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Colour Measurements in the Food Industries

By
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Introduction

The use of colour as an index of quality is fundamental in the behaviour of buyers and consumers of foodstuffs, and the importance of colour is often accentuated by the fact that other methods of sampling foods are not always freely available to purchasers. It follows that those who handle foodstuffs in bulk, and processors of foodstuffs, are vitally interested in the colour of the goods they offer for sale. For example, colour is a good index of the maturity and freshness of many fruits and vegetables and of the heat treatment given to some processed foods. Laboratories attached to food industries may be called on to solve problems into which colour enters as a major factor. These problems may be very diverse in their nature and may include the task of standardizing the colour of a product which is known to the public under a familiar name or trademark. The problem of standardization may apply to the package as well as to the product.

In the sense used here, the word colour refers to the surface appearance of an object to an observer. It is advantageous to consider separately the property which might be classified as texture and the quality of the light which comes from the surface. The greater part of the following discussion is concerned with the quality of the light and applies also to coloured liquids where surface texture does not intrude. As the visual response to an object can be very variable depending on the viewing conditions and also on the momentary visual characteristics of the observer, colour cannot be specified in exact terms unless care is taken to standardize the methods of measurement.

Specification of Colour

It has been shown that it is possible to specify a colour by means of three numbers and the methods to be followed in deriving a standard specification have been agreed on by an international conference, the Commission International de l'Eclairage (1931). The specification is devised to deal with problems of colour matching and the mixing of coloured lights.

The spectral reflectance (transmittance) curve gives the most complete specification of the light in physical terms, but a good deal of calculation is involved in putting the information in a form suitable for colour work. This is discussed by Hardy (1936) in his book " Handbook of Colorimetry ". The reason for it lies in the nature of the visual response of the eye which cannot discriminate between all the distributions of light throughout the spectrum which are physically different (the ear is not subject to this limitation in the sound spectrum). In fact a suitable mixture of only three monochromatic radiations selected from the red, green and blue parts of the spectrum, respectively, can in general be found to match any given coloured light. Moreover there is a great deal of latitude in the choice of the three primary radiations and they do not need to be restricted to narrow parts of the spectrum. The I.C.I. (Commission Internationale de l'Eclairage or International Commission on Illumination) specification takes into account these properties of the eye and defines a set of three primary stimuli by means of their spectral distributions. The importance of the specification is due to the fact that it provides a common language for colour work, in spite of some possible minor imperfections.

Although it is not always necessary to use the I.C.I. specification of colour, the nature of the illumination is of fundamental importance in all methods of determining colour and should always be carefully defined to meet the requirements of the problem. As ordinary daylight is of variable quality, a specified quality known as illuminant C is widely used as a standard illuminant. Illuminant C and other standard illuminants can be provided by means of lamps with tungsten filaments and suitable filters.

Methods of Colour Measurement

As might be expected, methods of grading colour range from the simplest, which give a rather wide tolerance, to elaborate arrangements which measure colour precisely and are more sensitive than the unaided eye. In general the simple methods use the eye for determining a colour match, while a photo-electric device is generally preferred for the more precise measurements required to meet rigid specifications. When there is any difficulty in choosing a method, the best solution is to obtain the spectral distribution of the light by means of a spectrophotometer. These data will indicate whether routine work can be carried out by means of simpler and less expensive instruments.

Most people are familiar with word descriptions of colour which are used for such materials as butter and honey. These give an approximate grading and are not concerned with small differences. The placing of a sample in any grade depends almost entirely on the memory of the observer for the colour described in the words of the specification. Very often the presence of several samples ensures that they can be placed in their relative order correctly even though the absolute grading may differ from time to time.

Dependence on memory may be eliminated by the provision of physical standards of the same material when it is reasonably permanent or of some other material which closely resembles it. Arny (1912) gives details of solutions which can be made up to match many coloured liquids. These are prepared from half-normal aqueous solutions of cobalt chloride, ferric chloride and copper sulphate with 1 per cent. hydrochloric acid. The solutions give, respectively, the red, yellow and blue components of the mixture. If these solutions do not meet the requirements, others which are available are described by Kelly (1945). Coloured glasses which are reasonably permanent can also be used for matching a wide range of colours. Although these are generally more useful for matching the colours of transparent materials, it is possible to use them with opaque materials. A well-known instrument using coloured glasses is the Lovibond Tintometer, which has three series of glasses in red, yellow and blue. The glasses are graded in intensity and numbered so that when a colour is matched a definite specification of the colour can be given in terms of the appropriate glasses. With some models of this instrument it is possible to convert the readings to I.C.I. values.

Charts comprised of colour chips also come into the class of physical standards for visual comparison. The Maerz and Paul Dictionary of Color (1930) and the Munsell Color Book (1929) are two examples which have been widely used. The large difference between adjacent colours in a practical set of colour chips makes the matching of intermediate colours rather difficult. The Munsell charts have an advantage over some others in that it is easier to interpolate in a system which has equal visual steps and definite numbers can be set down for the three attributes of colour, viz. hue, value and chroma. A further advantage of the Munsell system is its easy application to the use of spinning discs to obtain a match for intermediate colours as described by Nickerson (1946). Although this method of matching colours to obtain a standard specification has been shown to be quite useful, it is difficult at present to obtain suitable equipment.

None of the methods so far mentioned make use of the fact that the light from a coloured surface can be dispersed throughout the visible spectrum. A measurement of the light in different parts of the spectrum provides information about the nature of the colour. A crude method of applying this principle is to examine the light through a set of filters each of which transmits only part of the light in the spectrum. The intensity in each case is compared with that from a standard surface (white or otherwise). A more precise measurement can be made by using a spectrophotometer which measures accurately the relative amount of light throughout the spectrum from red to violet. Instruments which automatically draw a spectral reflectance or transmission curve are described by Hardy (1935).

The possibility of measuring colour in terms of three primary coloured lights has given rise to a group of instruments called tricolorimeters. Although they do not give the precise information about the distribution of light through the spectrum which is given by a spectrophotometer, they can be quite adequate for the precise matching of colours under specified illumination.

Methods and Apparatus

When one comes to choose a method or instrument from the possibilities as briefly indicated above, each problem must be treated on its merits and account must be taken of the precision required in the particular application. For many applications an arbitrary scale is adequate, but in general a standard specification and higher precision are required to meet the demands of quality control and scientific research. Where colour is taken as an index of changes in other properties, accurate measurement of small differences might be more important than the accurate measurement of colours on a standard specification. A choice must also be made between visual methods and those depending on the use of a photo-electric cell. The latter may be made even more sensitive than the eye if this is found necessary, but it is difficult for any one such instrument to measure all the characteristics of a surface colour that are immediately obvious to the eye. If required, however, it is possible to make independent measurements of such properties as surface gloss by photo-electric means.

The main disadvantages associated with visual methods are the variability among different observers and the effects due to fatigue in any one observer. These disadvantages can be made less in photo-electric instruments, but it should not be assumed that they are entirely or automatically eliminated. Generally it is found easier to set up a photo-electric instrument when high precision and good reproducibility are required because the measurements do not then depend on a carefully chosen and trained observer.

A photo-electric spectrophotometer, although expensive and requiring skilled attention, can give maximum information about the light from a coloured surface. A technical disadvantage is that the data must be converted to a form which can be interpreted in terms of visual response to the light. The conversion is carried out by a set of tables which relate to a "standard observer" as defined by international agreement. *Vide* International Commission on Illumination (1931) and Hardy (1935). A tri-stimulus specification of the colour is derived and, as mentioned above, this is adequate for all matching problems provided the illumination is standardized. If necessary, a comparison can also be made with specifications in the Munsell system or in terms of dominant wavelength, purity and luminance.

Using suitable filters and photo-electric cells, tricolorimeters can be designed which directly give values approximating to the standard tri-stimulus specification. Deficiencies in the filters and photo-cells may cause serious inaccuracies when measuring some colours. Undoubtedly improvements will be made in these components, but at present the instruments should not be relied on for standard measurements unless they are carefully checked and calibrated. On the other hand they can be very useful for demonstrating small differences between colours, as long as the apparatus, including the illumination, is properly standardized. It might be pointed out that any filter-photocell combination can be used to give arbitrary measurements of coloured light, but the data cannot in general be reduced easily to a standard specification in terms of international units.

Finally it should be emphasized again that each problem must be considered on its own merits, and a choice made from the available methods to find a satisfactory solution. If something better than a rough visual matching is required, information on the colours should be obtained with a spectrophotometer, and an examination of these data should indicate whether a simpler instrument will be adequate for routine work.

It is hoped that particular problems in colour measurement which have wide interest will be dealt with in future issues of the QUARTERLY.

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The Effect of Oxygen on Flavour Deterioration and Loss of Ascorbic Acid in Canned Orange Juice*

By

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Introduction

Orange juice is perhaps the least satisfactory of the canned fruit juices, because of its instability at the normal summer temperatures in countries such as Australia. This instability results in a rapid development of an objectionable flavour, sometimes described as "stale", and in a loss of ascorbic acid which significantly reduces the anti-scorbutic value of the product. Tressler, Joslyn and Marsh (1939) have shown that, at storage temperatures above 70° F. (21° C.), canned orange juice has a "life" in terms of acceptable palatability of only about three months. Moschette *et al.* (1947) and Sheft *et al.* (1949) respectively found 25% and 38% loss of ascorbic acid from canned orange juice stored 12 and 18 months at 80° F. (27° C.).

In the literature of orange juice technology it is widely stated that the changes in flavour and nutritive value described are oxidative in nature. For instance, quoting von Loesecke, Mottern and Pulley (1934), "Although the mechanism of the changes taking place in canned orange juice is not fully understood, numerous workers have indicated that oxidation plays an important role". This assumption of an oxidative mechanism has led in turn to a general belief in the necessity to remove dissolved and occluded oxygen from orange juice by the process of de-aeration. Mottern and von Loesecke (1933) state that "thorough de-aeration of orange juice is necessary to protect it from flavour changes as well as to preserve vitamin C which is readily oxidized".

The present paper describes investigations, commenced in 1946, which sought to elucidate the role of oxygen in the deterioration of canned orange juice and to determine the usefulness of the de-aeration operation. The broad aim was to compare the keeping quality of orange juices canned in the presence and in the absence of oxygen.

The first stage in the project was the working out of a reliable, rapid, polarographic method for the determination of oxygen in orange juice (Lewis and McKenzie, 1947). Making use of this method, it was found that orange juice, extracted by hand-reaming on high-speed heads, was saturated with air, i.e. it contained approximately 0·5% oxygen by volume in solution. It was also found that this dissolved oxygen was

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consumed in chemical reactions so that approximately 25% disappeared in two hours at 30° C. However, at 5° C. there was negligible consumption in three hours.

Various procedures were tried for oxygen removal. A de-aerator of the vacuum-spray type achieved only 90–92% removal of oxygen even when operating under optimum conditions of slight evaporation [Boyd and Peterson (1945), Smith (1949)]. This efficiency is of the same order as the highest efficiencies (91%) found by Lachele (1938) in commercial de-aerators. Pulley and von Loesecke (1939) report efficiencies as high as 97% oxygen removal in centrifugal de-aerators. The only procedure found to give approximately complete removal of dissolved oxygen was de-aeration by inert gas bubbling. This method has since been advocated by Bayes (1949) and Smith (1949).

Three series of test packs of canned orange juice were therefore compared, one prepared without de-aeration, one vacuum-spray de-aerated, and one de-aerated by hydrogen displacement.

Experimental Procedures

(*a*) *Inert Gas De-aeration.*

Freshly harvested Valencia oranges were held overnight at 5° C., and all the operations of extraction, de-aeration, can filling and sealing were carried out in a room at this temperature in order to minimize oxygen consumption by the juice. The juice was extracted from the halved fruit with high-speed reamers, then screened through 12 mesh and 20 mesh screens into a stainless steel tank fitted with vertical baffles. Hydrogen gas was bubbled through the juice from sintered glass bubblers and at the same time the juice was agitated with a propeller stirrer. A foam-breaker arm attached to the stirrer shaft controlled the depth of the blanket of foam which formed on the surface of the juice and prevented access to atmospheric oxygen. Samples of juice were withdrawn at frequent intervals by means of a siphon tube and the oxygen content was determined polarographically.

During the first five minutes 95% of the oxygen was removed, but about 30 minutes were required to reduce the oxygen content to the limit of detection (oxygen content less than 0·005%). At this stage the juice was filled into cans using a siphon tube which reached to the bottom of the can. A small sintered glass bubbler in the can passed hydrogen continuously through the juice during filling; the can was filled completely, without headspace, and sealed immediately. By careful adherence to this technique it was possible to obtain juice in the sealed can with an oxygen content less than 0·005%. The time which elapsed between the commencement of extraction and the completion of sealing was approximately 45 minutes.

The canned juice was processed for two minutes in steam at 100° C., while the cans were rotated at 120 r.p.m., then immediately cooled, also with rotation.

(*b*) *Vacuum-Spray De-aeration.*

Juice from the same picking of oranges was extracted at room temperature, screened, de-aerated in a vacuum-spray de-aerator, filled into cans, vacuum-sealed, and processed in the same way. The oxygen content of the juice after de-aeration was approximately 0·05%.

(c) No De-aeration.

Juice from the same oranges was extracted at room temperature, screened, filled immediately into cans, sealed without vacuum, and processed in the same way. The oxygen content of the juice at the time of filling was approximately 0·5%.

Both plain and lacquered cans were used in each treatment. The test packs were stored at 20° C. and 30° C., and examined at intervals. Flavour changes were assessed by a trained panel of six tasters, ascorbic acid was determined by indophenol dye titration, and changes in oxygen content were followed by polarographic measurements and headspace gas analyses.

Results

Flavour.

At 30° C., from one month onwards there was no detectable difference in flavour between the three treatments ; all showed marked deterioration.

At 20° C., after three, six and 12 months, the difference in flavour between low-oxygen and high-oxygen packs was probably significant but slight. Certainly inert gas de-aeration did not eliminate flavour deterioration. As has been observed before e.g. Boyd and Peterson (1945), the nature of the off-flavour was different in lacquered and plain cans. The juice in lacquered cans developed typical " staleness ", while plain cans imparted a flavour described variously as " tinny ", " fishy ", etc. Tasters differed in expressing a preference between the juices in the two types of can and the overall preference was not significant.

Ascorbic Acid.

Loss of ascorbic acid was followed only in treatments B and C at 30° C. The results are set out in the following table.

Loss of Ascorbic Acid in Canned Orange Juice at 30° C.

Treatment.	Initial Oxygen Content Per Cent.	Rate of Loss of Ascorbic Acid, mg./100 ml./day.		Percentage Loss After Seven Months.
		First Period.	Second Period.	
B. *De-aerated*—				
Plain can	0·05	1·2	0·1	31
Lacquered can ..	0·05	0·5	0·08	31·4
C. *Not de-aerated*—				
Plain can	0·5	1·2	0·08	27·7
Lacquered can ..	0·5	0·8	0·09	28

The highly interesting fact emerged from these figures that the loss of ascorbic acid occurred in two stages—a short period of rapid loss, followed by a much slower loss during subsequent storage. The initial period of rapid loss varied with the type of can, being approximately 100 hours for plain cans and 200 hours for lacquered cans. These times correspond closely with the times at which total disappearance of oxygen was observed in the respective cans. At the moment the mechanism of this effect of the presence of free oxygen on the rate of loss of ascorbic acid is obscure.

The differences between treatments in percentage loss of ascorbic acid after seven months are not statistically significant. It is of interest to note that these losses are in close agreement with estimated losses calculated from the nomograph of Freed *et al.* (1949).

Can Corrosion.

In agreement with American observations made by Lueck and Pilcher (1941), and by Boyd and Peterson (1945), it was found that de-aeration appreciably reduced the rate of can corrosion. In the high-oxygen packs lacquered cans showed lifting of the lacquer and some hydrogen swells appeared.

Conclusions

Reduction of the initial oxygen content of canned orange juice to a very low level failed to eliminate flavour deterioration in storage and had no effect on ascorbic acid loss.

The main practical effect of de-aeration on canned orange juice is to reduce the rate of can corrosion and to delay the development of hydrogen swells.

This investigation is being continued and complete results will be published elsewhere at a later date.

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Citrus Wastage Investigations at the Gosford Citrus Processing Research Laboratory*

By

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Introduction

The Gosford Citrus Processing Research Laboratory, opened on October 25, 1948, is situated 50 miles north of Sydney (New South Wales). It is operated jointly by the Division of Horticulture of the New South Wales Department of Agriculture and the Division of Food Preservation and Transport of the Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.). The investigations are directed by a Citrus Wastage Project Committee representative of both bodies.

Close contact is maintained with the citrus industry, especially with the packing houses in the Gosford-Wyong area. The laboratory possesses a semi-commercial scale processing plant which has an output of 25 bushels per hour, and other necessary facilities. Early in 1950 an additional building was erected, mainly for storage and examination of fruit.

The objects of the work of the laboratory are to define the best methods of handling and treating oranges and other citrus fruits destined for markets within Australia and overseas. The investigations cover studies of handling and transport, mould wastage, cleaning of fruits, and of treatments designed to minimize wilting and maintain " condition ". The work on lemons is essentially a study of the curing and storage of the winter crop.

Wastage in coastal citrus fruits is due principally to green mould (*Penicillium digitatum*) and stem-end rots (mainly *Phomopsis citri*). In normal marketing, involving periods of no more than two weeks, almost all wastage is caused by green mould which often causes serious economic loss. Over longer periods, more particularly in the summer months when temperatures are higher, and especially in stored lemons, stem-end rots often cause most loss. To date the work with oranges has been mainly an assessment of the problems in terms of levels of wastage experienced and variability between orchards. Using existing knowledge, an experimental handling and processing schedule to control green mould and to maintain " condition " has been designed and extensively tested in comparison with commercial methods.

Work with Oranges

(1) *Wastage Due to Green Mould.*

(*a*) *Variation between Orchards.* With Navel oranges, after four weeks' holding at ordinary temperatures, the amount of green mould in

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* This article is a progress report only, to indicate the scope of the work and to present briefly the more interesting of the results so far obtained. As the investigations are still in progress, the findings, at this stage, are not to be regarded as specific recommendations. It is appearing also in the *Agricultural Gazette of N.S.W.*, Vol. 51, No. 12, December 1950.

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fruits from different orchards varied from 1·3% to 8·5% in 1949 and from 3·7% to 16·2% in the 1950 season. There was also a significant amount of wastage in most lines after only two weeks' holding. With Valencias similar variation was found. In 1948–49, after four weeks, the amounts of green mould varied from 4·8% to 16·7% and in 1949–50 from 1·0% to 5·6% after three weeks, 1·0% to 9·0% after five weeks, and 6·8% to 25·0% after holding for seven weeks. It has been shown statistically that many of these differences between orchards were highly significant.

In earlier work, reported by Huelin (1942), there were differences in mould wastage between the lowland and highland sections of the Gosford district. In this recent work there have been no consistent differences in keeping quality between fruits from the lowland areas (Lisarow, Ourimbah, etc.) and fruits from the highland areas (Somersby, Mangrove Mountain, etc.). Both good keeping and poor keeping oranges have been obtained from each area.

The complex of factors responsible for these differences in keeping quality between orchards is being investigated, but this is necessarily a long-term project, and as yet there is no definite information on the effects of factors such as strain variations, soil variations, cultural and fertilizer programmes.

(*b*) *Effects of Handling Methods.* Handling is used to cover all operations in picking and transport to the packing house, whereas processing is used to refer to the packing house operations of cleaning, sterilizing, grading and packing. Experimental handling was designed to reduce mechanical damage to the fruits to a minimum, and involved the use of gloves by the pickers, careful clipping of the fruits from the trees, careful transfer from the picking bag to the field case, the use of smooth, clean field cases with wood wool on the bottoms, avoidance of over-filling of the cases and careful handling of the cases during transport to the packing house. Under commercial conditions no gloves are used, the oranges are pulled from the trees and the field cases are often rough and dirty.

On the average, there was less green mould following experimental handling than there was after commercial handling but the effects were variable between growers. Therefore, on the data available no definite conclusions can be drawn concerning the effects of handling methods.

The average figures for all growers and all examinations, for commercial processing only, were as follows:

	Per Cent. Green Mould.		
	Navels.		Valencias. 1949–50.
	1949.	1950.	
Commercial handling ..	8·8	12·0	9·2
Experimental handling ..	5·1	9·6	5·3

However, earlier work and investigations overseas have shown that careful handling reduces wastage and the individual grower should, in his own interests, see that his fruit is handled as carefully as possible.

(*c*) *Effects of Experimental Processing.* The experimental processing schedule was as follows:

(1) Fruits conveyed by inspection belt to first tank. From this belt, all fruits showing breakdown were removed, in order to minimize contamination of the tanks.

(2) First tank—soaked for 30 seconds in proprietary cleaning agent at 100° F.

(3) Combined hot water rinsing and brushing.

(4) Second tank—soaked for 30 seconds in solution of 5% borax at 110° F.

(5) Moisture eliminating rollers to remove excess solution.

(6) Third tank—immersion of fruits in solution at 100° F., made up as follows:

1 volume wax emulsion (Brytene 6170).
4 volumes water containing 4% borax+2% boric acid.

(7) Moisture eliminating rollers to remove excess solution.

(8) Passage through hot-air draught-drier at 120° F. for $2\frac{1}{2}$ minutes which dried the fruits completely.

(9) Grading, sizing, packing.

In all recent experiments this processing schedule has very effectively reduced wastage caused by green mould. Table 1 shows reductions

TABLE 1.

Effects of Processing Methods on Green Mould Wastage.

The figures given indicate the mean percentage wastage due to green mould after processing and subsequent storage.

Processing Method.	Storage Period in Weeks.	Washington Navels. 1949 Season. Mean of 4 growers. Unit= 16 Cases.	Washington Navels. 1950 Season. Mean of 5 growers. Unit= 20 Cases.	Storage Period in Weeks.	Valencias—1949–50 Season. Mean of 10 growers (Unit=40 cases). First Picking.	Valencias—1949–50 Season. Mean of 10 growers (Unit=40 cases). Second Picking.
Commercial ..	—	3·0	5·0	—	3·5	7·6
Experimental	2	0·2	1·8	3	0·3	1·2
Commercial ..	—	4·1	11·3	—	3·9	7·2
Experimental	4	0·5	3·5	5	0·3	1·9
Commercial ..	—	13·4	16·0	—	13·9	14·7
Experimental	7	5·5	5·3	7	2·5	4·1

achieved by the experimental processing as compared with normal commercial processing. In commercial processing borax is not used in effective concentrations, the fruits are not waxed and are often incompletely dried. The main emphasis in processing in commercial citrus packing houses is on cleaning and polishing the fruits to produce a bright and attractive pack. Processes designed specifically to improve keeping quality have not yet been fully adopted by the industry, largely because of their cost. From the evidence it seems certain that the gain by experimental processing is mostly due to the use of borax. The wax emulsion itself reduces shrivelling appreciably but has no effect on mould wastage. However, because borax increases shrivelling, it is desirable to follow its use with a waxing treatment, which need not necessarily be in the form of an emulsion dip.

(2) *Wastage Due to Stem-end Rots.*

There have been large, significant variations between growers in the incidence of stem-end rots; these variations were more marked than for green mould. Probably because of the higher temperatures prevailing later in the season, there was more stem-end rot in Valencias than in Navels. In 1948–49 the variation in stem-end rot development in Valencias from four growers after four weeks' holding was 4·3% to 14·0%, while in 1949–50 the variation between ten growers was 0·0% to 10·4% after three weeks' holding and 0·6% to 54·7% after five weeks.

Handling methods have had little effect on stem-end rots. On the average there has been less stem-end rot in oranges experimentally processed than in comparable lots commercially processed but the reduction has not been consistent between growers and is not statistically significant. However, in two experiments just concluded with late Navels, experimental processing did greatly reduce stem-end rots. Under some conditions this treatment can bring about a valuable reduction in the incidence of this form of wastage. This will be investigated further to find an explanation for the inconsistencies.

It has long been known that stem-end rot control is essentially an orchard matter requiring control of melanose infection (which is caused by the same fungus). This involves regular spraying, removal of dead wood and maintenance of good tree vigour; full details of recommended control measures can be obtained from Departments of Agriculture.

(3) *Shrivelling of the Fruit.*

Oranges are continually losing water by evaporation from the skin; after they are removed from the tree this water is not replaced and obvious shrivelling eventually results. It has been found that shrivelling becomes apparent when the amount of water lost reaches about 5% of the original weight of the fruit. The time taken to reach this stage will depend mainly on the temperature and humidity and whether the oranges are wrapped or waxed.

Experimental processing with borax and wax emulsion has reduced weight loss by 20% to 25%. This reduction is similar to that which is obtained by waxing treatments in American citrus packing houses. The net effect of the control of green mould and reduction of shrivelling by experimental processing has been that full, firm packs of bright, attractive, fresh-looking fruits have been maintained very much longer than by commercial processing.

(4) *Market Tests of Experimental Processing.*

Following upon these successful results, it was decided that, during 1950, a series of marketing experiments using the experimental processing method under commercial conditions should be carried out. For this purpose the brand name " Keepswell " and a special label were used to distinguish the experimentally processed fruits on the market.

The experimental (or " Keepswell ") processing method is based on recommendations which have been made by the Department of Agriculture for many years. The initial investigations were made by the Citrus Preservation Technical Committee before the Second World War. Careful handling, good shed hygiene (including regular spraying with a disinfectant), design of machinery to reduce damage to the fruits to a minimum, and complete drying of the fruits before packing are important factors in the experimental method.

For these marketing experiments, consignments of oranges which had been picked by various growers and forwarded to the packing shed in the usual commercial manner were divided into two equal lots. One lot was processed and packed by the packing shed in the normal way, whilst the other lot was processed and packed at the laboratory using the experimental processing method. Both lots were forwarded in the usual way to the specified agent at the Sydney Municipal Fruit Markets. The fruit was not pre-selected in any way. In fact, the agent, in his report, stated that he was " disappointed in the quality of the fruits selected to make the tests ".

TABLE 2.

Effects of Processing Treatments on Wastage under Commercial Conditions.

Date of Process-ing.	Processing Method.	Post-Processing Treatment.	Holding Period in Days.	Percent. Wastage Due to:	
				Green Mould.	Brown Rot.
14.7.1950	Commercial.	Held at Gosford.	18	34·7	2·0
	Experimental.	,, ,,		7·2	0·3
21.7.1950	Commercial.	Held at Gosford.		21·7	8·4
	Experimental.	,, ,,		0·4	12·0
	Commercial.	Forwarded to Sydney.	21	27·4	10·2
	Experimental.	,, ,,		2·2	4·0

The figures given indicate the mean percent. wastage for 2 c/s. unit.

The results of examination of sample cases from two test consignments are given in Table 2. Wastage due to green mould was greatly reduced by the " Keepswell " process. The rather high development of brown rot (due to the fungus *Phytophthora citrophthora*) was due to very wet weather. The agent to whom the consignments were sent reported that retailers were keenly interested in the " Keepswell " fruit because of its superior keeping qualities, at a time when the bulk of the oranges on the market were breaking down rapidly. The opinion was expressed that treated fruit, once it became known, would readily command a premium of at least two shillings per case. At one period, when the market was heavily supplied, processed fruit was successfully cool stored for two weeks until the market improved.

The costs of the experimental processing, if carried out under commercial conditions, are not known; but a consignment of 150 bushels was put through the full process in the laboratory plant for a total cost of fivepence per case for all tank materials. On a large scale this would be greatly reduced. The wax emulsion, which is the expensive item, has been kept in use in the laboratory machine for a fortnight without deterioration so that it is fairly certain that its cost would not be prohibitive in commercial operation.

(5) *Other Investigations.*

A long-range experiment designed to test the effects of fertilizer treatments on keeping quality has been commenced. New cleaning and sterilizing materials are being tested. So far no other fungicide has proved to be as effective as borax in controlling green mould. However, the use of fruit wraps impregnated with the chemical, diphenyl, appears promising. The use of 2,4–D and 2,4,5–T as pre-harvest sprays or post-harvest dips to control stem-end rot is being investigated. These materials are reported to be effective in America, particularly with lemons. The work has not proceeded far enough to test whether these claims can be substantiated here.

Lemon Storage

The main lemon crop is produced during the winter months, when demand and returns are lowest. It is therefore necessary to store these lemons until the warmer weather, if possible until summer months. Lemons are normally stored in orchard sheds under ordinary atmospheric conditions. It is unlikely that the American method of storage in large air-conditioned spaces will be practicable in this country for some time to come.

Investigations into shed storage were commenced in 1948. The chief causes of wastage were found to be green mould, stem-end rot, and shrivelling, the latter two becoming important towards the end of storage with the onset of warmer weather. The work so far has shown tree vigour to be very important. Only fruit from vigorous healthy trees will keep well; freedom from melanose is especially important because of its association with stem-end rots. The best maturity seems to be the light green to silver stage, as shrivelling is more severe in greener fruits and it is difficult to select fruits of sufficient size—they should be at least $2\frac{3}{8}$ inches in diameter at picking.

Lemons must be carefully clipped from the tree and handled very carefully to avoid injury, otherwise wastage due to green mould is likely to be serious.

Wastage due to both green mould and stem-end rot and shrivelling has been greatly reduced by dipping the fruits after harvest in a wax emulsion (e.g. "Brytene 6170") containing the fungicide sodium salicylanilide (e.g. "Shirlan W.S.") in the following proportions: wax emulsion 1 gallon, water 4 gallons, "Shirlan W.S." 2 ounces. The dip is used cold and the cases of dipped fruits should be allowed to drain and dry before stacking. It was found that the wax could be omitted if the lemons were individually wrapped, but best results were obtained when they were both waxed and wrapped. Typical effects of tree vigour and dipping in "Shirlan W.S." on wastage, as found in the 1948 experiments after four months' shed storage, are illustrated in Table 3.

TABLE 3.

Effects of Tree Vigour and Shirlan Dip on Wastage in Stored Lemons, 1948.

Treatment.	Percent. Wastage.	
	Green Mould.	Stem-end Rots.
Vigorous young trees	1·2	6·2
Weak trees	3·9	28·2
Undipped	2·8	14·7
Dipped in Shirlan	1·2	6·4

Current investigations on lemon storage include the effects of various spray schedules and of the plant hormones 2,4-D and 2,4,5-T on stem-end rot development, further testing of Shirlan and further tests of the effects on weight loss of various types of wraps, waxing, fruit size and position of the case in the storage stack.

Summary

Investigations being conducted at the Gosford Citrus Processing Research Laboratory have established that there are large variations in wastage, due both to green mould and stem-end rots, between oranges from different orchards in the Gosford district. It has also been demonstrated that both careful handling and improved processing methods will greatly reduce the amount of wastage due to green mould. Handling and processing methods have been less effective on wastage due to stem-end rots. The control of this form of wastage is primarily an orchard problem. In addition, investigations into the best methods for the storing (or " curing ") of the winter lemon crop have already yielded some valuable information.

Acknowledgements

The authors would like to express their thanks to the Gosford Bulk Loading Rural Co-op. Society Ltd. and their staff for their invaluable co-operation and assistance ; also to the Associated Growers' Selling Agency, City Markets, Sydney, for their comprehensive reports on the marketing of experimental consignments.

Reference

HUELIN, F. E. (1942).—Comm. Sci. Ind. Res. Org. (Aust.) Bull. 154.

Courses of Instruction in Food Technology in Australia

Commencing in 1951 two Diploma courses in Food Technology will have been established in Australia.

Hawkesbury Agricultural College.

The Hawkesbury Agricultural College diploma course in Food Technology (Fruit and Vegetables) is designed to train students for positions as production managers, technologists and supervisors in factories concerned with the processing and preservation of fruits and vegetables.

The course, which is of two years' duration, will deal with the following subjects:

Principles of Food Technology (Parts 1 and 2).

Crop Production; chemistry; physics; applied botany; applied entomology; microbiology (Parts 1 and 2); engineering; mechanics; book-keeping and business principles; organic chemistry; advanced chemistry and bio-chemistry; nutrition; food industry economics and public relations.

Throughout the course students will spend approximately one-half of their time on practical work in the College Cannery. They will also obtain practical experience in the orchard and vegetable garden.

Enquiries concerning this new diploma course which is to commence on 1st February, 1951, should be addressed to the Principal, Hawkesbury Agricultural College, Richmond, N.S.W.

Reference to this course and to the training facilities available at Hawkesbury College has already been made in the QUARTERLY (Richardson, 1950).

Sydney Technical College.

The Food Technology diploma course at the Sydney Technical College comprises six stages of one year each; the first three being identical with the Chemical Engineering diploma course. Full details of the syllabus and conditions of enrolment will be found in the Handbook published annually by the Department of Technical Education. An account of this course also appears in an earlier number of the QUARTERLY (Reuter, 1949).

References

REUTER, F. (1949).—Food Pres. Quart. 9: 1.

RICHARDSON, H. R. (1950).—Food Pres. Quart. 10: 12.

Notices of Recent Publications by the Staff of the Division of the Food Preservation

(1) A Colorimetric Method for the Determination of Esters. By Adrienne R. Thompson. Australian Journal of Scientific Research A3: 128–135 (1950).

This paper presents a method for the determination of volatile esters, which is suitable for the measurement of volatile ester production by fruits. The esters are converted to hydroxamic acids, which form red complexes with ferric iron.

(2) The Bactericidal Properties of Certain Cationic Detergents. By M. R. J. Salton. Aust. J. Sci. Res. B. 3: 45–60 (1950).

Cationic detergents are known to possess remarkable bactericidal properties, although their limitations and their application in many fields have yet to be discovered. This paper deals with two such compounds, namely "Cetavlon" and "Fixanol C" and describes the susceptibility at seven pH levels of a number of Gram-positive and Gram-negative organisms.

(3) The Emuneration of Heated Bacterial Spores.

(i) Experiments with Clostridium botulinum and other species of Clostridium. By A. M. Olsen and W. J. Scott. Aust. J. Sci. Res. B 3: 219–233 (1950).

(ii) Experiments with Bacillus Species. By W. G. Murrell, A. M. Olsen and W. J. Scott. Aust. J. Sci. Res. B 3: 234–244 (1950).

Knowledge of the effects of heat on bacterial spores is essential in determining safe heat processes for canned foods. These two papers provide evidence that there are considerable technical difficulties in the detection and enumeration of Bacillus and Clostridium spores that have have been subjected to lethal conditions of heating. Optimum temperature of incubation, favourable pH of media, and the removal of inhibitory substances from the media all lead to a more reliable and precise technique for evaluating rates of destruction of heated spores.

Copies of the above papers are available from the Librarian, Division of Food Preservation.

Book Review

Recent Advances in Fruit Juice Production. Edited by V. L. S. Charley. Commonwealth Bureau of Horticulture and Plantation Crops, Technical Communication No. 21, 176 pp. and 64 photos. (1950.) Sydney price, 18/9.

An earlier publication by Charley and Harrison (1939) has proved to be a most useful source of information on British and European techniques of fruit juice production. The present volume, in which Dr. Charley is associated with a group of expert collaborators, brings together advances in fruit juice technology in the succeeding ten years. The most spectacular advances during this period have originated in two countries, Switzerland and U.S.A. Swiss techniques of handling apple juice, which have spread to other European countries and to Britain, are described very fully, but American developments in citrus products technology, with which the contributors have not been directly associated, are treated much less adequately.

Dr. Charley himself describes and illustrates modern equipment for the unit operations of milling, pressing, centrifuging, filtering, bottling, and juice storage by the Boehi method and the Escher-Wyss " snow " system. The fundamental basis for the enzyme clarification of fruit juices is outlined in a valuable review of pectin degrading enzymes by Mr. W. W. Reid of H. W. Carter & Co. Ltd., Coleford.

Two chapters on the tomato, apple and grape juice industries in Canada, by Atkinson and Strachan of the Summerland Experiment Station, have already appeared in another form (Atkinson and Strachan, 1949).

An excellent discussion of de-aeration and pasteurization is contributed by Cyril Hunnikin of the A.P.V. Co., but the importance of de-aeration is perhaps over-emphasized. It is true that de-aeration will reduce can corrosion and eliminate foaming during filling and flotation of suspended pulp, but investigations in the Food Preservation Research Laboratory, C.S.I.R.O., failed to indicate that de-aeration had any beneficial effect on flavour stability and ascorbic acid retention in orange juice. Desirable emphasis is given to the point that " flash " pasteruization is of little benefit when juices are allowed to remain hot for significant periods in filler bowls and in the closed cans. This difficulty does not arise in pasteurization " in the can ", involving rapid heating and cooling with rotation, a procedure which is not considered.

A chapter on the concentration of fruit juices provides a very useful summary of the present position in vacuum evaporation and some excellent illustrations of equipment. Comment on the Mojonnier evaporator, widely used in America for the preparation of frozen concentrated juices, fails to make clear the fact that the outstanding quality of these products is due not so much to the concentration procedure as to the low temperature storage and the practice of adding back fresh juice to restore lost volatiles. The alternative practice, employed in the Kestner evaporator and in the U.S. Department of Agriculture apple essence process, is to condense a volatile fraction which is subsequently added back to the concentrate. This procedure gives good results with apples and most soft fruits but not with blackcurrants. Some less well known types of vacuum evaporators by Fraser, Sulzer and Brown-Boveri are also described. The choice of equipment in this field must finally be determined by engineering considerations. Evaporators incorporating thermo-compression will be favoured only where electric power is cheap and economy is necessary in the use of coal and cold water.

The story of the use in Britain of fruit syrups—blackcurrant, orange and rose-hip—as special sources of vitamin C for vulnerable groups leads up to a comprehensive review by Dr. A. Pollard, of the University of Bristol Research Station at Long Ashton, on vitamins in fruit juices and factors affecting vitamin retention in processing and storage. The final chapter is composed of a number of short contributions setting out developments in fruit juice production in several countries of the Commonwealth.

This volume reaches a high standard in content, production, binding and indexing. One error was noted on page 104, where mg./100 g. should read mg./g. It will provide stimulating reading not only for food technologists interested in fruit products but also for those handling other beverages and liquid foods.

References

ATKINSON, F. E., and STRACHAN, C. C. (1949).—Canada, Dept. Agric., Tech. Bull. No. 68, Publication 828.

CHARLEY, V. L. S., and HARRISON, T. H. J. (1939).—Imp. Bur. Hort., Tech. Comm. No. 11.

J.F.K.

CORRECTION

In the article on "The Swiss Süssmost Industry", by D. Martin (FOOD PRES. QUART., 1950, Vol. 10, page 19), the quantity mentioned in line 21 should read "$\frac{1}{8}$ litre", not "$\frac{1}{2}$ litre".