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Market Quality of Eggs in Australia

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By the time it reaches the consumer's table a commercially marketed egg in Australia is likely to have lost some of the attributes it possessed when newly laid. In this article Mr. Shenstone discusses the factors that influence the quality of an egg, and the measures that can be taken to ensure good initial quality and its maintenance during marketing. He reviews Australian investigations on egg quality since 1957, and some articles published in foreign journals. The article is based on material submitted in July 1966 to the Technical Subcommittee on Poultry Production, a group of specialists set up to advise the Australian Agricultural Council, a national governmental body.

THE QUALITY of an egg is influenced by many conditions. Its quality at the time of laying may be affected by the genetics, husbandry, diseases, and history of the hen. Its internal quality is subsequently influenced by, among other things, the period of time required for marketing and the temperatures experienced during the process.

In assessing the quality of an egg, the consumer takes into account both its external and internal characteristics. Changes in internal quality between the farm and the retail outlet are particularly important.

External Quality

The external attributes of an egg, which have an important influence on the economic return to the farmer, are egg size, shell strength, and the shape and cleanliness of the egg. Under the marketing system in Australia, standards covering these aspects are supervised by the Egg Marketing Boards in the several States.

Egg Size

All States in Australia have agreed to grade eggs by weight in accordance with specifications laid down by the Council of Egg Marketing Authorities of Australia. There are three grades, designated respectively as 24-oz, 21-oz, and 18-oz, and each figure represents the lowest acceptable weight of one dozen eggs in the specified grade. The National Standards Commission (1966) has specified further that the weight of each egg shall be not less than 2 oz in the 24-oz pack, and shall be between $1\frac{3}{4}$ and 2 oz in the 21-oz pack, and between $1\frac{1}{2}$ and $1\frac{3}{4}$ oz in the 18-oz pack.

It is usually taken for granted that high egg weight is synonymous with high egg quality, and 24-oz hen eggs are generally described as first-quality. There is no similar symbol of quality for the smaller grades. Nevertheless, a high proportion of eggs of smaller size and weight are those laid by young hens, and on the basis of internal quality such eggs average out better than some larger eggs, for instance those laid by hens more than 14 months old (Kline, Meehan, and Sugihara 1965). The smaller eggs produced by younger hens usually have thick white of better quality. They also have fewer shell and internal defects. Thus the increased monetary return to the producer for the heavier eggs does not indicate their true worth in terms of quality. Accordingly some alteration in the current system of grading by weight range alone seems to be called for to encourage greater production of smaller eggs from younger hens. This may provide a desirable and feasible alternative to the production of 2-oz eggs as the major single market grade.

Although Morris (1963) has indicated that hens bred specially to give high laying rates tend to produce smaller eggs, much attention is being given to the selection of breeding strains of hens capable of laying eggs that are mostly over 2 oz in weight. It may be noted that the evaluation of the economic productivity of laying hens by the Random Sample Laying Test technique must be based on the premise that a high rate of production of eggs over 2 oz in weight is the most desirable goal because this yields the highest financial return

Table 1
Average Weights and Weight Grade Distribution of Eggs from Random Sample Laying Test Flocks

Consec. No. and Season for each Test	Av. Wt. (oz)	Percentage of Eggs in each Grade			
		First quality			Second
		>2 oz	2–$1\frac{3}{4}$ oz	$1\frac{3}{4}$–$1\frac{1}{2}$ oz	quality*
Western Australia					
3rd 1959–60	2·06	60	26	9	5
4th 1960–61	2·01				
5th 1961–62	2·00	51	26	16	7
6th 1962–63	1·99	50	29	15	6
7th 1963–64	1·93	44	28	18	10
8th 1964–65	2·00	49	33	14	4
New South Wales					
13th 1964–65		49	27		
Tasmania					
3rd 1961–62	1·97				
4th 1962–63	1·93				
5th 1963–64	1·97	50	30		
6th 1964–65	1·98				
Queensland					
1962–63	1·96				
1963–64	1·90	38	33	19	10
Victoria					
1st 1957–59		90			
2nd 1958–60		84			
3rd 1959–61	2·10	78		14	8

* Broken, cracked, bad, or pullet (less than $1\frac{1}{2}$ oz in weight) eggs, based on examination at the farm.

under commercial farming conditions. Random Sample Laying Tests carried out between 1959 and 1965 in several States showed that the average egg weight throughout Australia was very close to 2 oz (Table 1). Except in Queensland, and excluding Victoria (where the data are not sufficiently detailed), about 50% of all eggs produced exceeded 2 oz in weight.

The relative distribution of weight grades of eggs received by the New South Wales Egg Marketing Board between 1963 and 1965 is given in Table 2, and in other States the distribution of weight grades seems to be very much the same as that found in New South Wales. It is interesting to note that the weight-grade distributions shown in Tables 1 and 2 are alike, even though Table 1 relates to grading at the farm and Table 2 refers to market grades. In both sets of data eggs that failed to qualify as first-quality grade never exceeded 11%. Such a low percentage of reject eggs leaves little doubt that among eggs classed as first-quality by candling, there are many with thick white of poor quality. In Australia, commercial grading for egg quality, as distinct from weight grading, is based on candling. Candling shows up defects in the shell and air cell, and also reveals more severe abnormalities such as blood and meat spots in the body of the egg. But candling gives no indication of the condition of the thick white, which is a most important criterion of egg quality.

Table 2
Grade Distribution of Eggs received by N.S.W. Egg Marketing Board*

Grade	Percentage of Eggs in each Grade	
	1963–64	1964–65
First quality		
Over 2 oz	51	51
2–$1\frac{3}{4}$ oz	27	28
$1\frac{3}{4}$–$1\frac{1}{2}$ oz	11	11
Second quality		
Includes broken, cracked, bad, and pullet† eggs	11	10

* Based on data for 1963–64 and 1964–65 from annual reports of N.S.W. Egg Marketing Board.

† Eggs less than $1\frac{1}{2}$ oz weight.

Shell Strength and Appearance

The exact proportion of eggs cracked in the course of marketing is not known, though estimates suggest that on the average the losses do not normally exceed 10% of total production, even after including unbroken eggs rejected because their shell surface appears to be defective. Nevertheless, the wastage losses are high enough to warrant a close investigation of contributory factors. In particular, more information is needed on the physical properties of the shell and on the factors inducing or aggravating shell defects.

Instruments designed to measure the resistance of shell eggs to breaking (Brooks 1960) or to determine the shell deformation under load (Schoorl and Boersma 1962) have been used to evaluate the strength of egg shells. Gaisford (1965) concluded that for routine work shell thickness, estimated indirectly from the specific gravity of the whole egg or measured directly on pieces of shell with a micrometer, provides the most practical indication of shell quality.

A suitable method for determining the specific gravity of an egg has been described by Moffatt (1960), and the specific gravity of an egg was shown by Bartlett and Podger (1962) to be related to the thickness and strength of the shell. The ability of hens to produce eggs of high specific gravity is heritable (Morris 1964), and it is therefore possible to breed hens capable of producing eggs with sound shells of satisfactory thickness by selecting eggs of high specific gravity for hatching. A specific gravity of 1·080 is now commonly considered to be the lower limit for eggs intended for hatching, if excessive shell fragility is to be obviated in the next generation of layers.

In the Random Sample Laying Tests carried out by the Queensland Department of Primary Industries the specific gravity of successive batches of eggs is measured four times over the specified laying period. Data for the 1963–64 period showed that the specific gravity of eggs laid by 7-month-old hens that had just commenced laying was 1·088, but $11\frac{1}{2}$ months later the average specific gravity of eggs laid by hens of the same flocks was just over 1·080 and, because of the range of values from egg to egg, about one-half of the eggs must have been below the accepted lower limit of 1·080 previously mentioned. Other data obtained in Australia on the relation of specific gravity of eggs to the age of the hens laying them have been given by Morris (1964) and by Bartlett and Podger (1962), and both these surveys revealed a trend similar to that evident in the Queensland data. In the light of this evidence there are strong grounds for suggesting that an age limit be placed on hens providing eggs for the shell egg market since this will tend to minimize the proportion of eggs having weak shells.

Internal Quality

Yolk Colour

Yolk colour is one of the major factors affecting the consumer appeal of table eggs, yet it is often lacking in eggs produced by present-day methods because the feedstuffs do not contain adequate sources of yolk pigments. According to a survey by the Victorian Department of Agriculture (Bartlett and Barlow 1963), the preference of most housewives in Victoria is for eggs with a deep golden colour; but it would be unwise to assume that all consumer markets would respond similarly, for it is not unusual to find that different groups have markedly different preferences. A striking instance was reported by Banks and Voss (1962) who found two homogeneous groups in one area of St. Louis, U.S.A., whose preferences for medium and light yolk colours were in direct opposition.

In 1961, the Western Australian Egg Marketing Board began to pay a bonus of one penny (now $\frac{5}{6}$ cent) per dozen for eggs satisfying a minimum standard of yolk colour. This minimum standard was $6\frac{1}{2}$ on a colour scale which ranged from 1 (pale lemon) to 12 (dark orange). In 1965 the standard was raised to 8 on this same scale, and the bonus was increased to three and later to four pence (now 3·5 cents) per dozen. At present 95% of Western Australian eggs qualify for the bonus, and the rich colour of the yolk is being well received by the market. In the egg quality survey carried out in Victoria (Bartlett and Barlow 1963), consumers gave first preference to eggs with yolks with a colour index corresponding to 10 on the above colour scale.

Investigations have been made to ascertain what colours may be conferred on yolks and what extra cost would be incurred by adding to the diet of the hens such materials as lucerne, maize, clover, grass and green plants, seaweed, or synthetic xanthophyll pigments (Burton 1963; Morris 1959; Nobile 1964; Smetana 1961, 1965; Vale and Smetana 1965). Most of the pigment sources mentioned produce a stable, uniformly deep yolk colour at a cost which, within the bonus scheme operating in Western Australia, is economically feasible. An improved synthetic xanthophyll yolk-pigment mixture marketed under the name Carophyll Golden has recently been introduced by Roche Products Pty. Ltd. It has been stated by Parkinson (unpublished data, 1966) that this pigment gives a satisfactory yolk colour at an estimated cost of about 0·5 cent per dozen eggs.

The Western Australian egg marketing scheme of paying a premium price to producers who can satisfy the Egg Marketing Board that the eggs being produced have a specified yolk colour is a notable forward step, because it represents a first move by egg producers to use technical methods of quality control to satisfy consumers' requirements. There is no apparent reason why other States in Australia should not modify yolk colour in whatever manner seems likely to enhance its consumer appeal and in fact Queensland has just begun to market eggs with a standardized high yolk colour. Western Australia has now adopted a yolk colour standard of 10 on a new scale which has been re-standardized and extended to range over 15 units. The New South Wales Egg Marketing Board has suggested that farmers should ensure that eggs have a yolk colour of 10 units on this new scale.

White Structure

Eggs broken out for frying or poaching look best when the yolk is surrounded by a compact gel of egg thick white. The gel structure of the thick white breaks down continuously as the egg ages in the shell, the deterioration occurring more rapidly in eggs held at higher temperatures. A consequence of the breakdown of the gel structure is a higher proportion of thin white in the egg, so that the white of an egg broken out of the shell spreads considerably during cooking. Moreover, whatever thick white does remain in a relatively stale egg will have lost much of its original structural rigidity and therefore be less able to remain compactly around the yolk when the egg is broken out, as is normal for an egg of good internal quality. The quality of the thick white, which may vary widely even in freshly laid eggs, is an important factor influencing consumer acceptance, as was shown in surveys by Banks and Voss (1962) and by Bender and Voss (1963). The measurement of certain physical characteristics of the egg contents has been found to be essential for assessing internal quality, and a more reliable guide to egg quality than size grading and candling. The quality of the thick white is readily expressed in Haugh units, the lowest possible quality being represented by 0 and the highest by a Haugh unit value of 110. Determination of Haugh unit values was improved by Brant, Otte, and Norris (1951), and the use of this method was described later by Bartlett and Podger (1962). Brant, Otte, and Norris (1951) also devised a chart that depicts pictorially 12 grades or scores for egg quality based on the appearance of the yolk and white of broken-out eggs. The approximate relation between market grades as promulgated by the United States Department of Agriculture and the corresponding scores derived from the pictorial chart are shown in Table 3 along with the equivalent Haugh unit values.

Table 3
Relations between Quality Assessments of Eggs

Haugh Unit Value	Quality Score (U.S. Dept. of Agriculture)	Market Grade (U.S. Dept. of Agriculture)
110–79	1–3	AA
79–55	4–6	A
55–31	7–9	B
31–0	10–12	C

Yolk Structure

When an egg of good quality is broken out from its shell into a pan the yolk does not break but remains intact, and it is well rounded, and stands high in the pan. As the egg ages the yolk becomes more flabby and tends to lie flat in the pan when the egg is broken out; also the vitelline membrane enclosing the yolk becomes progressively weaker as the egg stales, and is more easily ruptured.

The change in yolk appearance is conveniently expressed in the yolk index, which is the ratio of the height of the yolk to its diameter when the yolk is separated from the thick white and the isolated intact yolk is placed on a flat surface.

Functional Properties

When eggs are used in culinary operations, the extent of foaming that can be induced in the egg white and the stability of the foam are critical properties, as also are the fat-emulsifying and leavening properties of the whole egg. These characteristics can be evaluated by appropriate whipping and cooking tests. The functional qualities of egg white have so great an influence on the quality of many baked products that the serious deterioration of this functional quality that accompanies aging of the egg is reflected in the poorer quality of these baked products.

Flavour

Eggs have a characteristic fresh flavour which decreases in intensity and is gradually superseded by stale flavours as the egg becomes older. Flavour in eggs is usually evaluated by panels of tasters.

Abnormalities

Internal defects that may be present include blood or meat spots, mottling of the yolk, discoloration of the white or yolk or both, structural irregularities, and infections by bacteria and moulds. Freedom from these abnormalities is usually determined by visual inspection.

Changes in Internal Quality

The structure of the thick white and the causes of losses in its gel strength are of considerable interest. The thick white differs chemically from the thin white in having a higher proportion of the protein ovomucin. Although ovomucin can form fibrous gel structures, it is not certain whether these structures alone would account for the gelling of the entire thick white.

Attempts have been made to identify the causes of the deterioration of thick white. Among the mechanisms investigated are: attack by enzymes (Lineweaver *et al.* 1948; Lineweaver, Fraenkel-Conrat, and Bean 1949), interaction of proteins (Cotterill and Winter 1955), chemical hydrolysis, and chemical reduction. It has been shown that materials such as cysteine, thioglycollic acid, hydrogen sulphide, and sulphur dioxide cause thinning of egg white and cause the yolk membrane to weaken (MacDonnell, Lineweaver, and Feeney 1951; Feeney *et al.* 1952). The causes of the changes in the rigidity of the thick white during aging are still not known, though they have been investigated in recent years (Brooks and Hale 1959; Brooks 1960).

The CSIRO Division of Food Preservation is currently engaged on a research project, the principal aim of which is to determine whether the viscous and elastic properties of egg thick white and alterations occurring in them can be satisfactorily explained in terms of the molecular structure of the major protein constituents ovalbumin and ovomucin, and whether breakdown of the gels is paralleled by changes at the molecular levels.

The pH of the white is known to have some part in controlling changes in the thick white gel, some of which may arise from interactions among the various proteins present in the white. The pH is dependent on the carbon dioxide concentration in the white and may be modified by oiling the egg shells (Shenstone and Vickery 1958).

Investigations in this Division have shown that ovalbumin, the main protein of egg white, can occur in two forms, which differ in that one has a much higher resistance to denaturation by heat, though in all other respects their physical and chemical properties are similar, if not identical, when examined by the means at present available (Smith 1964; Smith and Back 1962, 1965). The proportion of the more heat-stable form of ovalbumin present in whole eggs increases during storage at a rate which will also increase with a rise in the pH of the white. The conversion takes place at the expense of the less heat-stable form; in 2 weeks at 68°F about 60% of the total ovalbumin is present as the heat-stable form. In this connection it has been found in the United States of America that the unsatisfactory performance of egg whites in cake-making is a result of the use of whites from old eggs (Lineweaver *et al.* 1962; Meehan, Sugihara, and Kline 1962), and that the defect is probably associated with changes in the ovalbumin. Investigations aimed at relating the functional properties of the two forms of ovalbumin to their structures are at present being carried out at the CSIRO Division of Food Preservation.

Pink Whites

The 'pink white' disorder in eggs is characterized, among other indications, by the pink or orange-red discoloration apparent in the whites of eggs that have been stored for some time. This disorder is now known to be a consequence of the hen having ingested feeds containing the esters or other derivatives of malvalic or sterculic acids, both of which are fatty acids containing the reactive cyclopropene group in the carbon chain of the acid. These acids have been isolated from plants of the botanical order Malvales (Shenstone and Vickery 1956, 1959, 1961; Macfarlane, Shenstone, and Vickery 1957; Fogerty *et al.* 1965). They are also present in cottonseed meal in sufficient quantity to cause disorders in animals, especially laying hens, to which the meal is fed. Both acids have many biochemical and physiological effects on the properties and functions of animal organs and tissues (Phelps *et al.* 1965; Shenstone, Vickery, and Johnson 1965).

In the CSIRO Division of Food Preservation a study is being made of the nature and mechanism of the biochemical effects induced in the hen when cyclopropene fatty acids are present in their diet. The work has been stimulated by the increasing scale of cotton production in Australia, which will result in large quantities of cottonseed meal being used as a protein supplement in animal and poultry feeds.

Control of Retail Quality

It has been shown that candling is not a satisfactory means of assessing the internal quality of eggs (Baker and Forsythe 1951; Moffatt and Byrnes 1961; Bartlett 1964*a*, 1964*b*). However, the condition of the thick white is a satisfactory index of the internal quality of an egg, and measures which maintain high quality in the thick white have been shown to benefit other attributes of quality, for example, the yolk index. For this reason the practice has been adopted in the U.S.A. of breaking out a small sample of eggs from consignments to obtain Haugh unit values, on which the eggs are graded for the market. The method can also be used at the point of retail sale.

Shenstone and Vickery (1964) and Coote *et al.* (1966) have described market surveys carried out by CSIRO to determine the internal quality of eggs in Australia at various stages of marketing, from the time of laying to retail sale. Quality was assessed in terms of Haugh unit values, USDA scores, yolk index figures, and scores by flavour panels. Some of the data are presented in Figure 1, which relates observed Haugh unit values of eggs to the month during which they were marketed. The average quality of eggs at the point of retail sale was generally above 62 Haugh units during only the four winter months. The internal quality of retail eggs at other times of the year ranged down to B grade on the American scoring system. It is interesting to compare these results with standards in the U.S.A., where eggs are retailed throughout the year with average Haugh unit values above about 80 for AA grade eggs and above 62 for the A grade (U.S. Department of Agriculture 1960).

The decline in egg quality takes place from the time of laying to arrival at grading floors, and from the grading floors to the time of sale in shops. The rate of decline during these two stages of marketing is clearly influenced by temperature. In the summer months, when recorded mean air temperatures were 69–72°F, it was 9–12 and 18 Haugh units in the respective stages, and in the winter months, when recorded mean air temperatures were 52–55°F, it was 3–5 Haugh units during each stage. It was concluded that on the average the quality of eggs in shops in summer could be improved and that defects were apparent at all stages of production and marketing.

In 1959–60, investigations were carried out by the Queensland Department of Primary Industries to appraise the quality of eggs received at the Egg Marketing Board and graded out for sale (Moffatt and Byrnes 1961). This survey showed that in Brisbane, over different periods of the year, the average Haugh unit quality of eggs graded as first-quality by candling ranged from 68 to 76. Similar values (Fig. 1) were obtained at the grading centre

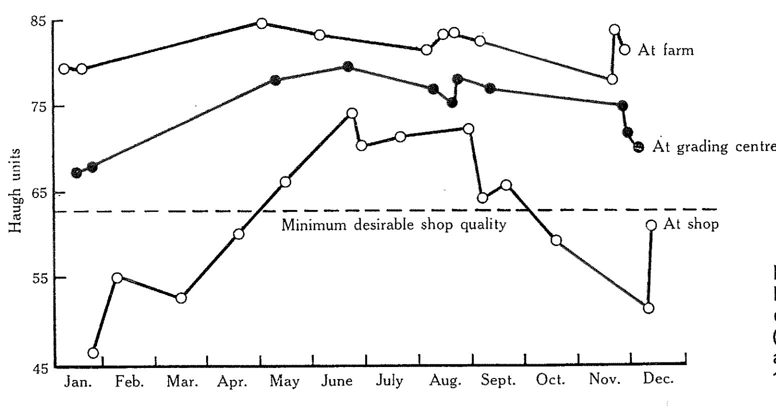

Fig. 1.—Seasonal variation in Haugh units of eggs at different stages of marketing. (From a survey in the Sydney area, 1960-63 (Coote *et al.* 1966).)

in New South Wales during the survey by the CSIRO Division of Food Preservation.

To retain high quality, the time elapsing between the laying of eggs and their retail sale in Australia must be reduced, and also the eggs must be maintained at a temperature below 55°F at all times. If the eggs are to be kept for a long time, the temperature should be as near as possible to 32°F. Efforts are being made by producers and marketing authorities to reduce storage temperatures for eggs on the farms, during transit, and at the grading centres.

The application of mineral oil to the shells has also been used to retain the internal quality of eggs. However, Shenstone and Vickery (1958) concluded that significant benefits were obtained by oil coating only if the oil was applied to the eggs preferably within 8 hours, but not later than 24 hours, after they were laid, for its chief function is to prevent loss of carbon dioxide from the interior of the egg. In practice the oil would have to be applied to the eggs on the farm and this could be carried out with spray jets over the belt conveyors in mechanized grading and packing equipment. Since oiling is the last operation before packaging, the oil would be absorbed into the shell before the eggs were handled again. At high temperatures the rate of loss of internal quality in oiled eggs is reduced to at least half that of unoiled eggs. When the weather during marketing is hot, oiling may be a useful adjunct to refrigeration for preventing the loss of internal quality. Similarly, Moffatt (1961) found that the Haugh unit loss during storage of eggs packed in cartons was lower if the cartons had been over-wrapped with

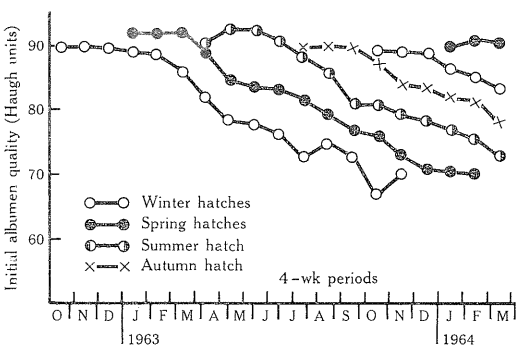

Fig. 2.—Relation between initial albumen quality and age of hens hatched at quarterly intervals (after Bartlett 1964*a*).

Table 4
Effect of Age of Hens on Initial Quality of Eggs in some Random Sample Laying Tests

Queensland				
Hen age (months)	8	11	14	17
Haugh units				
Fresh eggs, 1963–64	80·9	75·8	69·7	60·8
New South Wales				
Hen age (months)	8	10½	12½–14	15
Haugh units				
Fresh eggs				
9th test, 1960–61			72·0	
10th test, 1961–62			70·7	
12th test, 1963–64		79·8	73·3	68·2
13th test, 1964–65				72·6
14th test, 1965–66	80·0			
Eggs after storage				
9th test, 6 days at 45°F			69·9	
10th test, 6 days at 40°F			61·6	
12th test, 7 days at 60°F		70·7	61·8	57·9
13th test, 7 days at 60°F				58·6
14th test, 7 days at 60°F	60·0			

MSAT 300 cellulose film, which helps to retain carbon dioxide.

Low retail quality may be due also to poor quality at the time of laying, caused by flocks of hens which are too old or of unsatisfactory genetic strains (Funk *et al.* 1958; Cunningham, Cotterill, and Funk 1960; Mueller, Maw, and Buss 1960; Snyder 1962; Kline, Meehan, and Sugihara 1965).

The values quoted in the above surveys were determined on eggs randomly sampled in a way that would provide reliable averages for all flocks on the selected farms and for as many of these farms as possible; but the values do not indicate the extent to which the age of the hens affects the quality. This has been demonstrated by Bartlett (1964*a*, 1964*b*) in studies of Australian hen stock hatched at different periods of the year. Figure 2 shows that the quality of freshly laid eggs decreased by 20 Haugh units over a 14-month laying period, up to the age of about 19 months, which is not an unusual length of time for hens to be maintained for egg laying. Clearly, the eggs from these older hens would be too poor initially to be of even moderate quality when they reached consumers.

The effect of the age of hens in decreasing the initial quality of eggs is clearly shown by the Haugh unit values obtained from some Random Sample Laying Tests of commercial laying flocks in Australia (Table 4). The quality of fresh eggs from hens aged 15–17 months ranged from 72 to 60 Haugh units. At 8 months the quality was 80 Haugh units. However, the latter value is 10 units lower than that readily obtainable from hens with good genetic characteristics.

Conclusion

The quality of retail eggs in Australia could be improved by making grading systems conform more closely to those of the United States Department of Agriculture. The U.S. system of marketing recognizes the importance of flock age and husbandry practices. It also recognizes the need to keep eggs cool at all stages of marketing, and to set a time limit on their retail life. Most important, it stresses the evaluation of internal quality by breaking out regular samples of eggs from consignments for determination of Haugh unit values. An indication of the scale of the organization of this scheme is that in 1966 one-quarter of the U.S. egg production was graded under the USDA regulations. This corresponds to ten times the total annual commercial production in Australia.

Further Reading

A comprehensive review of the definition, measurement, and control of quality in eggs has been written by Snyder (1962). An article by Bartlett and Podger (1962) is also a valuable source of information on egg quality. Vickery and Shenstone (1961) have written on the effects of the nutrition of the hen on egg quality. Shenstone (1964) has described the differences in the marketing of shell eggs and egg products in Australia and the U.S.A.

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New Materials for Food Cans

By P. W. Board

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The author spent 11 weeks in Japan, the U.S.A., Britain, and Europe in the second half of 1967 studying new developments in canning technology and in metal packaging materials for foods. In this article he reviews some of the current overseas trends which may become important in Australian industry in the near future.

THE most significant developments in metal packaging materials in recent years have led to more efficient use of tin and steel in tinplate manufacture, improved performance of tinplate, the introduction of so-called tin-free steels, and expansion of the use of aluminium. The incentive for these developments comes partly from competitive pressure to reduce the cost of cans, and partly from the desire of the major canning nations to be less dependent on supplies of raw tin from other countries.

Tinplate

Mainly as a result of the threat of commercial competition from other metal packaging materials, considerable effort has been made by tinplate manufacturers to reduce the cost of tinplate. This has led to the widespread use of electrolytic tinplate and to double-cold-reduced (2CR) plate.

Electrolytic Tinplate

The main economic advantage of electroplate is the saving in tin metal; electroplate with coatings as low as 0·25 lb* is now frequently used whereas years ago hot-dipped plates with coatings of 1–1·25 lb were the only ones available. An indication of the wide acceptance of electroplate by the U.S. canning industry is the fact that at least one of the steel companies in that country has ceased production of hot-dipped plate. It is also significant that most food cans used in the U.S.A. have 0·25 lb external tin coatings, although 1·0 lb coatings are still used in some areas such as Hawaii where storage and transport conditions are conducive to external corrosion. It has been suggested that the use of 0·25 lb external coating gives very little less protection against rusting than 1·0 lb coating. Careful attention is given in the U.S.A. to maintaining favourable conditions in transport and storage of canned foods to avoid external rusting. Warehouses are of sturdy construction and effectively protect the canned goods from the effect of changing weather conditions.

Electrolytic tinplates having as little as 0·1 lb coating have been produced experimentally but they had a poor appearance and were unacceptable commercially.

Double-reduced Plate

A more recent development in tinplate technology is double-cold-reduced (2CR) plate which now constitutes about 40% of U.S. tinplate production. Originally this plate was made by cold-rolling tin-plated steel strip of normal substance (about 100 lb per base box, i.e. 0·011 in. thick) with the aim of approximately doubling the output from existing tinplating lines. The resultant product, however, had poor solderability and unattractive appearance and therefore 2CR plate is now made by electroplating the double-cold-reduced steel strip. Since 2CR tinplate is only about 55 lb substance or 0·006 in. thick, it is supplied in the fully hard state (temper 9) to give strength to the cans. The highly tempered thin plate is, however, susceptible to seam fracture if roughly handled and this has caused problems in the U.S.A. where transport of cans on pallets is widely practised. Some modification of closers and can-making lines and changes in the profile of can ends are sometimes needed to compensate for the brittleness of 2CR plate. Similar difficulties might be expected in Australian industry when 2CR plate of local origin becomes generally available in the near future.

* Throughout this paper tin coating weights are expressed as lb per base box, which represents the weight of tin on an area of 62,720 sq. in.

The shelf life of cans made wholly from 2CR plate is reported to be similar to that of cans made of ordinary plate, but where the two types of plate are used together there may be up to 20% reduction in shelf life, probably because of the anodic character of the 2CR plate. This problem may be worse if the 2CR plate is beaded. The main uses of 2CR plate are in cans for beer, beverages, and frozen juice concentrates, but it is also used for products which are packed with a vacuum such as meat, fish, vegetables, fruit, and juices.

Grade K Plate

Another significant development is the widespread commercial use of Grade K tinplate. Grade K plate, originally called Grade A, is plate which gives a current of less than $0 \cdot 12\,\mu$A/sq cm in the alloy–tin couple (ATC) test. This test involves electrolytic detinning of a sample of tinplate to expose the layer of $FeSn_2$ alloy which occurs on the steel surface. The detinned sample is then connected electrically to a large area of tin immersed in deaerated grapefruit juice containing stannous ions. After some hours the corrosion current flowing between the two electrodes is measured to give the ATC test value. There is a correlation between the ATC value and the corrosion resistance or shelf life of the plate in some but not all canned products. The ATC test seems to be useful for grading tinplate for most products that contain citric acid and normally cause detinning. Grade K plate of $0 \cdot 75$ lb coating usually gives a shelf life equivalent to ordinary 1 lb plate for many such products, and the lower coating weight is now used commercially in the U.S.A. At present, Grade K plate does not carry a premium price in the U.S.A. and it is sought for many products for which it has no special advantage. For example, Grade K plate has given little or no improvement in shelf life with canned vegetables.

The ATC test value of tinplate can usually be related to the morphology of the alloy of the plate; the lowest ATC values and highest corrosion resistance are found in plates in which the coverage of the base steel by the alloy is most complete. Many factors in the manufacture of tinplate undoubtedly determine whether a plate is Grade K or not, but the condition of the steel surface at the moment of tinning is probably most critical. It seems that the surface of the steel should be cleaned and pickled so that as many crystallization nuclei as possible are present to give maximum coverage of alloy crystals. To achieve this condition, steel-making operations are controlled to reduce impurities and inclusions in the steel surface, and annealing atmospheres free of carbon gases are used. It is reported that Grade K plate can be readily made on alkaline electroplating lines, but careful control of conditions is needed to obtain Grade K plate from Ferrostan lines; Grade K plate is most difficult to make on a halogen line. One tinplate manufacturer in the U.S.A. is reported to have modified a halogen line to obtain Grade K plate by installing, ahead of the usual electroplating line, equipment to apply a flash coating of tin to the steel. This coating is reflowed, and the plate is then electroplated to the required coating weight and reflowed in the usual way.

Other methods for producing Grade K plate have been investigated. High-temperature reflowing of the plated tin was expected to increase alloy nucleation but did not result in lower ATC values and gave a rough tin surface. Flash coating the steel with nickel and then electroplating with tin and reflowing in the normal way gave ATC values about half the usual values, but there was little or no improvement in shelf life. The solderability of the plate containing nickel is significantly poorer than tinplate of the same coating weight. Work is continuing on flash coating with nickel, and on methods for forming the $FeSn_2$ alloy crystals flat on the surface of the steel and so improving the coverage.

Oxide Films

Although electrolytic tinplate is commonly given a chemical treatment to produce a protective oxide film on its surface, it is only in recent years that the importance of this film in container–product reactions has been recognized. Under some conditions the oxide may protect the plate from sulphur staining, while under other circumstances it may lead to non-uniform corrosive attack on the tinplate, which results in an unattractive appearance on the interior surface of the stored cans. Tinplates having different passivation treatments which are designed to improve the performance of the plate with specific products are now available in some overseas countries.

For example, treatments designated 310 or 311 (cathodic dichromate) give stable oxide films having good resistance to sulphur staining, while 410 treatment (cathodic sodium carbonate) is used for plate intended for canned milk, to avoid patchy detinning.

Tin-free Steels

The term 'tin-free steel' or 'TFS' is used for a range of products produced by chrome plating, or electrochemical chromate or chromate–phosphate treatment of steel sheet. Logically it would be preferable to give these materials more direct names, such as chrome-plated steel or chromed steel, and it is hoped that this change will be made before the term TFS becomes generally established. Commercial development of chrome-plated and chromate-treated steels for food cans began in Japan, and materials of this type are now being manufactured, or will soon be manufactured, in Japan, U.S.A., Europe, and Britain. Typical examples of these materials are Can Super made by Fuji Iron & Steel Company Ltd. and Hi Top made by Toyo Kohan. Can Super has a coating of chrome metal about 1 μin. thick, i.e. about 18 mg chromium/sq ft, and Hi-Top, which was originally thought to contain no metallic chromium, seems to have an extremely thin layer of metal under a passive chromate oxide film (the thickness of tin on 0·25 lb plate is about 15 μin.). One commercially available chromed steel in the U.S.A. has a chromium coating of 4–9 mg metal/sq ft with 2–4 mg of chromium as oxide in the passivating film. As with tinplate, the surface oxide film has an important influence on the resistance of the chromium plates to attack by foods, and on adhesion of lacquers.

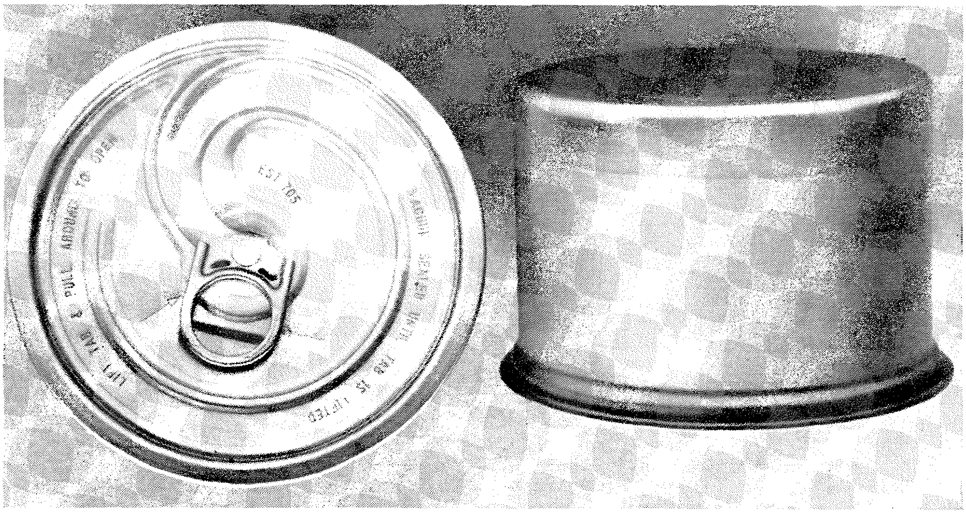
The chromed plates are highly susceptible to rusting and are therefore lacquered on both sides. The lacquer also helps to protect can-making equipment and closers from excessive wear which would result from direct contact with the hard chromed plate. Despite the need to lacquer both surfaces, chromed steels have proved in many instances to be more economical than tinplate, for example a price advantage of $US2 per 1000 cans has been reported for 12-oz beer cans made from chrome-plated steel. These materials have an attractive appearance, give excellent lacquer adhesion, and can be drawn as well as other steel-base materials; they are resistant to under-film corrosion and to sulphur staining, and are tolerant of the high temperatures encountered in high-speed continuous baking of the metal strips during lacquering.

None of the chromed steels can be soldered but techniques have been developed in the U.S.A. for forming side seams by high-speed pressure or forge welding (Continental Can Company process) or by using thermoplastic adhesive (American Can Company 'Mira-Seam' process). Cans having adhesive side seams cannot be used for products requiring high-temperature sterilization but are suitable for beer and carbonated beverages. Leakage has sometimes been encountered in the lap area of these cans if the adhesive is disturbed by double-seaming. Chromed steels are already being used overseas for cans for many products for which a fully lacquered tinplate can would normally be used, and these materials are also being used as lacquered ends on cans having tinplate bodies. Chrome-plated steels are also finding application for crown seals and screw caps, and for general line cans.

U.S. Steel Corporation has developed a chemically treated steel designated TFS 210 which is made by a cathodic chromate–phosphate process. This material is reported to show variable properties, especially with regard to lacquer adhesion, and this, of course, would affect the soundness of cemented side seams. TFS 210 is also reported to be susceptible to under-film corrosion, but appears to have applications for some mildly aggressive products such as beer.

Vapour Coatings

Development of techniques for continuous vapour coating of steel strip with aluminium has now reached the pilot-plant stage, and may soon be commercial. This material is made by passing the cleaned steel strip through a chamber under very high vacuum containing aluminium vapour. Coatings about 30 μin. thick seem feasible and the product has a bright, smooth surface and no intermetallic layer. The surface requires a chemical conversion treatment to give satisfactory lacquer adhesion. The main potential applications of this material appear to be for beer cans and crown seals. Staining of the wads in crown seals made from aluminium-coated steel is less of a problem than in crowns made from tinplate.



Two-piece aluminium can with an easy-opening lid.

Aluminium Alloy

Aluminium has been used for many years for cans for fish and meat paste, but recently there have been major developments in the use of this metal for packaging foods. In 1966 aluminium constituted 4·6% of metal used for cans in the U.S.A. Aluminium alloys, mainly of the 5000 series, are used for easy-opening ends for beer and beverage cans having steel-based bodies, and it appears that this will be the main application in the near future. Recently, however, commercial production commenced of two-piece aluminium cans for a wide range of products, e.g. meats, pet foods, fish, beer, and water for emergency use.

Aluminium bodies for cans are made by drawing from sheet, or by extrusion from metal plugs with or without ironing to increase the depth of the can. Sheets for drawing are usually lacquered or lithographed in the flat, but cans made by ironing or extrusion must, of course, be lacquered and decorated after fabrication.

The cost of aluminium cans varies markedly from one country to another, largely because of the cost of the raw metal. The costs of manufacturing aluminium cans are at present generally greater than for tinplate cans of similar size. Although the price of food in aluminium cans is usually greater than for the same food in steel-based containers, there is ready consumer acceptance of aluminium cans which often have easy-opening features and an attractive hygienic appearance, and can be readily crushed for disposal. A typical drawn aluminium can which is currently used for meat products in the U.S.A. is illustrated. In this can the double seam which holds the lid is offset from the sides to make it easier to remove solid contents. The can also has an easy-opening tag, and a white internal lacquer.

At this stage of development of aluminium cans they cannot be recommended for some foods which are particularly aggressive towards this metal. Acid foods containing chloride tend to perforate aluminium cans, particularly at the score line where the lacquer is damaged. Tomato and pineapple juices and some hot packs quickly cause perforation, but citrus juices tend to undercut the lacquer and produce hydrogen swells rather than pinholes. Fruit juices containing some artificial dyes cause fast perforation, the dyes being chemically reduced at the metal surface. Repairing the damaged lacquer at the score line with epoxy-phenolic sprays usually gives a marked improvement in shelf life with aggressive products. However, shelf lives of 6 to 9 months can often be obtained with less aggressive products without the lacquer being repaired. Most vegetables can be packed in cans made entirely of aluminium but perforations often occur in duplex cans because the tinplate body acts as an efficient cathode.

Foreign Objects in Fish Paste

By R. V. Holland and P. W. Board

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A somewhat novel example of the type of short-term investigation carried out by the Division of Food Preservation for the Australian food industry is presented in this paper.

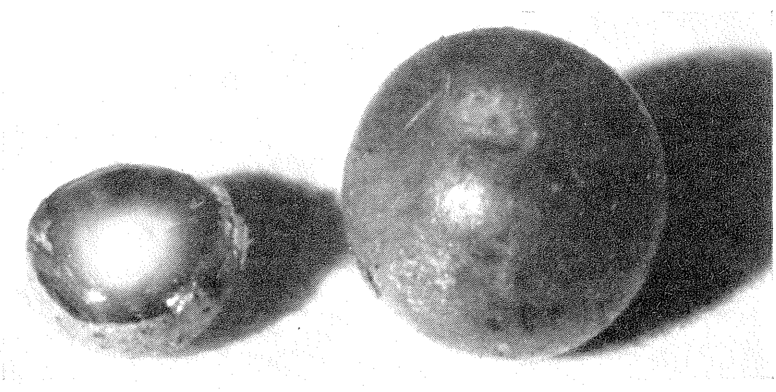
THE DISCOVERY of foreign objects, especially solid ones, in foods usually results in complaints by consumers and, in cases where the objects cannot be readily identified, tribulation for the manufacturer. Foods containing foreign objects are sometimes submitted to the laboratories of the Division of Food Preservation and in most cases the nature and source of the foreign material have been determined. Unusual objects in foods have many different origins; some, such as tartrate crystals in grapes, struvite in canned marine products (Board 1957*), or tyrosine in anchovy products are derived from the food itself, while others result from contamination by non-food materials. One recent instance of contamination of this type involved a fly, probably *Calliophora erythrocephala*, that was found in a can of meat (Casimir, unpublished data, 1962).

Recently a manufacturer of fish paste reported that a customer had found two small spherical objects in a paste that contained Australian anchovies (*Engraulis australis*) and smoked herring (*Clupea harengus harengus*) in addition to other ingredients. The objects, which were hard and had a pearl-like lustre, are shown in the illustration. The diameters of the objects were 0·061 and 0·094 in.

Since only two objects were available for examination, non-destructive physical methods were used for their identification. To test the suggestion that the objects could be otoliths or perhaps pearls they were subjected to X-ray diffraction measurements. This technique gives a pattern of spots or lines on a photographic film if the material is crystalline, and the position and spacing of the spots or lines can be used to identify the crystalline component of the objects. In this case, however, no diffraction pattern was obtained, and therefore the material was probably amorphous.

The specific gravity of the objects was determined by flotation in mixed organic liquids and was found to be 1·28 and 1·30. This result in conjunction with the failure to obtain an X-ray pattern indicated the objects were predomin-

* BOARD, P. W. (1957).—Glass-like deposits in canned foods. *CSIRO Fd Preserv. Q.* **17**, 75.



Fish-eye lenses foundi n fish paste (about 21 times natural size). A portion of the surface of the lens on the left has been removed.

antly organic. A small fragment of one sphere was then mounted in a disk of potassium chloride and its infrared spectrum was measured. The infrared spectrum demonstrates the presence of many types of chemical groups in a molecule, and in this case the pattern of infrared absorption showed the objects were predominantly composed of protein. These results suggested that the objects were probably the lenses of fish eyes and this identification was confirmed by Dr. F. H. Talbot, of the Australian Museum. Dr. Talbot reported that eye lenses are often found in fish stomachs, but in this case they could have come from the eyes of anchovies, which are used whole in the paste.

Further confirmation of the identity of the lenses was obtained by measurements that were taken from eyes of anchovies and smoked herrings after the eyes had been heated in water for 30 min at 240°F; the lenses would then have had a heat treatment similar to that received by the lenses in the fish paste. The characteristics of these lenses are given in the table.

Characteristics of Processed Lenses from Eyes of Australian Anchovies and Smoked Herrings

Property	Anchovies	Herrings
Diameter (in.)	0·061–0·078	0·086–0·117
Specific gravity	1·22	1·20

The infrared spectra of lenses obtained in the laboratory from the eyes of anchovies and herrings were identical with the spectrum obtained from the objects found in the commercially processed paste.

Financial Contributions, 1966-67

The Division of Food Preservation has pleasure in once again placing on record its deep appreciation of contributions to its work from the Australian food industry and associated industries. In the financial year 1966–67 contributions amounting to $17,537 were received from no less than 106 companies. The Division is gratified that its work is so widely supported and it has endeavoured to use the contributions in ways best calculated to assist the food industry.

In the year ended June 30, 1967, the Division of Food Preservation's budget was $1,221,036, of which $1,096,536 came from the Commonwealth Treasury. The balance ($124,500) was mostly in the nature of contributions for specific researches from Government departments and statutory bodies.

Within Australia grants were made by the following:

Australian Meat Research Committee
Research on the quality, processing, storage, and transport of beef

Australian Apple and Pear Board
Apple and pear storage investigations

Australian Dried Fruits Association
Investigations on dried tree fruits

Australian Egg Board
Investigations on packaging of egg pulp

Australian Meat Board
Investigations on the mechanical skinning of sheep

Department of Primary Industry*
Fruit fly sterilization investigations

Metropolitan Meat Industry Board, Sydney
Muscle biochemistry investigations

New South Wales Department of Agriculture
Fruit storage investigations

The Rice Marketing Board for the State of New South Wales
Investigations on the drying of rice grain

The U.S. Department of Agriculture continued to contribute to the cost of investigations on the chemical structure of albumen until the end of 1966, and it is still supporting the Division's research on cyclopropenoid compounds.

* Central funds, made up of contributions from the Commonwealth, the six States, and the Australian Banana Growers' Council, administered by the Commonwealth Department of Primary Industry.

Contributors to General Donations Account, 1966-67

Abattoir Construction & Engineering Co. Pty. Ltd.
Anderson Processed Foods Pty. Ltd.
W. Angliss & Co. (Aust.) Pty. Ltd.
Ardmona Fruit Products Co-op. Co. Ltd.
William Arnott Pty. Ltd.
Australian Bakels (Pty.) Ltd.
Australian Cellophane (Pty.) Ltd.
Australian Consolidated Industries Ltd.
Australian Cream Tartar
Australian Fibreboard Containers Manufacturers' Association
Australian Packaging Industries Pty. Ltd.
James Barnes Pty. Ltd.
Batlow Packing House Co-operative Ltd.
Bell Bryant (Refrigeration) Pty. Ltd.
Bender & Co. Pty. Ltd.
Lewis Berger & Sons (N.S.W.) Pty. Ltd.
Berri Co-operative Packing Union Ltd.
Berri Fruit Juices Co-operative Ltd.
Big Sister Foods Ltd.
British Tobacco Co. (Aust.) Ltd.
Buderim Ginger Growers' Co-operative Association
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Craig Mostyn & Co. Pty. Ltd.
Curlwaa Co-operative Packing Society Ltd.
Cygnet Canning Co. Ltd.
Dark's Ice & Cold Storage Ltd.
Darling Downs Co-operative Bacon Association Ltd.
Davis Gelatine (Aust.) Pty. Ltd.
Elmer Products Pty. Ltd.
Fletcher & Pickett Pty. Ltd.
F.M.C. (Aust.) Limited
Fountain Bingo Products Ltd.
Fremantle Cold Storage Co. Pty. Ltd.
Frig-Mobile of Aust. Pty. Ltd.
J. Gadsden Pty. Ltd.
W. G. Goetz & Sons Ltd.
Golden Circle Cannery
W. R. Grace Aust. Pty. Ltd.
Griffith Co-operative Cannery Ltd.
Griffith Producers Co-operative Co. Ltd.
Gumeracha Fruitgrowers Co-op. Ltd.
Hall-Thermotank (Aust.) Pty. Ltd.
Keith Harris & Co. Ltd.
H. J. Heinz Company Aust. Ltd.
Hunter Valley Co-operative Dairy Co. Ltd.
H. Jones & Co. (Sydney) Pty. Ltd.
Jusfrute Limited
Kyabram Preserving Co. Ltd.
Lawley & Housego Pty. Ltd.
Leeton Co-operative Cannery Ltd.
Henry Lewis & Sons Pty. Ltd.
McCarron Stewart Ltd.
Mayfair Hams & Bacon Co.
P. Methven & Sons Pty. Ltd.
Muir & Neil Pty. Ltd.
Nestlé Company (Aust.) Ltd.
R. K. Newman & Co. Pty. Ltd.
Northern Pear Growers Association Ltd.
Nugan (Griffith) Pty. Ltd.
Orange Fruitgrowers Co-operative Cool Stores Ltd.
P. & O. Lines of Aust. Pty. Ltd.
Harry Peck & Co. (Aust.) Pty. Ltd.
W. C. Penfold & Co. Pty. Ltd.
Pennant Refrigerators Pty. Ltd.
Pick-Me-Up Food Products
Thomas Plaimar Pty. Ltd.
Producers Cold Storage Limited
Producers' Co-operative Distributing Socy Ltd.
Queensland Cold Storage Co-operative Federation Ltd.
Read Industries Pty. Ltd.
Reckitt & Coleman Pty. Ltd.
Riverland Fruit Products Co-operative Ltd.
Roche Products Pty. Ltd.
St. Regis–ACI Pty. Ltd.
Sanitarium Health Food Co.
Schweppes (Aust.) Ltd.
Scotts Provisions (Holdings) Ltd.
Shaw Savill & Albion Co. Ltd. Shaw Savill Line
Shepparton Preserving Co. Ltd.
Sidac-Rayophane (Aust.) Pty. Ltd.
South Australian Fishermen's Co-op. Ltd.
Chas. Steele & Co. Pty. Ltd.
Swift Australian Co. (Pty.) Ltd.
Taubmans Industries Ltd.
Tooheys Limited
Uncle Ben's Inc.
Unilever Australia Pty. Ltd.
Union Carbide Aust. Ltd.
United Fruit Company Pty. Ltd.
Vegetable Oils Pty. Ltd.
F. J. Walker Limited
Watts Winter Pty. Ltd.
Western Australian Ice & Cold Storage Association
George Weston Foods Ltd.
Winn Food Products Pty. Ltd.
Woolworths Ltd.
Arthur Yates & Co. Pty. Ltd.
G. S. Yuill & Co. Pty. Ltd.
Yuill Trading Co. Pty. Ltd.

NEWS FROM THE DIVISION OF FOOD PRESERVATION

New Chief

The newly appointed Chief of the Division of Food Preservation, Mr. M. V. Tracey, took up his position on November 27, 1967. Mr. Tracey was formerly leader of the CSIRO Wheat Research Unit, which he joined in 1958. Prior to that he worked for 13 years in the Biochemistry Department of the Rothamsted Experimental Station, England. Mr. Tracey has published two books and many scientific papers on the biochemistry of the structural materials in plant and animal cells. His research interests of recent years have been concerned with the effects of water on the properties of biological systems.

Assistant Chiefs

The Division of Food Preservation now has three Assistant Chiefs. Dr. W. J. Scott, who was first made an Assistant Chief in July 1960, has been leader of meat research in the Division since 1964 and is now Officer-in-Charge of the CSIRO Meat Research Laboratory, Cannon Hill, Queensland, where he has been located since January 1967. Dr. Scott became Acting Chief of the Division when Dr. J. R. Vickery retired in July 1967. When Mr. Tracey took up his position as Chief, the CSIRO Executive appointed two additional Assistant Chiefs — Dr. J. H. B. Christian, head of the Division's Microbiology Section, and Mr. J. F. Kefford, head of the Food Technology Section — both of whom are located at the Divisional headquarters at North Ryde.

Appointments

Dr. G. D. J. Morton, a graduate of the Universities of Adelaide and Melbourne, was appointed Senior Research Scientist at the Division's Meat Research Laboratory, Cannon Hill, in July. At the time of his appointment, Dr. Morton was a post-doctoral fellow in the Department of Biochemistry, Western Research University, Cleveland, Ohio, U.S.A. At Cannon Hill, Dr. Morton is studying the fine structure of muscle and its relation to function.

Dr. Katherine Henrikson, who holds degrees from the Universities of Rochester and Harvard, U.S.A., joined the Division in December to take part in investigations on water in dough. The investigations are being directed by Mr. M. V. Tracey, Chief of the Division.

Guest Workers

Shortly after his retirement, Dr. J. R. Vickery became a guest worker in the Division. He is engaged on research into the composition of the fatty acids in the seeds of plants of the order Proteaceae. It is believed that these fatty acids may be of taxonomic significance.

Dr. V. C. Shah, of the University of Delhi, India, spent the months of June, July, and August in the Division's Plant Physiology Unit, where he made use of the technique of autoradiography to study nucleic acids in plant cells.

Overseas Visits

A feature of travel by the staff in 1967 was the number of invitations received to participate in scientific and technical activities in other countries.

In June, Dr. W. G. Murrell took a leading part in a symposium on bacterial spores at Cornell University, Ithaca, N.Y., U.S.A.

Dr. N. S. Scott was awarded a fellowship for a course on DNA–RNA hybridization, which was held at the International Laboratory of Genetics and Biophysics at Naples, Italy, in June.

Mr. V. Stekly was seconded to the Australian Department of External Affairs for about three months from June to enable him to complete the installation of equipment at the newly set up Food Processing Laboratory at Apia, Western Samoa. Finance for the Laboratory was provided under the Australian South Pacific Technical Assistance Programme.

In September Mr. F. S. Shenstone contributed a paper on egg quality to a symposium on that subject organized by the British Egg Marketing Board at the Harper Adams Agricultural College at Newport, Shropshire, England.

Dr. E. F. L. J. Anet was overseas from early June to early August. He visited Japan, Europe, and the North American continent for the purpose of holding discussions at centres of carbohydrate research and participating in conferences on carbohydrate chemistry.

Mr. P. W. Board visited Japan, the U.S.A., and parts of Europe in the course of a three-month tour which began on July 25. He studied the latest developments in the technology of can-making and the canning of foods. In October he attended the International Congress on Canned Foods in Vienna.

In the course of a short visit at the end of August and early in September, Dr. G. S. Sidhu attended the Twelfth International Congress of Refrigeration in Madrid, and a Technical Conference on the Freezing and Irradiation of Fish organized in Madrid by the Food and Agriculture Organization of the United Nations. Dr. Sidhu also visited fisheries research laboratories in Scotland, Canada, and the U.S.A.

Dr. R. M. Smillie attended the International Biochemical Congress in Tokyo from August 19 to 25. He also visited centres in Japan, Europe, and North America which are engaged in investigations on plant physiology and fruit storage. Dr. Smillie returned to Sydney at the beginning of October.

Dr. Thelma Reynolds, who spent the period from September 7 to November 6 on long-service furlough overseas, took the opportunity to visit a number of research laboratories in Great Britain and the U.S.A. Dr. Reynolds is particularly interested in the chemistry of pectin and in the carbohydrate moiety of ovomucin.

Mr. D. McBean took a position with the Western Utilization Research and Development Division of the United States Department of Agriculture at Albany, California, for 12 months from October 20. Mr. McBean is carrying out investigations on dried fruits in the Fruit Processing Technology Investigations Laboratory at Albany.

Recent Publications of the Division

Copies of most of these papers are available from the Librarian, Division of Food Preservation, CSIRO, Box 43, P.O., Ryde, N.S.W. 2112 (Telephone 88 0233).

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