FOOD PRESERVATION QUARTERLY

Vol. 15 No. 1 CSIRO March 1955

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

C.S.I.R.O.

Food Preservation Quarterly

- VOLUME 15
- NUMBER 1
- MARCH 1955

Published by the Division of Food Preservation and Transport
Commonwealth Scientific and Industrial Research Organization
Sydney, Australia

Agriculture is the basis of the economy of the Netherlands. Its efficiency is largely responsible for the high standard of living. Half the agricultural land is pasture, most of the other half is cultivated. Total cultivated area is about 6,000,000 acres (0·6 acre per head of population).

Food Research at

THE AGRICULTURAL UNIVERSITY OF WAGENINGEN (Anon. 1954; Thevenot 1953), which is now the national centre for agricultural science, has played an important role in bringing agriculture to its present state of efficiency. Its teaching curricula and research programmes embrace every branch of agriculture, horticulture, and forestry, and are adapted to the needs of both temperate and tropical climates. No less than 28 laboratories are dispersed throughout the town. Originally the primary function of the University was teaching, but gradually investigations into agricultural problems, often of a fundamental character, claimed more and more attention. In some departments research has become the main activity, much of the work being carried out by graduate students as part of their studies for the higher degrees which, at Wageningen, are the goal of all students.

Many autonomous institutes and experimental stations have been established at Wageningen to study the more practical problems in agriculture and horticulture. They collaborate actively with the University, many professors being on their boards of management.

The organization of scientific research in Holland differs somewhat from that in Australia. The National Council for Applied Scientific Research (T.N.O.) coordinates almost all applied research, whilst pure research is the responsibility of the National Council for Fundamental Research (Z.W.O.). At Wageningen the Minister for Agriculture also has considerable authority over the organization of research projects.

FOOD RESEARCH AND TECHNOLOGY IN THE UNIVERSITY

The following laboratories at the University carry out work on food science and technology:

- *The Laboratory of Technology.*—This is concerned with industrial chemistry or chemical engineering, and problems related to the processing of agricultural, horticultural, and forest products. Special attention is given to the problem of heat transfer in evaporators.
- *The Laboratory of Physics.*—Here are studied physical unit operations, solvent extraction, distillation, and heat transfer. Research is now in progress on the preparation of several products such as starch and glucose from Jerusalem artichoke (*Helianthus tuberosus*), which may be cultivated on very poor soil.
- *The Laboratory of Plant Physiological Research.*—Research projects include investigations on metabolism in compact organs (e.g. potatoes and bulbs) in connexion with storage and developmental problems and on the photosynthetic processes of microorganisms and higher plants.

FOOD RESEARCH INSTITUTES

- *The Institute for Research on Storage and Processing of Horticultural Produce.*—This institute, the work of which closely resembles that carried out by the Division of Food Preservation and Transport of C.S.I.R.O., is discussed more fully later in the article.
- *The Central Institute of Agricultural Research.*—This studies the utilization of

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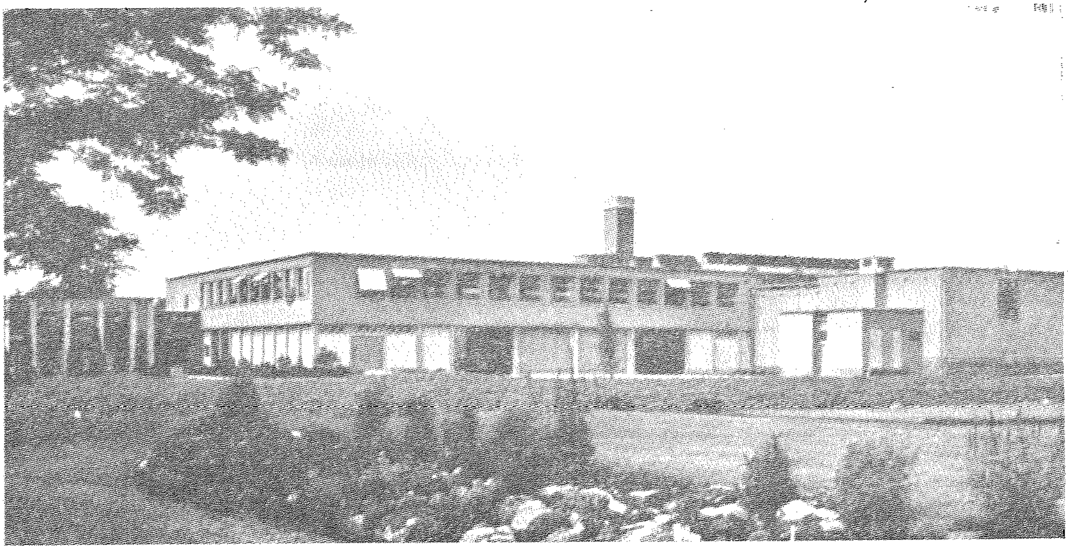
grassland and arable land, and the crops from the latter. It engages in research on cereals, legumes, potatoes, maize, storage problems, and the cooking quality of potatoes and legumes. It also carries out chemical analyses of crop plants.

A section of this Institute, known as the Drying Research Laboratory, studies the changes brought about by drying in green crops, cereals, and seeds. It investigates the performance of driers and moisture testers in order to improve their design and carries out research on storage problems.

- *The Central Institute of Nutrition Research* (*T.N.O.*).—This is situated at Utrecht, but a Cereals Section has been established at Wageningen. It studies cereal chemistry, milling and baking problems, and problems of the confectionery industry.

Many investigations concern the manufacture and quality of baked products, such as wheaten and rye bread, rusks, biscuits, cakes, and confectionery. Fundamental studies are being carried out on the causes of staling in bread and on the factors involved in flavour.

- *The Institute for Potato Storage.*—This institute investigates the storage and the shipping quality of potatoes, and is interested in the factors which affect the keeping quality of tubers.



The Institute for Research on Storage and Processing of Horticultural Produce (I.B.V.T.) at Wageningen, Holland.

FRUIT AND VEGETABLE PROCESSING IN HOLLAND

The processing of fruit and vegetables is of great importance to Dutch horticulture, as is evident from the fact that in the years 1946-51 about 13 per cent. of the total fruit and vegetable crop was bought by the processing industry. Though this overall percentage is not very high, the proportion for some crops, e.g. peas, gherkins, black currants, and raspberries, was in 1951 over 80 per cent.

In 1951 there were over 300 processing enterprises, of which more than one-third each processed at least 250-300 tons of vegetables and/or 70-80 tons of fruit.

The total quantity of vegetables processed in 1952 (about 105,000 tons) was treated as follows:

Canned and bottled	40%
Converted to sauerkraut	30%
Salted	15%
Dehydrated	10%
Frozen	5%
Total	100%

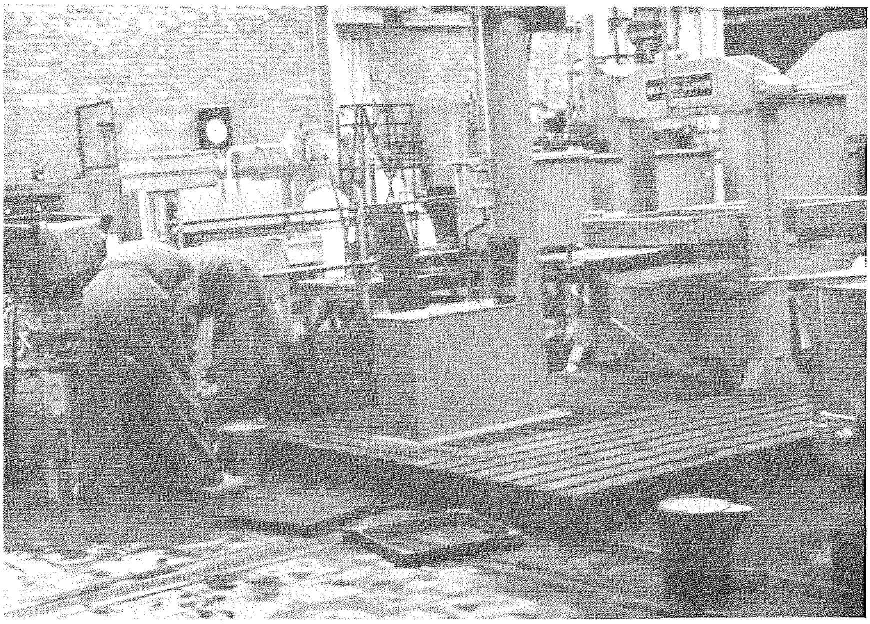
The quantity of fruit processed in the same year was 71,000 tons representing 12 per cent. of the quantity grown. Preservation took the forms set out below:

Pulp and jam	40%
Fruit juices, wines, etc.	18%
Apple syrup	13%
Apple sauce	10%
Preserved in syrup	11%
Frozen	2%
Dehydrated	1%
Others	5%
Total	100%

THE I.B.V.T.

The Institute for Research on Storage and Processing of Horticultural Produce (I.B.V.T.) (Zweede 1951, 1953) is one of four supervised by the Bureau of the Director of Horticulture within the Ministry of Agriculture. The other three horticultural institutes deal respectively with plant breeding, horticultural engineering, and phytopathological research (Thevenot 1953).

The I.B.V.T. originated in the Laboratory of Horticulture of the University. As early as 1923, when that laboratory was planned by its director, Professor Sprenger, facilities



The Processing Hall in the I.B.V.T., showing the apple juice press unit.

for the study of cold storage of fruit and vegetables were provided.

Later, about 1930, studies on fruit processing were commenced in an endeavour to find an outlet for substandard fruit, particular attention being paid to the production of fruit juices and cider. The Netherlands now has an industry with a capacity of about 2·2 million gallons of pure fruit juice and 1·1 million gallons of fruit wine.

By 1936 it was found that the research and development work was increasing so much that an autonomous foundation, the I.B.V.T., was set up, separate from the Horticultural Laboratory of the University. The Board of the Foundation consists of representatives of growers, the processing industry, consumers, the horticultural extension service, and other scientific institutes.

The work of the Institute is divided between original research and advisory and information services. To make some products better known to the general public, the Institute processes some itself and markets them under its own name.

A new laboratory for the Institute was built by the Netherlands Government in 1949-51. About 80 per cent. of the running expenses are met from the public treasury, the remainder coming from donations and payments for advisory services.

The work of the Institute is divided between three groups specializing respectively in storage, processing, and special research.

The Storage Group is concerned with preservation for a limited period. Its six sections deal with gas storage of fruits; marketing, grading, packing, and storage problems; air conditioning in storage rooms; improvement of flavour of fruits from cold stores; physiology of fruit in storage; and storage diseases (Jonathan spot, scald, etc.).

The Processing Group is concerned with preservation for long periods. It has six sections, which deal with heat sterilization and deep freezing; dehydration; jams and pulp; candying and ice cream; fruit juices, fruit wines, and pickles; and pectin and other by-products.

The Special Research Group includes the sections of analytical chemistry, biochemistry, and microbiology. Associated with it are the inspection laboratory, the documentation service and the library, the experimental kitchen, and groups specializing on statistical calculations, plant construction, and experimental plant.

Work of the Storage Group

This group is investigating means of improving the packing and transport of small fruits, vegetables, and pears. In particular, it is now studying the packing of prepared vegetables in consumer-type packages ready for immediate use.

Investigations are being made on the transport of lettuces, sprinkled with ice, in insulated rail cars.

A method of determining the optimal harvest time for apples and pears intended for storage has been devised by Doesburg (1953). It involves determining the pH level of the cell walls by using a number of indicators, the dyes being added 24 hours after the fruit is cut into halves. The method was successfully tested on a commercial scale in 1953, and is likely to be practised to a certain extent by the fruit-growers themselves.

Work is in progress on the grading, packing, and storage of asparagus, which has become an important crop in Holland. Grading and packing stations have been established in growing areas.

Investigations are being made on the ripening mechanism of fruit intended for storage, especially the changes during after-ripening of pears. Particular attention is being paid to the behaviour and transformation of pectin in soluble form (Doesburg 1951*a*; Boeke 1951).

Research is being carried out on the gas storage of fruit and cut flowers (Heile 1951). For certain flowers such as roses, carnations, chrysanthemums, narcissi, freesias, sweet peas, and larkspurs, it was found that storage in an atmosphere containing a high proportion of carbon dioxide improved their keeping quality and prolonged their life in the vase (Stuivenberg 1949, 1951). The technique has enabled the Netherlands to build up an export trade in "canned" flowers.

The relation between the keeping quality of fruit in storage and the time between first blossoming and picking is also being investigated (Boeke 1951).

Work on the quality of grapes includes studies on its relation to different soils, methods of cultivation, and sulphur dioxide treatment. The relation between the sugar content of grapes and the optimum storage temperature is also being investigated.

Work of the Processing Group

This group undertakes some work of a routine nature, such as:

The determination of the most suitable varieties of fruit and vegetables for canning, dehydrating, and deep freezing.

The introduction of new fruit drinks and fruit ice cream.

The quality inspection of jams and processed vegetables.

The group is also interested in a number of projects of a more specialized nature:

A new and rapid method of candying has been developed in which the fruits, etc. are placed in syrup and a vacuum applied (Thung 1951). Cherries, pears, apricots, peaches, melons, and orange and lemon peel have been treated in this way. More recently angelica stalks were candied (Thung 1953), and during a shortage of lemon peel, cucumbers and gherkins were used successfully as substitutes.

A type of chromatographic method has been used on jams and fruit juices to detect the presence in them of fruits other than those specified.

The disintegration of pulped strawberries was found to be caused by pectin-splitting fungi capable of growing in concentrations of sulphur dioxide up to 2500 mg per kg (Zweede 1954).

Problems which have assumed some importance are those arising in the production of fruit wines, which have been produced from apples, pears, cherries, sour cherries, raspberries, elderberries, and black, red, and white currants. Attention has been focused on such aspects as the de-acidifying of wines with ion-exchangers and the preparation of aromatic herb wines and of an aromatic apple beverage with the aid of the wine bouquet yeast *Candida humicola* (*Sachsia suaveolens*).

The problems faced by manufacturers of sauerkraut, particularly those bearing on the quality of their product, have been studied.

Cauliflowers being transported by water to an auction in north Holland. The numerous waterways provide cheap transport.

A method for preparing a non-curdling mixture of milk and fruit juices has been developed, and a patent taken out.

A small pressure-cooker has been developed suitable for domestic preservation of fruit in jars.

Special apparatus used by the group includes two commercial instruments for sterilization of fluids by ultraviolet radiation, a pilot-scale Luwa evaporator, and an apparatus built by the Laboratory of Physics for the recovery of volatile flavours.

Work of the Special Research Group

Two pieces of apparatus developed by this group are a gel strength tester (Doesburg 1950) and a hand-operated hardness tester (Doesburg 1951*b*).

The former arose out of work on the gel strength of pectin in high-pectin sugar gels. Standard rings one above the other are used to form cylinders of the gel. The substance is poured into these rings and allowed to stand for 20 hours. A wire is drawn between the rings and the upper ring and cylinder of gel removed. Removal of the lower ring then leaves a standard cylinder of gel, the sag of which is measured.

The hardness tester is used to measure the hardness or consistency of either raw or processed crops. In it a cylinder of product 9 cm long and 4 cm in cross section is compressed by a piston until a stage is reached when it is pressed through a grid in the bottom of the cylinder. At this stage the pressure is measured.

The apparatus is a general-purpose one and has already been used on raw shelled peas, canned peas, asparagus, cooked turnips, potatoes, beet, solid-pack apples, pickles, and sauerkraut.

It is cheap and can be used in the field, as it is operated by hand. Special attention has been given to making the apparatus easy to transport and capable of yielding consistent results (Lugt and Veenbaas 1954).

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Presented to a joint meeting of the Institute of Food Technologists, Australia Northern Section, and the Dietetic Association of N.S.W. at the Royal North Shore Hospital, Sydney, April 1954.

PROCESSED

THE RESPONSIBILITY OF THE FOOD TECHnologist is nowhere greater than in the production of foods for infants, and in this field above all other fields of food technology he requires the assistance of the dietitian. Moreover, not only do food technologists need the help of dietitians in formulating foods for maximum usefulness and acceptability to infants; the food manufacturer also needs their help in selling baby foods. Unless dietitians and experts in child nutrition are convinced of the value and safety of processed baby foods and are prepared to approve of their use, there is little hope of persuading mothers to use them.

For the purpose of this discussion, the term "processed baby foods" means strained fruits, vegetables, and meats, packaged in tinplate or glass containers, and processed by heat to render them stable against microbial spoilage. They represent a class of processed foods that has reached very high production in the U.S.A. (Anon. 1952*b*). This production embraces a wide variety of packs including fruits, vegetables, vegetable-meat mixtures, soups, meats, fish, and prepared desserts. Many of these products are presented in two forms: as strained foods for young babies and as chopped foods or junior foods for older infants. In Australia the production of baby foods is still small and they have not yet found wide acceptance for infant feeding.

TECHNOLOGY

The technology of baby food manufacture is not radically different from that of orthodox canned foods. It consists essentially of a series of kitchen operations conducted on a large scale. Operations in the production of two typical baby foods, strained pears and vegetables with bacon, which the author witnessed in an American plant, will serve to illustrate present practice in baby food processing (cf. Anon. 1946*a*, 1946*b*, 1947*a*; Cruess 1948; Slater 1954; Teiser and Harroun 1954).

Strained Pears

Ripe William pears were very thoroughly washed in dump tank washers. An acid bath to remove arsenate residues and a detergent bath to remove organic spray residues were followed by rinsing sprays. The pears were not peeled, since the peels were strained out later, but the stem and flower ends were removed by means of Hydrouts (Anon. 1947*c*). After a second washing the pears were fed into a grinder from which the comminuted material passed immediately into a continuous steam blancher to inactivate enzymes, which might cause browning. The blanched product was pumped into digesters (glass-lined steam-jacketed pans holding 400 gal), sugar was added, and the mixture cooked briefly to about 180° F. From the digesters, the product was dropped to a finisher of the paddle type from which it emerged as a smooth puree of small particle size. This straining operation is the essential step in baby food processing. The sizes of the screen openings used in the industry vary within the range 0·020-0·060 in. The strained product was pumped through a line incorporating a magnetic trap to holding tanks (glass-lined, jacketed, with scraper-agitators), from which it dropped to the bowl of a plunger filler which filled 5-oz

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BABY FOODS

glass jars at the rate of 300 per min at a filling temperature of 180° F. The jars were vapour-vacuum sealed and retorted in water for 8 min at 225° F. They were pressure-cooled in the retort to 130° F centre temperature and then air-cooled.

Most of the strained fruit and vegetable products are processed in a similar series of operations, although some require additional steps such as peeling (see below). Pressure digesters are commonly used for cooking vegetables prior to straining. In some plants the strained foods are de-aerated to remove air, which is beaten into the product in the finisher, since oxygen destroys labile nutrients and accelerates container corrosion.

Among the specific products of this type manufactured are the following:

Strained Fruits	*Strained Vegetables*
Prunes	Asparagus
Peaches	Spinach
Pears	Squash
Pears with pineapple (a very popular pack)	Carrots
Apples	Green beans
Apricots with apples (prepared from dried apricots)	Peas
Apricots with farina (prepared from dried apricots)	Beets
Plums with farina	Sweet potatoes
Plums with tapioca	Mixed vegetables
Bananas (cf. Guyer and Erickson 1954)	

Vegetables with Bacon

The raw materials for this product were carrots, potatoes, celery, onions, tomato pulp, bacon, and cereal. The carrots and potatoes were peeled in a continuous pressure steam peeler (Anon. 1947*b*) in which a screw conveyor moved the product through a steam chamber, where it was subjected to pressures of 30-70 lb per sq. in. for 25-30 seconds. This peeler peeled very cleanly with only about 15 per cent. waste and had an overall capacity of 5-7 tons per hour. It may be mentioned that in this plant the same peeler was used for apples. The other ingredients of the vegetables-with-bacon pack were prepared by hand. All the ingredients were chopped coarsely in stainless-steel hammer mills, then mixed in the required proportions in stainless-steel dollies, and the tomato pulp and cereal were added. The dollies were hoisted over the digesters and the contents dumped through bottom valves.

After cooking to approximately 180° F the product was canned in two styles: as a junior food without further subdivision, and as a strained food after passing through a finisher as described above. Both products passed from holding tanks to plunger fillers which filled 6½-oz cans at the rate of 300 per minute. Then the cans were retorted, cooled, labelled, and cased. Bacteriologically safe processes for low-acid baby foods in tinplate and glass containers have been laid down by the National Canners' Association (1948, 1950).

Again, the series of operations described for the preparation of this pack of vegetables with bacon would be generally applicable to a number of other baby foods, e.g. vegetables and lamb, vegetables and beef, vegetables and liver, vegetables and rice, and macaroni, tomato, beef, and bacon. There is also available a range of baby soups, such as vegetable soup, liver soup, chicken soup, beef broth, and beef and liver soup. Mention might also be made of prepared desserts for babies which contain eggs, milk, cornflour, and various flavourings. Among the varieties marketed are custard puddings in vanilla, chocolate, pineapple, orange, and butterscotch flavours, pineapple rice pudding, and apple-prune pudding with rice.

Strained Meats

Strained meats for infant feeding were developed comparatively recently, but they are now available in a number of packs, e.g. beef, lamb, veal, calf hearts, pork, liver, liver and bacon, liver and vegetables, beef and liver, and chicken.

The raw meat is boned and trimmed free from connective tissue, sinews, and visible fat, so as to maintain the average final fat content of the baby food below 4·5 per cent. The trimmed meat is chopped and milled finely and salt is added to a level not greater than 0·5 per cent. Then the product is cooked, strained, and filled into 3½-oz cans, which are vacuum-sealed and retorted. Chopped foods in similar varieties are not milled, but are diced into ⅜-in. cubes and filled into 5-oz cans which are also vacuum-sealed and retorted.

The range of processed infant foods has now been further increased by the addition of fish foods, such as strained tuna and strained codfish.

Cereal Foods

Many of the manufacturers of canned baby foods also manufacture packaged prepared cereal foods, designated as wheat cereal, oat cereal, rice cereal, or barley cereal. These products consist of the finely-milled cereal together with additives such as dried skim milk, dried yeast, wheat germ, calcium phosphate, sodium iron pyrophosphate, and salt. The ingredients are precooked in pressure digesters, strained, drum-dried, flaked, and packed in cartons. The final product is ready to eat on the addition of milk.

Containers

The most favoured containers for processed baby foods (Anon. 1952*a*) are 3½-oz and 4¾-oz cans and 5-oz and 8¼-oz jars. Present production is approximately equally divided between the glass pack and the canned pack (Anon. 1952*b*). Cans for baby foods are mostly internally lacquered to reduce corrosion and minimize metallic contamination.

One packaging problem encountered in glass-packed baby foods is an unsightly darkening of the food in the headspace of the jar, known as "ring darkening". This discoloration is due to oxidative reactions and can be controlled only by limiting the amount of oxygen in the container. The darkening is catalysed by iron and copper in concentrations around 10 p.p.m. (Kohman 1954; Kohman and Cole 1953; Livingston, Esselen, and Fellers 1954; Livingston *et al.* 1954).

USES OF BABY FOODS

Infant Feeding

Strained baby foods, even the meats, are fed to babies as young as 2-5 months. Junior foods are started between 8 and 18 months, but usually between 12 and 14 months. However, there appears to be a lack of definite information about the optimum particle size for foods to be assimilated by children at various ages. An interesting example of a product of controlled particle size is orange juice homogenized so that it will pass through rubber teats on feeding bottles (Anon. 1953).

Baby foods are packaged in small units because of the small servings required by infants, but even so there is often enough for two to three days. The unused food will keep quite satisfactorily for this period; it is necessary only to keep it cool and covered. The opened can or jar is a perfectly safe container in which to store the food.

Adult Diets

Processed baby foods are also widely used in special diets for adults, notably in cases of digestive disorders where a minimum of roughage is required.

Nutritive Value

It is not proposed to discuss the nutritional qualities of baby foods in detail, but there is little doubt that they are similar to those of the corresponding foods prepared in the home. With many foods it is highly probable that the processed product is higher in nutritive value, since the raw materials are rapidly handled from the field into the can with much less opportunity for loss of labile nutrients than in the usual procedures of "fresh" food marketing.

Convenience

The chief selling point for baby foods must surely be convenience. All mothers should be glad to avoid the tedious routine of forcing fruits and vegetables through a sieve. Mary Barber (1954), an American food consultant, recently wrote as follows: "The past few decades have made available better-tasting and more nourishing foods, but it is ease of preparation that has the greatest appeal for the homemaker."

If this statement is true for Australian housewives, then there must be a future for processed baby foods in this country.

DISCUSSION

In the very active discussion which followed this talk, dietitians present made the following points:

- Feeding of strained baby foods can be commenced very early, e.g. at 2-3 months.
- Strained foods marketed in Australia at the present time are much too finely divided.
- Strained fruits and meats, particularly liver, should be very well received by Australian mothers.
- Mixed vegetable packs are undesirable; it is preferable to present the child with separate vegetables.

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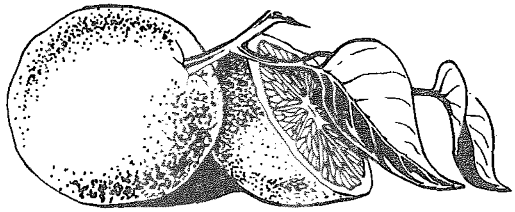

JUICE OF

In a study of some physiological gradients in citrus fruits, Haas and Klotz (1935) found that the juice from the stylar or blossom-end half of both Navel and Valencia oranges contained significantly more soluble solids than the juice extracted from the calyx or stem-end half of the fruit. Similar but smaller differences were found for lemons and grapefruit; their work also suggested that the differences were greatest in mature fruit. The possible existence of gradients in the opposite (transverse) direction has been tested in the laboratories of the Division of Food Preservation and Transport by comparing the acidity of the inner and outer juice from a number of samples of Valencia oranges and three samples of lemons.

METHOD

In 1953 tests were carried out on several samples of one line of Valencias picked at Griffith (inland New South Wales) early in September and cool stored for one to four weeks.

In 1954 Valencias from 20 different orchards in the Gosford district (coastal New South Wales) were examined; they comprised seven picked at the end of September and cold stored for six weeks, and 13 lots of fully mature fruit picked in November and analysed immediately. The lemons used were picked mature in November.

In 1953 duplicate samples of five fruits were taken at each removal from cool storage, and in 1954 one sample of 12 fruits was taken from each lot. The fruits were cut in half across the equator and the juice expressed on a glass, conical hand-extractor. The first half of the juice extracted from each sample, being the juice from the inner pulp, was kept separate from the remainder, which was the juice from the outer pulp, i.e. nearest the skin. All juice was strained through a fine screen of 30 meshes to the linear inch. The acidity of each portion was measured in the usual way by titrating 10

Acidity of Outer and Inner Juices in Citrus Fruits

Variety	Year	Number of Samples	Acidity (ml 0·1N NaOH per 10 ml of juice)				Ratio of Acidity Outer : Inner Juice	
			Outer Juice		Inner Juice		Range (%)	Mean (%)
			Range	Mean	Range	Mean		
Valencia	1953	7	17·1–23·5	21·3	27·3–32·0	29·6	65–82	72
Valencia	1954	20	10·6–32·8	17·8	12·0–39·0	20·9	72–92	85
Lemons	1954	3	82·7–88·1	85·8	93·0–96·2	94·3	88–93	91

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ORANGES

ml of juice, diluted with about 30 ml distilled water, with 0·1N caustic soda solution using phenolphthalein as the indicator. The total soluble solids content was determined by means of a refractometer and expressed as degrees Brix.

RESULTS

The results of the analyses of the juice fractions of 27 samples of Valencia oranges and three samples of lemons are summarized in the tables on page 12 and below.

In every sample the outer juice was considerably lower in acidity than the inner juice. In 1953, the acidity of the outer juice of seven samples of Valencias from Griffith averaged 72 per cent. of that of the inner juice. The mean titration values were 21·3 and 29·6 ml respectively. The mean values for 20 samples of New South Wales coastal Valencias in 1954 were: outer juice 17·8 ml, inner juice 20·9 ml; thus the acidity of the outer juice averaged 85 per cent. of that of the inner. The difference in acidity was not so great for the three samples of lemons, the values for the outer averaging 91 per cent. of those for the inner juice.

In 28 of the total of 30 samples the percentage of soluble solids in the outer juice was greater than that in the inner, in one sample it was the same, and in the remaining sample it was two per cent. less. The mean values for the seven samples of Griffith Valencias in 1953 were: outer 12·36 ml, inner 11·14 ml, the outer juice being 11 per cent. higher than the inner. For the New South Wales coastal Valencias in 1954 the means were: outer 10·09 ml, inner 9·35 ml, the outer averaging 8 per cent. higher than the inner. As with the acidity, the soluble solids differences in lemons were much less, the mean Brix values being 7·73 for the outer and 7·59 for the inner juice.

There was no relation between the observed levels of acidity and soluble solids on the

Soluble Solids in Outer and Inner Juices in Citrus Fruits

Variety	Year	Number of Samples	Soluble Solids (degrees Brix)				Ratio of Soluble Solids Outer : Inner Juice	
			Outer Juice		Inner Juice			
			Range	Mean	Range	Mean	Range (%)	Mean (%)
Valencia	1953	7	11·9 –13·1	12·36	10·8 –11·5	11·14	109–114	111
Valencia	1954	20	8·1 –14·0	10·09	7·5 –13·2	9·35	98–121	108
Lemons	1954	3	7·47– 8·23	7·73	7·34– 8·23	7·59	101–102	102

one hand, and the percentage differences between the outer and inner juice on the other.

DISCUSSION

These findings are important in their application to oranges. They show that when the juice is extracted by reaming on a fluted cone, the outer, or last extracted, juice is higher in sugar content and lower in acidity than the inner, or first extracted, juice. It was found, too, that the outer juice was richer in flavour than the inner. It is clear, therefore, that the acidity, soluble solids content, and quality of extracted orange juice will vary considerably according to the efficiency of the extraction.

This is of some importance in carrying out maturity tests. If extraction of the juice is incomplete the acidity of the juice may be 2-3 ml higher than it would have been had extraction been complete; likewise, values for soluble solids content would be too low. Huelin (unpublished data, 1935) investigated the effect of method of extraction on the yields of juice from oranges. The shape of the cone was most important in hand squeezing. The narrow, rather pointed cone of the ordinary lemon squeezer gave a lower percentage of juice than a broader, rounded cone more closely fitting the shape of an orange. The difference in yield was often as much as five per cent. The use of a power-driven extractor with a rotating cone, such as the "Sunkist" type, gave a full yield of juice. Therefore, in any work involving comparative analysis of orange juice, the method of expressing the juice should be standardized to give a complete extraction.

The existence of marked gradients within the orange in the composition of the juice is of considerable physiological interest. Minimum sugar content and maximum acidity occur inwards from the stem region, while maximum sugar content and minimum acidity occur in the outer pulp at the stylar or blossom end. This indicates similar gradients between different parts of the pulp in their ability to accumulate soluble solids and in their rate of ripening. It is well known, too, that the pulp of over-mature oranges commences to dry out at the stem end. The distribution of the main vascular system in the fruit is such that the outer and stylar-end portion of the pulp could be preferentially supplied with solutes for storage and with other respiratory materials.

Bartholomew and Sinclair (1941) found that the gradients from the stem to the stylar end were not apparent until the fruit was nearing maturity. They also found considerable differences in composition of the juice from different segments (carpels). These might also be related to differences in the distribution of vascular tissue in the fruit.

From these results it is clear that there is a large positional variability in the composition of the juice of the pulp of the orange. There is a similar but smaller variability in lemons. This variability should be recognized as it is of practical importance in maturity testing and juice processing.

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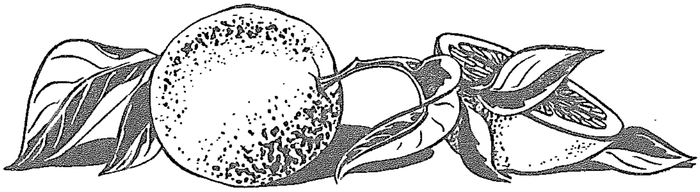

Presented to the Sixth Australian Canning Convention, held in Adelaide on September 21, 1954.

Blackneck in Tomato Sauce

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BLACKNECK IS A COLOUR DETERIORATION in glass-packed tomato sauce characterized by a darkening of the sauce in the neck of the bottle. The darkening is most intense at the surface in contact with the headspace and shades off into the body of the sauce. Blackneck is a chemical deterioration, but the chemistry of the reactions occurring has never been completely worked out. It is widely stated, however, that three factors contribute: iron, tannins, and oxygen. The mechanism postulated is broadly that iron in the sauce reacts with natural tannins to form black ferric compounds, and that oxygen is necessary to oxidize the iron compounds to the ferric state. These reactions have not been studied systematically in this Division, but in the course of investigations of several outbreaks of blackneck some information has been collected.

IRON CONTAMINATION

There is a widespread belief in the industry that the iron contamination contributing to blackneck comes from tinplate closures, following some corrosion. But against this view must be placed the fact that blackneck may occur in bottles with aluminium closures. It appears, therefore, that there may be sufficient iron present in tomato sauce to permit blackneck to appear if other conditions are favourable.

In one case investigated a sauce with an iron content of 7-8 p.p.m. developed slight blackneck. Under conditions of free access of oxygen, the condition reached its maximum development in about eight weeks at 100° F and did not increase in intensity thereafter, suggesting that the iron content may have been limiting. Another commercial sample containing 12·5 p.p.m. of iron showed much more pronounced blackneck, and when iron was added to a level of 25 p.p.m., there was a further increase in the intensity and extent of the blackneck.

These observations on the effect of iron content on blackneck are interesting in relation to the findings of Kohman and Cole (1953) and Kohman (1954) on surface darkening in glass-packed baby foods. The minimum iron content at which darkening occurred was about 6-8 p.p.m., but samples showing pronounced discoloration had iron contents of 10-15 p.p.m. It has been suggested, however, that in baby foods iron acts as a catalyst for oxidative browning rather than as a direct participant in the formation of dark-coloured compounds (Mellon Institute 1953-54; Livingston *et al.* 1954).

THE TANNINS

The tannins are a group of complex substances widely distributed in vegetable products (Bate-Smith 1954). The chemistry of the tannins has been incompletely elucidated, but they are known to contain polyphenolic groups with which the complex ferric compounds are presumably formed.

It is commonly thought in the industry that the tannins contributing to blackneck are derived from the cork wads in closures (Anon. 1950). Certainly, when a tinplate cap corrodes, the cork wad is often blackened, probably because of the formation of "iron tannates", and tannins may be leached from cork wads into tomato sauce. But this view cannot be the whole story because blackneck has been observed when the closure had a flowed-in rubber-base sealing compound and no cork wad was present. Therefore it must be assumed that in tomato sauce there are tannins, derived from the tomato pulp and seasonings, in sufficient amounts to permit the appearance of blackneck.

THE ROLE OF OXYGEN

Although iron and tannin may be present in a tomato sauce, blackneck does not appear unless oxygen also is present to oxidize the iron to the ferric state and permit the formation of black polyphenolic complexes. Frequently bottles of tomato sauce free from blackneck have developed the condition rapidly when oxygen was admitted, e.g. by puncturing the closures. Blackneck is most intense at the surface of such sauces, presumably because of the ready access of oxygen, and the spread of the discoloration into the body of the sauce evidently depends on the diffusion of oxygen. Oxygen will also accelerate the corrosion of tinplate caps, from which additional iron may enter the system.

When blackneck occurs in a bottle with an intact closure, it must be assumed that sufficient oxygen was present in the bottle to bring about the blackneck reactions. This oxygen may have been present initially or it may have entered through the seal.

Initial Oxygen

Oxygen will be present in a bottle of sauce at the time of packing, both among the gases dissolved and occluded in the sauce and in the headspace atmosphere. Fowler (1940) found 21 per cent. oxygen in the headspace gases of tomato catsup at the time of packing. After a period of storage and after the appearance of surface darkening, the oxygen content had decreased to 1-2 per cent.

The amount of oxygen remaining in solution in tomato sauce after boiling will be very small, but air may be beaten into the product during finishing and filling. For this reason, de-aeration of tomato catsup is widely practised in the United States of America, the de-aerator being inserted between the finisher and the filler (Fowler 1940; Smith 1949; Beale 1952).

The amount of oxygen in the headspace gases should also be small because high closing temperatures (180-190° F) in conjunction with steam vacuum sealing ensure high internal vacuums in the bottled product. Initial vacuums of around 15-20 in. Hg are normally found.

Thus there is generally not sufficient oxygen initially present in bottled tomato sauce to permit blackneck to become apparent. De-aeration is not justifiable solely on the grounds that it is necessary to eliminate blackneck, but it may be desirable to eliminate air bubbles, which expand in the body of the sauce under high internal vacuum and detract from the appearance of the pack.

Leakage of Oxygen

In our experience blackneck occurs in commercial tomato sauces only when oxygen (air) enters the bottle through the seal. There are three paths for the leakage of air through an apparently intact closure:

- Leakage between the bottle finish and the wad or sealing compound;
- Leakage between the metal cap and the sealing compound;
- Diffusion through the sealing compound or wad.

Modern types of closures are designed to eliminate leakage from all these sources (cf. Anon. 1954). The crown seal, now regarded as somewhat old-fashioned, is a very efficient closure, more so than some of the roll-on closures that are now favoured. Screw caps incorporating flowed-in rubber-base sealing compounds appear to be more efficient than those containing a cork wad with a coated paper liner.

The following table sets out the results of observations on a batch of sauce sealed with screw caps, some containing cork wads and the others a flowed-in compound. The more rapid vacuum loss and higher

Comparative Performance of Screw-cap Closures

Weeks of Storage at 100° F	Mean Vacuum (in. Hg)	
	Cork Wad and Liner	Flowed-in Compound
0	19·5	19·5
4	8·2	16·5
12	3·5	9·0
22	4·0	7·5
	Headspace Oxygen (%)	
22	13·5	6·3

headspace oxygen in the bottles with cork wad closures were regarded as evidence of more rapid leakage. All bottles eventually showed blackneck, but the condition developed more rapidly in those closed with cork wads.

In the table below are recorded some observations on three commercial tomato sauces in which blackneck had not been observed. The headspace gas composition was determined shortly after manufacture and again after four weeks at 100° F. The results show that in the early period of storage of tomato sauce oxygen tends to disappear from the headspace and carbon dioxide tends to accumulate. Unless leakage of oxygen occurs through the closure such sauces should be stable against blackneck throughout their storage life. Similar observations have been made on other glass-packed foods (Mellon Institute 1953-54).

Examination of Commercial Tomato Sauces

Brand	Closure	Storage (weeks)	Headspace Gases (%)	
			O_2	CO_2
A	Crown seal with composition cork wad	0	4·7	15·1
		4 at 100° F	0·5	14·5
B	Crown seal with composition cork wad	0	14·8	3·8
		4 at 100° F	1·9	11·5
C	Screw-cap with flowed-in compound	0	9·7	2·7
		4 at 100° F	3·0	8·9

STORAGE TEMPERATURE

The effect of storage temperature on the development of blackneck requires emphasis. The chemical reactions causing blackneck are accelerated at high storage temperatures, and the condition has been observed in as short a period as one week at 100° F. Therefore it is important to cool tomato sauce adequately before casing and stacking.

CONCLUSION

Finally, it should be pointed out that blackneck, i.e. the iron-tannin-oxygen reaction, is only one of the mechanisms leading to colour deterioration in tomato sauce. Ogle and Kramer (1954) describe oxidative browning and loss of red and yellow pigments in tomato ketchup in storage, and report that the browning was retarded by partial replacement of sucrose by corn syrup.

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ANSWERS TO INQUIRIES

BONE TAINT IN HAM AND BACON

What precautions should be taken during the preparation and curing of pig-meat to minimize bacterial deterioration, particularly "bone taint" in ham and bacon?

The available evidence favours the view that meat is infected at the time of slaughter and the infection is carried by the blood stream to deep tissues. However, in the case of ham and bacon there is the possibility that bacteria are introduced during the curing process. The speed with which adequate concentrations of curing ingredients reach the deep tissues may have a bearing on the growth of bacteria introduced with the pickle or earlier.

Some of the bacteria causing bone taint require minimum temperatures as high as 10-15° C for growth, which can therefore be controlled fairly well by prompt cooling of the tissues after slaughter.

It is not possible to discuss here the various causes of ham souring, for which the reader is referred to Jensen (1954).* Jensen draws attention to these methods of control:

Proper bleeding;
Adequate refrigeration;
Prompt handling;
Bacteriologically controlled pickle;
Strict general sanitation.

Other factors which may contribute to bone taint in hams are the time and temperature during smoking. Sometimes bacteria introduced at an early stage and controlled by low temperatures may grow and produce taint during the smoking process.

* JENSEN, L. B. (1954).—"Microbiology of Meats." 3rd Ed. (Garrard Press: Champaign, Ill.)

FREEZING OF PRAWNS

Information is sought on freezing prawns for marketing in Australia and the U.S.A.

In Australia most prawns reach the consumer whole, cooked, and iced; very few are frozen. In the U.S.A., on the other hand, a large proportion of the shrimp is marketed uncooked, mostly in the headed or peeled form. A fairly high percentage is frozen, but only a small proportion is cooked before freezing. The chief objections to freezing cooked prawns or shrimp are toughening of the flesh and loss of flavour. On the other hand, the product is ready for consumption after thawing. If cooked frozen prawns are to be marketed in Australia, the adverse effects of freezing may be minimized by holding at low temperatures and avoiding lengthy storage. Frozen, uncooked, headed prawns should be acceptable in the U.S.A., and special packs may be made of the shelled flesh, the yield being approximately one-half of the weight of the whole prawns.

In the U.S.A., where the shrimp catch is about 80,000 tons per annum, washing and removal of the "sand vein" are done mechanically, as is also the peeling (removal of the shell) in some cases. The equipment and the packaging and freezing of prawns are described in the *Fisheries Newsletter* **12** (12): 11, 13 (1953) and **13** (1): 11, 15 (1954).

One of the best-keeping frozen packs is obtained by freezing in a block immersed in fresh or sea water, but this process adds to the weight and increases transport costs. To obtain a frozen package with a regular shape, plate freezers should be used. These are portable, making it possible to freeze the prawns outside the room in which they are to be stored. It is possible to obtain a fairly good product by freezing the prawns on refrigerated shelf coils in a freezing room.

It is best to freeze the washed and graded prawns as soon as possible after catching, but if there is any delay the prawns must be iced promptly and efficiently. The safe storage life of frozen raw prawns handled under the best conditions is about 3 months at 0° F and 1½ months at 10° F (0° F or even lower is strongly recommended). Freezing in a block by immersion in liquid extends the storage life at the above temperatures by a month or more, and cooking prior to freezing reduces it by about one-third.

NEWS from the Division of Food Preservation and Transport

RESEARCH ON DRIED FOODS

The Division is engaged at present on researches on dried fruit and vegetables and dried meat, but it has also carried out investigations on dried egg. Research on dried foods was taken up by the Division during World War II and played an important part in the technological development of factories producing food for the armed forces.

● *Fruit and Vegetables.*—The staff working on dried fruit and vegetables is located at the Divisional Headquarters at Homebush and consists of one Research Officer and two Technical Assistants; another Research Officer has been seconded to the Commonwealth Department of Commerce and Agriculture as food technologist.

The laboratory is equipped for pilot-scale investigations on the dehydration of fruit and vegetables.

Since World War II the main lines of investigation have been a study of the effects of processing variables on the initial quality of dehydrated vegetables and on their subsequent storage behaviour, and the effect of dehydration on tree fruits.

Compression, gas-packing, and in-package desiccants have been used in attempts to increase the storage life of dehydrated vegetables. Work has also been done on the production of new dehydrated products such as green peas, sweet corn, and green beans. The process of dehydro-freezing vegetables is also receiving attention.

It has been shown that a product superior to sun-dried fruits can be produced by dehydration. Technological data have also been produced for the preparation of sugared or crystallized fruits. Experiments are in progress to determine the main factors affecting the absorption of sulphur dioxide by cut fruits and the loss of the gas during drying.

● *Meat.*—Investigations on dried meat are located in a laboratory a few miles from the central laboratories at Homebush. The staff consists of one Research Officer and three Technical Assistants.

The aim of the investigations is to produce a good-quality dried meat with a long shelf life.

Dried meats have been prepared from beef, mutton, and pork, some as dried mince and some in the form of dried slices. Problems investigated include the effects of age, breed, sex, grade, processing techniques, and packing methods on the quality and storage life of the product.

Chemical and physical methods are used to some extent to measure the quality of dried meat, but most of the assessment is carried out by tasting tests.

Provision has been made in the experimental programme for the collection of data on the effect of such factors as the temperature and speed of the air on drying rates.

Dehydration of meat saves much space and weight, yet it yields a product of good keeping quality. The meat from a mutton carcass of 40 lb dressed weight has, after dehydration, been compressed into a 6-lb corned beef can, in which it has kept in first-class condition for three years at room temperature.

There is a keen interest in dehydration in Australia. The Division receives inquiries on the drying of a wide range of foodstuffs—soups, mushrooms, cereal products, oysters, bananas, and fodder crops—and on the design of dehydration equipment.

PERSONAL

Professor J. C. MOYER and his wife, Mary M. K. Moyer, Fulbright lecturers in food technology at the New South Wales University of Technology for 1954-55, have been frequent visitors to Homebush since their arrival in Australia in December 1954. Professor Moyer is Professor of Food Technology at the New York State Agricultural

Experiment Station, Geneva, N.Y. In Australia Professor Moyer has renewed his interest in the work of Mr. L. J. Lynch and Mr. R. S. Mitchell, of the Division of Food Preservation and Transport, on the measurement and prediction of maturity in peas, and in the company of these two officers he has visited a number of pea production and canning centres in New South Wales and Tasmania. Professor Moyer has broad interests in food technology in U.S.A. and has been responsible for setting up experimental processing lines of advanced design for investigations on peas and tomatoes.

Mr. J. C. ANAND, an officer of the Central Food Technology Research Institute, Mysore, India, and a holder of a Colombo Plan Fellowship, is returning to India in March 1955. Mr. Anand, who has been a guest worker at Homebush since June 1953, has been engaged on research into the nature of heat resistance in bacterial spores.

Dr. A. S. F. ASH, a graduate of the University of Leeds, who joined the staff of the Division in January 1952, has resigned from C.S.I.R.O. to return to England. At Homebush Dr. Ash specialized in the use of chromatographic techniques for the separation of sugars, polyols, and related compounds from fruit. A letter on his researches has already appeared in *Nature*, and a paper in the *Australian Journal of Biological Sciences*. Two more papers have been submitted for publication.

PUBLICATIONS BY STAFF

EFFECTS OF SKIN COATINGS ON THE BEHAVIOUR OF APPLES IN STORAGE. IV. COMPARISONS OF SKIN COATINGS AND GAS (CONTROLLED ATMOSPHERE) STORAGE. *E. G. Hall and S. M. Sykes. Aust. J. Agric. Res.* **5**: *626-48 (1954).*

In previous papers of this series (see *Food Pres. Quart.* **13**: 42, 63; **14**: 20) some physiological effects of skin coatings on apples and the behaviour of coated apples in both non-refrigerated and refrigerated storage in air were described. This paper compares the effects of controlling the atmosphere in the store and controlling the atmosphere inside the apples by coatings on the skin in refrigerated storage. With Jonathan apples gas storage prolonged storage life more than coatings. Although with Delicious apples gas storage was somewhat better than coatings, the gain by either method was small.

With Granny Smiths, coatings were generally more successful than gas storage. This was due to better control of superficial scald and senescent scalds.

Both gas storage and skin coatings prolonged storage life, primarily by increasing the carbon dioxide tension and decreasing the oxygen tension inside the apple. However, differing effects on the volatile products of metabolism, other than carbon dioxide, caused important differences in the behaviour of the fruit.

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KETOSE OLIGOSACCHARIDES IN THE APRICOT FRUIT. *A. S. F. Ash and T. M. Reynolds. Nature 174: 602-3 (1954).*

A number of oligosaccharides, which are hydrolysed by invertase to fructose and glucose, were found in an 80 per cent. alcoholic extract of ripe apricots. The oligosaccharides were separated by chromatography on paper and on columns of charcoal or cellulose.

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REFRIGERATED TRANSPORT BY RAIL: INVESTIGATIONS IN AUSTRALIA. *E. W. Hicks and O. Barr. Refrig. J. 7 (11): 4-5, 16-17, 24-5, 27-8 (1954).*

This is a review of some of the main conclusions drawn from a series of experiments and test journeys carried out by the C.S.I.R.O. Division of Food Preservation and Transport and the New South Wales Government Railways. End bunker cars and roof tank cars are discussed, being treated as small cool stores with coolers of unusual design. The operation of these coolers is discussed in some detail.

Copies of the papers mentioned above are available from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O., Homebush, N.S.W. (Telephone : UM 8431, UM 6782).