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Division of Food Preservation

RESEARCH REVIEW, 1956-60

History and Function of the Division

Foundation

In 1926 the Council for Scientific and Industrial Research (as C.S.I.R.O. was then called) commenced meat preservation investigations at the University of Melbourne, and it subsequently extended its programme of food research to include the ripening and transport of bananas.

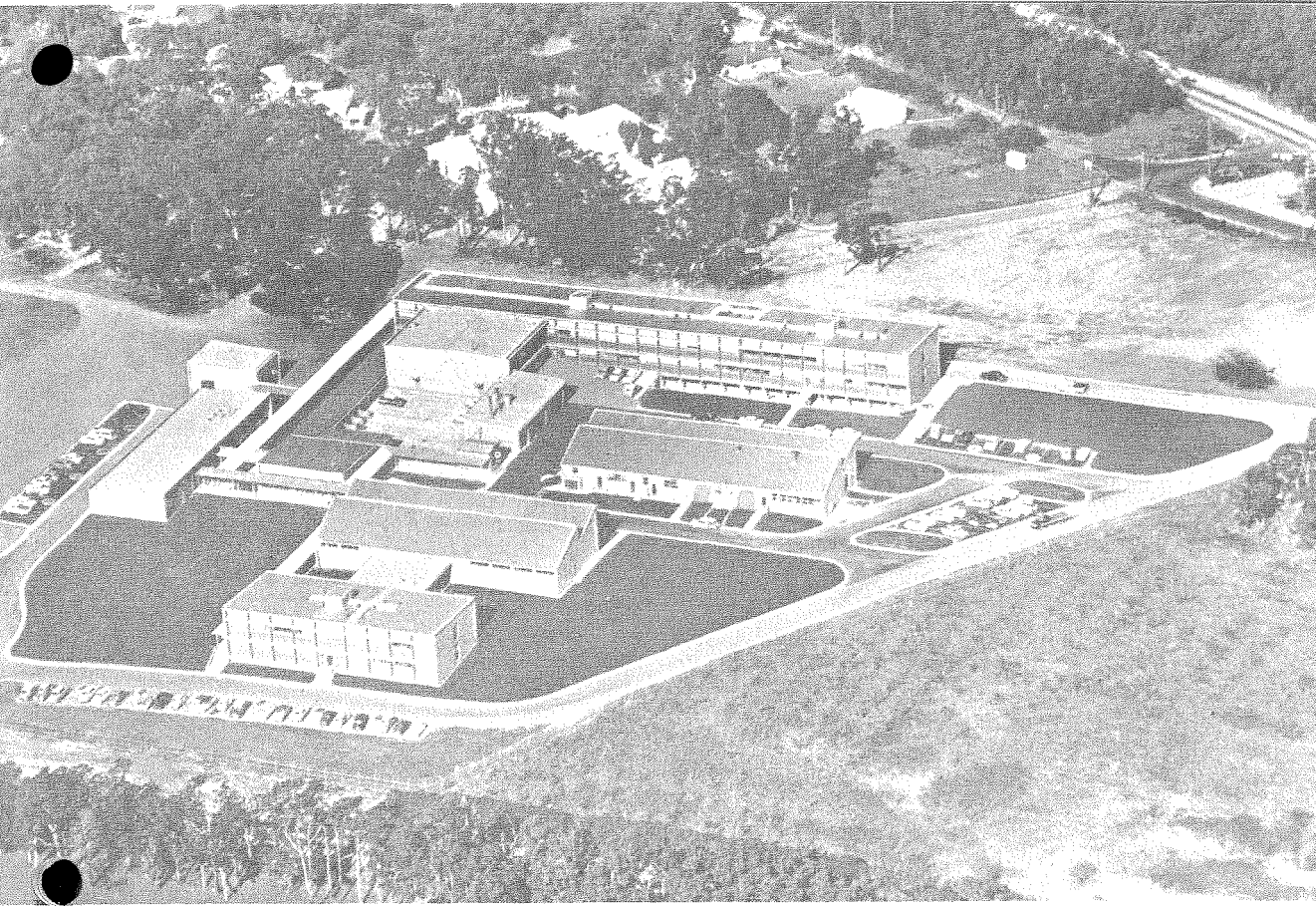
The Section of Food Preservation was established in 1932 (its status was raised to that of a Division in 1941) with a meat research laboratory in Brisbane and a fresh fruit research laboratory in Melbourne, the latter operating in conjunction with the Victorian Department of Agriculture. The Brisbane laboratory studied physical, chemical, and microbiological aspects of the preparation, chilling, and transport of chilled beef, while the Melbourne laboratory carried out investigations on the storage and ripening of pome, stone, and citrus fruits.

The War Years

The headquarters of the Division, which had been located at the Brisbane laboratory, were transferred to Homebush (N.S.W.) in 1938 where extensive central laboratories for the Section had been built in the grounds of the State Abattoir. A wider programme of research in food science and technology, including studies on fish and eggs, was commenced at Homebush, but it was soon interrupted by the outbreak of World War II. The Division was called upon to supply detailed technical information on a wide range of problems in the supply and transport of food for the Armed Services in the South-West Pacific area. This involved considerable reorganization, including the transfer to Homebush of all C.S.I.R. staff in the Melbourne laboratory and a concentration of research workers on problems of canning, dehydration, transport, and packaging. Laboratory space and staff at Homebush were doubled during the war period.

Post-War Developments

It was possible by 1946 to resume part of the research work which had been interrupted by the outbreak of war, and to begin conversion of the Division to its present form. Four basic groups, chemistry (including biochemistry), physics, microbiology, and plant physiology had been set up at Homebush, and applied groups were formed to work on canned, dehydrated, and frozen foods, and fresh fruit, eggs, and fish. Two new branch laboratories were established, one at Hobart for fruit and vegetable processing, and another at Gosford where in cooperation with the N.S.W. Department of Agriculture investigations on the wastage of citrus fruits were prosecuted. In conjunction with the University of Sydney, research units in plant physiology and in physical chemistry were formed and located in University laboratories.



Division of Food Preservation, North Ryde.

The staff of the Meat Research Laboratory at Brisbane was increased, and the range of its work extended to include investigations on meat quality and on causal factors in the formation of "drip" in frozen beef after thawing.

In November 1959 the Division suffered a severe loss in the death of Mr. E. W. Hicks. He commenced food research with C.S.I.R. in 1929, and his pioneering work in the application of physics and mathematics to the problems of the food industry soon gained him an international reputation. A tribute to his life and work was published in *C.S.I.R.O. Food Preservation Quarterly*, Vol. 20, pp. 22-9 (1960).

Aims

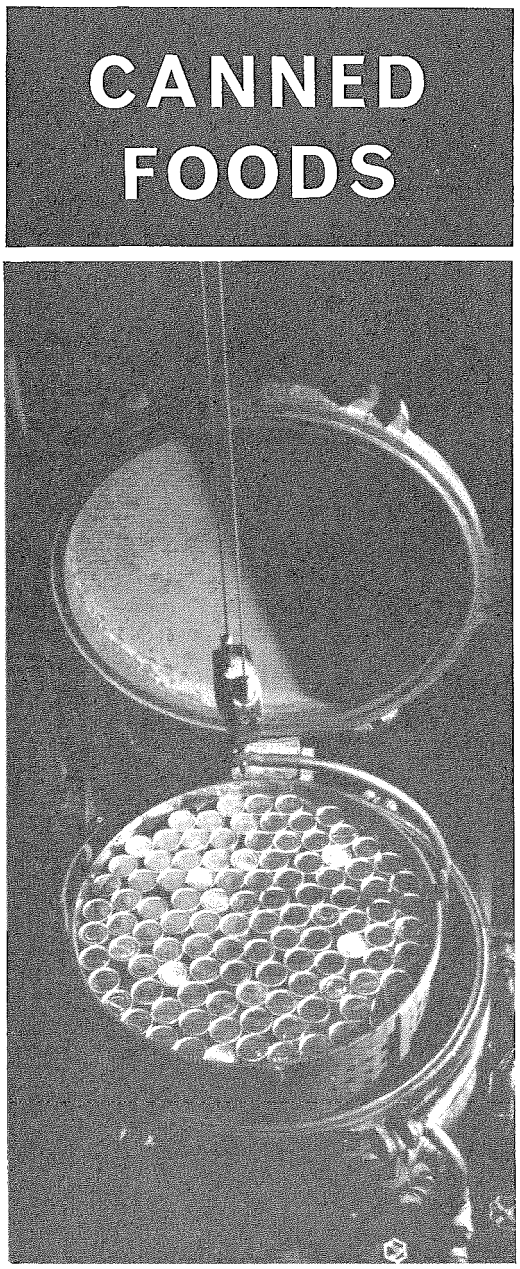
Three main aims in the selection of the research programmes have been:

- The elimination of food wastage.
- Raising the quality of preserved and processed food.
- Improvements in efficiency of preservation and processing techniques.

The lack of basic knowledge on foods and their reactions to preservation and processing operations has often hampered these investigations on food technology. A considerable part of the Division's resources has, therefore, been devoted to basic chemical, physical, bacteriological, and physiological studies on foods and their constituents.

Advice on technical problems encountered by government departments and the food industry has always been a useful service performed by the Division. Requests for technical advice and assistance in the more difficult short-term problems are increasing, and this demand probably reflects the acquisition by the staff of a thorough knowledge of all aspects of the handling, preservation, and processing of meat, fish, eggs, fruits, and vegetables.

Research Activities



Cans ready for heat processing in a vertical retort.

Heat Processing of Rotating Cans

The heating and cooling rates of canned foods are markedly accelerated by rapidly rotating the cans during processing. A small unit known as the Homebush spin-cooker, designed for heating and cooling rotating cans, was constructed in 1944. Recent work has been related to increasing the efficiency of heat exchange between the product and the heating and cooling media. The influence of steam and water flow rates, nozzle design, and distance of the nozzle from the can have been investigated. This work gave information which will enable modification of the cooker to improve its performance. The equipment is used for canned fruit and fruit products capable of being sterilized in steam at atmospheric pressure.

The Division has also developed an experimental spin-cooker in which low-acid canned foods are heated in steam under pressure. This is a batch-type unit which will enable a study to be made of changes in texture, flavour, and colour of canned meat and vegetable products during high-temperature, short-time processing.

Spin-processing enhances the quality of heat-sensitive high-starch packs such as creamed rice milk pudding. The work will be extended to study the influence of spin-heating and spin-cooling on pastes prepared from modified starches. The increasing use of specialized starches as food thickeners demands that full knowledge of their influence on the rate of heat transfer should be available.

Headspace Oxygen Increases Corrosion

Experiments have shown that the production of hydrogen from corrosion reactions in lacquered cans of beetroot and blackcurrants is accelerated in cans closed at high initial oxygen levels. Plain cans of pears and pineapples closed after flushing the headspace with oxygen showed severe detinning and some pitting of the baseplate during the early periods of storage. Pears packed in plain cans

and closed without vacuum show a higher average tin content at subsequent examinations than those closed with a normal vacuum. These results indicate that the removal of oxygen from the headspace of plain cans before closing reduces the intensity of corrosion during storage.

Sulphur Staining in Cans

The amount of sulphur staining in food cans depends upon a number of factors which include the nature of the product, the tinplate, the canning procedure, and conditions of storage of the processed product. Visual evaluation of the extent of staining is often unreliable. A photo-electric instrument has been developed and used to study the influence of can vacuum on sulphur staining in cans of fried rice, and to determine the effect of pea maturity on sulphur staining in canned green peas.

Electrolytic Tinplate Containers

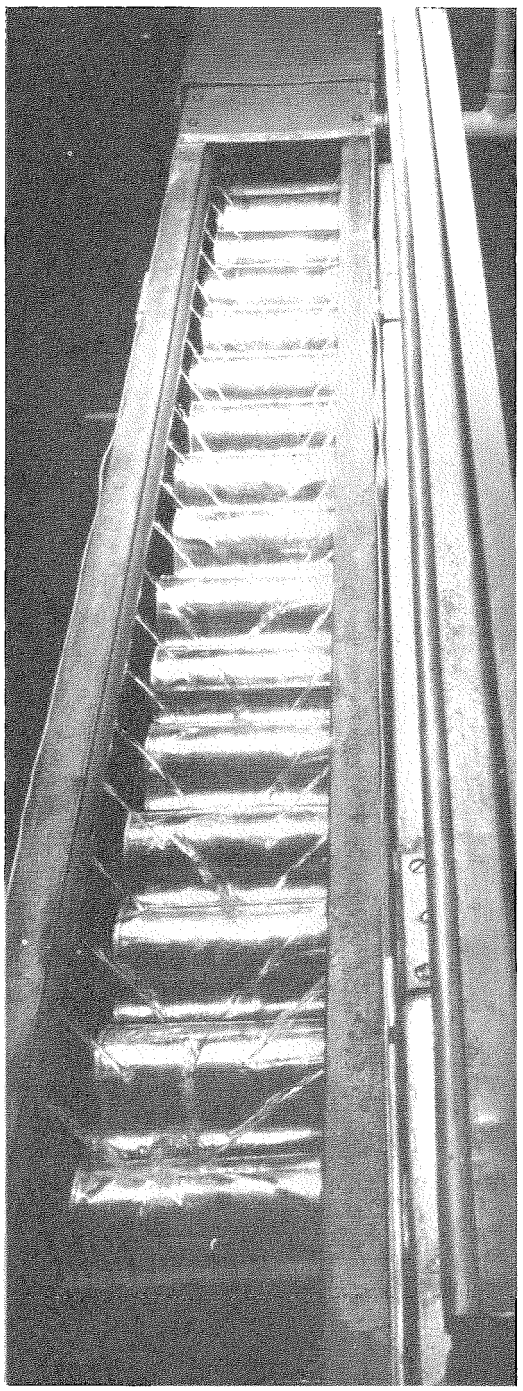
Investigations undertaken in cooperation with the Commonwealth Canmakers Association into the performance of 1·00-lb electrolytic tinplate and 1·25-lb hot-dipped tinplate have been completed. Tests were made on Australian canned foods, which included some which are normally packed in cans lined with sulphur-resisting or acid-resisting lacquers and others which are normally packed in plain cans.

Plain 1·00-lb electrolytic tinplate gave a satisfactory performance with plum jam, green peas, peaches, grapefruit juice, and tomato pulp, but was unsatisfactory with meat loaf, processed cheese, and green beans. Lacquered electrolytic cans performed well with meat-in-gravy and processed cheese packs. They were superior in performance to hot-dipped plate with boysenberries.

Some variation in performance was noted in 1·00-lb electrolytic tinplate from different sources, but the differences were small in four samples of American origin.

Hydrogen Swelling in Canned Pears

During the last few seasons losses from corrosion have been encountered in pears processed commercially in plain hot-dipped tinplate cans. The corrosion was typified by pits in the tinplate, and produced hydrogen gas which resulted in early swelling of the



Cans in a spin cooker being cooled after heat processing.

cans. Swelled and normal cans from commercial production and cans from experimental test packs have been examined with a view to finding the cause of the abnormal corrosion. The results of this work suggest that processing conditions which favour high initial oxygen contents in the headspace of cans contribute to the trouble, but it appears that other factors are also involved. The effects of fruit spray residues, and of high weights of tin-iron alloy on the tinplate are being studied at high and low initial levels of oxygen in the cans.

Flexible Film Packages

Investigations into methods for assessing plastic film containers for use as food packages have been started. Particular attention is being given to the permeability of samples of film and intact film packages to gases, especially oxygen, and to moisture. The work on intact packages will be extended to study variables associated with package construction such as heat seals, printing, and creasing.

Mechanized Harvesting of Green Peas

Recent trends towards complete mechanization of the harvesting of vegetable crops for canning, freezing, and dehydration have produced problems of efficiency and of the economics of using various types of mechanical harvesters.

During the past three seasons comparisons of the performance of two commercial mobile pea harvesters have shown that both gave lower yields of dry, cleaned peas than the stationary viner. Examination of the damage in canned material showed it to be greater in peas harvested by mobile viners, but economies in labour and transport may outweigh yield loss.

These trials have demonstrated the need for testing new equipment as it becomes available, both from the point of view of the manufacturer who needs details of performance for future modification, and of the user who requires comparative performance data on the units available.

C.S.I.R.O. Pea Maturometer

The maturometer, which was developed for rapid physical determination of the maturity of peas, has had its measuring system extensively modified. It now permits the use of a pressure range suitable for the measurement of texture in blanched and canned peas. The new measuring system consists of four ring springs which locate and give lateral stability to the pin-plate. This arrangement eliminates sliding friction on the pillars which located the pin-plate in the previous model.

The maturometer has been mechanized, and the rate of drive has been found to have no influence over the range 0·06 to 0·24 feet per second. This range covers the speeds at which the maturometer is normally hand operated.

Techniques for recording force-penetration curves during operation of the maturometer are being investigated to obtain a more complete understanding of the factors influencing the texture of peas.

Several modified cutting heads have been developed for the measurement of texture of products other than peas.

Maturity in Green Peas

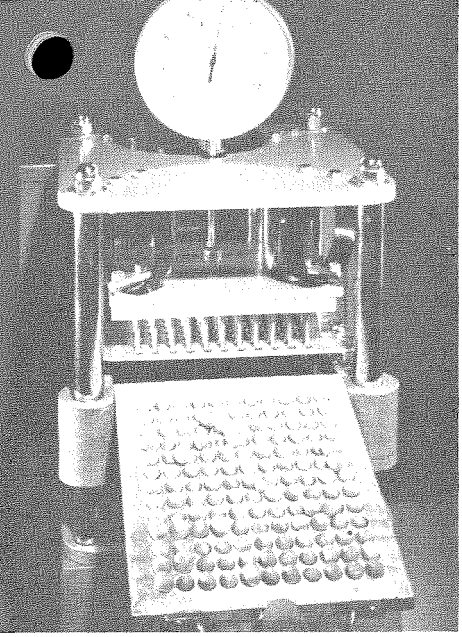
The relationship between maturometer reading (M.R.) and the percentage of alcohol-insoluble solids (A.I.S.), determined originally on Canners Perfection peas, has since been repeatedly confirmed for this and other pea varieties. Regression equations have not differed significantly from the original equation:

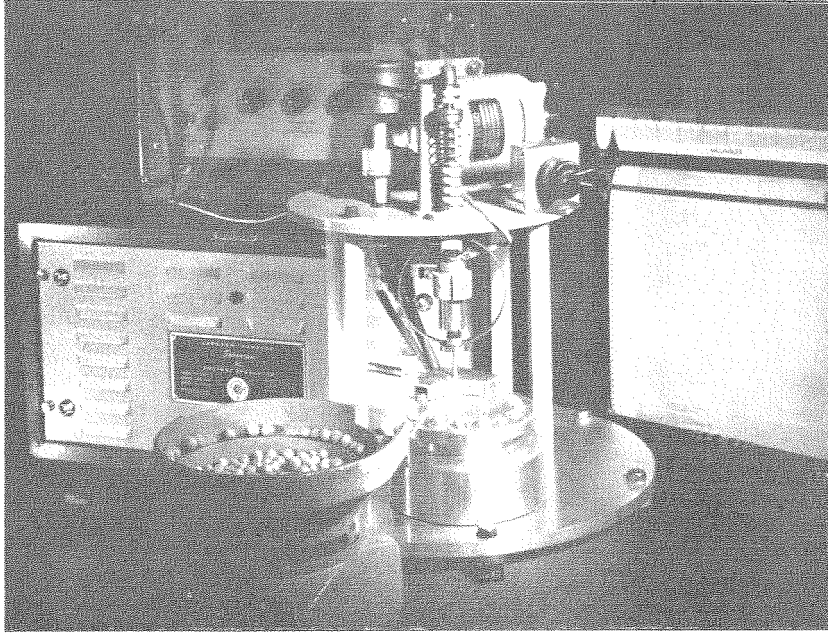
$$M.R. = 33\ (A.I.S.) - 153.$$

The maturometer prediction technique recommended by C.S.I.R.O. has been rechecked under commercial conditions and found to be reliable. Difficulties encountered by canneries have been traced to inadequate and unsatisfactory field sampling, and to the absence of continuous factory sampling. Careful field sampling is essential to reduce the errors in maturometer index (M.I.) values, and a true sample of the crop after delivery to the cannery is necessary to check the accuracy of prediction, and to provide the correct basis for grower payment.

Quality Grading of Peas

Peas may be segregated into grades or quality fractions by the use of brines of different concentrations. The percentage of peas floating in the brine (floaters) was found





Left: *The maturometer, an instrument devised in the Division of Food Preservation for measuring the maturity of samples of peas.* **Right:** *A maturometer designed to measure the maturity of individual peas.*

to decrease rapidly with increase in blanch time up to approximately 40 seconds, after which the number of floaters showed a progressive increase. The percentage of floaters also decreased with increase in time of immersion in the brine. These results indicate that blanching conditions prior to gravity separation must be closely controlled to obtain maximum efficiency in the gravity grader operation. The amount of damage which occurs during vining and subsequent handling also influences gravity separation.

Size grading and maturometer readings on floater and sinker fractions of peas from a commercial gravity separator showed that all but the largest size grades were separated into two definite maturity fractions. The floater and sinker fractions of the largest size grades had similar maturities, probably because incomplete expulsion of air during blanching prevented efficient gravity grading.

Pea Size Grader

Large quantities of accurately size-graded peas are used to investigate in detail the effects on quality of various treatments in the pea processing operation. A small continuous experimental shaker grader with a capacity of 4 lb of peas per minute has been developed for this purpose. The peas are fed from a hopper and shaken between a lower, perforated screen and an upper "Perspex" sheet. The frame containing the screen is mounted on springs and vibrated by an eccentric weight driven by a variable-speed motor.

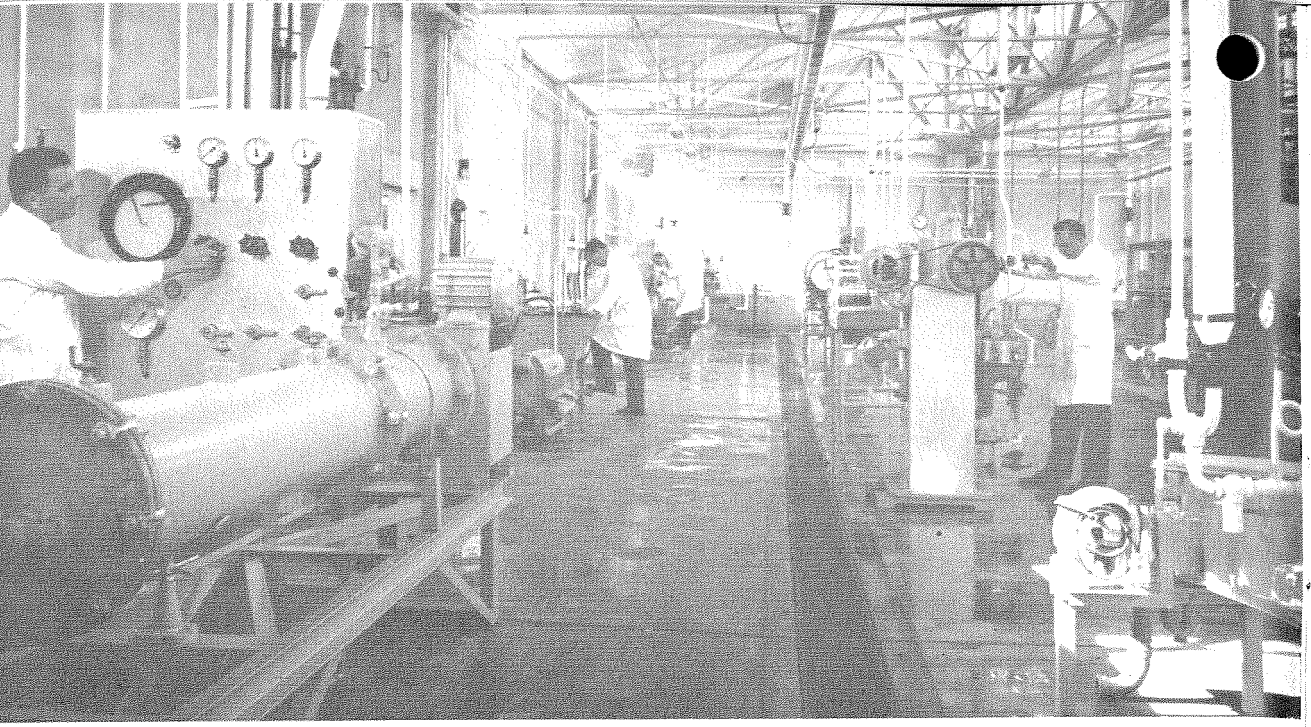
Green Pea Blanching

The water-blanching process for canning consists of immersing peas in hot water for about 3 minutes.

An extensive series of experiments have shown that the blanching function is completed after treatment for 20–40 seconds in water at 190–200°F. Taste tests of canned material have revealed that peas blanched for times between 30 and 60 seconds were preferred to longer blanches and to no blanch. This result suggests that peas for canning should be blanched for a period of 1 minute or slightly less.

Retention of Colour in Canned Peas

Chlorophyll content of Canners No. 75 peas was found to decrease as the peas matured. Colour retention in the canned product was achieved by adjusting the pH prior to processing and by using a high-temperature short-time process. Methods of pH adjustment recommended in the patent literature and its various modifications have been investigated. Although the green colour was retained in varying degrees, the texture and flavour of pH-adjusted samples were found to be adversely affected. None of the



A view of equipment in the food processing block.

procedures tested gave promise of commercial application, and this project has been discontinued.

Concentrated Orange Juice

An investigation into the possibility of preparing orange juice concentrate as a heat-processed pack has indicated that this product, pasteurized by spin-cooking, shows very satisfactory initial quality. It retains acceptable quality during storage when it is held at chilling temperatures, but at ordinary storage temperatures it shows rapid deterioration, with darkening and off-flavour. These degradative changes cannot be inhibited by the addition of moderate amounts of sulphur dioxide.

Bitter Principle in Orange Juice

Bitterness in canned orange juices, particularly Navel orange juices, is due to limonin, a compound naturally present in oranges. Although limonin has been known for more than 100 years, its chemical constitution was elucidated only recently by the combined efforts of chemists in Britain, Switzerland, and the U.S.A. Earlier chemical studies in this Division contributed usefully to the solution of this problem.

Yellow Spot in Pickled Onions

Anthocyanins and leucoanthocyanins are members of the general group of chemical compounds known as flavonoids. Another flavonoid, quercetin, is responsible for the condition known as "yellow spot" or "yellow rot" in pickled onions. The yellow spots have been identified as crystalline aggregates of quercetin which appear to be formed by enzymic hydrolysis of a water-soluble derivative naturally present in onions. Yellow spot is a problem mainly when brown onions are pickled, because these contain six to ten times as much quercetin as the white varieties.

Blackcurrant Pigments

Among the natural pigments most sensitive to chemical changes are the anthocyanins, which are responsible for the red colours in fruits such as berries and cherries. Blackcurrants were selected as a convenient source of these pigments for chemical studies. In the first instance the six pigments present in blackcurrants were identified as cyanidin and delphinidin together with two glycosides of each of these compounds. A study of the degradation of anthocyanins by oxidation, reduction, and reactions with metal ions has

been commenced, and polarography appears likely to be a useful technique for this purpose.

Discoloration in Canned Pears and Bean Purée

In some circumstances, anthocyanin pigments may cause discoloration when they are formed during processing from precursor substances, known as leucoanthocyanins, which are present in some foods. Pink discoloration in canned pears and brown discoloration in green bean purée are two problems of this nature which are being investigated. Pears vary widely in leucoanthocyanin content between and within varieties and hence in susceptibility to pink discoloration. A study was made during two seasons of the effects of field and storage factors on the leucoanthocyanin content of pears. In green beans the presence of leucoanthocyanins is characteristic of varieties which have coloured flowers; such varieties should be avoided for the preparation of bean purée.

Canned Dessert Berry Fruits

Disintegration of the fruit, and colour deterioration are the main problems in the production of high-quality canned dessert berry packs. The use of syrups thickened with low-methoxyl pectin has been investigated, as a means of preventing loss of quality. Results show that there are practical difficulties associated with this procedure.

Spin-cooking and other techniques have been studied intensively as means for reducing the time of exposure of the product to heat.

Dehydro-Canned Apple

An American process for the dehydro-canning of apple involves a 50% reduction in the weight of the fruit by the removal of water prior to canning. Preliminary tests of the method with Tasmanian fruit in 1959 indicated that a double-strength product of good quality can be prepared. While some discoloration occurred during the initial dehydration procedure, the product reconstituted easily and the cooking and eating qualities were good.

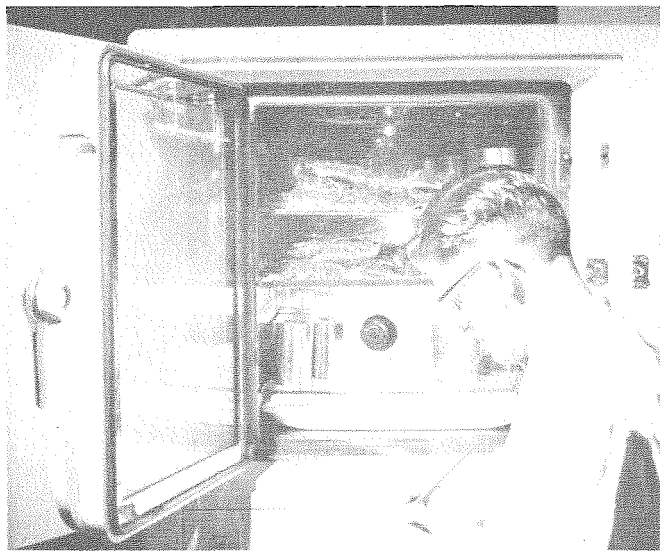
Canned Rice

The longer-grained "Calrose" rice variety has been shown to have better canning qualities than the short-grained "Caloro II" variety.

The use of an oil coating was found to prevent cohesion of grains in both boiled and fried white rice packs.

Heat processing in a pressure spin-cooker gave a satisfactory canned creamed rice milk pudding.

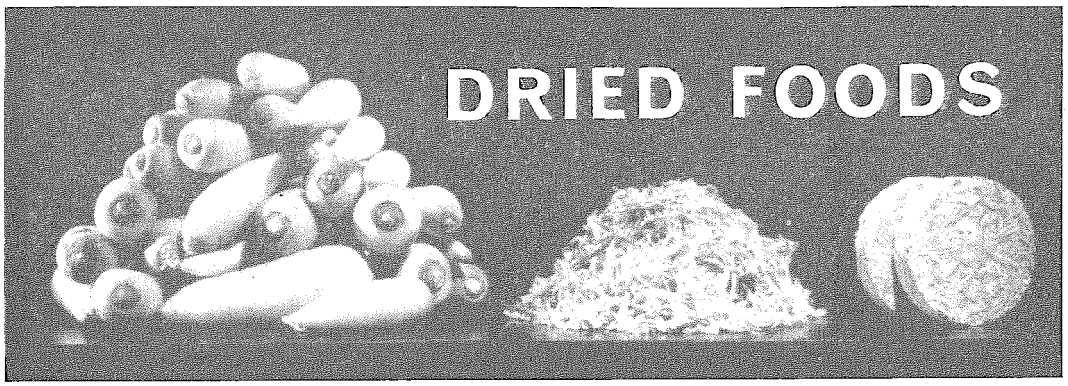
An acceptable pack of canned curried rice was produced by partial rehydration in the can without the aid of agitation during the thermal process.



Cabinet for studying the shelf life of foods kept in various types of containers under known conditions of temperature and humidity.

Canned Water for Survival Rations

Canned water is used by the armed and maritime services in emergency rations. When processed according to current specifications it often contains a rusty sediment after storage, and it may sometimes develop a slight off-flavour. The technique of canning drinking water was investigated by the Division, and it has been recommended that the process consist in boiling the water and filling hot into cans, which are then closed, inverted, and allowed to cool in air. Water treated in this way was found to be free of sediment and off-flavour after 3 years' storage at 100°F.



Quicker Cooking of Dried Green Peas

Dehydrated green peas require a long soak in water before they can be cooked. This is a disadvantage to the consumer, and experiments aimed at reducing the preparation time have been carried out by the Division. Chemical treatment of the skin did not result in increased rate of reconstitution, but mechanical slitting of the skin gave shorter soaking and cooking times. Current tests are aimed at producing a material closer to the instant-type product. This involves the drying of fully pre-cooked peas which have been passed through a slitter.

Partial Water Removal Prior to Canning, Freezing, or Drying

The removal of 50–60% of the weight of raw fruits and vegetables by dehydration, followed by freezing, canning, or further dehydration, offers economic advantages in packaging, distribution, and storage of these foods.

Tests by the Division have shown dehydro-frozen peas to be of excellent quality. Experiments are to be undertaken with a special type of drier capable of efficient removal of water from vegetable tissues.

Packaging of Moist Prunes

Changes in methods of merchandising in recent years have created a demand for high moisture content prunes in small plastic film containers. Methods for preventing deterioration of these packs by the action of micro-organisms are being investigated by the Division. Tests have shown that the addition of certain chemicals (epoxides) to the bags will sterilize the prunes. These and other additives may not be used in Australia at present because they contravene the Pure Food Regulations.

Heat sterilization of prunes in plastic films was tested, in a preliminary way, with promising results. This method involves filling the prunes as hot as possible into bags which are sealed then heated in a water bath.

Sulphuring Dried Tree Fruits

Sulphur dioxide is used to protect the natural colour and flavour of apricots, peaches, and pears during drying, storage, and distribution to the consumer. Since Australia and importing countries, by regulation, impose maximum limits for this preservative in dried tree fruits, it is essential that processors should have adequate control over its application and retention by the fruit during drying.

During the last five years factors affecting the rate of absorption of sulphur dioxide by fruit, and losses occurring during the drying process, have been investigated. The application of these results on a pilot scale is proceeding, and appropriate recommendations on sulphuring methods will be made to the industry in due course.

Dried Meat Mince

An investigation has been completed on methods for preparing air-dried meat mince of better quality than that produced in Australia during World War II. The effects of age, sex, and grade of the animals on the initial quality and shelf life of the product were examined and found to be small. Processing variables, including methods of precooking, mincing, concentration of cooking liquors and their addition to the mince, and drying, were also studied. The work on

drying included measurements of drying rates for use in designing driers, and measurements of the effects of drying temperature, air speed, and humidity on the initial quality and shelf life of the product. Problems of packaging, including gas packing and compression into blocks, were investigated. The addition of sulphur dioxide to the pack and the reduction of the moisture content of the mince retarded deteriorative changes. It has been found that certain flavouring additives can be incorporated to improve palatability and to extend shelf life. Under optimum storage conditions the product remains in good condition for periods in excess of two years. The process devised is equally suitable for mutton and beef.

Efficiency of Apple-Drying Kilns

In Tasmania apples are dried in large kilns in which air, heated by a wood-fired furnace, rises by convection through a bed of sliced apples on a slatted floor. Measurements of temperature, humidity, moisture loss, and air movement made in typical kilns have shown that the hot air passing through the fruit is utilized with reasonable efficiency to evaporate moisture. The method of heating the air below the drying floor is generally inefficient from the point of view of fuel consumption, and any improvements in kiln performance will probably be applied to this part of the plant.

Moisture Meter for Dried Apples

Dried apple processors in Tasmania have been seeking a rapid factory method for estimating moisture in the dried product. A prototype model of an electrical resistance moisture meter designed specifically for dried apples and known as the Stowell Meter has been constructed. It has proved to be suitable for measurements in the factory. A set of instructions and calibration tables have been prepared for use with the meter.

Frozen Foods

Raw Material Studies

Detailed data have been obtained on the suitability for freezing of different varieties of a number of fruits and vegetables. The influence of raw material characteristics, including maturity, on the quality of the frozen product has also been assessed. Maturity in peas and sweet corn was found to be an important factor in determining quality, and maturity limits appropriate to quality grades have been proposed.

Work is in progress to determine the cause of a grey discoloration which occurs in cauliflower during frozen storage. Results obtained so far indicate that the discoloration results from excessive exposure of the curd to sunlight.

Processing Investigations

Studies on methods of processing of vegetables have been directed to blanching, since inadequate blanching can lead to rapid deterioration after freezing. Suitable blanching times have been determined for a range of vegetables.

Fruit processing work has provided information on the amount of sugar or syrup which should be added to the pack. Quality retention in passion-fruit pulp and diced pineapple was better when these products were frozen without addition of sugar or syrup, while total immersion in syrup was considered to be essential for tree fruits. The addition of ascorbic acid to the syrup was found necessary to control enzymic browning of frozen tree fruits. Berry fruits, such as strawberries and raspberries, may be effectively preserved with sugar or with syrup.

The most common form of deterioration in frozen fruits and vegetables is the development of off-flavour. The nature and mode of development of a hay-like flavour in frozen peas is being studied with a view to prevention.

Frozen strawberries and raspberries may have certain defects of flavour and texture after thawing. Strawberries, for example, may have an off-flavour and be somewhat over-soft after freezing. Various treatments, such as mild heating, partial dehydration, vacuum syruping, and the addition of thickening agents to the syrup, have been applied. None of the treatments has so far been successful in overcoming the flavour and texture defects, but further variations of the same processes are being tried.

Fruit and Vegetable Storage

Fruit Development

A knowledge of the anatomical, physiological, and chemical changes in the growing fruit on the tree is essential to the proper understanding of its behaviour after harvest. Fruit development from the flower stage to full maturity has been studied, and chemical investigations have been carried out on oranges, apples, and pears. The work on pears included a study of the formation of stone cells, which give the fruit a gritty texture. This investigation is being extended to a detailed study of the fine structure of the fruit cells, using the electron microscope.

Tree Nutrition and Fruit Quality

Some of the effects of soil fertility on fruit quality are known in a general way, but there is little detailed information on the storage quality and consumer acceptability of fruit from fruit trees subjected to different levels of nutrition.

A preliminary study of the effect of nitrogen fertilizers on the keeping and eating quality of Delicious apples is in progress, and this work will be continued and extended to other plant nutrients.

Citrus Fruits

A major objective of the C.S.I.R.O.—N.S.W. Department of Agriculture Citrus Wastage Research Laboratory at Gosford is to produce an effective control for wastage caused by green mould. A dip treatment using sodium orthophenylphenate solution has been developed and is being used with great benefit to the citrus industry, but work is continuing to make the treatment more effective over a longer period of time, and to combine the dip more efficiently with waxing of the fruit.

The special problem of mould wastage during ethylene de-greening of citrus fruits in colouring rooms is being investigated. Following encouraging reports from overseas, fumigation with ammonia gas was tried with promising results. As both phenate and ammonia can damage fruit, especially early Navels, a study of factors concerned with fruit injury is an important part of these investigations. More fundamental investigations of spore loads on fruit, infection by green mould, and the mode of action of phenate are continuing.

Two cheap and efficient washing techniques have been developed for cleaning of citrus fruits whose appearance is marred by skin blemishes caused by sooty mould, Australian sooty blotch, and dirt. One method is suitable for small orchard use and the other for use in large packing houses.

The appearance of citrus fruits can be improved by waxing, which also reduces shrinkage of the fruit caused by water loss. A number of methods of waxing have been evaluated and recommendations made to the industry. Foam curtain waxing with a water-wax emulsion has been shown to be cheap and efficient, and is being increasingly used in packing houses.

Waxing considerably reduces the post-harvest development of black spot, which is the most serious disease of coastal Valencia oranges. Work is continuing on the wax formulation, and on the effects of incorporating fungicides in the wax emulsion.

Internal Breakdown of Stored Apples

Internal breakdown is a major problem in the prolonged cool storage of apples. Its development is influenced by variety, maturity, fruit size, crop size, climate, tree nutrition,

and storage temperature. Low-temperature breakdown has been shown to be related to the composition of the storage atmosphere, and evidence is accumulating that moisture content and moisture stresses in the fruit are also concerned. Breakdown is increased by storage in saturated atmospheres which occur, for instance, in "Polythene" box liners. Work is continuing on the effects of storage atmosphere, moisture, and tree nutrition.

Controlled-Atmosphere Storage

By controlling the composition of the storage atmosphere, in addition to temperature and humidity, the storage life of pears and many varieties of apples can be usefully increased. In addition, the life of the fruit after removal from C.A. storage is greatly extended. A storage atmosphere containing 5% carbon dioxide and 2–3% oxygen can increase the storage life of some varieties by 30–100%. More recently the separate effects of carbon dioxide and oxygen on the behaviour of the fruit have been studied in order to define more closely the optimum conditions for C.A. storage.

Storage Scald of Apples

Superficial scald continues to be an important problem in prolonged cool storage of Granny Smith apples, and it is serious also with other varieties in C.A. storage. Work at the Division's laboratories confirmed overseas findings that treatment of apples with diphenylamine will control scald completely, both in air storage and in C.A. storage. The treatment is more effective than the oiled wraps currently in use, and may be applied by pre-harvest spraying, post-harvest dipping, or impregnation into fruit wraps, trays, and other packing materials. However, its use by industry cannot be recommended until toxicological studies in progress in the United States have been completed and the necessary approval obtained from Australian health authorities.

Investigations by the Division have shown that the development of scald in C.A. storage of apples can be reduced by having low concentrations of oxygen in the storage atmosphere. A histological study of scald has shown it to originate in the hypodermal layers of cells, immediately below the skin. The fine-structure of apple skin tissue is being examined with the electron microscope in order to study changes in the cells which may possibly be associated with the development of scald and other disorders.

New Containers for Fruit

The effects of new types of containers such as fibreboard cartons and bulk bins on the behaviour of fruit during transport and storage are being studied. Bruising of apples can be eliminated almost entirely by using tray packs or cell packs in cartons, but fibreboard containers are not an entirely satisfactory container for storage. The cooling rates of apples in different kinds of bulk bins are also being examined.

"Polythene" Box Liners

Construction of a controlled-atmosphere store is more expensive, and its operation more exacting, than a normal cool store. The use of sealed plastic-film box-liners offers the possibility of what may be called "in-case" C.A. storage. This is illustrated on page 52. "Polythene" film of 1·5 mil (or "thou") thickness has suitable characteristics, and storage of fruit in sealed bags of such material provides an effective kind of C.A. storage. During storage the carbon dioxide content of the air in the bag rises and the oxygen level falls. At cool store temperatures the equilibrium atmospheres are generally satisfactory, but at higher temperatures the fruit may be damaged because of accumulation of carbon dioxide and depletion of oxygen within the bags. Methods have been developed for the successful storage in "Polythene" bags of some varieties of pears, and these methods are being used by growers. An important advantage of "Polythene" liners is that they control shrinkage of the fruit during storage so that it remains "tree-fresh" in appearance.

Unfortunately, storage scald and breakdown in apples are greatly increased by storage in "Polythene" liners. Although scald can be controlled by diphenylamine, the problem of breakdown is still under investigation. However, excellent results have been obtained with selected fruit not susceptible to either disorder.

The composition of the atmospheres in "Polythene" liners — especially the oxygen content — are variable, and the reasons for this variation are being studied. The use of plastic film stack covers in cool storage, as a substitute for a controlled atmosphere room, is also being studied.

Meat Investigations

Stowing chilled beef for shipment.

Research in Meat Quality

The work of the Meat Research Laboratory at Cannon Hill, Qld., is concerned with the relation between quality of the meat and pre-slaughter and post-slaughter treatments. Emphasis is given to meat as a biological material, and fundamental studies of the physico-chemical and biochemical properties of muscular tissue and its proteins are being conducted as independent programmes by the Division's Physical Chemistry and Muscle Biochemistry Units.

Meat from the progeny of British-breed cows crossed with bulls of British, Afrikander, and Brahman breeds is being examined for eating quality, and for moisture and fat distribution in the carcass. Attention is being paid to whether individual sires within any of the breeds show consistent differences in the quality of the meat of their offspring.

Techniques have been developed to study the effect on beef steer quality of rail transport without adequate periods for recovery.

Early work indicated that variations in tenderness of meat were to some extent associated with the biochemical condition of the meat. An endeavour is being made to produce such chemical changes during the processing of the carcass. Success with these experiments will mean not only the possibility of producing tender meat, but will also give some indication of the factors which are important in determining tenderness and which should be sought in breeding programmes.

Microbial Spoilage

The level of microbial contamination of the surface of the carcass is a factor limiting the storage life of chilled beef. Present methods of processing give a product which remains in satisfactory condition for a period not greater than 45 days. Handling procedures for chilled beef are being re-examined at Cannon Hill in an effort to reduce limitations imposed by existing techniques. The effect of condition of the animal, and the stages in the processing, on the level of initial microbial contamination and on microbial development are being examined.

Chilled beef is shipped to overseas markets in a refrigerated atmosphere containing about 10% of carbon dioxide gas. This procedure contributes greatly to storage life by controlling the growth of low-temperature spoilage organisms. Little is known of the biochemical action of carbon dioxide with respect to growth of microorganisms, and investigations designed to remedy the deficiency in our knowledge are in progress. The ultimate aim of the work is to find means for increasing the effectiveness of carbon dioxide and thereby increasing the storage life of chilled beef.

The atmosphere of the chilling space is a source of microbial contamination of beef

carcasses. Complete sterilization of the chilling area is difficult, but sterilization of the air offers a means of preventing spread of such contamination. Work has begun on the evaluation of the efficacy of various materials used as aerosol sprays in destroying organisms present in the air at chiller temperatures.

Storage and Transport

When chilled meat is stored or transported the temperature of the air should be as low as possible without producing incipient freezing. Since temperature control is not perfect, it is important to know how the meat reacts to small departures from the desired temperature, especially when the air temperature falls below the freezing point of the meat. In particular, we must know how much freezing may occur under such conditions.

Owing to a lack of knowledge of the thermal properties of such a heterogeneous material as meat, and in particular of the way in which freezing is initiated and propagated, the temperature distribution cannot be determined from theoretical considerations. Experiments are being conducted at Cannon Hill to study temperature changes in meat held near the freezing point, and to establish whether ice formation occurs readily or whether the meat remains in a supercooled condition.

Freezer-Burn Studies

Freezer-burn is a greyish-white discoloration which occurs on the surface of stored frozen products. It is caused by sublimation of ice from the surface of the product and evaporation of water from the concentrated solutions resulting from ice formation. Freezer-burn can be prevented by the use of completely impermeable wrappers, but efforts are being made to develop less costly methods. It has been shown at the Meat Research Laboratory, Cannon Hill, that the extent of damage is a function of the amount of desiccation of the surface, but the effectiveness of such desiccation in producing freezer-burn is determined by the treatment of the material before and during freezing. There appears to be a strong probability of controlling freezer-burn by pre-treating meat products with certain concentrated solutions. This has the effect of modifying the structure of the surface and the nature of ice crystal formation.

Ozone Sterilization

Ozone retards the development of micro-organisms on the surface of meat and meat products, but it also causes quality deterioration by change in colour and by rancidity development. At high concentrations these adverse effects may make the product unacceptable, but it is not yet clear whether similar changes take place at lower concentrations. Also, owing to the rate at which ozone reacts with organic materials, it is very difficult to maintain high levels of ozone concentration in meat stores, and such levels are frequently used intermittently. The present work is aimed at providing methods of treating meat continuously with constant low levels of ozone to determine whether this gives worthwhile retardation of bacterial growth without serious deterioration in quality.

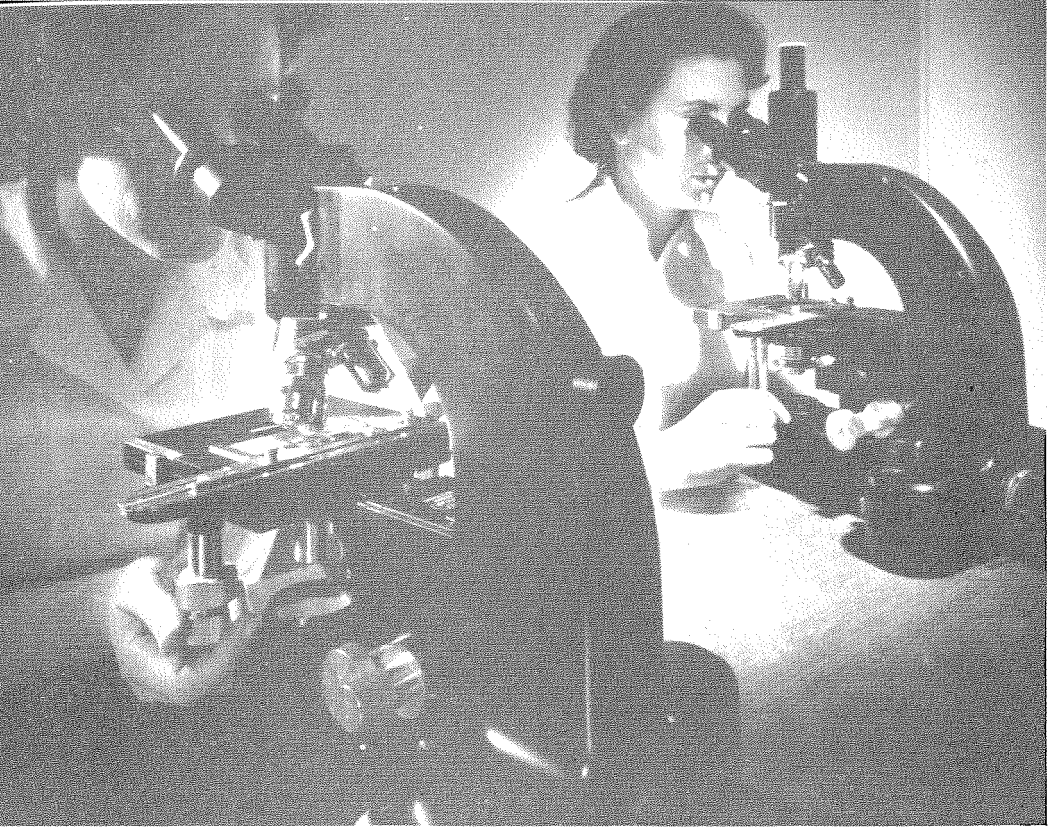
Taint in Meat

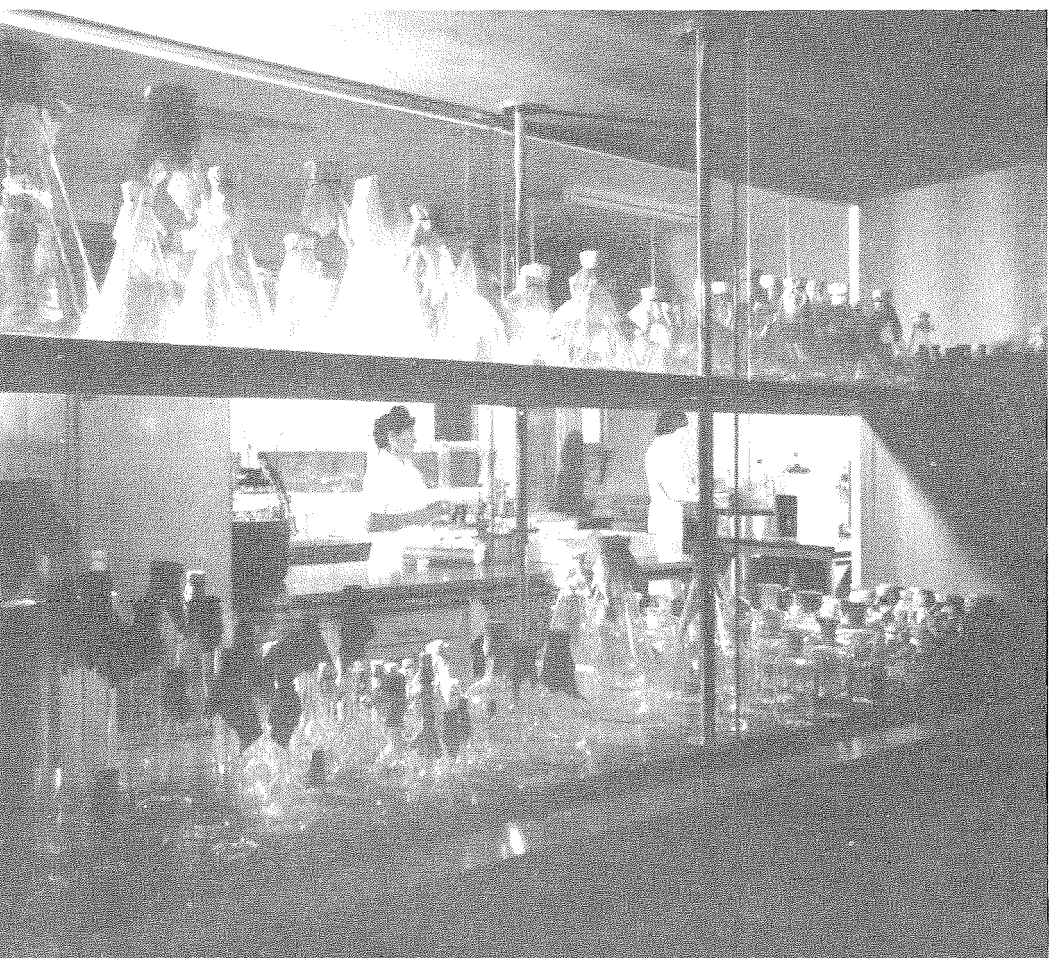
Taint and off-odours in carcasses of beef sold in Sydney have been investigated. The taint was more pronounced in the fatty tissue than in the lean and was found to be caused by extremely small concentrations of skatole, a substance which gives a pronounced faecal odour. It was suggested that the skatole accumulated in the fatty tissues when the normal excretary processes which remove this substance from the animal were disturbed by the animal eating certain weeds.

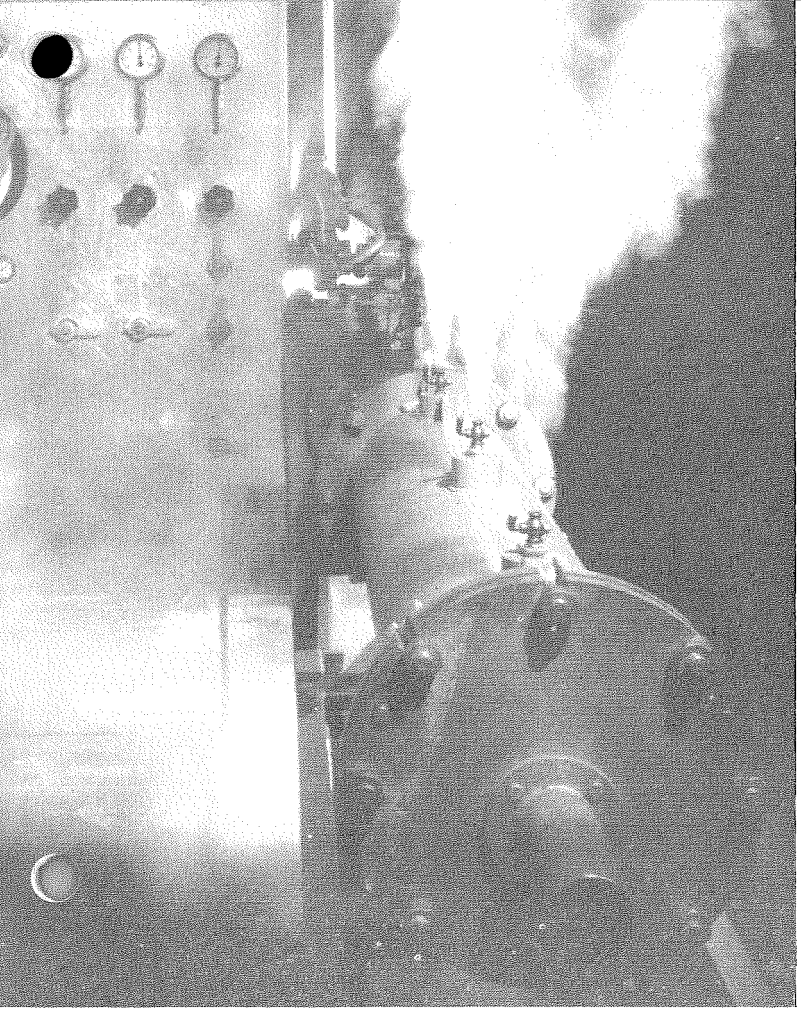
A case of tainting in packaged bacon slices was traced to a phenolic compound used as a fungicide in the package adhesive.

Surface Discoloration

In another investigation in Sydney, discoloration of the surfaces of carcasses in chill rooms was found to be caused by the meat becoming contaminated with nitrite. The nitrite was formed by microbial activity from small quantities of ammonia dissolved in drops of condensed water on the ceilings of the rooms. When the drops of water fell onto the carcasses the nitrite discoloured the meat.







Top left:

Microbiologists examining bacteria under binocular microscopes.

Top right:

Operating a pressure spin cooker.

Bottom left:

View of microbiology laboratory. The cupboards, which house clean or sterile glassware, are accessible from inside and outside the laboratory.

Bottom right:

The infrared spectrophotometer, which is kept in an air-conditioned room, is used to elucidate the structure of chemical substances.

Egg Investigations

Properties of Egg White

Attempts are being made to measure changes in the properties of egg white during storage, since these changes affect the appearance and properties of opened eggs. Several methods and instruments have been investigated but none has given a completely satisfactory measure of these important changes.

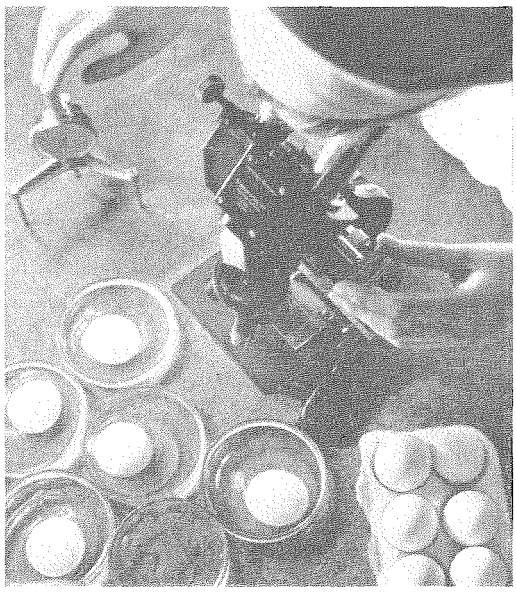
Survey of Retail Quality

Surveys are being carried out on the quality of eggs available for purchase from Sydney retail shops. This investigation is designed to give information about those factors in the handling of eggs which lead to quality deterioration, and to give a basis for recommendations on improved handling methods.

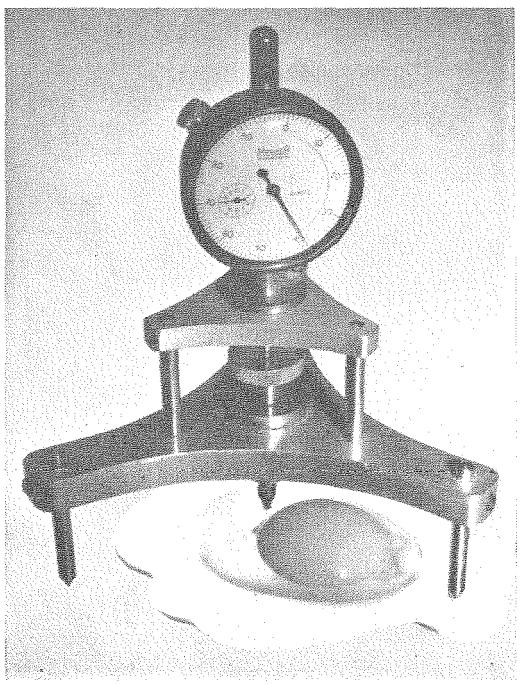
Changes during Storage

Methods for preventing or retarding adverse quality changes in stored eggs, such as weakening and flattening of the yolk, loss of thickness in the white, and flavour changes have been investigated. The investigations have helped resolve contradictory results published by other workers on the effect of cool storage and oiling on quality retention in eggs. Oil coatings give beneficial results only when applied to eggs within 24 hours of laying. Less flattening of the yolk and improved appearance of the white is obtained by oiling, but these effects only become apparent after prolonged cool storage.

The cause of pink discoloration in egg white and of a mottled, salmon-coloured, and sometimes enlarged appearance of the yolk of some stored eggs has been investigated. These effects are produced when hens eat cotton-seed or certain weeds of the mallow family. A new compound, malvalic acid, which was isolated from the oils of these plants and from the seeds of the Illawarra flame tree and the Kurrajong caused eggs to discolour when fed to hens.



The quality of eggs may be investigated by means of the microscope and spherometer. The latter is used to measure the depth of the thick white of eggs.



Fish Investigations

THE DEVELOPMENT of "black-head", a black discoloration of the head of uncooked prawns, has caused rejection of large quantities of this food by wholesalers. Investigations have shown that the discoloration is promoted by enzymes which produce a black pigment from natural constituents of the prawn. The condition can be controlled by cooking the prawns sufficiently to inactivate the enzyme.

Methods used for cooking and transporting prawns have been investigated in order to ascertain the origin of bacterial spoilage, which has resulted in consignments of prawns being rejected at fish markets. The water used for cooling the prawns after cooking and for ice making was found to be the main source of the spoilage organisms. Recommendations were made to the industry to use chlorinated water for cooling and ice making in order to control the spoilage.

Changes in the texture of frozen fish stored at −10 and −18 °C have been found to be related to changes in the solubility of fish muscle protein. The quantity of salt-extractable protein and the texture acceptability of the fish decreased as storage continued. Deterioration was greater in samples stored at 14 °F than those stored at 0 °F.

The quantity of volatile bases in fish muscle is indicative of the level of spoilage of the fish. A method has been developed for estimating volatile bases in fish muscle under field conditions, using comparatively simple equipment.

Irradiation of Foods

Insect and Mould Control

The Division recently established a small group at the Australian Atomic Energy Commission laboratories at Lucas Heights, N.S.W., to work in collaboration with the Commission on possible applications of ionizing radiations in the Australian food industry. Since large doses of radiation cause adverse quality changes in foods, particularly off-flavours, the work has been concentrated on such problems as insect and mould control, where smaller doses are effective.

Exploratory experiments show that infestations of citrus fruit by the Queensland fruit fly may be controlled by irradiation. Although large doses are required to kill the insect within a day or so, moderate doses prevent emergence of flies, and still smaller doses may control the fly by sterilizing the males. This work is of particular interest since the fruit fly has appeared from time to time in previously uninfested citrus areas. Quarantine regulations in some States and countries which import citrus fruit prohibit the entry of fruit from infested districts.

Experiments with rice showed no adverse effect on the grain from doses of radiation sufficient to control insect infestation.

Mould growth on strawberries has been successfully controlled by moderate doses of radiation, while lower doses gave a useful extension of storage life. Promising results have also been obtained with other fruits.

Studies on Spores

Techniques for the sterilization of food by means of ionizing radiations are being investigated in overseas laboratories. Some factors such as temperature, oxygen, and water availability influence the effect of ionizing radiations on the bacterial spores, and these are being studied by the Division. The experiments are being carried out with the aid of the cobalt-60 source at the University of New South Wales and the reactor rods at Lucas Heights.

Food Chemistry

CHEMICAL and biochemical research of a fundamental or applied character constitutes a large part of the work undertaken in various laboratories of the Division. Such research has embraced investigations into the water-holding capacity of muscle and other proteins, which is relevant to the processing and storage of protein foods, and has included fundamental studies on the reactions involved in the browning of foods. Other projects have included a study of the anaerobic decomposition of ascorbic acid, and examination of the volatiles responsible for the flavour and certain other properties of fruit, for example the susceptibility of stored apples to superficial scald.

Chemical investigations have also been carried out on a number of specific matters, among them being the natural coating of apples. Analytical methods for estimating certain fumigants in the atmosphere, or as spray residues, have been developed in the Division's laboratories as part of a broader programme of work on the control of fruit fly.

Protein Denaturation

The intramolecular change causing protein denaturation is an important factor in the deterioration of protein-rich foods, particularly in relation to the loss of solubility in dried egg and milk, and to changes in texture and water-holding capacity of meat and fish. In order that the nature of these changes might be understood, work is being carried out on the effect of heat, freezing, and urea on the molecular properties of purified proteins extracted from eggs, milk, fish, and meat. Changes in molecular size and shape are being measured by means of techniques involving sedimentation in the ultracentrifuge, diffusion, and viscosity. Other molecular changes have been followed with the aid of electrophoresis, optical rotation, and ultraviolet absorption measurements.

Quality Changes in Meat

A Muscle Biochemistry Section has been established within the Division to study the changes which take place in muscle tissue after slaughter. Experimental work is directed towards defining the fundamental factors which contribute to the eating and keeping quality of meat, and to elucidating the processes which are responsible for the exudation and loss from frozen and thawed meat of the reddish liquid known as "drip".

The work is essentially long term in nature and involves a study of the chemical, physical, and associated quality changes which occur in meat during rigor mortis, the resolution of rigor, and aging; also the effect of environmental conditions on these changes. The investigations on drip are mainly concentrated on the post-mortem changes which take place in meat before freezing and after thawing and, in particular, those changes which affect the water-holding capacity of the muscle proteins.

The Role of Lipids

Work on the hitherto uncharacterized oil fraction in the natural coating of apples has been in progress for some years and the fatty acids have now been identified. The importance of this work was emphasized by recent evidence that the incidence of superficial scald may be related to the composition and permeability of the natural coating. Changes in the lipids of avocado during development and storage have also been investigated. Work on the lipid associated with actomyosin, the structural protein of muscle, has been started.

Ethylene Dibromide Investigations

Ethylene dibromide is an effective fumigant for fruit, being useful for destroying the larvae and eggs of fruit fly. Accurate methods for determining its concentration in air and in the fruit have been developed by the Division in the course of investigations on the

fumigation of citrus fruit. As there were unaccounted losses in the fumigation experiments the absorption of ethylene dibromide by, and possible reaction with, all materials used in the fumigation trials is now being investigated.

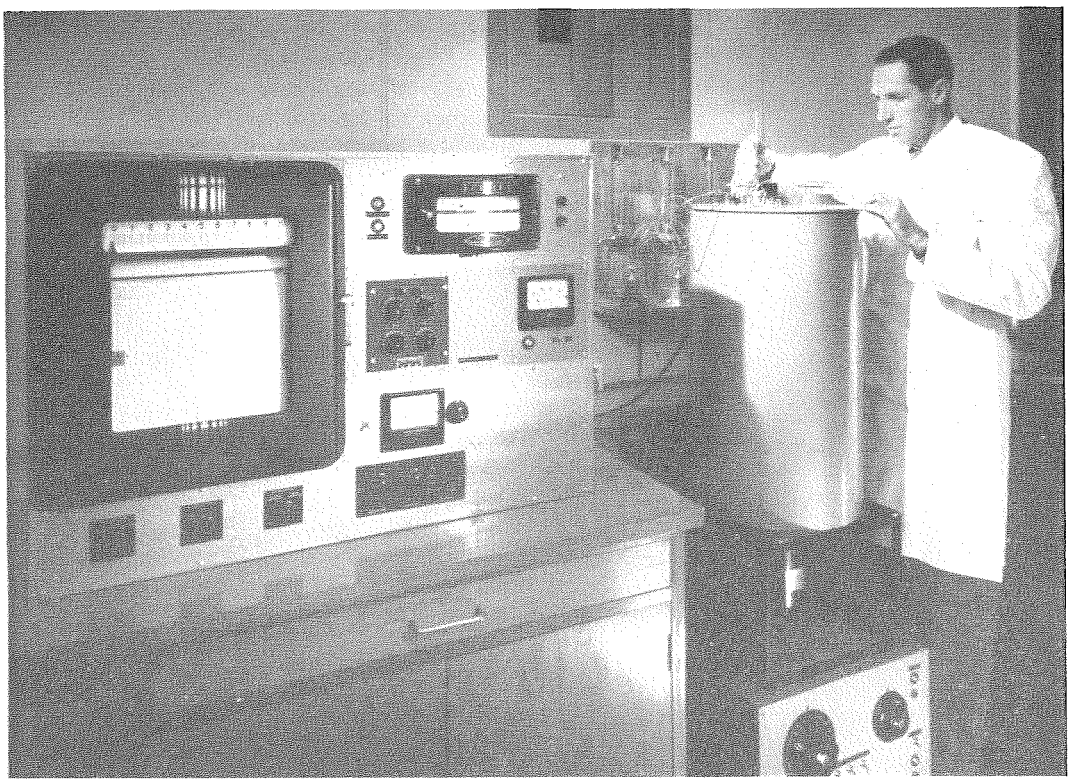
Decomposition of Ascorbic Acid (Vitamin C)

The decomposition of ascorbic acid in the absence of oxygen is the reaction responsible for the loss of vitamin C from stored canned foods, since the concentration of oxygen in cans becomes negligible shortly after processing. Recent work has been concerned with the formation of furfural during decomposition of ascorbic acid under varying conditions, and with the identification of other products. The presence of an unstable reducing substance and a more stable acid has been demonstrated by paper chromatography.

Chemical Factors in Superficial Scald

The relation of superficial scald in stored apples to ventilation suggests that this disorder is caused by volatile substances produced by the fruit itself. Acids, alcohols, esters, and carbonyl compounds, which are formed by the fruit, have been tested for their effect on the incidence of scald. Scald-like injuries were produced by certain esters, but only in excessive concentrations. The search for other natural volatile substances which may be related to scald is continuing, and the unsaturated hydrocarbons are at present being investigated. Tests with this wide range of substances have shown that many reduce or inhibit scald, and systematic studies of inhibitors are in progress. Control by diphenylamine (first demonstrated overseas) is still the most effective, but benzylaniline is almost as good.

View of a laboratory engaged on research on the chemical and biochemical aspects of frozen foods.



Gas chromatography equipment is used, in the course of researches on food flavour, to detect minute quantities of chemical substances.

Volatile Substances

The facilities in the Division for work on volatile substances are being extended so that flavouring constituents of foods may be studied more fully. Various types of gas chromatography apparatus have been constructed for the identification of the compounds by infrared or mass spectroscopy.

Browning Reactions

Chemical reactions involved in the promotion and inhibition of non-enzymic browning in foods are in progress, and some advances have been made in this field. The browning reaction is important because it causes deleterious changes in the colour and flavour of concentrated and dried foods, and desirable changes in baked and roasted foods.

There is some evidence that sugars and amino acids existing naturally in dried fruit combine to form a series of compounds (fructose-amino acids) which are involved in the browning reaction. Studies with model systems have now shown that fructose-amino acid compounds are converted step-wise into a reactive compound (hydroxymethyl furfural) which readily forms brown pigments with amino acids. Certain organic acids which occur naturally in foods have been shown to accelerate the formation of the sugar-amino acid compounds by catalysis.

The fate of bisulphite in foods is being investigated in order to obtain information about the part it plays in inhibiting browning. Four reactions, namely, the formation of bisulphite-sugar addition compounds, oxidation of bisulphite, oxidation of sugars, and esterification of sugars have been studied. The investigations have shown that oxidation reactions may be important in bisulphite inhibition of browning.

Physics

WORK in the Physics Section has been concerned largely with problems involving heating and cooling. In the field of heat transfer, extensive studies have been carried out on thermal processing of canned foods, and on the performance of rail cars used for transporting perishable foodstuffs.

On the theoretical side, a programme of work is proceeding which aims to provide solutions to the mathematical equations governing the transfer of heat and mass between fluid streams and surfaces over which they flow.

The Physics Section has also assisted other Sections of the Division on problems of physical measurement, and with work in the fields of freeze-drying, colour measurement of foodstuffs, and instrument design for the measurement of relative humidity in cold stores.

Heat and Mass Transfer Theory

Transfer of heat from one point to another takes place by three processes, namely, conduction, radiation, and convection. Methods already exist for estimating rates of heat transfer by conduction, but not, as yet, for the more complicated process of convection.

Work is in progress in the Division to obtain solutions to the mathematical equations which govern convective transfer processes, in order to enable tables and charts to be drawn up which will simplify the estimation of heat transfer rates for any general problem involving convection.

An important aspect of this work which has come into prominence in recent years is the way in which mass exchange between a fluid stream and the surface past which it flows may affect the heat transfer rate. Mass exchange, a knowledge of which is in itself important, involves the loss or gain of matter through a boundary layer as, for example, when a drop of water evaporates at its air surface whilst falling freely. Its effect on heat transfer rates is of practical importance in the drying of foods and other industrial products, in the cooling of mechanical parts of gas turbines by evaporation, and particularly in calculations of combustion rates.

Studies have shown that, whilst mass passing from a fluid to the surface over which it flows tends to increase the heat transfer rate, mass flow in the opposite direction tends to decrease it. At present only laminar flows, not turbulent flows, are being considered. Within this restriction, the results will apply to any shape of body, for any fluid, and for any rate of mass transfer. Although the equations being used apply strictly to forced convection, there are indications that they may also be useful eventually for free, or natural, convection.

These theoretical investigations will have wide applications in many fields of technology where heating, cooling, and drying processes are involved.

Uncertainties in the Calculation of Retort Processes

Thermal processes are calculated from experimental data of two kinds:

- Physical data obtained from heat penetration measurements which determine the rates of heating of the pack.
- Bacteriological data which specify the resistance of microorganisms to heat treatment.

The late E. W. Hicks examined the effects on calculated lethal values of uncertainties in these data of the heat treatment. He found that they lead to large uncertainties in lethal values of processes, the effect of uncertainties in bacteriological data being considerably greater than that of uncertainties in physical data. He also critically examined the large but often ill-defined safety factors which are incorporated in thermal processes recommended for vegetables, meats, and fish.

Ice being loaded into the roof bunkers of a refrigerated rail car.

Cooling Period of Retort Processes

A large part of the effective heating and sterilization of cans and solid foods takes place during the initial part of the cooling period. The behaviour of the pack during this period is fairly complex. Work in the Division has emphasized the importance of the contribution of the cooling phase in the total sterilizing process, and has helped to define the physical processes which occur during the cooling of solid packs.

Heat Transfer into Canned Foods

Investigations have shown that the free space between the top of the product and the top of the can, called the "headspace", offers an appreciable resistance to the transfer of heat into the can during retorting. Where the product is in direct contact with the can the heat transfer rate is some hundreds of B.t.u./ft^2 hr °F, but through the headspace it is as low as 10 B.t.u./ft^2 hr °F. Neglect of the headspace resistance introduces important errors into the calculation of the temperature history of cans of solid foods, particularly if they are squat cans. The slowest heating point in the can, previously thought to be at the can centre, is in fact a short distance above the centre because of the reduced rate of heat transfer through the headspace.

Thermal Properties of Canned Foods

Because the thermal conductivity of foods increases slightly with temperature, heat penetrates cans of solid foods more readily towards the end of a heating process, when the food is hot, than at the beginning, when the food is cold. The change of thermal conductivity with temperature is small, but a study of the effect has helped to explain why measured heat penetration curves differ from those calculated on the assumption that the thermal properties are constant.

Thermocouple Conduction Errors

The temperature changes of canned foods during retorting are measured by thermocouple wires which penetrate the can wall to the point inside the pack where the temperature is being measured. Because of the relatively high heat conductivity of metals,

heat may be conducted along the thermocouple wires faster than through the product, and this results in errors in the temperature measurement. These errors have been studied in some detail, and recommendations have been made to overcome them. In general, thick copper wires can lead to large error, but fine-gauge wires of substances such as nichrome-constantan, which have much lower conductivities, give negligible error.

Measurement of Humidity

It is usually difficult to measure accurately the relative humidity of air at low temperature and high humidity — conditions often experienced in cold stores. The difficulties increase when it is desired to measure humidity in confined spaces, such as in the air between fruits in a case.

Several methods of measuring humidity in these circumstances have been investigated, including the use of small "probes" coated with a metallic oxide film. The electrical conductances of these films change with changing humidities. The results obtained so far indicate that a "probe" coated with selenium oxide may give the most satisfactory performance.

Freeze-Drying

In many types of research there are important advantages in being able to remove water from materials in the frozen state at temperatures well below the freezing point. Special equipment has been designed and constructed in the Division so that conditions during drying can be controlled precisely. The equipment is used to study the behaviour of sensitive biological materials and of living microorganisms under specified conditions of drying in the frozen state.

The principles of controlling the final water content and temperature of the material without over-drying at any stage have been studied, and equipment embodying these principles has been constructed and operated.

Freezing of Fruit

In commercial practice there is some danger of fruit becoming frozen in cold storage. This may result in serious deterioration in the quality of the fruit when it is taken out of store for marketing. However, some fruits may be partially frozen without any subsequent ill effects. One observation which is of interest to biologists, as well as to owners of fruit cool stores, is that live plant tissue seems to have a markedly different freezing point from that of the expressed juice. The actual difference depends on the technique of measurement, and it has been found that the only reliable method of measuring the true freezing point is to determine the freezing point of the expressed juice itself. The rate at which freezing injury develops under cool storage is also being investigated.

Weight Loss in Cold Storage

Foods in cold storage gradually lose weight, due largely to a distillation process whereby moisture evaporates from the foods into the store atmosphere and condenses on the refrigeration coils and other cold surfaces within the store. These losses reduce the saleable weight of the food and sometimes greatly depreciate food quality.

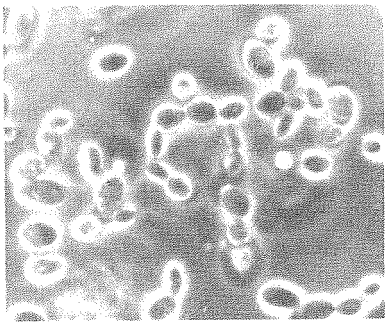
The Division has investigated the loss of weight from various kinds of fruit, particularly apples and pears. Theoretical and experimental studies in this field have been carried out simultaneously and it was found that, when no convective movement of the atmosphere takes place within a case of fruit, weight losses to within 20% of measured values can be predicted by theory.

Factors which affect weight loss are the temperature and humidity in the store, the position of the fruit in the case, the position of the case in the store, the presence of wraps around the fruit, and the materials from which the fruit cases were made. It has also been found that apples from different growing areas lose weight at different rates.

Performance of Rail Cars

Earlier work on the performance of rail cars for the transport of vegetables, fruit, and meat is continuing. Recently, observations have been made on the transport of tomatoes in louvred vans from Adelaide to Melbourne.

The work on railway cars has contributed substantially to improvements in the design and operation of these vehicles, and to our understanding of the behaviour of a large number of foods during loading, transport, and unloading.



Microbiology

WORK in the Microbiology Section of the Division has been directed towards investigations of the effects on food spoilage bacteria and bacterial spores of exposure to various physical agencies such as moisture, heat, and cold, and dehydration. The causes and prevention of food spoilage by microorganisms, of discoloration of cured meats, and of bone taint have also been the subject of study. These investigations have produced useful results, and in some cases the conclusions have resulted in considerable savings by commercial firms.

Food Poisoning Bacteria

Because outbreaks of bacterial food poisoning generally occur only when large numbers of the causal organisms (or large quantities of their poisonous products) have been ingested, investigations are continuing in order to improve our knowledge of the many factors affecting the survival and growth of these organisms.

Recent experiments with marine strains of *Clostridium botulinum* have shown that these organisms produce spores which are very easily destroyed by heat, but are able to grow and produce toxin at much lower temperatures than the common types occurring in soil. The water requirements for the growth of food poisoning organisms have been described in several papers, and further experiments have extended the observations to a wider range of experimental conditions. These results will help define the extent to which the requirements for water, nutrients, temperature, and acidity are interdependent.

Microbial Spoilage of Processed Foods

Commercial processing plants frequently submit samples of foods spoiled by microorganisms to these laboratories for investigation. Such inquiries average about one per week. The products affected range from canned fish to cordials, but usually they are low-acid foods such as canned vegetables and canned meat packs. Twenty-eight separate spoilage outbreaks of this type were examined in 1959.

The organisms causing spoilage are isolated and identified and from this, and other relevant information on processing procedure, the cause of the spoilage is diagnosed. Most commonly it is due to contamination of the product through leaky cans.

Fermentation by yeasts of products that depend on acidity and high concentration for their preservation is another common industrial problem.

Discoloration of Cured Meats

Cured meats frequently show grey or green discolorations which are usually caused by bacteria growing on the surface. A number of investigations undertaken at the request of smallgoods manufacturers have shown that this condition may be avoided by ensuring that the product is prepared hygienically, cooled rapidly, and stored at appropriate temperatures.

Bone Taint

Bone taint is a term used to describe bacterial spoilage in the deeper tissues of meat, for example, in hind quarters of beef and hams.

Studies of organisms isolated from tainted tissues have demonstrated that spoilage must, in some instances, have occurred while the meat temperatures were above 50 or even 60°F. With hams this indicates that spoilage occurred before or after curing at 38–40°F, and with beef it points to spoilage during the first few hours after death.

Investigations are continuing in an attempt to develop reliable control measures.

Water Requirements of Microorganisms

A sufficient reduction in water availability or water activity of an environment will prevent growth of all microorganisms. However, there are large differences in the amount of drying needed to arrest the growth of different types, and reasons for these differences in water requirements are being sought.

Recent results show that the solutions inside bacterial cells are at least as concentrated as the solution in which they are grown. As the external water activity is reduced the contents of the cells become more concentrated, largely due to an accumulation of potassium salts and amino acids.

When different organisms are grown in different batches of the same medium, bacteria with the greatest tolerance to dry conditions have the highest potassium contents. Other investigations deal with leakage from bacterial cells, and swelling and bursting of the cells in solutions of various substances at different concentrations.

Death of Dried Microorganisms During Storage

Investigations have shown that extreme dryness will not prevent death of microorganisms during storage in the dried state and that survival is often greatest at relative humidities around 15–20%. Storage under drier conditions was particularly damaging in the presence of air. It was also shown that some sugars increase the death rate during storage while others decrease it. Sugars which increase the death rate contain carbonyl groups, and this suggests that these damage the cells by browning-type reactions with important cellular components such as enzymes or other proteins. This hypothesis is supported by the results of many experiments and has led to new methods for preventing death during storage.

Freeze-Drying of Microorganisms

The method of drying cells from the frozen state has been widely claimed to be the best method for avoiding death during drying, but results of experiments in this laboratory show that this is not always true. Under some conditions some organisms were almost completely destroyed during freeze-drying, but all survived drying from the liquid state.

Another investigation has shown that the process of rehydrating dried cells can be an important cause of death with some organisms.

Heat Resistance of Bacterial Spores

Severe heat treatment is required to destroy heat-resistant spores in canned foods, and the heating process may have a detrimental effect on the quality and nutritional value of the product. A better understanding of the heat resistance of spores may provide a basis for reducing the severity of the canning process.

A popular theory is that the vital components of heat-resistant spores resist destruction because the interior of the spore is relatively dry. This may explain why spores have been found to possess a wide range of resistance even when heated in dilute aqueous solutions. Controlled drying has a very marked effect in equalizing the resistance of spores, which normally differ widely in their susceptibility to heat. Laboratory investigations have shown that heat resistance of very labile spores increased more than 80,000 times after drying, while the very resistant spores increased theirs only 10 times. Attempts to explain this effect by studies on the permeability of spores to water and to various solutes have not yet revealed an explanation of these marked differential responses to drying.

Structure and Composition of Bacterial Spores

An alternative attack on the problem of variable heat resistance of spores is through isolation of the various components and their separate examination by chemical and physical means. It has been found possible to remove the coat layers from spores by shaking with minute glass beads. These layers may then be separated from the contents by the use of a centrifuge. Coat layers from a number of organisms with greatly different heat resistances are being analysed chemically in the hope that the chemical nature of the components contributing to the heat resistance may be determined.

Very thin sections of whole spores, of coat layers, and of the spore contents, are being studied with the aid of an electron microscope to obtain more information on the physical structure of spores.

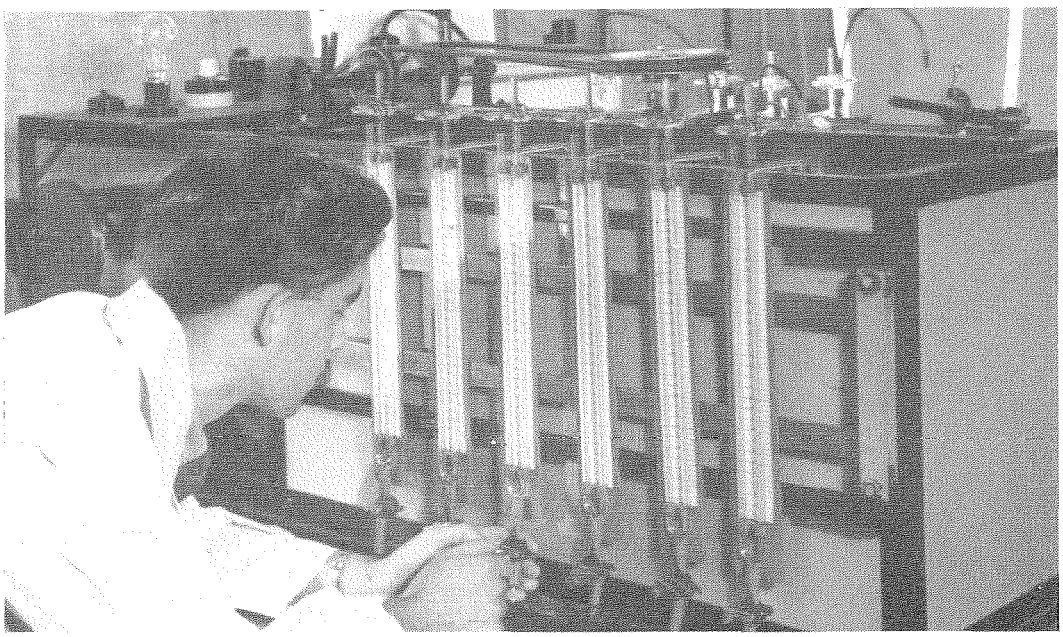
Plant Physiology

Chemical Changes in Fruit and Vegetables

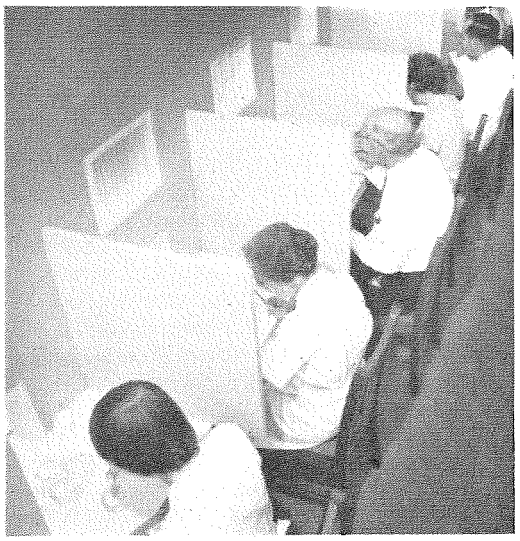
Fundamental investigations in plant physiology have been undertaken within the Division to give a better understanding of the reactions of fruits and vegetables to storage and processing conditions. The work has provided information about changes in the chemical constitution, enzyme activity, and respiratory behaviour of apples, pears, and peas during development and maturation, and after harvesting. One of the enzyme reactions associated with the ripening of fruit has been worked out, while the changes which take place in the sugars and starches of peas as they mature, and which are important in determining quality, have also been investigated. In the course of these investigations much fundamental information was obtained about the role of enzymes, proteins, amino acids, organic phosphate compounds, and carbohydrates in living plant tissue. Factors controlling the movement of salts into plant cells and the effect of these salts on the metabolic processes of the tissues have been studied, and the results showed that salts have many important effects on the chemical and physical properties of the tissue.

The effects of climatic factors on the chemical composition of peas have been studied in collaboration with the California Institute of Technology. For these studies peas grown to maturity under a range of climatic conditions in a phytotron, which is an apparatus for controlling such factors as temperature, humidity, light intensity, and day length, have been examined at the Plant Physiology Unit.

Warburg manometers being used to measure the respiration of plant cells.



Information AND Technical Services



Taste testers at work.

Library

The library of the Division of Food Preservation, the most extensive of its kind in Australia, contains all important journals publishing original research on food science and technology, and a representative collection of those dealing with physics, chemistry, biochemistry, microbiology, nutrition, and refrigeration and engineering. Abstracting journals, indexes, and bibliographies contained in the library provide the key to this published information, and books provide handy summaries. Journals of a more popular type keep the research staff in touch with new developments in the food industries and in other laboratories. The library now takes approximately 450 periodicals, including 20 abstracting journals, and has just over 1000 books and an extensive collection of pamphlets and reprints.

The library serves members of the staff who wish to review previous research on their subjects, as well as those who seek information normally available from reference works, whether it be a recipe, or analytical method, or the physical properties of a particular chemical compound.

The facilities of the library are available to all persons engaged in food industries, and books and literature not available in public libraries may be lent to organizations having a librarian. A library is also maintained at the Cannon Hill branch laboratory for research staff working on meat.

C.S.I.R.O. laboratories are served by a central Translation Service which makes research results in all languages available to officers of the Division.

Taste Tests — Consumer Assessment of Quality

Consumer assessment of eating quality is an indispensable feature of many investigations involving the storage of foods. Taste tests evaluate such qualities as flavour, odour, and texture, none of which are readily measured by chemical or physical methods, but it is essential that such tests should be carried out under close supervision and with proper facilities.

The Division has facilities and trained staff for carrying out taste tests under carefully standardized conditions in its testing laboratories. The tasting laboratory is equipped for the preparation and service of foods under uniform conditions, and has eight tasting booths where tasters assess the samples in seclusion. More than 200 tasting sessions are held each year and each session involves between 10 and 60 tasters drawn from all parts of the Division.

The main function of the taste test laboratory is the assessment of samples of food from the Divisional research programmes.

This work has included the evaluation of canned tomato juices prepared from different varieties of tomato, the effect of storage conditions on the quality of frozen fruits and vegetables, the effect of packaging materials and can lacquers on the flavour of foods, and the effect of agricultural sprays on the flavour of processed foods.

In addition to taste tests on material from research programmes, a restricted range of taste tests are carried out for commercial organizations which do not possess facilities for this work. In 1959 taste tests were conducted for ten firms, mainly to assess the acceptability of products based on modified formulations and processes, and to determine the cause of quality defects such as taints and off-odours.

Engineering and Workshop Services

The Division employs a professional engineer to advise research staff on the design and manufacture of laboratory apparatus and special equipment, and a skilled glassblower is also on hand to fabricate special apparatus in glass. The workshops, which are in course of development, have already manufactured the following specialized equipment:

- A micromanipulator with a sensitivity of 1/25,000 of an inch in any dimension. This was used for research on plant cells.
- A motorized maturometer for determining the maturity of single peas (in the course of researches aimed at raising the quality of canned peas).
- A device for vacuum-packing and thermo-sealing foodstuffs in plastic bags.

The workshops are also responsible for the operation and repair of refrigerating, air-conditioning, and space-heating plant, and for the various services, such as gas, water, and electricity, without which the laboratories could not function.

Sources of Finance

THE COST of maintaining the Division's laboratories and its scientific, technical, and auxiliary staff for the financial year 1960–61 was estimated at £330,044. Of this amount, the sum of £307,300 — or 93% — was provided by the Commonwealth Treasury under the following categories:

	£
Salaries, and payments in the nature of salary	233,762
Equipment, including special grant of £9000 for 1960-61	26,526
Consumable supplies, food supplies, services, travel, general maintenance, etc.	47,012
	£307,300

As in past years, considerable financial aid was given by Government Departments, statutory bodies, and private industry. Details of funds contributed for specific researches in 1960–61 are set out below:

	£
Australian Meat Board	
Special grant (£4000) for equipment for Muscle Biochemistry Investigations, and grant for meat investigations at Cannon Hill, Qld.	4305
Metropolitan Meat Industry Board, Sydney	
Muscle Biochemistry Investigations	500
Queensland Meat Industry Board	
Investigations at the Meat Research Laboratory, Cannon Hill, Qld.	1275
Department of Primary Industry	
Fruit fly sterilization investigations on citrus fruits and investigation on removal of spray residues from fruit	5300
N.S.W. Department of Agriculture	
Fruit storage investigations	2364
Australian Apple and Pear Board	
Apple and pear storage investigations	500
Australian Dried Fruits Association	
Investigations on mould attack on prunes	250
Australian Egg Board	
Investigations on egg storage	750
Egg Producers' Council	
Egg quality investigations	1500
Broken Hill Pty. Co. Ltd.	
Tinplate corrosion investigations	6000
	£22,744

In addition to funds provided by the Commonwealth Treasury and the contributions made by various organizations for specific researches, the Division of Food Preservation has, since 1956, received a considerable number of general donations from the food industry. By June 30, 1961, over £21,000 had come from this source, including £6500 in 1960-61. The staff of the Division has been greatly heartened by this response, and wishes to place on record its grateful appreciation of the food industry's generous expression of its interest in the work of the Division.

Contributors to the General Donations Account for the Financial Year 1960-61

Ardmona Fruit Products Co-operative Co. Ltd.
Arthur Yates & Co. Pty. Ltd.
Australian Paper Manufacturers Ltd.
Batlow Packing House Co-operative Ltd.
Berri Co-operative Packing Union Ltd.
Cascade Cordials Pty. Ltd.
Containers Ltd.
Corona Essence Pty. Ltd.
Cottee's Ltd.
Cygnet Co-operative Canning Society Ltd.
Dewey and Almy Pty. Ltd.
F. J. Walker Ltd.
G. Centofanti & Sons
Gordon Edgell & Sons Ltd.
Harry Peck & Co. (Aust.) Pty. Ltd.
H. B. Selby & Co. Pty. Ltd.
H. J. Heinz Co. Pty. Ltd.
H. Jones & Co. Ltd.
James Barnes Pty. Ltd.
J. Gadsden Pty. Ltd.
John Darling & Son Pty. Ltd.
Kyabram Preserving Co. Ltd.
Leeton Co-operative Cannery Ltd.
Lewis Berger & Sons Pty. Ltd.
Pick-Me-Up Food Products Ltd.
Port Huon Fruitgrowers' Co-operative Assoc. Ltd.
Port Huon Fruit Juices Pty. Ltd.
Riverstone Meat Co. Pty. Ltd.
Roche Products Pty. Ltd.
Shepparton Preserving Co. Ltd.
Sidney Cooke Pty. Ltd.
Tasmanian Breweries Pty. Ltd.
Taubmans Industrial Coatings Pty. Ltd.
Thomas Playfair Pty. Ltd.
Tom Piper Ltd.
W. G. Goetz & Sons Ltd.
Wilson Meats Pty. Ltd.

Staff of the Division

The following persons held positions on the scientific or administrative staff of the Division of Food Preservation in the period 1956–60

Administration

Chief — J. R. Vickery, M.Sc., Ph.D.
Assistant Chief — W. J. Scott, B.Agr.Sc., D.Sc.
Technical Secretary — R. B. Withers, M.Sc., Dip.Ed.
Administrative Officer — B. P. Byrne

Scientific Services

Library
Miss B. E. Johnston, B.Sc.

Taste Tests
Miss E. M. Christie, B.Sc.

Editor
G. E. Cunningham, B. Sc., Ph. D.

Engineer
I. A. Rey, A.S.T.C.

Architect
K. M. Digby, A.S.T.C.

Physics

E. W. Hicks,* B.A., B.Sc.
M. C. Taylor, M.Sc.
H. L. Evans, M.Sc., Ph.D.
N. D. Cowell, B.Sc.(Hons.)
J. D. Mellor
Mrs. W. Szulmayer, Dipl.Phys.
Mrs. J. A. Anet, B.Sc.

Microbiology

W. J. Scott, B.Agr.Sc., D.Sc.
W. G. Murrell, B.Sc.Agr., D. Phil.
J. H. B. Christian, B.Sc.Agr.(Hons.), Ph.D.
R. H. Leach, M.Sc., D. Phil.
B. J. Bloomfield, M.Sc.
D. F. Ohye, D.I.C.
Miss B. J. Marshall, A.S.T.C.
Miss J. A. Waltho, A.S.T.C., B.Sc.
A. D. Warth, M.Sc.
Miss K. M. Smith, B.Sc.

* Deceased.

General Chemistry

Biochemistry
F. E. Huelin, B.Sc.(Hons.), Ph.D.
J. B. Davenport, M.Sc.
I. M. Coggiola, A.S.T.C., B.Sc.

Physical Methods
B. H. Kennett, A.S.T.C.

Physical Chemistry
H. A. McKenzie, M.Sc., Ph.D.
M. B. Smith, A.S.A.S.M., M.Sc.
Miss J. F. Back, B.Sc., Dip.Ed.
Miss K. O. Kelly, B.Sc.

Organic Chemistry
Miss T. M. Reynolds, M.Sc., D. Phil.
E. F. L. J. Anet, M.Sc., Ph.D.
D. L. Ingles, M.Sc., Ph.D.
Miss D. E. Fenwick, A.S.T.C.

Muscle Biochemistry
(Ian Clunies Ross Animal Research Laboratory, Prospect, N.S.W.)
R. P. Newbold, M.Sc., Ph.D.
C. A. Lee, B.Sc.

Plant Physiology

R. N. Robertson, B.Sc., Ph.D., F.R.S., F.A.A.
D. D. Davies, B.Sc., Ph.D.
J. F. Turner, M.Sc., Ph.D.
A. B. Hope, B.Sc., Ph.D.
H. S. McKee, B.A., D. Phil.
Mrs. D. H. Turner, M.Sc., Ph.D.
S. I. Honda, M.Sc., Ph.D.
M. D. Hatch, B.Sc. (Hons.), Ph.D.
J. D. McLean, B.Sc.(Hons.)
J. Giovanelli, B.Sc.Agr., Ph.D.
Miss R. F. Mullens, B.Sc.(Hons.)
J. Smydzuk, Ing. Ch.
N. F. B. Tobin, B.Sc.(Hons.)
Miss J. E. King, B.Sc.
E. S. Blanch, B.Sc. (Hons.)
K. S. Rowan, M.Sc., Ph.D. (*Botany School, University of Melbourne*)

Fruit and Vegetable Storage

E. G. Hall, B.Sc.Agr.(Hons.)
Miss J. M. Bain, M.Sc.
J. K. Long, B.Sc.Agr.
(*Department of Agriculture, Gosford, N.S.W.*)
D. Leggo, B.Sc.Agr.
(*Department of Agriculture, Gosford, N.S.W.*)
J. G. Gellatley, B.Sc.Agr.
(*Department of Agriculture, Gosford, N.S.W.*)
K. J. Scott, B.Sc.Agr., Dip.Ed.
D. E. Finlay, B.Sc.Agr.

Canning

L. J. Lynch, B.Agr.Sc.(Hons.)
J. F. Kefford, M.Sc.
R. S. Mitchell, M.Agr.Sc.
B. V. Chandler, B.Sc.(Hons.), Ph.D.
E. G. Davis, B.Sc.(Hons.)
P. W. Board, B.Sc.(Hons.)
D. J. Casimir, M.Sc., Dip.Ed.
K. A. Harper, M.Sc., A.S.T.C.
R. G. P. Elbourne, A.S.T.C., B.Sc.

Dried Foods

D. McG. McBean, B.Sc.
A. A. Johnson, A.S.T.C.

Frozen Foods

J. Shipton, B.Sc.Agr.
J. H. Scheltema, M.Sc.
J. H. Last, A.S.T.C.

Processing of Fruit and Vegetables

(Tas. Reg. Lab., Hobart)
S. M. Sykes, B.Sc.Agr.
R. A. Gallop, M.S., A.S.T.C.

Irradiation of Foods

(A.A.E.C., Lucas Heights, N.S.W.)
J. J. Macfarlane, M.Sc.

Fish Preservation

W. A. Empey, B.V.Sc.
W. A. Montgomery, A.S.T.C.

Meat Investigations

(Meat Res. Lab., Cannon Hill, Qld.)
A. Howard, M.Sc.
G. Kaess, Dr.Ing.
C. A. McChesney,* B.Sc., Ph.D.
N. T. Russell, D.I.C.
M. F. Meaney, B.Sc.(Hons.)
P. E. Bouton, B.Sc.
J. F. Weidemann, B.Sc.
D. R. Davy, B.Sc.
L. E. Brownlie, B.Sc.Agr.

Meat Dehydration

(Auburn, N.S.W.)
A. R. Prater, B.Sc.Agr.
F. J. Gardner, B.Sc.Agr.

Egg Investigations

J. R. Vickery, M.Sc., Ph.D.
F. S. Shenstone, A.S.T.C.

* Deceased.