural college at Alafua—the South Pacific Regional College of Tropical Agriculture—to train personnel and operate field stations, and has brought agricultural experts to the country.

Food Processing Laboratory

In 1967, after his retirement from CSIRO, Mr. L. J. Lynch became director of the newly completed Food Processing Laboratory, and in collaboration with Mr. R. S. Mitchell, of the CSIRO Division of Food Preservation, was responsible for installing the equipment, a considerable amount of which was provided by the Australian Government through its South Pacific Technical Assistance Plan.

The writer of this article arrived in 1967 and all installations were concluded and the laboratory officially handed over to the Government of Western Samoa in September 1967.

In 1969 the Laboratory was taken over as an F.A.O. Project under Dr. V. B. Reddy of India, and Mr. A. W. Martin, a Sydney food technologist, was appointed to direct its operations.

The Food Processing Laboratory at Alafua (Fig. 2) consists of two buildings, a processing area of approximately 1700 sq ft and an office and laboratory block of about 1200 sq ft, connected by a covered breezeway.

The processing area is equipped for the more important food processing operations. For preparation of foods there are stainless steel tables and trolleys, a slicer, a pulper, a comminuting machine, and a variety of utensils. Canned foods may be sealed on a hand-operated vacuum can-closing machine and processed in an atmospheric spin cooker

or in a retort fitted with a temperature recorder-controller. Among the other equipment are an electric forced-draught dehydrator and a refrigerated heat-exchanger. Steam and water services are connected to appropriate equipment, or available from several general-purpose outlets. An elevated mezzanine area serves to store containers and raw materials, and it carries two domestic-type refrigerators and two deep-freeze cabinets. There are also two small storage rooms in the main processing area, one for finished products and the other for ingredients.

The covered breezeway is large enough to receive one delivery truck and to store produce temporarily. It also accommodates a permanently installed cool-room of approximately 150 cu ft capacity.

The laboratory block is divided into three sections: a large laboratory, which is air-conditioned, a small office for a typist, and a separate office for the Director. The laboratory is equipped for quality control and some analytical work, and it contains many text and reference books.

Western Samoa has only a small food manufacturing industry: some tropical fruits have been canned, aerated soft drinks are made (from imported ingredients), bread is baked, and chips are made from the taro tuber.

With a view to encouraging the development of food processing, the Government built the Food Processing Laboratory at Alafua, adjacent to the College of Tropical Agriculture. The functions of the Laboratory are to demonstrate the canning and freezing of food, to investigate methods of processing native foods, e.g. palolo and palusami, to give technical guidance to food processors and to those planning to establish food factories, and to assist in training food technicians.

International Institute of Refrigeration

Australian National Committee

The International Institute of Refrigeration (I.I.R.), whose headquarters are in Paris, has a world-wide membership. It actively advances both the science and application of refrigeration, particularly in the preservation of food, and encourages liaison between countries and organizations through ten Commissions. Australia has been a member country for some time with representation on the Executive Committee. An Australian National Committee was recently formed to promote the objects of the I.I.R. within Australia and to facilitate active participation in I.I.R. affairs. The Australian Liaison Officer and Secretary of the National Committee, Mr. F. G. Hogg, CSIRO Division of Mechanical Engineering, P.O. Box 26, Highett, Victoria 3190, would be pleased to hear from any persons or organizations interested in the work of the Commissions, which are in the following fields:

Commission I — Cryophysics and cryo-engineering

Commission II — Heat and mass transfer

Commission III — Refrigerating machinery

Commission IV — Refrigeration of perishable produce

Commission V — Cold storage facilities

Commission VI — Air conditioning

Commission VII — Refrigerated land transport

Commission VIII — Refrigerated sea transport

Commission IX — Applications of refrigeration to chemical, civil, and industrial engineering

Commission X — Cryobiology and freeze-drying

Analytical Problems with Fruit Products

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ALL of the advanced countries have found it necessary to set up regulations governing the quality and composition of foods. Australia, with the United States of America, pioneered this type of legislation in 1908. Having established regulations it is necessary to lay down procedures by which they can be policed, usually by one of two methods: by inspection at the point of manufacture, or by taking samples of the final product at the point of sale and subjecting them to examination and analysis. Enforcement authorities usually prefer to sample at the point of sale because they are then examining and analysing the product that the consumer actually receives, and indeed this is the only possible procedure when the product is an imported one. The analyst, therefore, is an important member of the enforcement team.

Fruit Content

One aspect of the composition of foods that is commonly regulated is the fruit content. The original motive for this was no doubt protection of the consumer, who buys a food or beverage labelled with the name of a fruit expecting it to have a reasonable content of that fruit. Fruit products need legislative protection because they are easily imitated by the use of artificial colours and flavours.

Strong pressure to regulate the fruit content in foods has also come from fruit growers, who simply want to sell more fruit. An interesting example of this is found in the Commonwealth Sales Tax Regulations which provide for a rebate of sales tax on soft drinks containing 5% and on cordials containing 25% of Australian fruit juice. Nearly all Australian soft drinks now contain citrus juice or apple juice in order to qualify for rebate of sales tax.

As well as in soft drinks and cordials, fruit content is commonly regulated in fruit juices and concentrates, in jams, and in tomato products. For instance, the model Standard for Jams of the National Health and Medical Research Council states that a jam 'shall contain not less than 40 parts per cent by weight of fruit of the variety named'.

The food analyst, therefore, may be presented with the problem of determining analytically the fruit content in a compounded food or beverage. This is a much more complex problem than, for instance, analysis of a food for poisonous metals, such as lead and arsenic.

Index Compounds

What is a fruit from a chemical point of view? It consists of 80–90% water, 1–2% insoluble structural material, and 10–15% of soluble solids in great variety. What the analyst looks for is a particular constituent of the fruit that can be followed through into the final product and used as an index of the fruit content. The ideal constituent would be one that was specific to a particular fruit and had the same concentration in that fruit at all times and places, was stable to processing, was amenable to convenient and accurate determination, and was so rare or so expensive that it was unlikely to be added as an adulterant.

The ideal index constituent does not exist. Fruits are in fact very variable in composition, and the concentrations of all their constituents are influenced by many factors: by variety, by maturity, by growing area, by climate, and by a host of horticultural factors such as fertilization and irrigation practice. So the composition of a fruit cannot be defined in an

absolute way, but only in terms of ranges and averages with the usual statistical specifications to indicate the variability.

The constituents of fruits present in greatest amount are sugars, mainly glucose, fructose, and sucrose, with minor amounts of other sugars. The acids are generally next in order of concentration, for instance, in citrus fruits, citric acid with a range of other acids. The sugars and acids are of little use, however, as indexes of fruit content, because sugar and acid are commonly added to soft drinks, cordials, and jams as legitimate ingredients, and they may be added as deliberate adulterants to fruit juices and concentrates.

Over the years many minor constituents of fruits have been investigated as indexes of fruit content: inorganic elements, nitrogen compounds, polyphenolic compounds, vitamins, and pigments. Some of these may be looked at in detail with particular reference to citrus fruits because they have been studied more intensively than other fruits.

Inorganic Constituents

Early procedures recommended for estimating the fruit content of citrus products involved determining the ash content, as a gross measure of inorganic elements, the alkalinity of the ash, expressed as K_2CO_3, as a measure of potassium, and the phosphate content (Stern 1943, 1954; Morgan 1954).

Obviously the validity of these procedures depends upon the fruit ingredient being the only source of ash constituents. This assumption is reasonable when the only other ingredients in the food are water, refined sugar, edible acids of high purity, and volatile flavouring materials. But if the product is preservatized by the addition of sulphite or benzoate as the potassium or sodium salt, a source of error is introduced. A method for correcting for such additives has been described by Morgan (1963). The product is ashed with a weighed amount of calcium carbonate which protects sulphates and chlorides from reaction with sugars to form carbonates. Then the total alkalinity of the ash obtained by titration is corrected for sulphites, benzoates, and phosphates, after each has been separately determined. From the results is calculated an index, 'combined acids as citric acid', which represents the organic anions in combination with inorganic cations. The values of this index for citrus fruits from a number of regions appeared to range less widely than other indexes based on inorganic constituents.

Analysts now tend to favour direct determinations of the inorganic elements in fruits, taking advantage of rapid and convenient techniques such as flame photometry.

Potassium, phosphorus, and nitrogen are the elements most often used as indexes of fruit content. Citrus fruits contain about 2000 p.p.m. of potassium, about 200 p.p.m. of phosphorus, and about 1000 p.p.m. of nitrogen (Kefford and Chandler 1969). Thus if an orange drink was analysed and found to contain 500 p.p.m. of potassium, the conclusion might be drawn that the drink was made up with 25% orange juice.

But, as already mentioned, the potassium content of orange juice will vary greatly according to the horticultural history of the sample. Therefore in order to interpret the results of such analyses it is necessary to draw upon a large volume of accumulated information about the composition of citrus juices. For orange juice, the normal range of potassium content appears to be 1200 to 2600 p.p.m.; calculations using the extremes of this range then give the result that the orange drink might have had a pure juice content anywhere between 19·2% (500/2600) and 41·8% (500/1200).

Similar considerations apply when using the phosphorus content or the nitrogen content as an index. However, as Steiner (1949) has pointed out, a more reliable measure of fruit content can be obtained by calculations making use of more than one index compound. Thus Hulme, Morries, and Stainsby (1965) recommended the combined formula for comminuted orange drinks:

$$\text{Fruit content} = 0{\cdot}05\ (7k+10p+3n),$$

where k, p, and n are the calculated fruit contents based on analyses for potassium, phosphorus, and nitrogen respectively.

Now, quite apart from the uncertainties arising from the variable composition of fruit juices, if somebody is bent on adulterating a juice it is not difficult to circumvent these analytical tests based on inorganic elements. There is a great temptation to add water to juices, and then the next step is to add some sugar, acid, potassium salts, ammonium salts, and phosphates to bring the analytical results in line. In Europe there is

reported to be available 'orange ash sugar', i.e. sugar doctored to make its ash conform with that of orange juice. So analysts have had to devise more cunning methods to outwit the ungodly.

Phosphorus Compounds

Very recently, American workers at the Fruit and Vegetable Chemistry Laboratory of the U.S. Department of Agriculture at Pasadena, California, have examined the forms in which phosphorus is combined in citrus juices (Vandercook and Guerrero 1969). They determined total phosphorus, inorganic phosphorus, lipid phosphorus, and an ethanol-insoluble phosphorus fraction which was in combination in nucleic acids and phosphoproteins. While they concluded that none of the individual phosphorus fractions alone was a satisfactory index of the authenticity of citrus juices, they established an inverse relation between inorganic phosphorus and ethanol-insoluble phosphorus, as percentages of total phosphorus, that might find application for this purpose.

Nitrogen Compounds

Among the nitrogen compounds in citrus juices are a number of free amino acids, and a gross measure of the total amino acid content is given by an index known as the 'formol value'. When the free amino groups are blocked by reaction with formaldehyde, forming *N*-methylene amino acids, the carboxyl groups may be titrated with alkali. The juice sample is first neutralized to pH 7, neutralized formalin is added, and the titre with alkali to pH 8·4 is then the formol value. There may be some uncertainty as to the groups titrated at pH 8·4 (Taylor 1957), but the procedure was sufficiently reproducible in collaborative studies to be accepted at the first action stage by the Association of Official Analytical Chemists (Yokoyama 1965). Information is available on the formol values of citrus juices from many growing areas throughout the world (Kefford and Chandler 1969; Floyd and Rogers 1969).

Again, however, determinations of fruit content based on amino acids are not proof against adulteration. It is also reported that there are available in Europe amino acid tablets prepared for addition to citrus juices. It is presumably expensive to put up a mixture approximating closely to the natural composition of orange juice, so when a citrus juice is adulterated by the addition of water, sugar, and acid, usually only glycine is also added to bring up the formol value.

Now it happens that the natural glycine content in citrus juices is low, so it is not too difficult to detect glycine addition by chromatography. Mrs. Alvarez (1967), of the firm of Bush Boake Allen, has described a qualitative procedure based on thin-layer chromatography on silica gel.

When the plates are developed with aqueous propanol, and sprayed with ninhydrin, added glycine appears as a pink spot just ahead of a yellow proline spot. Generally no glycine spot is visible with pure juices.

Another way to increase the formol value in an adulterated juice is to add a protein hydrolysate. This, too, can be detected by examining the distribution of the amino acids. For instance, citrus juices contain the rather rare amino acid, γ-aminobutyric acid, at a concentration about four times that of the leucine–isoleucine amino acids. Protein hydrolysates, however, are relatively high in leucine–isoleucine and they disturb this concentration relationship when they are added as adulterants (Vandercook, Rolle, and Ikeda 1963).

Some individual nitrogen compounds provide useful quantitative indexes of fruit content.

If orange juice is passed through a strongly acid cation exchange column, the amino acids and nitrogen bases are absorbed and may be eluted with ammonia. Individual nitrogen compounds may then be determined in the eluate. Different analysts have selected different members of this group as indexes of fruit content. R. H. Morgan (1966), who is a London Public Analyst, favoured the amino acid, serine. Serine has a terminal secondary alcohol group which yields formaldehyde by periodate oxidation, and the formaldehyde is reacted with chromotropic acid to give a coloured compound amenable to spectrophotometric estimation. In addition, serine is fairly uniformly distributed through all the parts of the orange: the juice, the pulp, and the peel. This aspect is important in the analysis of comminuted beverages, which incorporate a substantial proportion of the whole fruit, and which have become popular in England. English regulations specify a potable fruit content in which all the fruit constituents are counted, not only the juice.

Morgan (1966) found reasonable uniformity in the serine contents of the peel, pulp, and juice of oranges from Australia, South Africa, Israel, Cyprus, and Spain, with an overall average figure of 0·192 mg/g. When he applied this factor in the analysis of orange drinks and cordials for fruit content he obtained good agreement with values estimated from the potassium and phosphorus contents.

On the other hand, W. M. Lewis (1966), who is a City Analyst in Coventry, selected the nitrogen base, betaine, as the basis for a very similar procedure. Betaine is also retained on the cation-exchange resin and eluted with ammonia, but it is then separated from amino acids and other ionic species by passage through a second ion-exchange column containing a mixture of the hydroxyl form of a weakly acidic cation-exchange resin. The betaine passes through and is precipitated with Reinecke's salt. The betaine salt is dissolved in aqueous acetone and determined spectrophotometrically. Betaine is peculiar to citrus fruits and therefore this procedure is useful, for instance, for determining the orange content in a mixed orange–apple drink. The betaine content of orange products on the Canadian market was examined by Coffin (1968).

Both the serine and betaine procedures are being subjected to collaborative examination by the Association of Official Analytical Chemists (Gerritz 1969).

Citrus fruits also contain another interesting group of nitrogen bases which are phenolic amines of the ephedrine type and have pharmacological properties (Kefford and Chandler 1969). For instance, tangerines contain tyramine and octopamine, while oranges contain synephrine. These bases may be isolated by ion-exchange chromatography, and estimated by ultraviolet spectrophotometry. They have not yet been made the basis for quantitative estimates of fruit content, but they might be useful for the diagnosis of adulteration, including adulteration of one kind of citrus juice with another, for instance, the addition of mandarin juice to orange juice.

Vitamins

In addition to being nutritionally important in citrus juices, the vitamins may have a subsidiary value as indexes of fruit content. Ascorbic acid is the principal vitamin present, but it is of little use to the analyst because synthetic ascorbic acid is cheap and is a known adulterant. Among the other vitamins, workers in the laboratory of the Government Chemist in London have drawn attention to nicotinic acid as a useful index compound (Sawyer 1963). Nicotinic acid analyses on a large number of samples from different growing regions indicated an average content of 0·29 mg/100 ml of juice, with 95% confidence limits of $\pm 0 \cdot 14$ mg/100 ml. Therefore any samples of orange juice containing less than 0·15 mg of nicotinic acid per 100 ml should be regarded with suspicion. To the chemist, nicotinic acid has the basic disadvantage of requiring microbiological assay.

Following on from this work, and again applying the ideas of Steiner (1949), Lisle (1965) of the Government Chemist's laboratory examined another minor constituent, inositol, as an index compound. In oranges from Israel, South Africa, British Honduras, and Southern Rhodesia the inositol (A mg/100 ml) and nicotinic acid (B mg/100 ml) contents showed reasonable and similar coefficients of variation of about 12%. A formula combining these two indexes was calculated for the concentration (C) of orange juice concentrates, in units of 18° Brix juice, as follows:

$$C = 2 \cdot 20B + 0 \cdot 0025A.$$

Polyphenolic Constituents

A group of polyphenolic constituents, including flavonoids, flavonoid glycosides, and coumarin derivates, is present in citrus juices, and the total polyphenolic content may be estimated by ultraviolet spectrophotometry on the clarified juice serum. Two peaks are observed, at 273–277 and 326–332 nm, and it is the absorbance at the latter peak that is used as the measure of total polyphenolics (Vandercook and Rolle 1963). The procedure has recently been adopted officially at the first action stage by the Association of Official Analytical Chemists (Yokoyama 1965). The individual polyphenolics may be identified by paper chromatography followed by spraying with standard reagents (Vandercook and Stephenson 1966).

The total polyphenolic content has been chiefly investigated as an index of fruit content in lemon products, by American workers

(Vandercook and Rolle 1963) who also examined malic acid for the same purpose (Vandercook, Rolle, and Ikeda 1963).

Malic Acid

The dominant acid in lemon juice is citric acid, but there are also present appreciable amounts of malic acid, which may be estimated by the optical rotation of the uranyl acetate complex (Yokoyama 1965; Fernandez-Flores, Johnson, and Blomquist 1968).

If apple juice is added to adulterated lemon juice to increase the malic acid content, the adulteration may be detected by a change in the ratio of the absorbance of the two polyphenolic peaks in the ultraviolet spectrum, and by the appearance of foreign spots on paper chromatograms.

Like the English workers, the American workers found that the use of multiple indexes to estimate fruit content gave more reliable results than single variables (Rolle and Vandercook 1963). To test the authenticity of lemon juice samples they recommended the formula:

$$c = 36{\cdot}54+12{\cdot}04a+2{\cdot}71m+30{\cdot}06p,$$

where c is the calculated citric acid content, a is the amino acid content, m is the malic acid content, p is the polyphenolic content, and all the concentrations are expressed in milliequivalents per 100 ml of juice. If the acidity determined by titration exceeds the calculated citric acid content (c) by more than 20%, the sample is considered to be abnormal. The validity of the formula was not affected by processing variables nor by the presence of sulphite, benzoate, and sorbate preservatives (Vandercook *et al.* 1966; Vandercook and Guerrero 1968).

It may be mentioned here that workers in Beecham Products (U.K.), who are major processors of black currants, have devised a procedure for estimating the fruit content of black currant products based on calculations combining the total polyphenolic content, the phosphorus content, and the chloramine value (see below) (Ayres, Charley, and Swindells 1961, 1962).

Carotenoid Pigments

In the course of their very thorough search for index compounds in lemons, the American workers (Vandercook and Yokoyama 1965) also looked at carotenoid pigments and sterols, but the correlations between the concentrations of these compounds and the citric acid content were not close enough to make them useful indicators of authenticity.

Italian workers have claimed to be able to detect the addition of lemon juice to orange juice by examination of the chromatographic pattern of carotenoids on alumina (Safina and Trifiro 1953), while for detection of the addition of mandarin juice to orange juice Koch and Sajak (1965) suggest estimation of the cryptoxanthin content, which is much higher in mandarin juice than in orange juice.

Addition of synthetic carotenoid pigments, such as β-carotene, β-apocarotenal, and canthaxanthin, to citrus products may be detected by two-dimensional thin-layer chromatography on silica gel (Primo and Mallent 1966).

Adulteration with Peel and Rag

One way of adulterating citrus juices is to add extracts of the peel and rag; the residues after extraction of the juice are mixed with water and pressed to give an extract which is added to the juice. There are a number of tests by which the analyst may detect this form of adulteration.

European analysts have made much use of an empirical index called the chloramine value. The sample is mixed with a solution of chloramine T (sodium *N*-chloro-*p*-toluenesulphonamide), and the mixture is allowed to stand in the dark for 15 minutes; some crystals of potassium iodide are added, the solution is made acid, and the iodine liberated is titrated with sodium thiosulphate. The chloramine value is then the number of millilitres of 0·01N chloramine T solution reacting with 1 ml of juice. It might be described as a gross oxidizing index since the chloramine T oxidizes ascorbic acid, proteins, polyphenols, pigments, and flavouring constituents; sugars and acids are unaffected. Chloramine values of peel extracts are significantly higher than those of juice samples, and therefore provide a means of detecting adulteration with peel extracts (Wucherpfennig and Franke 1966). The ratio of the chloramine value to the formol value has also been suggested for this purpose (Di Giacomo and Rispoli 1966).

Still another approach to this problem is through the additional pectin incorporated in the juice from peel extracts, and the pectin content can be expressed in terms of another index, the pentose equivalent (Sawyer 1963; Benk 1968). When the sample is destructively distilled with hydrochloric acid, xylose is produced by hydrolysis and converted into furfural, which in turn is reacted with orcinol and ferric chloride to permit colorimetric determination. The pentose equivalent is considerably higher for rag and peel extracts than for juices.

In the peel of citrus fruits there are a number of highly methoxylated flavonoid compounds which may also be used as analytical indexes. They may be separated from juice and beverage samples by chromatography on alumina. For the detection of the presence of orange peel in orange products, Miss R. Born (1957), of J. Lyons and Company, made use of the presence of 3′,4′,5,6,7-pentamethoxyflavone in the peel. After chromatography of a benzene extract of the sample on alumina, a fraction showing intense violet fluorescence under ultraviolet radiation was collected and the absorption of this fraction was measured at 325 nm. Authentic orange juice samples showed an absorption less than 0·2 units, while samples containing peel gave values in the range 0·3–0·9.

Bitter Principles

It may be of interest to conclude with an analytical procedure that was devised in Australia. For some years the CSIRO Division of Food Preservation has been investigating the problem of bitterness in orange juices caused by the presence of triterpenoid bitter principles of which the one present in greatest amount is limonin, a triterpenoid ketone. Orange juice is detectably bitter when the limonin concentration reaches 7–9 p.p.m. and the maximum concentration encountered is about 30 p.p.m.

Early investigations were hampered by the lack of a chemical method for the determination of limonin, and Australian workers (Chandler and Kefford 1966) were first to develop a practical procedure for limonin assay in citrus products. After selective extraction, limonin is converted into the 2,4-dinitrophenylhydrazone which is then separated from other substances by thin-layer chromatography on silica gel. The spot of the limonin derivative is removed from the plate, dissolved in acetone, and measured spectrophotometrically. Recent work points to the possibility of accelerating the analysis by direct densitometric measurements on limonin spots on thin-layer plates.

Workers in California (Wilson and Crutchfield 1968) subsequently described a more rapid but less specific analytical procedure based on conversion of limonin, which also has lactone groups, to the hydroxamic acid, followed by colorimetric determination as the ferric complex.

As a rather unreactive constituent, specific to citrus fruits and not readily accessible otherwise, limonin may possibly be a useful index compound for assessment of fruit content and detection of adulteration, but it has not so far been seriously investigated from this point of view.

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Phosphate Corrosion in Canned Meat

By P. W. Board

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

THE State Pure Food Regulations permit the addition of soluble inorganic phosphates to canned meats up to 0·3% of the total weight, calculated as phosphorus pentoxide. It is the practice in Australia and in some overseas countries to use tetrasodium pyrophosphate, acid sodium pyrophosphate, sodium hexametaphosphate, or sodium tripolyphosphate, or mixtures of these compounds. Polyphosphates are claimed to improve product yields by increasing the water-holding capacity of the meat, to reduce fat separation, to improve texture and slicing characteristics, and to improve the appearance of the product. The wide use of polyphosphates in canned meats, especially hams, is evidence that some of these claims are valid.

There are, however, disadvantages in adding polyphosphates to canned meats, the main ones being the tendency of these salts to increase the rate of corrosion and to intensify sulphur-staining of the tinplate. In the 1950s, ham canners in the U.S.A. began using polyphosphates in curing brines with the result that the tin was quickly corroded from the interior surface of the cans, and the surface of the product was discoloured by corrosion products. The use of fully lacquered cans did not overcome the corrosion problem because attack on the tin and iron occurred at areas of metal exposure, particularly at the score-lines and side seam, and the product in contact with these areas often became discoloured. It was found that corrosion at discontinuities in the lacquer and consequent product discoloration could be effectively prevented by welding a small square of aluminium to the lacquered tinplate so that the aluminium acted as a sacrificial anode and prevented solution of tin and iron at the small areas of exposed tinplate (McKernan *et al.* 1957). The so-called 'anodized' can having a sacrificial aluminium anode is now widely and successfully used for phosphate-cured hams (American Can Company 1955).

Accelerated corrosion in cans of cured meats containing added phosphates has also been a problem in the Danish industry. Pedersen (1964) reported on an investigation aimed at comparing the effect of different polyphosphates and of phosphates of different acidity on corrosion in cans of luncheon meat. In one trial a pork luncheon meat containing one or another of several types of phosphate, or proprietary mixtures of phosphates, was processed in internally lacquered and scored cans, and in plain hot-dipped tinplate cans. After one week the cans were examined for discoloration of the product at the score-line of the lacquered cans, and for staining of the plain cans. The polyphosphates varied in their effect on these disorders; sodium tripolyphosphate and disodium pyrophosphate were most aggressive, and sodium hexametaphosphate had little or no effect. The non-aggressive phosphates, however, do not seem to improve the quality of the meat product, and they are likely to be hydrolysed during retorting of the cans. It was concluded that the mechanism of action of the polyphosphates on tinplate was complex and could not be explained in terms of the effect of additives on product pH only.

Investigations in the Division

Commercially processed cans of meat loaf containing added polyphosphates have been submitted to this Division for examination following complaints of unusually heavy sulphur-staining and corrosion of the plate, staining of the surface of the product, and loss of vacuum and swelling of the cans resulting from accumulation of hydrogen. To determine the influence of polyphosphates in producing these adverse changes, three lots of canned corned beef loaf were prepared with varying levels of added polyphosphate. The cans were stored at 100°F (37·8°C) and 68°F (20·0°C) and examined at intervals for sulphur-staining and corrosion.

Canning Method

The product contained 75% minced beef, 10% flour, 13% water, 1·5% salt, and a commercial curing mixture containing salt, nitrate, and nitrite. The polyphosphates were added as a mixture of equal weights of disodium dihydrogen pyrophosphate (63·9% P_2O_5) and tetrasodium pyrophosphate (53·5% P_2O_5) dissolved in water. The concentrations of polyphosphates added were equivalent to 0, 0·15, 0·3, 0·45, and 0·6% P_2O_5. The products were filled into 401 × 201 plain cans that were closed under 25 in. vacuum and retorted for 100 min at 235°F (112·8°C) and water cooled. Three lots of cans were used in this investigation, the first two lots made from 1·25 lb per basis box hot-dipped tinplate while the third lot was 100/50 electrolytic tinplate that had received a cathodic dichromate passivation treatment; the heavier coating of tin of the electrolytic tinplate was in contact with the product.

Examinations

The concavity of the ends of the cans stored at 100°F (37·8°C) was measured at monthly intervals to follow changes in the internal pressure of the cans caused by accumulation of hydrogen gas. Samples of the different products were analysed for total phosphate by a colorimetric method using the phosphovanadomolybdate complex (Snell and Snell 1949), and the pH of the contents was determined. Iron and tin determinations were not usually done because of the difficulty in obtaining satisfactory samples of the product in contact with the can wall, but determinations on selected samples of discoloured material showed large concentrations of tin and iron.

After cleaning the cans with hot detergent solution the interior surfaces were examined for sulphur-staining and detinning. These examinations were assisted by rubbing selected areas of the cans with a wet, soft rubber eraser, which effectively removed sulphur-staining from the tin surface but did not alter the shape of the detinned areas. This simple procedure allowed dark, sulphur-stained areas to be distinguished from detinned areas.

Results

The data in Table 1 show that the time in weeks for a 0·01 in. decrease in concavity varied with the concentration of added polyphosphate. The most rapid change in concavity occurred in cans containing approximately the maximum permitted level of added polyphosphate (0·3% equivalent P_2O_5). Cans containing only half this level of added polyphosphate showed markedly faster changes in concavity than the cans containing no addition. Cans containing gross quantities of added polyphosphates (e.g. 0·60% equivalent P_2O_5) showed less rapid change in concavity than cans having smaller additions.

Table 1

Phosphate Added (% P_2O_5)	Time (wk) for 0·01 in. Decrease in Concavity			
	Hot-dipped Tinplate A	Hot-dipped Tinplate B	Electrolytic Tinplate	Treatment Mean
0	75	96	37	69
0·15	67	59	32	53
0·30	39	57	31	42
0·45	39	57	27	41
0·60	66	67	31	55

The changes in concavity were a good index of progressive corrosion of the cans. Figure 1 shows typical areas ($1\frac{3}{4}$ in. by $2\frac{5}{8}$ in.) of body plate taken from cans made from a batch of hot-dipped tinplate; the product in these cans contained 0, 0·15, 0·30, and 0·60% equivalent P_2O_5 added phosphate. The cans were stored for 2 days and 4 months at 100°F (37·8°C) before examination. Figure 2 shows the same coupons of body plate after the sulphur-staining had been removed with a rubber eraser. Figure 3 shows coupons from the electrolytic tinplate cans; the absence of sulphur-staining on these cans allowed unhindered observation of the detinned areas.

The electrolytic tinplate cans lost vacuum more rapidly than the hot-dipped tinplate cans at all levels of added polyphosphates. This observation involves only one sample of electrolytic tinplate but is consistent with other reports (e.g. Davis 1961) and industrial experience which show that for meat products electrolytic tinplate tends to detin faster than hot-dipped tinplate.

Additions of 0·3% and 0·6% equivalent P_2O_5 as mixed polyphosphates raised the pH of the product by about 0·1 and 0·2 pH units respectively from an initial pH of 6·1.

The phosphate determinations confirmed that the product contained the expected levels of phosphate above the natural levels which were about 0·25% to 0·30% equivalent P_2O_5.

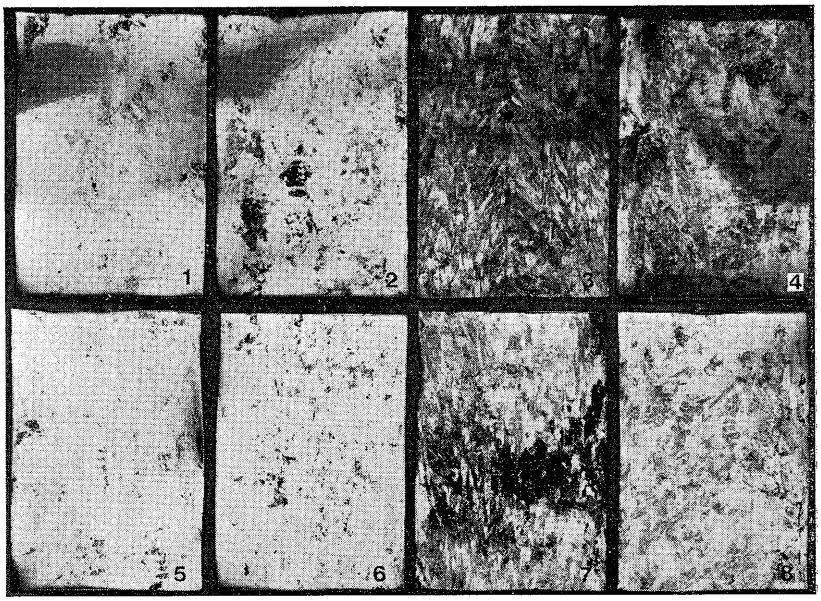

Fig. 1.—Coupons ($1\frac{3}{4}$ in. by $2\frac{5}{8}$ in.) of hot-dipped tinplate taken from the body of cans that contained meat loaf with added phosphates. Coupons 1–4 were from cans that were stored for 2 days at 100°F (37·8°C) and coupons 5–8 were from cans stored for 4 months at 100°F (37·8°C). The levels of added phosphate as equivalent P_2O_5 were: coupons 1 and 5, nil; coupons 2 and 6, 0·15%; coupons 3 and 7, 0·30%; coupons 4 and 8, 0·60%.

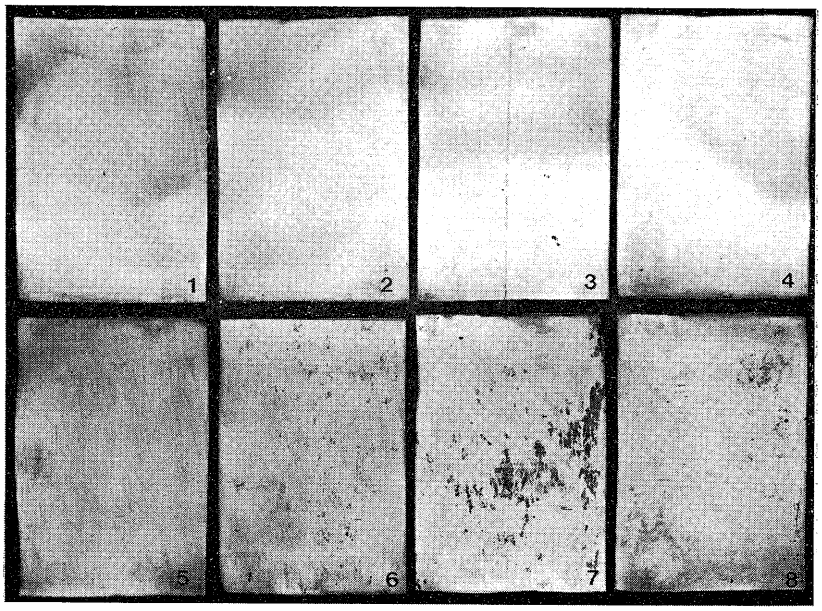

Fig. 2.—The same coupons as in Figure 1 after removal of sulphur stain to reveal detinned areas.

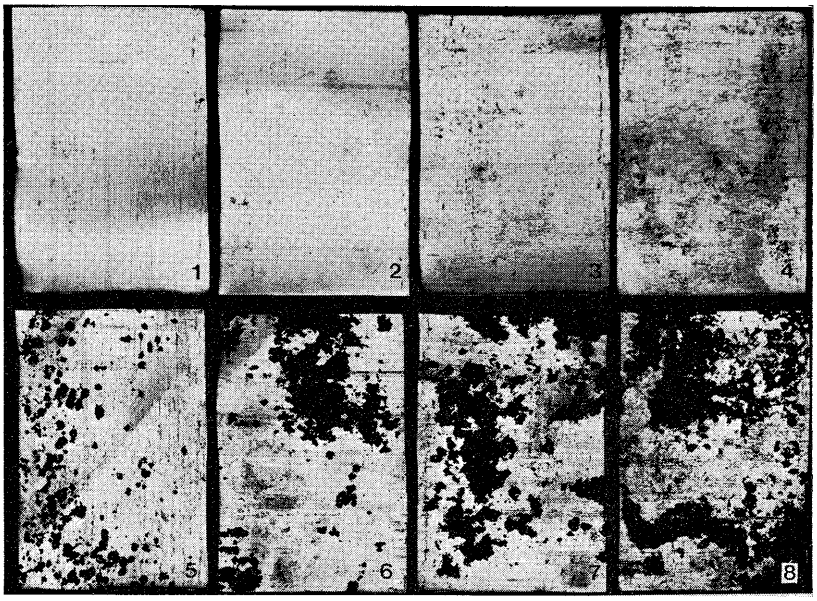

Fig. 3.—Coupons ($1\frac{3}{4}$ in. by $2\frac{5}{8}$ in.) of electrolytic tinplate taken from the body of cans that contained meat loaf with added phosphates. Coupons 1–4 were from cans that were stored for 2 days at 100°F (37·8°C) and coupons 5–8 were from cans stored for 4 months at 100°F (37·8°C). The levels of added phosphate as equivalent P_2O_5 were: coupons 1 and 5, nil; coupons 2 and 6, 0·15%; coupons 3 and 7, 0·30%; coupons 4 and 8, 0·60%.

Conclusions

Examination of the test pack cans confirmed earlier reports that addition of polyphosphate increased the intensity of sulphur-staining, increased the rate of corrosion of the tin coating, and reduced the vacuum in the can by formation of hydrogen.

The products of corrosion frequently caused unsightly black staining of the surface of the product. The deleterious effects seem to be most pronounced in the packs having approximately the maximum permitted level of added polyphosphate.

There was a marked difference in the performance of electrolytic tinplate and hot-dipped tinplate in these tests. The electrolytic tinplate was resistant to sulphur-staining at all levels of addition of phosphate, but showed more rapid detinning than hot-dipped tinplate. The dark, detinned areas in the electrolytic tinplate were most obvious against the surrounding bright tin coating, and may therefore be as objectionable to consumers as the uniform heavy sulphur-staining in the hot-dipped plate.

Canners who add polyphosphate to meat products to improve certain attributes and yields are therefore advised that the storage life of the canned product will be shortened by accelerated corrosive attack on the tinplate, and that marketing of these products should be carefully supervised to minimize the time the products are held before use.

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NEWS

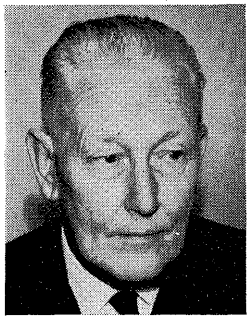
from the Division of Food Preservation

Retirement

Mr. R. B. Withers retired on November 7 after 23 years as Technical Secretary of the Division. Previously he had spent 24 years with the Victorian Department of Education and in his retirement he is returning to the teaching of geography. He holds the M.Sc. degree from the University of Melbourne and in his early career established a commendable research record in geology.

Mr. Withers pioneered the position of Technical Secretary in the Division in 1946, and quickly became an indispensable aide to the Chief and the senior officers. His major function was to serve as Secretary and Executive Officer of a number of committees which coordinate the research work of the Division with other Commonwealth and State authorities.

The Committee for Coordination of Fruit and Vegetable Storage Research was set up in 1946 to bring together the Commonwealth Department of Primary Industry, the Departments of Agriculture of the six States, and the CSIRO Divisions of Plant Industry and Food Preservation to plan the investigation of problems that affect the distribution of fruits and vegetables within Australia and particularly to export markets. Every four years this committee organizes a major conference which is also supported by representatives from New Zealand.



Mr. R. B. Withers.

In 1938, an Advisory Committee on Fruit Cool Storage Investigations in New South Wales had been formed to oversee the joint investigations on fruit storage carried out by the Division and the New South Wales Department of Agriculture, and to receive reports on related work in plant physiology in the Division and the University of Sydney. A subcommittee, the Citrus Wastage Research Committee, lays down research programmes for the Gosford Laboratory.

Increasing interest in processed foods led in 1949 to the establishment of a Committee for Coordination of Fruit and Vegetable Processing Research in N.S.W. on which are representatives of the N.S.W. Department of Agriculture from the Divisions of Horticulture and Plant Industry and Hawkesbury Agricultural College, of the University of N.S.W. from the Department of Food Technology, and of the fruit and vegetable processing industry.

Then, in 1956, a Fresh Fruit Disinfestation Committee was formed to recommend disinfestation treatments for fresh fruits and vegetables against insect pests, principally the Queensland fruit fly.

Mr. Withers has served on all of these Committees, most of them from inception, and the continuing vigour and value of their activities are largely due to his keen sense of duty and painstaking attention to detail. He has, moreover, been responsible for the relations between these committees and the Commonwealth Standing Committee on Agriculture.

Within the Division also Mr. Withers had executive responsibility for several committees. Notably he had been Chairman for many years of the Divisional Editorial Committee which supervised the production of this journal, *Food Preservation Quarterly*, the Division's extension organ. Before the recent appointment of a Food Technology Liaison Officer, Mr. Withers had been the initial target for numerous daily telephone inquiries,

serious and otherwise, that the telephonist could not immediately assign to specialist officers.

In his outlook, Bob Withers is humanitarian, with a wide interest in social questions, and he found practical application for his philosophy in looking after the many visiting workers and new appointees in the Division, particularly those from Asian countries. His attention to their needs went far beyond the expected function of settling them with the Division; he was assiduous in arranging those details of housing and transport that are worrying to newcomers in a strange country, and most generous in opening his home to them in warm hospitality.

Mr. Withers was also charged with the organization of visits to the Division by groups from industry, universities, and schools; although inherently sympathetic to the desire of many groups to inspect the laboratories, he was careful to protect the research scientists from unreasonable interruption.

In the course of discussions about the appointment of a successor, Bob Withers remarked that the principal qualification for a Technical Secretary was 'an ability to get on with people', and he might have added 'especially the rather peculiar people who are scientists'. This ability Bob has amply demonstrated from the time of his appointment, when by his friendly self-effacement he persuaded scientists that there was a place for an intermediary to relieve them of administrative chores. Now at the time of his retirement his colleagues look back on their association with him with warm affection, with admiration for his fortitude in the face of personal setbacks, and with sincere gratitude for the wisdom and tact with which he exercised his role through the years.

Appointments

Dr. R. W. Lewis, who holds a degree in marine biology from the University of California, has joined the research team in the Division of Food Preservation which is investigating the mobilization and deposition of lipids in cattle and other animals. Dr. Lewis was appointed as a Senior Research Scientist on September 29. He was Assistant Professor in the Institute of Arctic Biology, University of Alaska, in 1965–67, and immediately prior to coming to Australia he carried out research in the Food Chemistry Division of the New Zealand DSIR.

Dr. D. G. Oakenfull has been appointed Research Scientist to work on the possible effects of the state of water and its structure on the activity of hydrolytic enzymes. After taking his Ph.D. at the University of London in 1966, Dr. Oakenfull gained research experience in the Chemistry Department, Cornell University, Ithaca, New York, and in the Graduate Department of Biochemistry at Brandeis University, Waltham, Massachusetts, U.S.A. Dr. Oakenfull joined the staff initially in the United States in August and commenced at North Ryde on September 30.

Mr. L. R. Fisher commenced duty in the Division on August 25 as an Experimental Officer. He is studying the properties of thin films of water by measuring their dielectric constants, and interpreting their infrared spectra.

Overseas Travel

The Chief of the Division of Food Preservation, Mr. M. V. Tracey, accepted an invitation to participate in a symposium at Montebello, Quebec, Canada, on the Impact of Food Processing on Nutrition. Mr. Tracey was overseas from October 17 to 27.

Dr. R. M. Smillie, joint leader of the Plant Physiology Unit which the Division operates in conjunction with the University of Sydney, visited laboratories in the United States, Britain, and Europe and attended several conferences while he was overseas from August 17 to October 7. He attended a Gordon Research Conference on Post-harvest Physiology and the International Botanical Congress in Seattle, U.S.A. (August and September). During the latter month he was present at a symposium in Britain on the Biogenesis of Chloroplasts and Mitochondria, arranged by the Society of Experimental Biology, and later contributed a paper to an international symposium in Moscow on Theoretical Foundations of Optimization of the Photosynthetic Activity and Productivity of Plants.

Thanks to financial support from the N.S.W. Citrus Growers' Federation and the United Farmers' and Woolgrowers' Association, Dr. W. B. McGlasson, Senior

Research Scientist in the Division's Plant Physiology Unit, was able to accept an invitation to attend a Gordon Research Conference on Post-harvest Physiology in Seattle, U.S.A., from August 18 to 22, and to contribute a paper to a session on physiological and biochemical problems in the post-harvest handling of crops. The session leader was Dr. J. M. Lyons, who was a guest worker in the Division of Food Preservation during 1968–69. Dr. McGlasson also attended the Eleventh International Botanical Congress in Seattle from August 24 to September 2.

Dr. R. W. Burley, Principal Research Scientist, who is engaged in research in muscle biochemistry at North Ryde, is at present working with Dr. J. Gergely in the Muscle Research Department of the Retina Foundation for Biological and Medical Research, Boston, Mass., U.S.A. Dr. Burley left Sydney on August 23.

Dr. D. L. Ingles, Principal Research Scientist, who has done much research on the inhibition of non-enzyme browning, was invited to address the Jubilee Conference of the British Food Manufacturing Industries Research Association in London on October 20 and 21. In the course of his return he visited several centres for carbohydrate chemistry in the United States.

Dr. A. R. Johnson, Senior Principal Research Scientist and leader of the Division's Animal Products Section, is spending about nine months as a guest worker at the Unilever Research Laboratory, Colworth House, Sharnbrook, Bedfordshire, England, with Professor A. T. James. He left Australia on November 10 and made contact en route with scientists in Djakarta, Bangkok, and Geneva. While overseas, Dr. Johnson will visit research centres in Europe and America, and attend several international congresses. These include the 7th International Symposium on the Chemistry of Natural Products (June 1970) in Riga, where he will deliver a paper on the use of cyclopropene fatty acids in the study of impermeability, the International Congress of Biochemistry in Rome (September 1970), the Meeting of the World Poultry Science Association in Madrid (September 1970), and the joint meeting of the American Oil Chemists Society and the Institute of Fat Research at Chicago (September 1970). Dr. Johnson plans to return to Divisional headquarters in October 1970.

Flavour Chemistry

The flavour of a food is important because it determines the food's acceptability to the consumer. A food of excellent nutritive quality but of poor flavour will not normally be eaten if a food of good flavour yet possibly negligible nutritive quality is available. Since acceptability to the individual largely determines market price, food flavour is of great economic importance. Unfortunately there are many opportunities during processing for loss of flavour components by leaching or evaporation, or by chemical alteration to products which may be either without flavour or of an undesirable flavour.

To investigate such problems a Flavour Chemistry Section has recently been formed in the Division, consisting of three Research Scientists (Dr. K. E. Murray, Mr. J. Shipton, and Dr. F. B. Whitfield), three Experimental Officers (Mr. B. H. Kennett, Mr. J. Last, and Mr. G. Stanley), and six supporting staff.

One of the major difficulties in flavour investigations is maintaining the integrity of the characteristic flavour of particular foods. Because of this, the Section has devoted much initial effort to the development of satisfactory techniques for the isolation and concentration of the flavour volatiles, and for the complete separation of the flavour constituents by high-resolution gas chromatography prior to their examination by mass spectrometry and, where applicable, other spectroscopic means.

Many of the most significant flavour compounds are present in such minute amounts that the only means available for their identification is by their mass spectra supported by gas chromatographic retention values. Much effort has therefore been devoted to the improvement of the new technique of gas chromatography–mass spectrometry in order to obtain high-quality mass spectra. To assist in the interpretation of the spectra several microchemical techniques, such as hydrogenation and hydrogenalysis, have been developed for sub-microgram amounts of material.

The work of the Section has included investigations of the volatiles of bananas, frozen peas, and passion-fruit and of a 'kerosene' taint of mullet. It is hoped that the flavour team will shortly be augmented by a Research Scientist whose role will be to make a sensory assessment of the contribution of individual components to overall flavour.

Review

POST-PROCESSING SANITATION IN CANNERIES. By R. H. Thorpe and J. R. Everton. Fruit and Vegetable Preservation Research Association Technical Manual No. 1, August 1968.

This 187-page manual contains sound practical advice on problems of cannery sanitation gleaned from a 10-year programme of co-operative investigations involving 25 British canneries and staff of the Fruit and Vegetable Preservation Research Association and of the Research Department of the Metal Box Co. Ltd. This manual draws attention to many important aspects of cannery practice that have tended to be neglected. It was commonly thought that the use of chlorinated cooling water virtually eliminated the problem of post-processing contamination, but evidence has now been obtained that contamination may occur in the can handling operations after the cans have left the cooling water.

The manual warns that post-processing infection of canned foods may not always cause the cans to swell; such organisms as the staphylococci may produce food-poisoning toxins without forming gas in the can. Leaker spoilage without swelling of the can may in fact occur more frequently than leaker spoilage that causes swelling and in one survey up to 0·6% of commercially processed cans were found to be infected and sour but not blown. Clearly such cans cannot be detected by external examination so they will in due course reach the consumer and may be a cause of food poisoning.

The manual states that 2–3% of cans with good commercial seams, i.e. seam measurements within accepted tolerances, have temporary leaks induced during cooling and soon afterwards. Seams of poor quality or cans that have been mechanically abused will have a higher incidence of leaks. The greatest risk of cans becoming infected is when the seams are wet and they contact dirty runways or other contaminated can handling equipment or cannery personnel. The risk of infection by food-poisoning organisms is greatest when wet cans are handled manually; it is negligible when the seams are dry.

The essential measures to minimize infection are discussed in detail in the manual. They include good seaming control, adequate disinfection of cooling water, minimizing can abuse, good hygiene of can handling equipment, attention to personal hygiene of operatives who handle processed cans, and accelerated drying of cans. The manual contains detailed advice on sanitation of can runways and other can handling equipment, bacteriological tests of the efficiency of cleaning operations, the role of chlorine in controlling contamination, the design of equipment to minimize can abuse and bacterial contamination, chlorination of water and water re-use, and sanitation procedures and materials. Special attention is given to the problems of contamination and sanitation of hydrostatic cookers, and of personal hygiene of operatives who handle cans.

This manual should be read by cannery management and technical staff and every effort should be made to implement advice that it contains. It is available from the Fruit and Vegetable Preservation Research Association, Chipping Campden, Gloucestershire, at a cost of £5.5.0, which includes postage by surface mail.

P.W.B.

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