FOOD PRESERVATION QUARTERLY

Volume 13, No. 3 SEPTEMBER, 1953

Editorial Executive:
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Published by
THE DIVISION OF FOOD PRESERVATION AND TRANSPORT,
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH
ORGANIZATION, HOMEBUSH, NEW SOUTH WALES, AUSTRALIA

Egg White and Yolk Substitutes

By

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INTRODUCTION

Egg white and yolk are used in many ways in commercial baking, household cooking and confectionery making. The white has the property of forming a stable foam which is used for leavening cakes, and in sugar confectionery, hard and soft meringues, and fillings. The yolk possesses the power of emulsifying fat ; and of shortening—and to some extent of leavening—pastry and cake mixtures. The whole egg is used in custards and other desserts on which the heat coagulated proteins confer a rigid structure. Whole egg is also valuable as a binding agent in cooking.

The search for substitutes has been stimulated by shortages, the high price of eggs, and by the desire to find outlets for surplus by-products.

THE FORMATION OF FOAM

The formation of foam by egg white is due to the action of the protein in lowering the surface tension of the water in which it is placed and in providing a mixture of suitable viscosity. The protein becomes concentrated on the liquid-air interfaces where it is changed to an insoluble film (denatured). The change, which is hastened by beating, is irreversible, hence protein foam possesses a high degree of stability, and unlike soap foam cannot be rebeaten (Lowe, 1950). The stability of protein foam is important in food products : at the same time such foam is acceptable nutritionally.

The tendency of proteins to form insoluble films and hence foam is greatest at their iso-electric points which in the case of egg proteins are below pH 7. Ovalbumen, the main protein in egg white, has an iso-electric point at pH 4·8.

The egg proteins used for producing foams are irreversibly coagulated by heat to give a relatively rigid structure, possessing enough elasticity to allow the foam structure to expand during cooking. These characteristics are not always possessed by the proteins in egg substitutes.

Sugar must be added to some products : its effect on egg white is to retard the surface denaturation and increase the coagulation temperature in direct relation to the amount added, and to increase the stability of the foam.

SUBSTITUTES

The most successful substitutes are those for egg white—where foaming is the main consideration. The foam made with the egg white substitute from milk is rendered less stable when sugar is added.

It has proved difficult to find a substitute closely related chemically to egg yolk which is 30 per cent. lecitho-protein. Nevertheless useful substitutes have been made which share with egg yolk the property of emulsifying fats and oils.

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Various raw materials have been converted to egg white or whole egg substitutes and efforts have been made to reproduce as many of the properties of egg as possible. A description of three of the successful processes is given below. All three originated in Germany at the time when "Ersatz" products were to the fore, but they may still be useful. Synthetic foaming or emulsifying agents have also been proposed.

(a) *Wiking Eiweiss*

Wiking Eiweiss is a soluble albumen made from fish. It was first made in Germany in 1934, and the output at one plant rose to 700 tons per annum in 1943. Details of the production of the fish albumen at Wesermünde are given in the British Intelligence Objectives Sub-Committee Final Reports Nos. 32, 1481; Overall Report No. 14, p. 88; and the Field Information Agency, Technical, Final Report No. 520.

For the production of edible egg substitute good quality fillets of white fish are required. Fresh codfish was used, but through the war air-dried cod was the main source, together with some dried shrimps. The yield of dried Wiking Eiweiss from the several raw materials was:

Fresh fish fillets	14 per cent.
Dried cod	50 per cent.
Dried shrimps	75 per cent.

The fish was skinned, filleted, and uniformly shredded. The dried fish was shredded and then soaked in water for up to 18 hours, which made it equivalent to fresh fish in the subsequent processing. The fish pieces were leached with 0·5 per cent. acetic acid at 80° C. for 30–60 minutes. This removed soluble nitrogenous constituents, broke down the connective tissue and possibly reduced the ash content of the Wiking Eiweiss. Washing in running water was carried out in a drum sieve and the fish was pressed to reduce the water content to 40 per cent.

The oils and fat were extracted from the press cake for 1–5 hours with 95 per cent. alcohol. (If the press cake has been dried for storage, a water-immiscible solvent, such as trichlorethylene, may replace alcohol.) In the circulating extractor used, the condensed solvent flowed over the fish (held on a grid), and returned to the boiler. The final fat content had to be below 0·1 per cent., otherwise the Wiking Eiweiss developed off-flavours and rancidity due to fatty acids liberated in the final alkali treatment. A high fat content might also repress the foaming property. Excess solvent was completely removed in a vacuum drier at 70° C. and recovered for treatment with the rest of the solvent in a fractionation plant.

The dried material was ground to a fine powder. At this stage the fish protein was in an insoluble state, but it was rendered soluble by hydrolyzing with aqueous alkali. Caustic soda (5–6 per cent. of the weight of the fish protein) and water (6 gal. to 10 lb. protein) were milled with the powder for about 2 hours at 80° C. in a roller mixer similar to a chocolate conche machine. The opalescent solution was neutralized with acetic acid and spray dried. An inlet air temperature of 130° C. and outlet air temperature of 60° C. were used.

The fish albumen is a slightly grey, odourless, tasteless and readily digestible powder of high protein content. Analyses have indicated ash contents up to 20 per cent. since sodium acetate is formed in the neutralization. It is claimed that a 7 per cent. solution will whip into a foam equivalent to natural egg white, the latter containing 12·5 per cent.

solids. The Wiking Eiweiss is not coagulated by heat and cannot be "overbeaten", which indicates that the proteins are not easily surface-denatured.

Possible uses are in aerated bakery goods, sugar confectionery, ice cream, mayonnaise, custard powder, pharmaceuticals; and in the textile and leather industries. A low-grade coloured Wiking Eiweiss, made from salt fish and fish scraps, and possessing a strong odour, has been used in foam fire-extinguishers. The property which Wiking Eiweiss possesses of not being coagulated by heat is useful in the preparation of mayonnaise, which may then be pasteurized without affecting the texture.

(*b*) *Plenora*

Plenora is an egg white or whole egg substitute made from blood serum. It was made at Hamburg during the Second World War, the output being about 1000 tons per annum. Animal blood was treated at the abattoirs with sodium citrate or sodium phosphate to give a 1 per cent. concentration. This prevented congealing during transport to the processing plant. The blood was passed through a centrifugal separator to yield two-thirds of clear serum and one-third of red blood corpuscles. The serum was refrigerated for production of the albumen, while the blood corpuscles were used as a flavouring ingredient in soups. The serum, containing about 8 per cent. solids, was spray dried, using inlet air temperatures of 160° C. and outlet air temperatures of 60–65 °C. The faintly coloured fine powder of dried plasma was used as a base for the manufacture of egg substitute by mixing with fillers to give two grades of Plenora:—

Plenora Standard:

- Dried plasma—25 per cent.
- Wheat, maize or potato starch or dried milk—68 per cent.
- Carob-bean meal—7 per cent.

Plenora Concentrated:

- Dried plasma—43 per cent.
- Starch filler—50 per cent.
- Carob-bean meal—7 per cent.

Of the constituents other than the plasma, the starch is rather inactive but possibly possesses some gelling power; and the carob-bean meal probably increases both the whipping and emulsifying powers of the Plenora. The Plenora Standard was used for binding, thickening and emulsifying, in soups, sauces, mince meat, pancakes, and mayonnaise. The Plenora Concentrated was used where better foaming properties were required, as in meringues. Samples of Plenora K (Concentrated) produced foam only after beating four times longer than egg white, and required beating at 60° C. The foam volume was smaller, and the addition of sugar decreased it to 70 per cent.—as happens with egg white. The sugar foam made a satisfactory meringue. Attempts were made to produce Plenora in the Homebush laboratories of C.S.I.R.O. and also in England, but the spray dried plasma powder rapidly developed a strong and offensive odour which made it quite unsuitable for food. The plasma powder made a stable foam but the volume was less than that from egg white.

(c) *Milei*

Egg substitutes made in Germany from skim milk were marketed as Milei. There were three grades:

Milei—W (Weiss)—substitute for egg white.
Milei—G (Gelb)—substitute for egg yolk.
Milei—V (Vollei)—substitute for whole egg.

Production details are to be found in the British Intelligence Objectives Sub-Committee Final Reports Nos. 32, 275, 1513, and Overall Report No. 14, pp. 88–92.

Because of the scattered sources of supply of skim milk the Milei products were made at a number of plants and sent to a central packing station. Several levels of pH were used to effect the alteration of the proteins. There were also variations in the methods of drying the product and in the fillers added.

(i) *Milei W.* Skim milk (or up to 50 per cent. whey with skim milk) with a fat content below 0·01 per cent. and a pH higher than 6·4 (adjusted with sodium carbonate or sodium hydroxide if necessary) was vacuum concentrated to 40 per cent. solids. Calcium hydroxide was added to the condensed milk to bring the pH to within the range 8 to 12, and the mixture was spray dried. The air inlet temperatures used were 130–160° C. and outlet temperatures 60–70° C.

The Milei W, with a moisture content of 3–4 per cent., should be packed in an air-tight container, for it is hygroscopic, and carbon dioxide is thought to be responsible for the loss in whipping power of Milei W stored in contact with air.

The Milei W can be used where marked foaming properties are required, as in leavening baked goods and in meringues.

(ii) *Milei G.* Skim milk with a pH about 7 was concentrated to 40 per cent. solids and, after cooling, run to a mixing pan. A slurry of carob-bean meal in water was added at the rate of 6–10 lb. per 200 gallons original skim milk. A food-grade yellow dye was mixed in, and the pH was brought to 7·5 (6·7–6·8 in some reports) with disodium hydrogen phosphate. The mixture was immediately roller-dried to 3–4 per cent. moisture.

Milei G was said to have the flour-holding and binding properties of egg when used in bakery products and cooking, and also to have good emulsifying properties. The output of Milei W and G taken together was 6000 tons in 1943, and again in 1944.

(iii) *Milei V.* Milei Vollei was prepared in two stages. Firstly the concentrated milk was adjusted to pH 6·0–6·2 with phosphate, yellow colouring was added and the mixture roller dried. In the second part the final pH was 6·6–7·2 and 1·2 per cent. of Kefir Casein was added before roller drying. The two powders were blended in the ratio of 65 of the first to 35 of the second, and 3·5 parts of dried Kefir Casein added. (Kefir Casein is a symbiotic growth product of lactic acid bacteria and yeast, to which is added a mixture of ortho-, pyro-, and metaphosphates—apparently to improve the flour-holding capacity for baking.)

Milei Vollei replaced whole egg in cakes, and in 1943 and 1944 the output was 6000 tons per year.

(d) *Synthetic Substitutes*

A food grade of methyl ethyl cellulose possesses foaming properties which may allow it to replace egg white. It is a white solid which swells and dissolves in cold water but precipitates almost completely on heating to 60° C. The foam is very stable and the foaming properties are not depressed by the presence of small amounts of fats. Methyl ethyl cellulose is more efficient on a weight basis than other albumen substitutes.

Morrison and Campbell reported (1949) that a mixture of methyl ethyl cellulose and sodium carboxymethyl cellulose forms stable, non-foaming, non-creaming oil emulsions in water. This mixture could replace egg yolk as an emulsifying agent.

Production in Australia

There is some prospect that egg substitutes will be produced commercially in Australia from milk proteins. The Dairy Research Section of C.S.I.R.O. has re-investigated the production of egg white and whole egg substitutes from milk by the German processes and has modified the original technique, which did not always yield a satisfactory product. It is possible that the German substitutes were never high enough in quality to compete with eggs in normal supply; in any case it has been difficult to obtain a precise assessment of their quality.

The work of the Dairy Research Section was first directed to making egg white substitutes and the method used did not differ greatly from the German process. Calcium hydroxide was added to the concentrated skim milk over a period of 5 hours, with continual stirring, till the weight added was equal to 4 per cent. of the milk solids. After adding a stabilizer solution prepared from maize starch, gelatine, tragacanth and carob-bean gum, the mixture was spray dried. The product formed a stable foam, and was shown by Kumetat (1951) to be a suitable substitute for egg white for some purposes. It has been found that treatment with lime for 48 hours at a low temperature renders the addition of the stabilizer unnecessary. The product then obtained has a more stable foam and a better sugar uptake.

A stage has been reached where 80 per cent. of the egg in sponge cakes can be replaced by a whole egg substitute. The process is the subject of a patent application by C.S.I.R.O. (1953). The procedure for treatment of the skim milk with sodium hexametaphosphate, sodium pyrophosphate or trisodium citrate and sodium carbonate is being studied with a view to the complete replacement of eggs by substitutes.

The future of egg substitutes in Australia seems to lie with the Milei products from skim milk. The disadvantages of the Milei substitutes are that at present they cannot completely replace whole egg and that the proteins cannot be coagulated by heat.

The Plenora substitute from blood serum ranks next. It is reasonably satisfactory, and it may be possible to eliminate the off-odours by solvent-extracting the phospho-lipoids with which these odours are probably associated. It might also be possible to increase the foam volume, which does not come up to that of egg white, by modification of the proteins. Blood serum is a raw material which is available in large quantities but its initial cost is likely to be high because it would be collected by hand.

Wiking Eiweiss from fish is practically ruled out because of the paucity of fish supplies in Australia. Only the best quality fresh fillets of white fish, equal in quality to those used as fresh fish, can be used if the strong flavour and colour is to be avoided. The cost of such fillets in Australia is 1/6 to 2/– per lb. wholesale, which would make the price of Wiking Eiweiss too high to compete with eggs. It may be worth investigating the value of whale meat as a source of protein although there is some indication that the Germans tried this and found it unsatisfactory. In Norway, soya-bean proteins are used as the raw material for a substitute, presumably after alteration to give them foaming properties.

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LOWE, BELLE (1950).—Experimental cookery from the chemical and physical standpoint. 3rd ed. (John Wiley & Sons: New York.)

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C.S.I.R.O. Publications

(1) The Production and Utilization of Microbiological Protein: A Review of the Literature. By Jessie M. Baldwin. (Melbourne: C.S.I.R.O., 1953. Inf. Serv. Rept. T.11, 100 pp.)

Published work on the production of proteins by micro-organisms, mainly yeasts, is reviewed. Yeasts are intermediate in food value between the higher plant and the animal proteins, and may be used to supplement protein-deficient diets of humans and livestock. They have been manufactured in bulk from various waste materials, namely wood sugars and molasses, etc. (Germany), molasses (United Kingdom), wood sugars and citrus wastes (United States). Other fungi and certain bacteria appear to have possibilities. Mass culture of unicellular algae, especially *Chlorella*, has been investigated also. It is considered that these various processes, if developed, might help to overcome the world shortage of protein foods. There is a classified and annotated bibliography of 541 references, together with an author index and a list of research centres.

(2) Directory of Australian Scientific and Technical Research Centres. By G. J. Wylie and Nona F. Lowe. (Melbourne: C.S.I.R.O., 1953.)

C.S.I.R.O. has issued a handbook of Australian research centres in the pure and applied sciences, including medicine. The 295 entries cover many establishments, including a number of government departments which one does not normally associate with research. Reference is made to the five research associations now operating in Australia: they are financed partly from government and partly from industrial sources.

The value of the Directory has been enhanced greatly by the incorporation of alphabetical indices of the research centres, the localities in which they are situated, and the subjects of research. The comprehensiveness of the subject interest is shown by the fact that there are 24 entries under Food, in addition to bread, dairy products, eggs, fish, flour, fruit, meat, sugar and vegetables. A valuable feature of the Directory is the inclusion of notes on special equipment possessed by the research centres.

Both the above publications may be obtained free from the Secretary (General Administration), C.S.I.R.O., 314 Albert St., East Melbourne, C.2, Victoria, Australia.

Correction

Attention is drawn to the following errors in the FOOD PRESERVATION QUARTERLY, Volume 12, page 8.

In Table I, the delay before blanch for the sample bearing code number P.M.10 should read "20 hr. at 32° F.", not "20 hr. at 70° F." The same correction should be made for sample P.N.5.

Overseas Practices in Packaging Fresh Fruit

By

E. G. Hall*

Introduction

The wooden case is still the principal container for packaged fresh fruit, and for export and domestic use in most countries is likely to remain so for some years ahead. Recently, however, there have been considerable developments in America in the use of corrugated fibre-board containers as direct substitutes for the wooden box for both fresh fruits and vegetables. The fruit industry has sought substitutes because of the scarcity and high cost of case timbers, and partly because of sales pressure from the rapidly expanding fibre-board industry. Appreciable economy in the amount of wood used in the container and in the amount of labour required in the packing house had been made earlier by the development of wire-bound collapsible boxes and crates for a number of products.

Improvements in the manufacture of fibre-board and attention to the design of containers have led to the production of fibre-board boxes possessing the features required in a fruit case, namely, regular shape (to allow stacking), structural strength, and low cost. Containers for fruits and vegetables in common use in the U.S.A. have recently been listed and discussed by Carey (1950), who made a special plea for simplification and standardization of the large number of existing types.

The packaging of fruits and vegetables into small packages for the consumer is spreading in U.S.A. but is by no means universal. The practice has grown up along with the supermarket or self-service store, largely to avoid damage by handling and to provide a cleaner and more attractive product. Experience in America has shown that all produce must be of consistently high quality to ensure the success of consumer packaging.

Packaging of Apples

The United States is by far the biggest producer of apples; the bulk of the production is in the Pacific North West. The principal container is the North Western apple box (Fig. 1) which, with the normal bulge pack, holds 42–45 lb. of fruit. This is the standard box in Western Canada, Argentina, South Africa and New Zealand, and is extensively used in Australia. Its most serious disadvantage is that it requires a pressure pack which very often results in serious bruising and stem punctures. Martin (1949), in discussing the packaging of apples as seen in U.S.A. in 1947, stated that the trade was becoming increasingly dissatisfied with the North Western apple box. He considered that the use of moulded pulp trays in either wooden boxes or cartons appeared more promising than the other substitute packaging methods being developed. To-day less fruit is being put into apple boxes in America.

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* C.S.I.R.O., Division of Food Preservation and Transport, Homebush, N.S.W. During 1952, Mr. Hall observed fruit packaging in the United Kingdom, in several countries in Europe, and in U.S.A.

so that excessive bulges are now rare and case bruising has been greatly reduced. Even so, proper packing to reach full net weights without undue bruising requires both care and skill. In eastern U.S.A. and Canada, where softer varieties such as McIntosh are grown, the common containers are slightly larger wooden boxes, with or without lid, which are packed without a bulge to avoid pressure damage. Similarly in England and Europe the bulge pack is not used, open-top and lidded boxes being flat packed so that there is no pressure on the fruit (Fig. 2). Bruising is rightly looked upon as a serious defect.

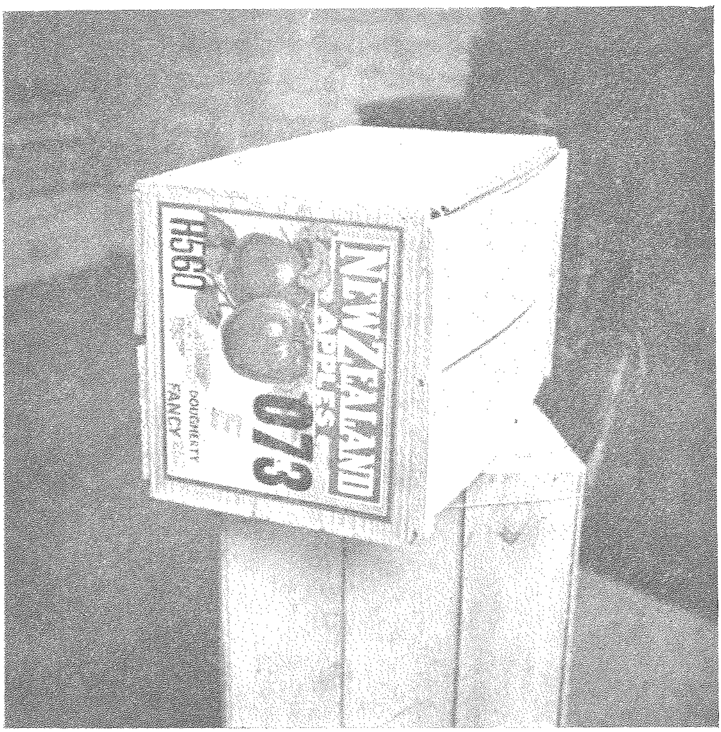

Fig. 1.—*The standard apple box.*

Various "filler packs" have been designed to minimize bruising. They have gained a degree of popularity in America, mainly in the east, and have been introduced to a limited extent into England. They include moulded-pulp trays and cell-type light fibre-board fillers, such as are used for eggs; both are giving satisfactory results in cartons and in wooden boxes. However, even though the absence of wrapping reduces labour costs for these packs, they remain relatively expensive and have been adopted in America only for special lines of high quality fruit.

In the Yakima Valley, Washington State, which is the biggest apple growing centre in the world, one large packing house specializes in the handling of Golden Delicious. The incoming fruit is washed in a fungicidal solution, rinsed, and thoroughly dried under a strong current of cold air. All fruit of sufficiently high quality is packed in cartons. Larger extra-fancy fruit goes into a volume-bushel cell pack and the remainder into a less expensive moulded tray pack (Fig. 3). All the

Fig. 2.—Italian pear boxes. Note absence of bulge.

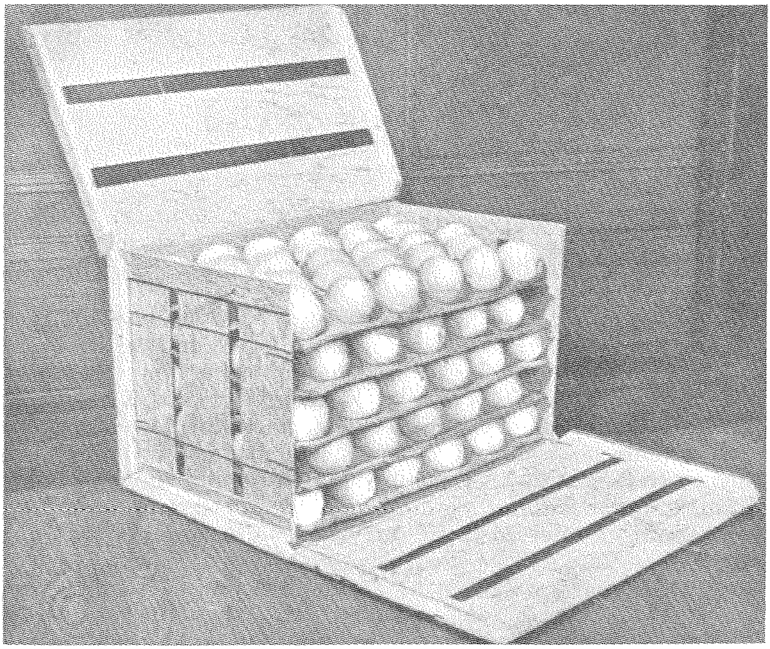

Fig. 3.—Moulded tray pack. The trays vary to accommodate fruit of different sizes. They may be placed in fibreboard or wooden containers.

(Photograph by Martin.)

apples are wrapped in printed wraps, mainly for the sake of sales appeal. The cartons are made of corrugated fibre-board; the cell pack is stitch-sealed, while the tray pack carton is glue-sealed. In the cell type packing cells of different sizes are provided and, to ensure that the contents are a full bushel, boxes of slightly different sizes are needed. The moulded trays are varied in design to accommodate the main sizes of fruit but all are of the same dimensions and fit into a standard container measuring $11\frac{1}{2}$ in. $\times$ 12 in. $\times$ 20 in. internally. This is commonly a wire-bound box, but cartons are being used to an increasing extent.

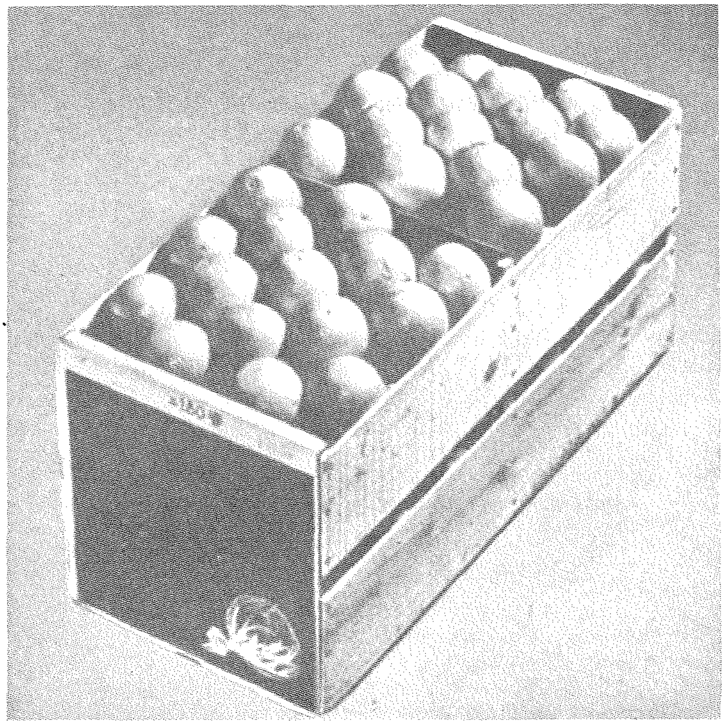

Fig. 4.—The standard Californian 2-compartment citrus box.

Consumer unit pre-packaging of apples, though firmly established in America, does not account for more than a small proportion of sales. Most of the consumer packaging is done in the packing houses but a significant proportion is carried out at terminal-market warehouses. The most popular packages are 5 lb. mesh bags which are bulk-packed into fibre-board boxes, or even secondhand wire-bound citrus boxes, holding 45–50 lb. of fruit. Also coming into use are bags of transparent film, partly perforated for ventilation. For cheaper packs, open-top paper bags with reinforced-paper carrying handles are used.

Packaging of Citrus Fruits

In California the two-compartment wooden box (Fig. 4) holding approximately $1\frac{1}{2}$ bushels is still the standard container for oranges and grapefruit, but in the last two years the fibre-board carton has become the most common package for lemons. In Florida and Texas the usual container is a one-compartment wooden box measuring 12 in. × 12 in. × 24 in.

In Florida the box, known as a Bruce Box (Fig. 5), is made of wire-bound light boards, and when filled and closed with wire clips, bulges on all sides. The bulging does not affect the fruit as seriously as might be thought, for all fruit is slightly wilted or "sweated" before packing. The Californian $1\frac{1}{2}$ bushel wooden box is the standard container for oranges exported from most countries except Australia.

A big impetus to the use of fibre-board cartons in America has been given by two recent developments. The first is the impregnation of the inner faces of the carton with the chemical diphenyl which acts as

Fig. 5.—The wire-bound Bruce box for citrus. Note bulges.

a fungistat, and the second is "volume fill" packing. Cartons treated with diphenyl are being used very extensively for Californian lemons and to some extent for Florida oranges. In the 1951–52 season about half the Californian crop of approximately 12 million boxes of lemons was shipped in such cartons and during the 1952–53 season over 80 per cent. was packed in them. This has been largely due to the successful use of the new economical "volume fill" pack with lemons. The fruit is run loose into the carton, without wrapping or place packing, and vibrated down to give a satisfactory fill. Net weights are practically equivalent to those in the standard wooden box.

The carton used is "half box size", holding about 35 lb. of fruit, the internal dimensions being $10\frac{1}{4}$ in. × 11 in. × $16\frac{1}{2}$ in. This is about the maximum size which can be made economically from corrugated board and yet have enough structural strength for a fruit box. A strong case can be built of duplex or " Duo-arch " board which is made with an inner double-ply corrugation and somewhat heavier outer layers. This board is now being made with glues which make it strong and more resistant to water. As yet these cartons, when packed, do not stand up to compression well enough to allow them to be stacked to normal heights. Despite this they came through shipping tests from both Florida and California to New York fairly well, provided the number of cartons in a vertical row did not exceed seven or eight. In warehouses in eastern U.S.A. they can be stacked only five high during humid weather, compared with fourteen high for the standard wooden box. So far it has not been suggested that the carton is strong enough to replace the wooden box for export shipment.

The development of " volume fill " packing in the fibre-board carton has greatly reduced the cost of packing lemons (Smith 1952). Although the carton costs almost as much as the wooden box, total packing costs have been reduced to 60 per cent. of those for the standard wooden box. The method makes packing very much faster, and the elimination of wraps and place-packing has greatly reduced the need for skilled labour. " Volume fill " works excellently with lemons, but is less satisfactory with oranges, which do not pack down so well. Its application to oranges is being thoroughly investigated and it is probable that a satisfactory method will be worked out.

Use of Diphenyl

The use of a volatile fungicide such as diphenyl is an integral part of the carton " volume fill " method. Since the fruit is not wrapped and the sealed carton is a closed container, wastage is likely to be more extensive than in the standard box pack.

The concentration of diphenyl is 7½ g. per carton, which is rather more than the 40 mg. per 100 sq. in. of paper allowed in diphenyl-treated wraps on fruit imported into the United Kingdom. It is dissolved in an oil-wax mixture and applied to the board before manufacture of the cartons. Diphenyl has been shown by Hopkins & Loucks (1947) and others, including Australian workers, to control decay. Diphenyl has also been used effectively in wooden boxes by impregnating a Kraft paper liner with the chemical at the rate of 17 g. per box (equivalent to two cartons).

As diphenyl is volatile at ordinary temperatures it is lost fairly quickly from the cartons and liners. Workers at the Citrus Experiment Station at Lake Alfred in Florida have shown that at 70° F. bundles of unassembled cartons lose about 20 per cent. in two months, while individual boxes full of fruit lose about 60 per cent. of their original content in four weeks. Thus treated cartons must be used soon after manufacture. Although as effective in preventing wastage as diphenyl wraps, the treated case-liners have been somewhat less effective than the treated cartons, because the diphenyl is lost more quickly.

There is some tainting of the fruit when diphenyl is used but the absorbed diphenyl is mainly confined to the rind and it is claimed that the taint disappears a day or two after the fruit is removed from the treated material. It was found in America that, although there were initial complaints from the market because of the smell of the diphenyl, receivers soon accepted it on account of the improved out-turn of treated fruit. So far consumers seem to be largely unaware of any taint. Despite the American experience, it is not certain that the taint problem would be unimportant in Australia. According to recent advice from America the Federal Food and Drug Administration regards diphenyl as a toxic chemical but has not prohibited its use on citrus fruits.

Packing in sealed cartons gives substantial control of shrinkage of the fruit: at the end of equivalent storage periods the weight loss from oranges in cartons has been found to be 40 per cent. less than that from fruit in wooden boxes.

The temperature inside the carton is important. If it is more than about 70° F. decay control falls off quickly and there is a serious risk of the fruit developing off-flavours. This brings about serious difficulties with oranges and grapefruit, as effective cooling—either before or after packing in the carton—is not easy to fit into packing house operations. Cooling of the fruit in iced water (hydro-cooling) before packing has been tried, but even with this rapid method a cooling time of at least 30 minutes is required. Some operators are cooling oranges in a cold store after processing, either before or after packing, and find that, although time-consuming, it is still economically sound. The same temperature difficulties do not arise with Californian lemons which are packed straight from the storage houses which are run at a temperature of about 53° F. It can be expected that a practical solution will be found to the problem of cooling oranges and grapefruit.

Consumer packages for citrus fruits are mainly mesh bags or open-top paper bags holding seven or eight pounds, but quarter-box and even half-box sacks of either mesh or solid paper are also used, particularly in Florida and Texas. To minimize shrinkage and maintain appearance of fruit in these consumer packs it is very desirable that it all be waxed before packing.

Packaging of Other Fruits

Fibre-board "lugs" of approximately half-bushel capacity are being developed in the United States for the larger stone fruits and grapes. One excellent but relatively expensive type for grapes is made with ends of six thicknesses of fibre-board. Along the top of the centre four is a wooden cleat on which a light wooden lid may be nailed. This package is very strong, stacks well and affords very good protection to the contents. An interesting fibre-board container for peaches was made on the hamper principle, the lid fitting down over the whole body of the box, both being perforated for ventilation. A moulded paper-pulp tray is coming into use for cherries. It is laid on the bottom of the standard wooden box and the first row of cherries placed in the moulds to give a perfect face-pack when the box is opened.

In Europe stone fruits are packed for export in light wooden "corner post" trays or shallow boxes (Fig. 6). These are not lidded and stack on the corner posts which project about an inch above the side of the box. Packing is elaborate, fancy paper liners, individual fruit wraps and shredded coloured paper being used. South Africa packs the considerable quantity of peaches and plums exported to England in light quarter-bushel trays with wooden lids. This also is an expensive pack, but was found necessary for export.

The bulk of the tomatoes sold fresh in America are retailed in 1–2 lb. consumer-size cartons (Fig. 7) which have no lid, or a cut-away lid, and are over-wrapped with transparent film. The tomatoes are picked green, place-packed into 30 lb. wooden lugs or, more recently, jumble-packed into somewhat larger containers and ripened and repacked by the wholesalers. They are carefully graded for both colour and size, and the consumer " trays " usually contain three to five fruits of the one size and colour. These " trays " are packed into fibre-board carrier containers for distribution.

Fig. 6.—Italian peaches in light " corner post " trays.

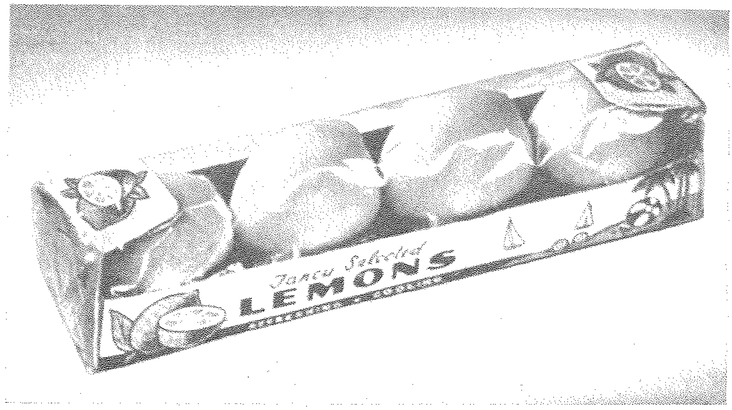

Fig. 7.—Consumer package. Printed 1-2 lb. chipboard tray over-wrapped with transparent film.

(Photograph from " Modern Packaging".)

Large quantities of tomatoes are imported into England for most of the year, mainly from the Channel Islands and Canary Islands, where they are grown in the open, and also from Holland, where they are grown under glass. Appreciable quantities are also grown in English glass-houses. It was interesting to observe that in all cases the tomatoes were picked with the stalk attached : it is well known that leaving the stalk on the fruit retards ripening.

The containers used in the Islands are either half-bushel solid wooden baskets (Fig. 8) or light tubs, both lidded, into which the predominantly small spherical tomatoes are loose filled. The Dutch tomatoes are loose-packed into " corner-post " deep trays, and a heavy paper cover is tacked over the fruit. Three trays are wired together, the top one being covered with a light wooden lid (Fig. 8).

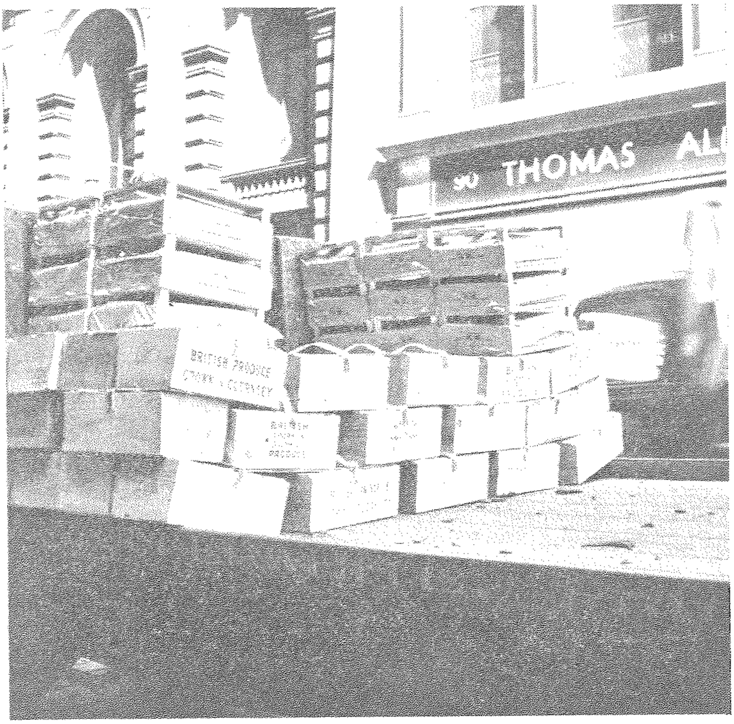

Fig. 8.—Tomato containers.
On top : *Deep " corner post " trays, wired together in threes.*
At bottom : *Half-bushel wooden baskets.*

Developments in Australia

A considerable amount of experimental work is being carried out on fibre-board boxes but as yet they are too expensive to substitute for wooden cases on a large scale. Nevertheless half-bushel cartons have been successfully used for commercial shipment of tomatoes from Queensland to southern States. In addition lightweight corrugated fibre-board cartons have been developed for the air transport of fresh fruits. Tests are being conducted on diphenyl-treated cartons for citrus fruits but again their commercial adoption will depend mainly on their cost. There is some interest in consumer packaging, particularly of citrus, but present retailing methods do not encourage adoption of this practice. The best prospects appear to be with tomatoes packaged along American lines, and with graded and washed potatoes put up in four or seven pound paper bags. Filler type packs, such as the moulded tray pack, while greatly reducing bruising, would appear to offer little advantage for the export of apples or pears. They would be more expensive and, as admitted even in U.S.A., bruising in the standard wooden box can be greatly reduced by proper packing and handling.

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Sulphur Dioxide in Dried Fruit

The regulations of the Health Departments of the Australian States have until recently laid down that in New South Wales, Victoria, Queensland and South Australia dried fruit should contain not more than 14 grains of sulphur dioxide per pound (2,000 parts per million). In Western Australia and Tasmania the figure was 7 grains per pound (1,000 parts per million).

It is now permissible for dried fruit to contain 21 grains of sulphur dioxide per pound (3,000 parts per million), amendment to the regulations having been gazetted as follows :

Western Australia	14 December, 1951.
Victoria	19 December, 1951.
New South Wales	15 February, 1952.
Tasmania	28 May, 1952.
South Australia	10 July, 1952.

Queensland has not gazetted an amendment pending a revision of Food Regulations, but has indicated that no objection will be raised to the new maximum.

The higher maximum was proposed by the Dried Fruits Processing Committee, a technical committee which operates under the aegis of C.S.I.R.O. and which is comprised of representatives from a number of Commonwealth and State departments.

The proposal was based on the results of storage trials on dried tree fruits. These demonstrated that a storage life of twelve months was possible only if the dried fruit contained 21 grains of sulphur dioxide per pound. With levels of 7 and 14 grains to the pound, appearance and flavour deteriorated rapidly, especially at high temperatures, even when the fruit was packed in sealed metal containers.

Answers to Inquiries

Glazing and Defrosting of Hams

Question : How can uncured hams be glazed, and the glazed hams defrosted for curing ?

Answer : The hams should be frozen to —20° F. then each dipped in two tanks of water held in a cool room at 32–34° F. They are then sprayed with cold water, and stored in bins. Once a month they are sprayed again to restore the glaze.

The glazed hams may be defrosted in 12 hours by immersion in a 10 per cent. pickle. This is kept at 45° F. by pumping continuously from a thermostatically controlled heating tank to the defrosting tanks. The pickle, which is circulated by a high-volume low-pressure pump, enters the defrosting tanks (usually two) by a 2-in. perforated pipe running along the bottom of each tank, and returns to the heating tank by an overflow pipe. All the tanks are made of suitable non-corrosive material. The operation may be carried out in one tank by fitting it with equipment for heating and also cooling the pickle. In this case the liquid is first held at 85° F. for two hours, by which time the outer glaze should be melted. The defrosting is then completed at 34° F.

Cool Storage of Passion Fruit

Question : What are the best conditions for the cool storage of passion fruit ?

Answer : The fruit should be held at 40–50° F., at which temperature it has a storage life of four to five weeks. After removal to ordinary temperatures it should retain its flavour for about one week, though it will lose little of its fresh appearance for several more weeks.

Storage temperatures below 40° F. cause a blood-red discoloration and breakdown of the rind, and this is often followed by mould infection.

The best results are obtained if the fruit is picked half-colour and handled carefully to avoid damage to the skin.

Food Science Abstracts

Investigation into the Control of Bitter Pit in Notaris Apples. (In Dutch with English summary.) J. H. M. van Stuivenberg and A. Pouwer. *Meded. Dir. Tuinb., 's Grav.*, 1950, **13** : 201–211.

Experiments were carried out in 1948 and 1949 to investigate the effect of spraying with borax or with β-indole acetic acid on the incidence of Bitter Pit in apples. With boron sprays the effect depended mainly on the time of application ; for the Notaris variety of apple the best results were obtained by spraying about the middle of July. The sprays should probably be applied when the fruit is at a specific physiological stage of development ; the authors believe that this is the time at which the content of plant growth hormones in the pips is minimal. The development of Bitter Pit was also controlled by spraying in July with β-indole acetic acid. It appears probable that the occurrence of Bitter Pit in apples is correlated with a disturbance of growth hormones.

News from the Division of Food Preservation

The Work of the Physics Section

The Physics Section, which is located at the Divisional Headquarters at Homebush, has a staff of four Research Officers, two Technical Officers and two Technical Assistants. In addition the Section supervises the activities of the Divisional workshops, which have a staff of five.

Much of the time of the laboratory staff of the Section is devoted to advising and assisting other Sections of the Division with problems of a physical nature. This work covers a wide field: it includes the control and maintenance of the refrigeration system and constant temperature rooms, the measurement and control of temperature in food processing and other experiments, heat transfer calculations, the measurement and control of humidity, the measurement of various physical properties of foodstuffs, and the design and construction of special apparatus. The workshop staff is divided between maintenance, instrument and glass-blowing shops. The first is concerned mainly with the operation of the refrigeration system at the laboratory and with the repair of heavy equipment. The second and third undertake the repair and adjustment of laboratory equipment but their main task is the construction of special apparatus required for investigations. It is often found that instruments and apparatus obtainable from the usual suppliers are unsuitable for specific tasks, so that special equipment must be designed and built.

Apart from the service jobs and investigations being carried out in collaboration with other Sections, there are always several long-term researches being carried out by the Physics staff. These are generally related to the work of other Sections and often arise from it. Most of the long-term investigations going on at present are in the field of heat transfer. These include investigations into the performance of railway refrigerator cars, the performance of cool stores and the theory of the evaluation of canning processes. These studies require measurements of temperature at many inaccessible points; for this work use is made of thermocouples with portable potentiometers, and of special devices which have been developed to facilitate the measurements.

Problems in the exchange of water vapour between foodstuffs and the surrounding atmosphere are continually arising. A good deal has been done on the prediction and control of evaporation from foods in cold storage, but much more remains to be done before the more important processes going on can be thoroughly understood and precisely calculated. The relation between the water-content of dried foods and their equilibrium humidities is also being studied because of its importance in packaging problems and in the behaviour of the foods in storage.

Changes or differences in colour are of great importance in studies of the processing and storage of foods and in the food industries. Some of these changes are being studied with the object of elucidating their exact physical nature and, perhaps, devising simple instruments for measuring them.

Personal

Mr. A. R. Riddle, a member of the Division's research staff, reached retiring age on 23rd July, 1953.

Mr. Riddle held degrees from the University of Adelaide, South Australia, and Cornell, U.S.A., where he carried out post-graduate work in physics. He was appointed to the Section of Food Preservation at Cannon Hill, Queensland, in August 1934 to carry out research into the effect of various radiations on the viability of micro-organisms. Over the years Mr. Riddle played a prominent part in meat research in Queensland, and when a central laboratory for food preservation research was set up at Homebush, New South Wales, in 1938, he remained at Cannon Hill as Officer-in-Charge.

The Division of Food Preservation extends to him its very best wishes on the occasion of his retirement.

Publications by Staff

(1) Quantitative Chromatographic Analysis of Organic Acids in Plant Tissue Extracts. By F. Bryant (Prestige Ltd., Melbourne) and B. T. Overell (1953).—*Biochim. Biophys. Acta* **10**: 471–6.

Using extracts of plant tissues freed from inorganic salts, sugars and other interfering substances by passage through columns of anion exchange resin, a method has been developed for estimation of organic acids by paper partition chromatography. The technique relates concentration of acids to the weight of paper occupied by the spots. The concentrations of citric, malic, succinic and fumaric acids in apple and carrot tissues have been determined.

(2) Effects of Skin Coatings on the Behaviour of Apples in Storage. II. Common Storage Investigations. By E. G. Hall, S. M. Sykes and S. A. Trout (1953).—*Aust. J. Agric. Res.* **4**: 264–82.

In the first paper of this series, abstracted in the last issue of the Food Preservation Quarterly, the effect of skin coatings on the physiology and ripening of apples, was considered. This paper deals with their effects on wastage and storage life under non-refrigerated storage. It is a summary of a large number of results from experiments carried out from 1940 to 1945 in the laboratory at Homebush and in orchard sheds in New South Wales, Tasmania, South Australia and Western Australia, mainly with the variety Granny Smith. Under favourable conditions the storage life was increased by about 50 per cent. The greatest increase was with early varieties. Undesirable side effects are described and their relation to storage conditions discussed.

The most important factors influencing the storage behaviour of coated apples were temperature and maturity. Temperatures above 70° F., even for comparatively short periods, led to fermentation and alcoholic breakdown. Fruit picked at the optimum stage for cool storage held best after coating; picked either before or after this stage, it developed disorders in storage.

The best coating tested was an 8–10 per cent. alcoholic solution, known as C.O.S., consisting of two parts of castor oil and one part of wax-free shellac. It was satisfactory with most varieties in cool conditions, but sometimes caused slight spotting at the lenticels. Emulsions of medicinal-grade paraffin oil, alone or mixed with castor oil, were satisfactory on most varieties, for example Granny Smith, which develop a copious natural waxy coating. Waxes were also applied as emulsions; the best was a mixture of two or three parts of paraffin wax with one part of carnauba or lac wax. Emulsion coatings were generally improved by adding 25 per cent. of wax-free shellac in three per cent. ammonia.

C.O.S. was more effective than oil coatings and both were more effective than waxes in retarding ripening and in controlling disorders of senescence. Waxes reduced shrivelling much more than the other coatings. All coatings controlled Jonathan Spot and greatly reduced Bitter Pit. Only the alcoholic solutions reduced mould, which was often increased by emulsions.

(3) The Temperature Relations of *Clostridium botulinum*, Types A and B.. By D. F. Ohye and W. J. Scott (1953).—*Aust. J. Biol. Sci.* **6** : 178–89.

Ten strains of *Clostridium botulinum*, type A, and 10 of type B have been studied at 12 temperatures between 10 and 50° C., and rates of growth measured nephelometrically on sealed cultures. Growth proceeded from spore inocula at temperatures from 15 through to 42·5° C., but not at 12·5 or 45° C. When young, actively growing cultures were transferred to temperatures outside the range permitting spore germination, rates of growth were measured at 12·5, 45 and 47·5° C. After transfer to 10 or 50° C. no sustained growth was observed.

The temperature coefficient of the mean rates of growth was very large at temperatures less than 15° C., gradually decreased to zero at about 40° C., and became negative at higher temperatures. With spore inocula the deduced lag periods were least at 37° C., slightly greater at 42·5° C., and very much greater at temperatures less than 20° C. The total yield of cells was greatest at about 37° C. and fell considerably as the upper and lower temperature limits were approached. The 20 cultures studied formed a reasonably homogeneous group in their reactions to temperature.

Electronic Colour Sorting

Chlorophyll has a vital role in the development of new machines for electronic colour sorting of fruits and vegetables.

Experimenters at the University of California's Davis campus already have built and tested one machine which colour sorts lemons electronically by measuring the amount of light reflected by the fruit at various stages of colour ripeness. The degree of reflectivity is determined by the chlorophyll in the rind.

The sorter was developed by John B. Powers, agricultural engineer, assisted by Frederic C. Jacob and Jack T. Gunn, specialists in the College of Agriculture's Department of Agricultural Engineering at Davis. Early studies pointing up the need for such a machine were done by Harry B. Walker, former head of the Department.

Lemons are harvested year around, sorted according to colour, and stored until they ripen evenly for marketing. This procedure permits the heavy spring yield of green fruit to be preserved for the summer market. Usually the fruit is sorted into four grades of colour, fully ripe, silver, light green, and dark green.

The electronic lemon sorter was tested last summer and proved that it was as accurate as hand labourers who now do the work. The feeder unit in the machine, however, was not fast enough to make the sorter practical for commercial use. Its maximum speed was five a second.

But now the agricultural engineers working on this project are planning a new machine that will speed up the sorting. It is expected that the new electronic lemon sorter will grade the fruit at a speed of 15 to 20 a second.

—*From " The California Citrograph ", January,* 1953.