P Board.

FOOD PRESERVATION QUARTERLY

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To mark the Tenth Anniversary of Establishment of Central Food Preservation Research Laboratories for the Council for Scientific and Industrial Research at Homebush, New South Wales, Australia

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CONTENTS

LIST OF ILLUSTRATIONS

List of Staff of the Division of Food Preservation and Transport

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Foreword

By

SIR DAVID RIVETT, K.C.M.G., M.A., D.Sc., F.R.S.,
Chairman, Council for Scientific and Industrial Research

At a time when a bewildered world is more concerned than ever before with problems of food production, preservation and transport, it is well for Australia to ask whether her contribution to a solution is in accordance with her powers and responsibilities.

Over 20 years ago the C.S.I.R. was associated in Melbourne with the Australian National Research Council in studies on the freezing of beef. This work, of considerable local importance, illustrated the need to regard preservation work as an essential link between production of numerous food products in this country and consumption of them both here and abroad. Much was already known in some cases, partly from spasmodic local work and partly from the more systematic studies of other lands, particularly the United Kingdom and the United States of America, but questions without number were still unanswered. The complicated structures of foodstuffs of all kinds, especially meat and fruits, and the avoidance of conditions rendering them unstable, called for fundamental studies based on physics, chemistry, botany and bacteriology. Mere empirical observation of the results of exposure to different environments was insufficient : there was, and there still is, need for more accurate knowledge of the physiological and other reactions which occur.

In 1931 Dr. J. R. Vickery, an 1851 Exhibition Scholar who had spent four years at the Low Temperature Research Station in Cambridge, was invited to take charge of investigations. He will be the first to acknowledge the help which he has received throughout the years from colleagues in other laboratories. To the late Sir William Hardy we are especially grateful for the assistance he gave in training our men and in developing the close contacts which still exist between the L.T.R.S. and our Australian laboratories. Personal contacts between workers on similar lines in different parts of the British Commonwealth are the surest way to provide that measure of mutual aid which is necessary for rapid, successful work.

The original Section of Food Preservation and Transport, which was raised to the status of a Division in 1940, was established in the buildings of the Queensland Meat Industry Board at Cannon Hill, Brisbane, and it is a pleasure to record our gratitude to the members of the Board, and especially to its Chairman, the late Mr. E. F. Sunners, for the hospitality and continuous help accorded to us for more than 15 years. The Cannon Hill laboratory is now a branch specially devoted to problems of the meat industry, the main body having transferred in 1938 to its present quarters at Homebush. For ten years the Metropolitan Meat Industry Commission of N.S.W. has stood behind us in the provision of buildings, land for new laboratories, and facilities for our work. To its members, notably Mr. J. Merrett, we return our thanks for their demonstration of the active interest of an industry in the underlying science on which its future will in great part rest.

Since processing and storage of meat, fruits and other foodstuffs are often greatly influenced by the conditions of field production, close cooperation has been developed with workers in universities, in certain other Divisions of C.S.I.R., and in the several State Departments of Agriculture. Many conjoint investigations are under way, particularly with our colleagues in the N.S.W. Department.

This number of the Food Preservation Quarterly commemorates the first decade of our work at Homebush and gives an account of the labours of the laboratories during these years. The staff will this month welcome to an inspection many friends who have given generous help in various ways; and the members of the full Council take the opportunity to record their appreciation of the excellent work that has been carried out by all the members of this well-trained, enthusiastic and devoted staff.

The programme ahead of us is not only very broad, it is urgent. The need of the world is clamant for the foods which we can produce, and it is essential that preservation and transport be brought to maximum efficiency. Through these laboratories of the C.S.I.R. and their associates, the Government and people of Australia will contribute increasingly to the task of feeding nations less fortunately placed.

David Rivett

Chairman.

October 1, 1948.

J. R. VICKERY, M.Sc., Ph.D.,
Chief of the Division of Food Preservation and Transport.

An Historical Outline of C.S.I.R. Food Preservation Investigations

Australia is a major food exporting country and a considerable proportion of its export trade is rendered possible only by the adoption of various methods of preservation, such as refrigeration, canning, dehydration and salt-curing. In 1946-47, the exports of highly perishable foodstuffs amounted to about 530,000 tons, valued at over 53 million pounds.

The application of modern preservation and transport techniques is also essential for the well-being of the Australian people. Great distances separate many major food-producing areas from main centres of population, periods of glut and scarcity are not infrequent, and the sub-tropical and tropical climates obtaining in more than half of the Commonwealth make the use of preservation essential even for short-term storage.

Thus, both for export and internal markets, Australia has a vital interest in ensuring that deterioration of perishable foodstuffs is reduced to a minimum during storage and transport, and that every effort is made to effect continual improvements in standards of quality.

Soon after the formation of C.S.I.R. in 1926, its Executive Committee realized that scientific research could help in solving many of the problems in the handling, processing and storage of foodstuffs. Accordingly, C.S.I.R. invited Dr. Franklin Kidd, a senior officer of the British Department of Scientific and Industrial Research, to advise it on the programme of investigations which might be undertaken and the organization required to carry out the research work involved.

Owing to the onset of the trade depression in 1930, the scheme recommended by Dr. Kidd could not be implemented. In the meantime, however, several isolated investigations, including work on the ripening and transport of bananas and the freezing of beef, were carried out by the Council, under the direction of the late Professors W. J. Young and L. S. Bagster.

Early in 1932, the Council adopted a limited scheme of organized investigations and established a Section of Food Preservation and Transport.

Dr. J. R. Vickery was appointed Officer-in-charge, and initially the other officers were Mr. E. W. Hicks, Mr. W. A. Empey, Mr. N. E. Holmes (now at the British Ministry of Food) and Dr. S. A. Trout (now Director of Horticulture, Department of Agriculture and Stock, Queensland). Professor W. J. Young retained his connection with the work as Advisor on Food Preservation.

With the limited amount of money then available, only the most pressing work could be undertaken and restricted laboratory facilities provided. As the Council did not have sufficient funds to build laboratories for the new Section, the Officer-in-charge was instructed to enlist the help of outside organizations in securing laboratory accommodation for meat preservation and deciduous fruit storage investigations. The Queensland Meat Industry Board generously offered to bear most of the cost of establishing a small laboratory for meat investigations and in the course of only four months two laboratory rooms and four refrigerated chambers were built at the Q.M.I.B. Abattoir, Cannon Hill, Brisbane. The Victorian Department of Agriculture provided accommodation in Melbourne for fruit storage investigations to be carried out jointly with its staff. So, in two widely separated cities teams of investigators settled down to their respective studies, which have continued more or less uninterrupted since that time.

At the Brisbane laboratory, the main subject of study up to 1939 was the conditions of handling, cooling and transport required for the safe export of chilled beef to the United Kingdom.

In Melbourne, the cooperative investigations with the Victorian Department of Agriculture were concerned mainly with the storage and ripening of apples, pears, plums and peaches. Very notable contributions were made to the techniques of the storage and ripening of pears.

After about 1928 there was a rapid increase in the production of oranges in Australia and, consequently, a need to increase exports. Rather severe wastage was often experienced in the export consignments, particularly to England, and there arose a demand for research work on the problems associated with the handling and storage of this fruit. Extensive investigations, in which this Division and the Departments of Agriculture of New South Wales, Victoria and South Australia co-operated, were commenced in 1935 and continued for five years.

With the lifting of the trade depression, it became possible for the Council to put into effect some, at least, of its plans for an attack on a wider range of problems in the handling, processing, storage and transport of foods, through the provision of relatively large central laboratories. Buildings were provided by the Metropolitan Meat Industry Commission at the Homebush Abattoir, Sydney, and they were altered by the Council to provide a considerable number of laboratories and 15 cold rooms capable of maintaining temperatures in the range $-30°$ to $+50°$ C.

These central laboratories were occupied in 1938 and general chemical, physical and microbiological studies were commenced on refrigerated transport, the storage of meat, fish, eggs and fruit and the processing of fruit products. In the meantime, the work of the Brisbane and Melbourne laboratories was continued.

The staff and facilities of the Homebush laboratory were being steadily built up when serious developments in the World War in 1940 caused a rapid expansion of activities. As a result the Section of Food Preservation was raised to the status of a Division. The demands of the war also caused considerable reorganization of the staff and of research plans.

The help of the Division was sought by the authorities responsible for the supply of foodstuffs to the fighting forces. Assistance was afforded through the solution of technical problems encountered by the manufacturers of processed foodstuffs, through studies of the keeping quality of "defence" foodstuffs under a wide range of climatic conditions, through general physical studies on storage and transport and through special studies on the fabrication and performance of metallic and non-metallic containers.

Since for "defence" foodstuffs the emphasis was on canned and dehydrated foods rather than on preservation by cold, the reorganization required the setting-up of new sections on canned foods (particularly vegetables) and dehydrated foods (vegetables, meat and eggs). As the staff and facilities could not be expanded greatly to meet these new requirements, the position was met by greatly reducing the staff engaged on the problems of cold storage of meat, fish and fruit. In this connection it was necessary to withdraw the Division's staff from the cooperative fruit storage investigations in Melbourne.

At the close of the War in 1945, it was decided to retain the canning investigations as a permanent feature of the Division's work and to complete long-term investigations which were started during the War and which were necessary to supply basic scientific data hitherto not available. At the same time an endeavour was made to resume investigations on the handling and cold-storage of fruit, fish, eggs and meat and on the general physical problems of storage and transport by rail and ship. Notable progress has been made in investigations on fruit and eggs, but work on fish, meat and transport is still restricted by shortages of staff and facilities.

While the Homebush laboratory will continue to be the main centre for the Division's investigations, plans are well advanced for the establishment of more branch laboratories in several major food-producing areas in various States. In conjunction with the N.S.W. Department of Agriculture, a small laboratory recently opened at Gosford will be used for the study of the handling, processing and storage of citrus fruits. It is hoped shortly to commence investigations on the preservation of fish and fruit at the Council's Regional Laboratory at Hobart, and negotiations are now in progress for the erection of a small laboratory for fish preservation studies at a major fishing port in New South Wales.

When these laboratories are in operation, most aspects of the preservation of meat, fish, eggs, fruit and vegetables will be studied. In Melbourne, the Council has its Dairy Research Section to study the processing and preservation of milk products. Thus, the cereal industry is the only important food industry not being catered for by C.S.I.R. However, the State Departments of Agriculture are engaged in some research work in this field.

The work of the Division of Food Preservation and Transport has been made possible not only by liberal grants of money from the Commonwealth Treasury but also by continuing financial support from many public and commercial organizations. Many sections of the food industry have also given essential help to the research workers by providing large-scale facilities whereby the results of laboratory investigations have been tested commercially. The continued help received from industry is, in some measure, indicative of the value of the Division's work.

An Account of Research Work in the Division of Food Preservation

In the following pages an account is given of investigations which have engaged the attention of the Division. Reference is made mainly to the work of the last ten years, but earlier investigations have been included where this was necessary for the appreciation of more recent work.

It will be observed that the headings under which investigations are described do not correspond to the organizational units of the Division. Investigations on transport, for example, have been described as a unit, though the work has concerned both the Physics Section and the Fruit and Vegetable Storage Section. While this method of presentation gives the clearest picture of a research, it causes the work of some Sections of the Division to appear more restricted than it is in reality.

(1) Preservation of Meat

Although Australia normally exports only about 20 per cent. of its total meat production, the quantity is large, amounting to over 200,000 tons per annum, and the maintenance of this export trade is vital to the economic stability of the meat industry and to the feeding of the British people. Queensland exports nearly 50 per cent. of its total beef production, is responsible for about 90 per cent. of Australia's beef exports, and is contributing an increasing proportion of the beef supplies for the southern States.

In these export and interstate movements of meat, chiefly preserved by chilling or freezing, there have arisen a large number of difficult technical problems in preparation, cooling, storage and transport. Owing to the importance of the industry, the Division of Food Preservation has always devoted a considerable proportion of its resources to a study of these problems, particularly concerning beef.

Freezing of Beef

Under the auspices of the Institute of Science and Industry, which preceded the present Council, pioneer investigations were carried out on the effects of the rate of freezing on the formation of "drip" from frozen and thawed beef muscle. It was shown that "drip" was virtually eliminated by extremely fast rates of freezing, such as could be obtained by freezing relatively small pieces of beef in liquid media at temperatures of lower than $-40°$ F. The results clearly indicated, however, that the elimination of "drip" in normal units, such as beef quarters, was impracticable because sufficiently high rates of freezing could not be attained by procedures commercially possible.

After the formation of the Council in 1926, W. A. Empey showed that an increase in the hydrogen ion concentration in beef muscle, post-mortem, due to the formation of lactic acid from the glycogen normally present in living muscle, was a controlling factor in the formation of

" drip ". In general, the lower the hydrogen ion concentration the lower was the " drip ". This important observation may yet provide a clue to the means by which this troublesome defect in frozen and thawed beef can be eliminated.

Since the early work of Empey, only occasional investigations on the problems of freezing and thawing have been carried out by the Division.

During the War, investigations which defined the desirable conditions of preparation, packaging and freezing of special boneless cuts of beef packed in 60 lb. cases were of considerable assistance to the fighting forces in organizing meat supplies.

Export of Chilled Beef

In the pre-war years, Argentina, Australia's chief competitor in the British beef market, was able to export most of its beef in the chilled condition, thereby avoiding the formation of " drip ". But because of the much longer sea voyage, Australian beef could be sent to Great Britain only in the frozen condition, and in the early thirties the trade was beginning to languish.

When the Division's meat preservation laboratory was established in Brisbane in 1932, the major assignment was to define conditions of handling, cooling, storage and transport of chilled beef which would prevent deterioration during a normal voyage from Queensland ports to Great Britain, that is about 50 to 60 days, a period at least double that for a voyage from Argentina.

The Brisbane investigators based their studies on a discovery by workers at the Low Temperature Research Station, Cambridge, that the use of a storage atmosphere containing 10 per cent. carbon dioxide, a procedure known as gas storage, considerably prolonged the " life " of chilled beef. The Cambridge results were confirmed, but it was found that successful gas storage of beef for 50 days depended upon reducing the initial microbial contamination on the surface of the beef to a low level. Extensive microbiological and physical studies indicated the need for high standards of hygiene during slaughter, dressing and cooling, and for rapid cooling with high rates of forced air circulation. Adoption of the recommended techniques by the Queensland meat works and the refrigerated ships resulted in the successful carriage of gas-stored chilled beef to Britain. The amount of beef transported in the chilled form increased steadily until in 1939 it represented one-third of Australia's quarter-beef exports.

There remains a problem concerned with a loss of " bloom " or normal appearance of the meat which occurs during the long voyage. While this problem still awaits solution, the Brisbane workers obtained evidence that within certain limits the higher the rate of loss of moisture, the lower was the rate of loss of bloom.

Gas storage using carbon dioxide has the disadvantage that special gas-tight cargo spaces are required on shipboard. The use of ozone in low concentrations, which would not require gas-tight storage spaces, has often been suggested as an alternative. Investigations of the effect of ozone showed that while five parts per million applied intermittently could give some control of microbial growth, it also caused the development of off-flavours in the fat and poor colour in the flesh. Further studies are proceeding on the effect of extremely low ozone concentrations (less than one part per million).

Dehydrated Meat

By dehydrating meat the need for cold storage is avoided, and considerable savings are made in packaging materials as compared with canned meats. Dehydrated meat, therefore, became an important product during the war years. Mr. J. Cresswick, of the State Abattoir, Sydney, suggested a technique of preparation, and this Division co-operated with him in developing the technique and in testing the storage life of the product under different conditions. The method was used on a large scale in Australia during the War to prepare dehydrated mutton for the fighting forces.

Subsequently, all phases of meat dehydration technique were subjected to detailed study by the Division's officers in an endeavour to obtain a dehydrated product of better quality. It is now possible to define conditions of preparation and drying whereby this result can be obtained.

Canned Meat

Since the formation of the Canning Section in 1940, numerous bacteriological and chemical studies have been made on problems arising in the preparation of canned meat packs, particularly those containing cured pork.

Meat Extract

Manufacturers of meat extract attempt to "finish" it at a pre-determined moisture content, but the usual gravimetric methods of determining this value are slow and it is often left to the sometimes faulty judgment of the processor to determine when to stop the final evaporation of moisture. To overcome this difficulty, a rapid, hydrometric method for the determination of moisture content has been devised.

Other chemical problems associated with meat extract are being investigated, including the conditions giving rise to the formation of hard granules and "glass".

Work in Progress

The present programme for research on meat preservation includes investigations on the accelerated ripening or conditioning of beef, fundamental and applied studies on the loss of bloom in chilled beef, and the sterilization of meat storage spaces by aerosols.

(2) Transport

Rail Transport

From its inception the Division of Food Preservation and Transport has maintained an active interest in food transport problems. In the years 1929-31, an investigation of the carriage of bananas in louvred rail cars from Queensland to Melbourne was undertaken in collaboration with officers of the New South Wales Government Railways and with cooperation from the Victorian and Queensland Railways. The work was continued in 1932-34 mainly by C.S.I.R. officers.

Further work on ventilated cars used for the transport of fresh fruits and vegetables has been carried out in the last two years and more is planned for the near future. The main objects of this later work are:

(1) to compare the efficiency of different designs of louvred cars,

(2) to determine the reasons for observed temperature changes more completely in order to assist in the design and testing of new cars, and

(3) to explore the possibilities of improving conditions for some products by altering the type of package or the method of stowing in the car. Interest has been mainly in beans and peas, and the main work done so far has been a comparison of the out turn of beans packed in bags and cases.

Transport in refrigerated rail cars has also been studied and further investigations are planned. The main problems examined so far have been the carriage of chilled meat from Brisbane to southern markets and the carriage of export frozen meat from meatworks to the ships' sides. There are likely to be considerable changes in the numbers and types of Australian railway refrigerated cars in the next few years, and we are aiming not only to assist in solving existing or new problems in the transport of foodstuffs but also to collect fundamental data on the performance of cars which can be used by the Railways Departments to develop improved designs for cars.

Transport by Sea

Problems of transport of foodstuffs by sea also occupied the Division early in its history. In this work, too, we have collaborated closely, with other bodies, particularly the British Food Investigation Board, shipowners' organizations, exporters and, more recently, the newly formed Refrigerated Cargo Research Council in Great Britain.

Officers of the British Food Investigation Board began a study of methods of improving the control of conditions in refrigerated holds some 25 years ago, and the work is continuing under the direction of the Refrigerated Cargo Research Council. From time to time officers of the Division have taken part in investigations initiated by the British workers, and we have received a great deal of assistance from them in studies which we have originated.

The chief matters investigated have been:

(1) methods of obtaining a high degree of uniformity of temperature and rapid initial cooling of the cargo,
(2) temperature distributions, particularly with pear cargoes, in shallow 'tween decks cooled in various ways,
(3) control of temperature, CO_2 concentration and rate of evaporation in chilled beef lockers,
(4) prevention of dangerous accumulation of CO_2 in apple cargoes in the first few days after loading,
(5) temperature rises in frozen cargoes during the loading of a hold,
(6) temperature distribution in lower holds carrying frozen cargoes.

In addition to experiments designed primarily to study the physical conditions in ships' holds, a number of trial shipments of produce were made chiefly to study the behaviour of the cargo itself. Temperature histories of some of the experimental material were, however, obtained at the same time. The chief purpose of experimental shipments of fruit and eggs was to check predictions of the behaviour of the cargo based on land storage tests. Trial shipments of chilled beef were made with a rather different purpose, namely to obtain information on the effect of a number of factors on the condition of the beef on arrival in England. These factors included length of voyage, evaporation during carriage, and the initial quality of the beef and its treatment before shipment. With the return of normal shipping conditions between Australia and Great Britain, an export trade in perishable foods transported in refrigerated ships has been resumed and it is certain that this Division will again be called upon to assist in the solution of technical problems which arise.

(3) Storage amd Handling of Fruit

Investigations in this field have been an important part of the work of the Division for many years and have been carried out in close co-operation with the State Departments of Agriculture, particularly those of Victoria and New South Wales. Prior to the opening of the Homebush laboratories in 1938 most of the experiments were carried out in laboratories and experimental cold rooms at the Government Cool Stores, Melbourne, in conjunction with the Fruit Storage Officer of the Victorian Department of Agriculture.

The New South Wales Department of Agriculture is actively associated with the fruit storage work at the Homebush laboratories, most of the investigations being carried out jointly by officers of the Division and the Fruit Storage Officer of the Department.

Citrus Fruits

Because of serious wastage in Australian oranges exported to the United Kingdom, a five-year programme of investigations into the handling and storage of citrus fruits was commenced in 1935. The work was carried out in co-operation with the Departments of Agriculture of New South Wales, Victoria and South Australia and the Universities of Melbourne and Adelaide. All phases of handling and processing were investigated and a detailed study was made of the effects on cool storage life of a wide range of factors such as variety, maturity, cultural and handling practices and temperature of storage.

Wastage in Australian oranges during refrigerated transport overseas or during cool storage in Australia has been found to consist mainly of serious skin blemishes, of which storage spot or pitting is the most important. Mould wastage is often serious under refrigeration and it is the main cause of wastage at higher temperatures. The requirements for the control of mould wastage are now well established, the most important being avoidance of injuries to the skin and of contamination with mould spores by strict attention to care and sanitation during handling operations. Chemical antiseptics can be used and refrigerated storage should be employed whenever practicable.

The development of storage spots has been shown to be due to low temperature injury associated with the activity of latent fungal infections in the skin. Although a great deal of information has accumulated on the effects of many factors on this type of wastage, its control still remains a problem. The best storage conditions are those which avoid cold injury while not encouraging mould wastage and staling of the fruit, and a temperature of 38-40° F. is found generally to be the best compromise. Loss of condition due to wilting can be serious in long storage or distant marketing. It has been shown that certain commercial handling treatments increase wilting considerably and that it can be greatly reduced by waxing and by suitable handling methods.

THE STAFF AT HOMEBUSH.

BACK ROW: J. Shipton, D. McBean, A. Martin, R. Millington, S. Sykes, D. Ohye, P. Bond, A. Telfer, P. Maguire, R. Edwards, C. North, B. Chandler, P. Thompson, M. Smith, G. Rostos, A. Howard, T. Swan, F. Fitzpatrick, W. Barnes, R. Mitchell.

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FRONT ROW: J. Babicci, B. Whitcher, N. Taylor, T. Butler, C. Robins, J. Lipscombe, R. Fergusson.

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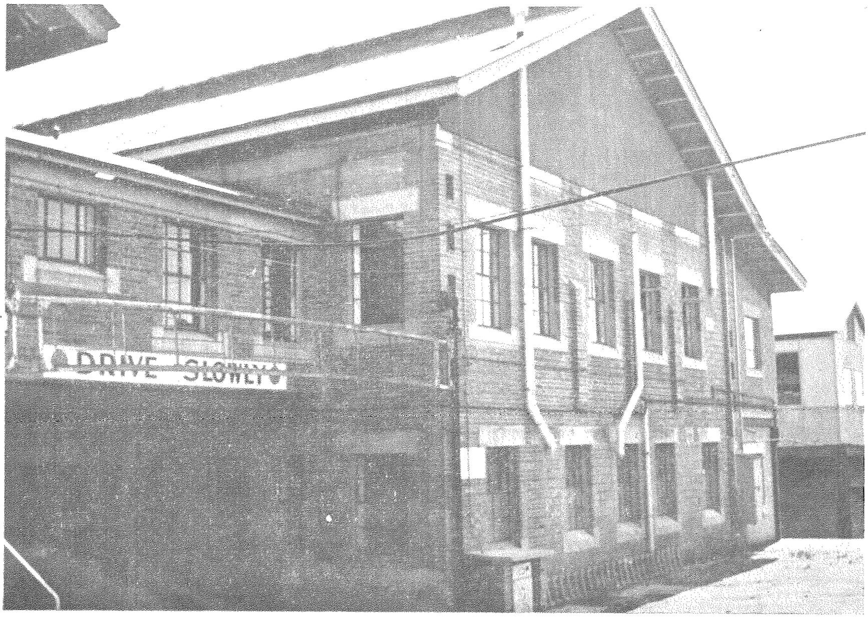
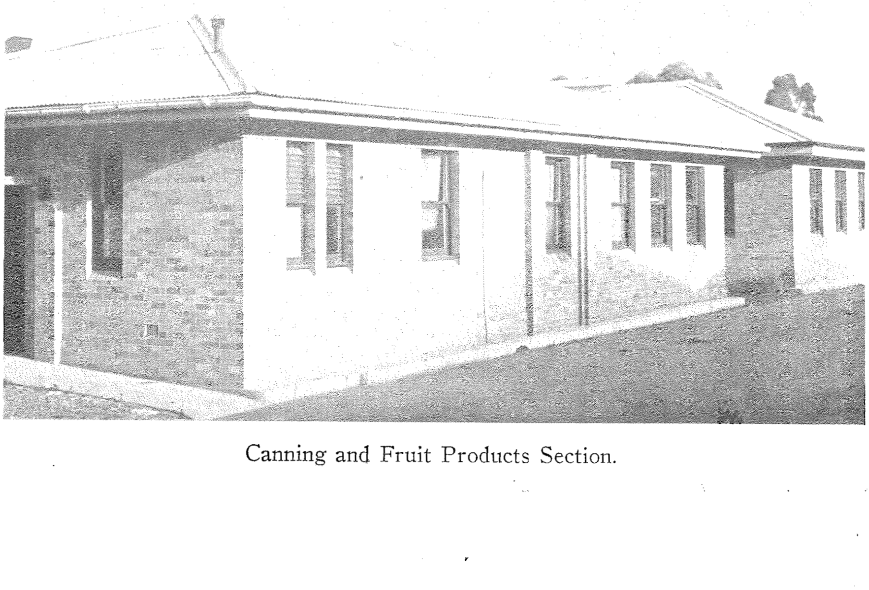
THE HOMEBUSH LABORATORIES.



Main Block.



Canning and Fruit Products Section.

Apples

A thorough investigation of the cool storage of the Jonathan apple, which is the principal variety grown in Victoria, was the main project studied in Melbourne. It was found that the serious storage disorder, soft scald, was a low temperature injury and could be controlled by storage at 36° F. for the first few weeks and then subsequently at 32° F. The storage life of Jonathans was greatly increased by gas storage at 36° F. in an atmosphere containing five per cent. of carbon dioxide. The effect of gas storage was tested over several seasons with a number of other varieties, but only some of these responded favourably.

During the first few years at Homebush, research on apple storage was mainly concerned with investigating the effects of various factors on the storage life of the leading New South Wales varieties. Commercial practices have been found to be generally satisfactory, but storage at a temperature of 32° F. instead of the usual 33-34° F. was found to increase storage life and decrease the susceptibility to storage disorders. The relatively short storage life of large fruit and of fruit from light crops was demonstrated. The results of the Victorian work on Jonathans were confirmed with New South Wales fruit, but the behaviour of other varieties was somewhat different. The gas storage of Jonathans can be safely recommended, but further work on other varieties is needed. More recently, the fundamental storage problem of variability in behaviour of the fruit between seasons, between districts and even between single trees in one orchard is being investigated and this work will be continued for some years.

Since 1941 extensive investigations into the use of skin coatings for prolonging the storage life of apples have been carried out at Homebush and in other States in cooperation with the Departments of Agriculture. A detailed physiological study has been made of the effects of skin coatings on the metabolism of the apple ; the Botany Department of the University of Sydney actively assisted with this phase of the work. Many coatings were tested with several varieties from various localities over a number of seasons in both cool storage and common storage and the effects of skin coatings have been closely compared with those of gas storage.

It has been found that if apples are coated with a very thin film of wax, oil or other protective substance, which can conveniently be applied by dipping the fruit in solutions or emulsions and allowing to dry, their storage life may be prolonged considerably, yellowing and shrivelling being greatly retarded and wastage from certain disorders reduced. Unfortunately, experimental results have been so variable and the effects of coatings have been found to depend on so many factors that this promising new storage technique cannot yet be recommended for commercial application.

Pears

As a result of work commenced in Melbourne and continued at the Homebush laboratories, the gas storage of pears has been developed to a stage where it can be successfully applied commercially. In an atmosphere containing five per cent. of carbon dioxide, which can be built up and maintained by controlled ventilation of a gas-tight store, the life of some varieties may be as much as 100 per cent. greater than in air. The importance of prompt storage, quick cooling and the maintenance of uniform low storage temperatures has been demonstrated. Investigations at Homebush have shown that in air storage pears keep much longer at 30° F. than at a temperature of 32° F.

Stone Fruits

Work on the cool storage of plums and peaches, initially at Melbourne and also later at Homebush, has been mainly concerned with investigating the possibilities of satisfactory export of these fruits. In general, their cool storage life is relatively short and is terminated by failure to ripen normally after removal to a suitable ripening temperature. In common with pears, stone fruits ripen best at a temperature of approximately 65° F. With plums, holding at 32° F. for a short period and then raising the temperature to 45° F., at which temperature they will ripen slowly but normally, will enable a number of varieties to be exported safely and to ripen satisfactorily in England. Only certain varieties of peaches, grown in Victoria, will keep long enough in cool storage to make distant export possible, but work at Homebush has shown that nectarines have a longer cool storage life and could be safely exported. Gas storage was found to be of no value for soft fruits, but in air storage life was significantly longer at 30° F. than at 32° F.

Tropical Fruits

The transport and ripening of bananas was thoroughly investigated some years ago and, as a result of this work, the commercial handling and ripening of bananas in Australia can be carried out most successfully. Recently the handling and ripening of papaws has received some attention, but little can be done while two important field problems remain unsolved : (1) variability in fruit type and quality, and (2) the high incidence of latent fungal infections.

(4) Fruit Juices

A need for developmental work on the utilization of surplus and cull fruit, which became apparent to Mr. L. J. Lynch in the course of his work as Citrus Storage Research Officer, prompted the initiation of investigations on the preservation of fruit juices. In the original equipment of the Homebush laboratory there was included a small-scale set-up for canning fruit juices, and a research programme was undertaken which represented the first activity of the Division in the field of food preservation by canning.

At first the work was confined to orange juice canning and among the early projects were varietal studies and can lacquer investigations. With the assistance of a local manufacturer, a lacquer was found which had the protective qualities and freedom from taint required in an internal coating for fruit juice cans. Varietal studies confirmed American experience that Washington Navel oranges are unsuitable for juice manufacture because of a characteristic bitterness which appears in the processed juice. Valencia oranges produced the best canned juice and, of the common oranges tested, the domestic variety Parramatta was most promising.

In 1940, fruit juice investigations were transferred to a new laboratory, adjacent to the main laboratory, which was equipped with a comprehensive range of pilot-scale equipment. Included were a citrus juice extractor, a grater mill and hydraulic rack and cloth press, a continuous centrifuge, a Seitz filter, a set of six stainless steel pressure vessels for Boehi storage, a de-aerator, a plate-type pasteuriser, and a vacuum can closer. With this equipment a considerable extension of fruit juice work was possible, and since that time experimental packs of a wide variety of products have been prepared—apple, pineapple, grape, tomato, prune and passionfruit juices, in addition to the citrus juices, and also pulpy juices or nectars prepared from peaches, apricots or tropical fruits. Varietal and blending trials were involved and exploratory work to determine the most satisfactory processing procedure for each type of product.

Concurrent with the interest of the Division of Food Preservation in fruit juice canning, there was some activity in the commercial field, at first mainly in the production of bottled apple juice. In order to encourage the maintenance of high quality standards in fruit juices, the Division instituted, in cooperation with the Apple and Pear Marketing Board, a Certification Scheme under which a Seal of Approval was granted to apple juices and ciders of satisfactory quality.

Commercial canning of orange juice commenced during the War years when the U.S. Army placed large local orders, which were met by a production programme organized very largely by officers of the Division. About twenty manufacturers of cordials were encouraged to instal juice canning lines incorporating equipment for de-aeration and flash pasteurisation developed at Homebush. Juice production, first in bottles and then in cans, reaching 2,000,000 gallons per season, was achieved over several seasons. Not only orange juice but also grapefruit juice, blended orange and grapefruit juice, lemon juice, apple juice fortified with vitamin C, and blackcurrant syrup were canned.

With the cessation of war-time demands, juice production declined, and at the present time canning of citrus juices is confined to the Murray Valley. Since 1945, therefore, there has been a diminishing need in the industry for day-to-day assistance and it has been possible to take up the study of fundamental problems in fruit juice preservation which war-time experience had revealed. Some of the difficulties encountered had been capable of rapid solution, for instance the breakdown of internal can lacquers in citrus juices containing excess peel oil; but there are two outstanding problems associated with the quality of canned orange juice which appear to require long-term study and which are also occupying research workers in several centres overseas.

The first of these problems is that of bitterness in Navel orange juice, which makes about half of Australia's orange crop unsuitable for juice production. The bitter principle, limonin, has been isolated in pure, crystalline form and its chemistry is being studied in the hope that this will lead to a method for the elimination of bitterness. One intriguing aspect of this investigation was the discovery that bitterness, due to limonin, also appeared in the juice from mature Valencia oranges which had been sprayed with copper-containing fungicidal sprays.

The second major problem referred to is the rapid development of a "stale" flavour in canned orange juice at storage temperatures above about 60° F. The chemistry of this flavour change is obscure, but it is generally regarded as an oxidative reaction. Following the working out of a rapid polarographic method for the determination of oxygen in orange juice, it was found that flavour deterioration occurred even in the complete absence of free oxygen.

This finding led to a reconsideration of the recommended procedure for commercial canning of orange juice and it was decided that deaeration is unnecessary. A further modification which has led to an improvement in quality is the substitution of cold filling and " in the can " pasteurisation for flash pasteurisation and hot filling. Rapid heat transfer during " in the can " pasteurisation is achieved by rotating the cans. The use, for this purpose, of a simple piece of equipment, in which the cans are spun by friction on an inclined moving belt, is being examined. High-speed cinematographic shots of rotating transparent cans have been taken to assist in the determination of the optimum speed of rotation for greatest agitation and quickest heating.

Future work on orange juice will be directed towards elucidation of the chemistry of the development of stale and bitter flavours. From most other fruits, canned juices of acceptable and stable flavour can be prepared according to established procedures. Following the successful marketing in America of several varieties of blended fruit juices, a number of attractive blends of apple juice with berry juices, lime juice, grapefruit, pineapple and passionfruit juices have been canned and will be introduced to the industry in this country.

A programme of research on techniques and equipment design for fruit juice concentration is also planned since there are prospects of profitable export outlets for concentrated apple and orange juices, particularly in Great Britain.

(5) Canning of Fruit and Vegetables

As indicated in the previous section, the earliest work on canning at Homebush was concerned with fruit juices. Expansion during the war period (1939-45) into the wider field of general food canning was inevitable, in order that some contribution could be made to the problems associated with the supply of food to the armed services.

One of the first wartime projects to be undertaken was related to the prevention of outbreaks of scurvy amongst Allied servicemen in the Pacific area. The work led to a general investigation of canned foods reputedly high in ascorbic acid, to modifications in processing procedures designed to reduce losses of the vitamin, and to means of fortifying suitable foods with synthetic vitamin. The use of canned broccoli was advocated, since the amount of ascorbic acid in the green sprouting variety when processed was found to be in the range 30 to 40 milligrammes per centum, of which 80 to 90 per centum was retained after storage for one year at room temperature. Canned broccoli was classed as an attractive vegetable but it was never grown in sufficient quantity to contribute materially to the prevention of dietary deficiencies.

Extensive plantings were made of silver beet, which in the fresh state contains up to 75 milligrammes per centum of ascorbic acid, but which has a mean content when commercially canned of less than 10 milligrammes. Modifications of the processing schedule increased vitamin retention appreciably. Similar improvement was effected in canned cabbage and tomatoes, but vitamin retention was never improved to the point of regarding these products as useful antiscorbutics in the army diet. This rôle was played by canned citrus juices and by artificially fortified canned apple juice. Problems relating to these juices are described in the preceding section.

From 1942 to the close of the War the Canning Section was called upon to provide solutions to problems of production, to advise military and civil authorities on technical aspects of canned foods, to assist in the formulation of food standards and specifications, and for a time to carry out the laboratory examination of canned foods for the whole of the Commonwealth. Subsequently close cooperation was maintained with Commonwealth Food Control, a wartime section of the Commonwealth Department of Commerce and Agriculture. These activities were to prove of ultimate value in the sphere of research, since they provided a means of acquainting research officers with a wide variety of canned foods, and with the difficulties involved in their production. Access to imported canned goods during this period also presented an opportunity to establish with certainty the comparative quality level of Australian foods.

From 1944 onwards special emphasis has been placed on quality improvement as a contribution to the post-war development of the canning industry. In this connection tomatoes, sweet corn, peas and peaches have perhaps received the greatest consideration.

Repetition of varietal work with tomatoes over four seasons has demonstrated that a number of existing varieties are equally suitable for canning when picked at correct maturity. Selection of a variety for commercial use, therefore, should be based on its response to the locality in which it is grown. Tomato investigations have shown the necessity to breed canning types for Australian conditions along lines that can now be clearly defined.

Sweet corn investigations were associated from their commencement with the first large-scale commercial production unit in Australia. The aims of the work, which was commenced in 1944, were to establish optimal picking maturity and to devise rapid and practical means of maturity assessment. The methods employed were based on conventional American practice, and the value of the refractive index determination as a measure of maturity was confirmed. One small scale variety trial has been undertaken, and its result suggests that Ioana is a suitable commercial type for the Windsor (N.S.W.) area.

The critical nature of picking maturity for best quality canned sweet corn led to an investigation of the possibility of predicting the maturity date. In spite of lack of climatic uniformity, it was found possible to predict with fair accuracy ten days prior to picking.

Pea canning work, which has been carried on since 1945, has followed an experimental pattern similar to that of sweet corn, in so far as the critical picking date for best canning quality requires the use of a rapid method of maturity determination together with pre-knowledge of the time of harvest. A small instrument known as the Maturometer has been developed and tested to give satisfactory maturity indication. Maturity prediction is more complex than in the case of sweet corn and has not yet been attempted.

Experimental investigation of the suitability of a range of clingstone peach varieties for canning was prompted by the desire of commercial canneries to extend the canning season, and to smooth out the embarrassing peak period that occurs during the harvesting of the Golden Queen variety. The problem was followed for two seasons at Leeton (N.S.W.), after which work was transferred to Shepparton (Victoria). Some sixty varieties have so far been tested with some indication of success. It will be necessary to follow the more useful varieties for some years to determine changes with time.

Concurrently with clingstone varietal investigations, quality improvement work has been undertaken, largely from the viewpoint of advancing picking maturity and reducing the cooking period in the can. Flavour and texture of the resulting products appear to be more attractive than in the commercial pack, but it remains to be seen whether these gains are offset by increased difficulties in the matter of transport and storage.

A notable increase in popularity of the canned freestone peach in U.S.A. has been responsible for initiating work in Australia intended to provide information on handling techniques, and to determine the suitability of local varieties for canning. Eighteen varieties have been tested to date, four of which, when canned, bear favourable comparison with freestone samples imported from America.

The canning of rockmelon is a final item worthy of mention. Eighteen varieties have been canned over several seasons and the product has been accorded favourable consumer acceptance. Both freestone peaches and rockmelon are critical as to maturity for satisfactory quality in the can.

(6) Dehydration of Fruit and Vegetables

Dehydration of fruit and vegetables has been practised for many centuries, but it was only during the 1939-45 war that any notable technical advances were made. The shortage of tinplate and of shipping space created a demand for foodstuffs of minimum weight and bulk, and dehydration was the process which best fulfilled the requirements. It immediately became apparent that existing knowledge was totally inadequate and research programmes were initiated in most of the combatant countries to fill the many gaps.

Vegetable Dehydration

Investigations in this laboratory started in 1941. The construction of a small cabinet type drier enabled studies to be made under controlled conditions of temperature and air-flow. The data derived from these experiments were used in the design of the early commercial dehydrators erected under the supervision of the Australian Department of Commerce. Subsequently officers of that Department and this Division investigated air movement and temperature distribution in relation to drying rates in commercial dehydrators of various designs. The effect of structural modifications was studied and the results used to improve the performance of the tunnels. Data were also obtained on thermal efficiency under various operating conditions.

Early in the War English workers found that blanching in boiling solutions of sodium sulphite was highly successful. Experiments in this laboratory indicated that steam blanching, which is preferred in large-scale commercial practice, was at least equally satisfactory, and it was adopted as the standard technique. Sulphiting was effected by dipping or spraying with sulphite solutions before or after blanching.

The requisite blanching and sulphiting procedures were established for cabbages, potatoes, carrots, silver beet and green peas. Techniques were also determined for processing beetroot, which is usually cooked before drying and is not sulphited, and onions, which are neither blanched nor sulphited. Some data were also obtained on parsnips, parsley, sweet potatoes, sweet peppers and swede turnips. As the work progressed, improved equipment was installed and detailed studies were made of the effect of varying, both individually and simultaneously, such factors as temperature and duration of drying, blanching and sulphiting.

The quality of the dried product was the criterion of the efficiency of processing. This was assessed in terms of its appearance when dry and its cooking quality. Determinations were made of sugar, ascorbic acid and carotene, where they were present in appreciable amount, and of other constituents which could serve as indices of quality, such as volatile sulphur in onions and starch in green peas.

It became evident at an early stage in the processing investigations that the quality of the raw vegetable was one of the prime factors determining the quality of the dehydrated product. Consequently detailed studies were made of the suitability for dehydration of different varieties of vegetables. This work was carried out in association with several of the State Departments of Agriculture, the C.S.I.R. Division of Plant Industry, and the C.S.I.R. Research Stations at Griffith and Merbein. Potatoes, cabbages, carrots, onions, beetroot and green peas all received attention. In addition to purely varietal effects it was found that soils, cultural practice and other local conditions could profoundly influence the quality of the vegetables.

Dehydrated vegetables derived from varietal and processing investigations were used to study the behaviour of these products under various storage conditions. The results showed substantial agreement with those of other workers, viz. that storage life is primarily determined by the storage temperature and the moisture content of the product, and that some vegetables (e.g. carrots) should be gas-packed, whereas other vegetables (e.g. beetroot) keep for long periods when packed in air. More recently, detailed studies have been made with carrots, potatoes, cabbage, beetroot and silver beet to provide more precise data on the effects of time, temperature, storage atmosphere and moisture on deterioration, as measured by chemical and palatability tests. These studies have also provided data on the effect of variations in processing methods.

Fruit Dehydration

Investigations to test the application of lessons learned from vegetable dehydration to the dehydration of fruit were started in this laboratory in 1944. It was soon realized that the process offered much promise, and studies of varieties, maturity and processing methods as related to the quality and storage life of the dehydrated product were undertaken.

Data on varieties are still being accumulated, but it is evident that quite marked differences exist. It has been found that the best results are obtained with ripe fruit.

It is unnecessary to peel apricots, but peeling is definitely desirable for peaches and pears. It increases the rate and uniformity of drying, and yields an article of superior appearance and palatability. Blanching also reduces drying times and gives a product somewhat resembling sun-dried fruit but of greatly superior quality. However, culinary tests have shown some preference for unblanched samples, which are quite distinctive in the dried state, being opaque and of natural colour, as compared with the translucent appearance characteristic of blanched fruit.

Discoloration during drying and subsequent storage is controlled with sulphur dioxide. The conventional method is to place trays of prepared fruit in a box with burning sulphur. Treatment with solutions of sulphite or metabisulphite salts has been suggested as a more convenient alternative, but it has given unsatisfactory results with pears and doubtful results with peaches and apricots.

The fruit has been dehydrated in various forms. Halves of apricots, peaches and pears, quarters and slices (eighths to twelfths) of peaches and pears, and thin transverse rings of pears have all been used. The smaller subdivisions require a shorter sulphuring time, dry more rapidly (peach slices taking only 3-4 hours, as compared to 11-16 hours for halves) and reconstitute readily when cooked. The calculation of drying rates for various drying schedules has indicated that quite high starting temperatures may be used without causing case-hardening or loss of quality.

Comprehensive investigations of factors affecting the storage life of dehydrated fruit have been made. Data have been obtained on permissible moisture contents, the necessary initial sulphur dioxide concentrations, the rate of loss of sulphur dioxide in storage and the effect of temperature on storage life. An adequate initial sulphur dioxide content has proved the most important factor in determining storage life, moisture content being less important.

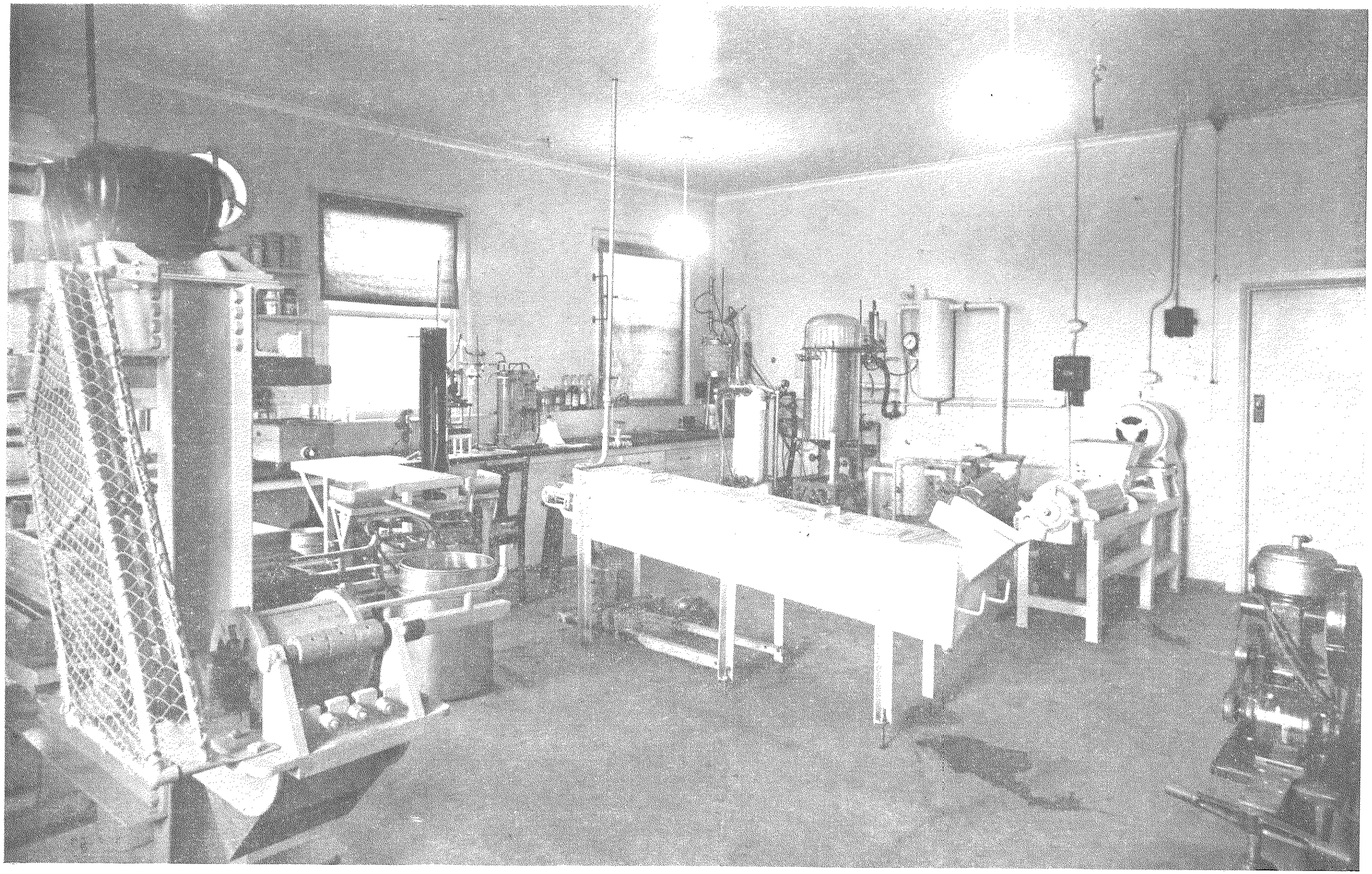
The production of sugared (or glacé) fruit by dehydration is also being investigated. The effect of the concentration and composition of the syrups in which the fruit is treated on the drying rate and quality of the dehydrated product is being studied. There are indications that the addition of sugar (especially non-reducing sugar) may improve keeping quality, and the storage life of such material is being tested.

(7) Preservation of Fish

The first work concerned with fish preservation was carried out by C.S.I.R. in Melbourne in 1928, when there was a growing interest in the application of rapid freezing to flesh foods in general. Studies were carried out over a period of approximately one year, dealing particularly with the characteristics of several species of Australian fish frozen at different rates and subsequently stored in the frozen condition. Because of limited staff and the need to undertake more pressing investigations, this work was discontinued and was not resumed until the year 1938. During the intervening years considerable progress had been made overseas in the development of improved laboratory techniques for studying the changes occurring in fish during freezing and frozen storage. By the employment of such methods the investigations carried out over a period of two years at the Homebush laboratory threw further light on the problems associated with the storage behaviour of Australian species of fish. In particular, this work embraced a study of the phenomenon of "denaturation" in the muscle proteins, leading to undesirable changes in texture of the flesh during frozen storage, and of the development of rancidity in the oils resulting in off-flavours in fish stored in the frozen condition.

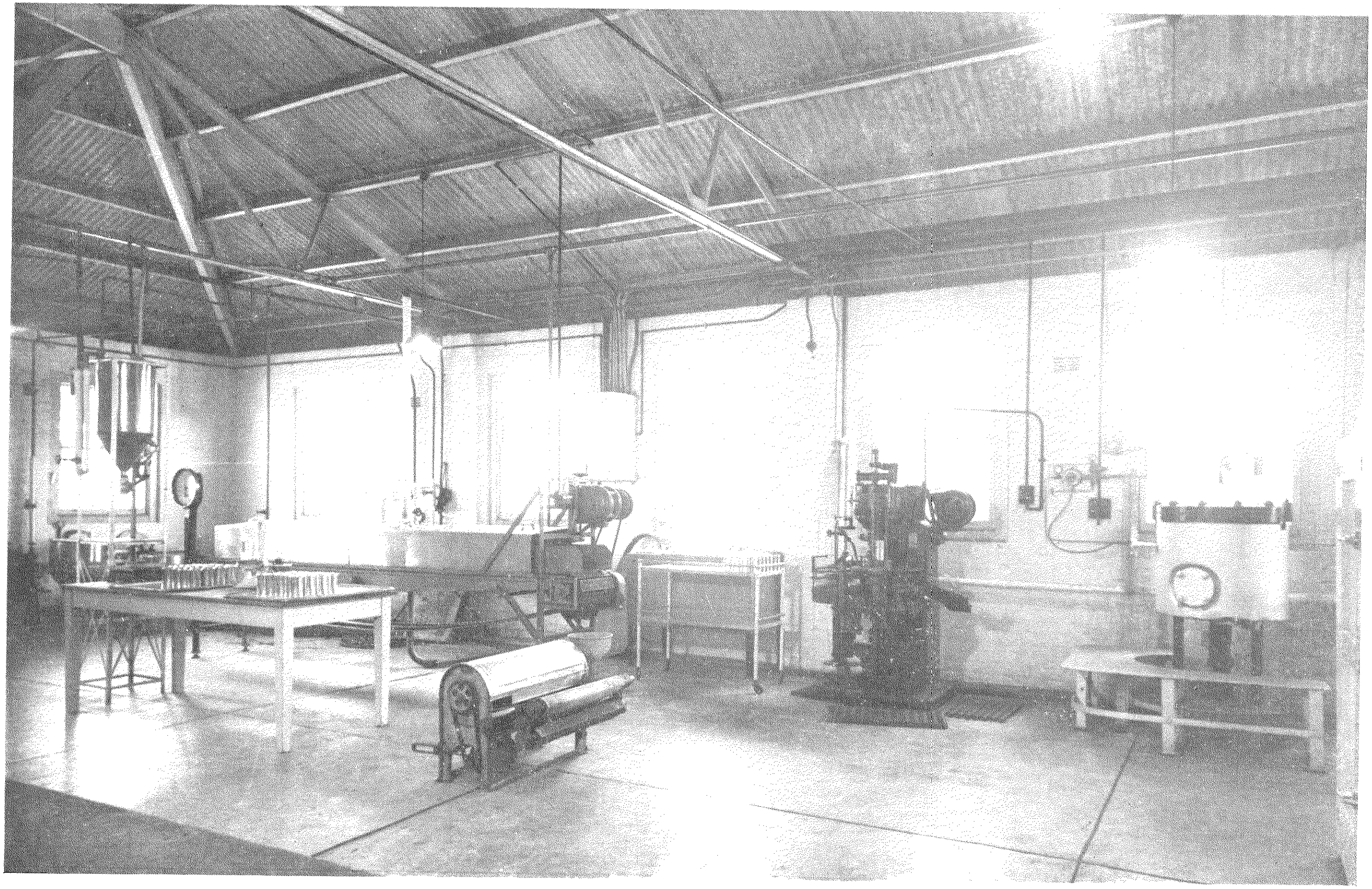
During the same period work was begun, in conjunction with the C.S.I.R. Fisheries Division, on the smoke curing of Australian species of fish. Large-scale smoking of fish overseas is carried out mainly in cooler climates than those of the Australian mainland and the difficulties encountered by Australian curers are due mainly to our relatively warm and humid conditions. The main objects of the work were to find out the highest temperatures and humidities in the kilns which could be used satisfactorily with the important Australian species, and to devise means of obtaining satisfactory conditions in unfavourable weather. It was found that mullet would stand relatively high temperatures in smoking, but some other Australian species seem just as sensitive to high temper-

PROCESSING FACILITIES AT HOMEBUSH.



Fruit Juice Equipment.

PROCESSING FACILITIES AT HOMEBUSH.



The Cannery. The equipment includes a steam blancher, a pea-huller, a can-closing machine, and a retort.

atures and humidities in the kilns as the main species handled in Europe and Canada. A small air-conditioned tunnel type of kiln was used for most of the investigations.

Due to conditions brought about by the 1939-45 War this work was suspended and canning became the only aspect of fish preservation which received attention. Investigations included studies on the suitability of various species of Australian fish for canning, the development of new products, and improvements in existing commercially canned packs.

Since the termination of the War there has been a rapid expansion in fish canning and the laboratory staff has tendered advice and assistance to the industry in the establishment of canneries and in the solution of various problems which arose from time to time. In addition a good deal of attention has been given to the special problem of spoilage due to the development of ammonia in the flesh of edible sharks.

The fish smoking industry has been assisted by advice on suitable methods for handling Australian species of fish and on the construction of forced circulation kilns. Work on the freezing of fish is to be resumed in the near future and, with the object of facilitating general investigations on fish preservation, laboratories and processing facilities are shortly to be provided at two large fishing ports.

(8) Preservation of Eggs

Shell Eggs

Experiments on the storage of shell eggs began in 1938, when it was known that losses, sometimes on a considerable scale, were occurring in eggs exported from this country to the United Kingdom. A comprehensive programme of experiments in each of the mainland States was then commenced in cooperation with the Australian Egg Producers' Council, to which body progress reports of investigations have since been made annually. The detailed results of the ten years' experiments are at present being prepared for publication, and the following is a brief account of the principal features of the work.

Some of the earliest experiments consisted of small experimental shipments which were compared with portions of the same consignment held in Australia for a similar period. It was shown that the out-turn of a particular consignment was substantially the same for exported eggs as for those stored in Australia. Such deterioration as occurred, therefore, could not be attributed to storage conditions in transit, but rather to conditions to which the eggs were exposed before they left Australia. Subsequently it was shown that most of the losses were due to rots caused by certain types of bacteria, and the main types were isolated and identified. The incidence of bacterial rots depended upon several factors, but primarily on whether or not the eggs were washed and on the method of cleaning which was used. For unwashed eggs the losses in storage were consistently low irrespective of whether the shells were clean or soiled at the time of gathering from the nests. This has been observed in many dozens of experiments in which the eggs have been held in cold store for about two to three months and examined subsequently three weeks after removal from cold store, the latter period being included to correspond to a period of marketing and distribution after refrigerated transport to the United Kingdom. Eggs washed by hand in various ways also remained substantially free from wastage, and losses rarely exceeded one per cent. when care was taken to prevent the immersion of eggs in fluids which were cooler than the eggs themselves. When, however, cleaning was done on various types of machines in use on poultry farms, it was found that wastage was frequently severe. Losses of over 50 per cent. were occasionally observed, and an incidence of spoilage of the order of 20 per cent. rots was very common. The reason for the deleterious effects of machine cleaning was shown to be due to the fact that the machines became infected with rot-producing types of bacteria which were transferred to the shells of the eggs. Immersion of machine cleaned eggs in strong disinfectant solutions was virtually without effect on the subsequent development of rots even though such disinfection was carried out immediately after cleaning. In other words it was shown that bacteria actually penetrated the shell at the time of cleaning, even though rots might not be apparent until weeks or even months later.

In view of the position stated above it would seem to be obvious that an effective control of rotting could be achieved merely by the elimination of washing, especially machine washing. This is indeed true, but with the present methods of poultry husbandry in Australia a considerable fraction of the eggs collected are soiled and some form of cleaning is necessary before these eggs are marketed. Furthermore, the shortage of labour on most poultry farms renders the use of machines attractive when large numbers of eggs require cleaning. For these reasons, therefore, some time was devoted to possible methods of overcoming the deleterious effects of cleaning machines. One of the methods tested was the use in machines of disinfectant solutions in concentrations sufficient to prevent infection of the eggs during the actual cleaning operation. A number of disinfectants was tried, but none proved to be effective unless used in inordinately large concentrations. This method of approach, therefore, failed to reveal a disinfectant which could safely be recommended to give uniformly satisfactory results under farm conditions. The second general method tested was the pasteurisation of the eggs in hot water, either during or after the washing operation. When the time and temperature of immersion were controlled within certain limits it was possible to obtain very substantial anti-bacterial effects without bringing about any detectable coagulation of the albumen. The method was found to be an effective means of controlling the wastage induced by machine cleaning, even when the heat treatment was applied several days after cleaning. While the conditions affecting the efficiency of pasteurisation are naturally complex, it will suffice to say that pasteurisation has been most effective when eggs were immersed in water at temperatures between 140° and 150° F., the actual time required depending on the temperature. Temperatures below 140° F. required excessively long periods of immersion and temperatures above about 150° F. were less effective. Pasteurisation has not been found to have any adverse effects on the internal quality of the stored eggs and, in fact, some beneficial effects, in addition to the control of wastage, have been observed.

Oiling has been found to be almost without effect on the amount of wastage in stored eggs, but it has caused the detection of some forms of rots to be so difficult that candling judgment by experienced operators has, at times, seriously underestimated the true level of wastage. Oiling has also been found to have some important effects on internal quality and at the present time this particular phase of the work is being continued with the object of elucidating the mechanisms underlying the observed changes.

Frozen Liquid Eggs

The cessation, during the second World War, of the export of eggs in shell, encouraged a rapid increase in the production of frozen egg pulp and for a time liquid egg for freezing and drying was being produced from stored eggs. Some work was, therefore, carried out on the bacteriology of this product as a result of which a rapid method for assessing its bacteriological quality was developed. The procedure, which depends on the reduction of the dye, resazurin, has proved of value in improving the bacteriological quality of frozen egg pulp.

Dried Eggs

Following the establishment in 1941-42 of several plants for producing spray-dried whole egg, investigations were commenced of the factors concerned in the production and keeping quality of the dried powder. At the time little was known regarding the stability of this product, but it was soon shown that it was relatively perishable when stored at ordinary air temperatures. During storage the powder suffered a progressive deterioration in flavour and solubility which soon affected its utility for uses such as custards and scrambled egg and, to a lesser extent, impaired its usefulness for general baking purposes. The rate of deterioration during storage was shown to depend mainly on three factors, namely drying conditions, temperature of storage and water content of powder. Drying at high temperatures resulted in poor initial quality and shorter storage life, and prolonged exposure of powder to even moderate drying temperatures caused considerable damage. During storage at tropical temperatures of 80-90° F. marked deterioration could occur in 6-8 weeks, whereas a similar loss of quality might not occur until after 6-9 months at 60-70° F., nor in 18-24 months at 40° F. It was shown that a decrease in moisture content increased the storage life of dried egg. This was in line with overseas work, which showed that dried egg with less than 2 per cent. moisture had more than double the storage life of a powder containing 5 per cent. moisture.

(9) Freezing of Fruit and Vegetables

At the present time in Australia there is considerable interest in the commercial quick freezing of fruits and vegetables, a relatively new method of preservation, which has developed in U.S.A. within the last twenty years.

Apart from a small group of experiments on the "cold packing" of fruit carried out some years ago, no extensive investigations have yet been undertaken by C.S.I.R. An officer of the N.S.W. Department of Agriculture has recently returned from the U.S.A. after making a study of quick freezing, and experimental work is now being commenced in conjunction with the Division of Food Preservation at the Homebush laboratory.

One of the early problems to be investigated is the suitability of different varieties of fruits and vegetables for freezing. Complete information on freezing rates and storage conditions in relation to the quality of the final product is not yet available, and it will probably be necessary to initiate work on these and other problems at a later date.

(10) Physics

Aspects of the Division's work involving the application of physical principles to problems in food storage, transport and processing may be classified under several headings.

Heat and Water Transfer Problems

Most of the physical work of the Division falls within this field and only a few of the major jobs undertaken can be mentioned here.

Investigations on chilled beef revealed the need for more precise information on the effect of chilling conditions on the rate of evaporation at different stages in the cooling process and on the total loss of water during chilling. Consequently a study of the cooling of a wet body was begun some years ago and is still in progress. Most of the work so far has been theoretical, involving numerical approximate solution of the equation of conduction of heat which, for this case, has non-linear boundary conditions, but the validity of the assumptions used has also been checked experimentally. Considerable progress has been made in determining the relative importance of different factors, but further arithmetical and experimental work is needed.

A problem in the transfer of water vapour which arose during the last war and is still important is that of assessing the suitability of various substitute containers for foodstuffs for which tinplate cannot be made available. Our work in this field involved two main jobs, namely (*a*) measuring the permeability to water vapour of various containers and wrapping materials, and (*b*) estimating the maximum permissible permeability of containers for particular products and storage conditions using existing data on their water relations and storage behaviour or, if necessary, measuring the relevant properties.

Measurement and Control of Temperature and Humidity

For storage tests on foodstuffs the Division is equipped with a considerable number of rooms and cabinets maintained at temperatures in the range from —30° C. (—22° F.) to 50° C. (122° F.). Temperature measurement and control in these chambers is the responsibility of the Physics Section. In some cases the humidity of the storage space is also controlled within close limits.

A survey is in progress of a number of commercial cool stores for fruit, in which temperatures, humidities and weight losses from stored goods are being measured in order to examine the degree of uniformity in conditions achieved in stores of different design and the factors affecting the efficiency of a cool store.

Water Relations of Foodstuffs

It is well known that if the equilibrium humidity of a foodstuff is low enough there is little risk of mould attack in storage. The equilibrium humidities of a number of materials, including fruit cake, puddings, jellies, etc., have been measured and, in some cases, the effects of composition and method of preparation studied in order to obtain the information necessary to overcome particular mould wastage problems.

Precise data on the vapour pressures of dehydrated foods are required for a number of purposes, and an apparatus has been designed and built, and used for measurements on several materials. During the War years a study was made of the suitability of several types of electric moisture meter for measurements on dehydrated foods of low water content.

Colour Measurement

In the inspection and grading of foodstuffs and in studies of quality changes during processing and storage, reliable assessment of colour is very important. In an attempt to obtain precise and objective colour measurements a photoelectric tricolourimeter designed by the National Standards Laboratory of C.S.I.R. has been adapted for application to foodstuffs and some colour measurements have been made on a Hardy recording spectrophotometer.

(11) Chemistry

A large proportion of the research projects undertaken by the Division make use of chemical procedures of investigation and analysis. The development of some of these procedures is here described and an account is given of a number of independent investigations mainly chemical in emphasis.

Vitamin C

Determinations of ascorbic acid (vitamin C) are very frequently required in studies on food processing. Procedures for the estimation of vitamin C were examined particularly in relation to the effects of interfering substances. Conditions for eliminating interference by ferrous iron were defined. Also it was shown that ferrous iron promotes the oxidation of ascorbic acid below pH 2, while copper promotes this reaction at higher pH levels.

When marked differences were observed in the percentage retention of ascorbic acid in different processed foods, a study was made of the fundamental factors affecting this retention. The effect of copper on the oxidation of ascorbic acid was studied both in pure buffer solution and in fruit and vegetable preparations. The pro-oxidant effect of copper was found to be reduced by a number of substances which occur in fruit and vegetables. The pro-oxidant effect of the natural enzymes, particularly those of cabbage and apple, was also studied.

It has usually been assumed that loss of ascorbic acid from foods is due to oxidation. However, loss still occurs in products where access of oxygen is negligible, and investigations have recently been initiated on the anaerobic (non-oxidative) destruction of ascorbic acid.

Ascorbic acid is oxidized to dehydroascorbic acid which has vitamin C activity, but is comparatively unstable. The effect of pH and temperature on its stability has been investigated. It has been shown that dehydroascorbic acid is most stable at pH 2, and that its destruction is promoted by borate. An analytical procedure which is more specific for dehydroascorbic acid than previous methods has been developed.

In connection with an investigation of the retention of added ascorbic acid by artificial cordials, it was found that many synthetic dyestuffs are decolorized by ascorbic acid. Of nine dyes tested, three only were stable to ascorbic acid.

Carotene

In the course of investigations on dried foods, it was necessary to develop an accurate method for determination of carotene (provitamin A). In the method finally used, the material is saponified with aqueous alcoholic potassium hydroxide and the pigments are extracted with petroleum ether. The carotene is purified by adsorption on activated magnesium oxide and then is determined colorimetrically.

Natural Coating of Apples

The loss of water from stored fruit and the rate of gaseous exchange are both affected by the chemical and physical constitution of the skin. The gaseous exchange (of oxygen and carbon dioxide) affects the composition of the internal atmosphere and hence the ripening and storage life of the fruit. An investigation of the resinous, waxy, and oily material in the skin of Granny Smith apples was undertaken, and is still in progress.

The resinous and waxy fractions have been shown to be similar to those isolated by previous investigators. In addition an oily fraction, consisting predominantly of unsaturated esters, has been isolated and studied. This oily fraction develops mainly after picking and hence may have an important relation to the increase of skin resistance and other changes which occur in storage.

Volatile Products of Apples

Superficial scald, a storage disorder of apples, has been shown to be due to the accumulation of volatile organic substances produced by the fruit. This disorder is controlled fairly successfully by the use of oil wraps, but further information on the rate of volatile production in relation to maturity and period of storage is considered desirable.

Investigations on volatile production by Granny Smith apples were first concerned with the determination of total volatiles by combustion. This procedure was found to yield only approximate results, and the present investigations are concerned with isolation and determination of the ester fraction. A colorimetric procedure, which is based on forming the hydroxamic acids and determining the colour of the iron-hydroxamate complex, is being used. An attempt is also being made to identify the volatiles.

Determination of Metals

Examination of canned foods frequently involves determinations of dissolved tin and iron and of the tin coating weight of tinplate. Existing analytical procedures were critically examined, and in some cases more reliable methods were developed. Tin is determined by wet digestion followed by direct titration with iodine, and iron by a colorimetric procedure using 1,10 phenanthroline.

For estimating tin coating weight of tinplate, volumetric determination after complete solution of the tinplate or stripping with Clarke's Reagent were found equally reliable provided suitable corrections were applied.

Polarographic Determination of Dissolved Oxygen

Deaeration studies in the canning of orange juice were found to require rapid determinations of dissolved oxygen. A rapid and accurate polarographic method was developed. Arising from this work, a study was made of the effect of various factors, including viscosity, on polarographic diffusion currents.

Determination of Curing Ingredients

Investigations on spoilage in canned cured meats (particularly canned bacon) involved many determinations of curing ingredients, i.e. chloride, nitrate, nitrite and sugar. A method was worked out for determining "fermentable sugar", representing that fraction of total reducing material which is available to spoilage bacteria.

Pectin

During the War years, investigations on the extraction and jellying properties of pectin were carried out. Pectin from overseas was then available only in limited quantities, while apple and citrus residues from processing plants were largely waste material. The use of pectin extracts for making solid jams to conserve tinplate was also suggested.

The effect of temperature and pH on the extraction of pectin, the effect of pH and sugar on jelly strength, and the heat destruction of pectin were investigated in some detail. Although there was a good deal of published information, much of this was found so contradictory that independent investigation was necessary. The results of this investigation have already been given by Huelin in the FOOD PRESERVATION QUARTERLY (1943, 1944, 1945).*

(12) Microbiology

As problems of a microbiological nature are a very common feature of most projects in food preservation, it is not surprising that the Division's microbiologists devote a good deal of time to numerous minor investigations. They are given frequent assignments involving the detection, enumeration and identification of micro-organisms in a wide variety of foods, particularly canned foods, and also such products as fresh fruit, frozen and dried meat, shell fish, cordials and cake. During the War years the bacteriological examination of canned foods assumed the proportions of a major activity, almost 10,000 cans being tested within four or five years.

The Division has also undertaken several microbiological investigations of a fundamental character, most of which have arisen from particular problems in food preservation. For instance, experiments with canned foods led to the discovery that several products dissolve from unlacquered tinplate containers sufficient tin to inhibit the growth of certain bacteria, including *Clostridium botulinum.* These studies have been extended to include a fairly detailed investigation of some of the environmental factors affecting the growth of this organism. The highly virulent toxin produced by *Cl. botulinum* is the subject of a project in which the factors which determine the stability of the toxin in canned vegetables are being elucidated. Studies of heat resistance in bacterial spores and of the factors influencing the germination of spores represent another example of fundamental bacteriological research which has been undertaken as a result of experience in the bacteriology of canned foods.

Egg investigations revealed a lack of basic knowledge of the reactions of bacteria to some types of disinfectants, and investigation on the mechanism of the anti-bacterial action of cationic detergents were accordingly commenced in 1946.

In a similar way a study of moulds growing on relatively dry foods has emphasized the need for further fundamental data on the water relations of micro-organisms, and detailed experiments have now been in progress for some time on moulds which have been found to be especially well fitted for growth in dry environments.

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* HUELIN, F. E. (1943).—Food Pres. Quarterly 3: 30-32.
HUELIN, F. E. (1943).—Food Pres. Quarterly 3: 34-42.
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It is by means of investigations such as these that the food microbiologist can contribute to the accumulated knowledge of microbial physiology, and so assist in providing more satisfactory answers to problems involving the microbial deterioration of foods.

(13) Plant Physiology and Biochemistry

An intimate knowledge of the physiology and biochemistry of fruits and vegetables is necessary for a thorough understanding of their behaviour during storage and ripening and is essential for the development of scientific storage techniques. In turn an understanding of the physiology of intact fruits and vegetables requires a knowledge of the behaviour of the individual plant cell which is the seat of the life processes.

Two problems in cell physiology are being investigated, in close collaboration with the Botany and Biochemistry Departments in the Universities of Sydney and Melbourne: (*a*) the organization of the plant cell and its relation to cell stability, and (*b*) the respiration of the plant cell, particularly in relation to the rôle of organic acids and the nature of the oxidative enzyme systems. Most of the earlier work was done with carrot tissue, but apples and peaches have recently been used.

At the Homebush laboratory over many seasons respiration studies have been made on whole fruits under a wide variety of conditions of harvesting and storage.

Physiological Studies on Apples

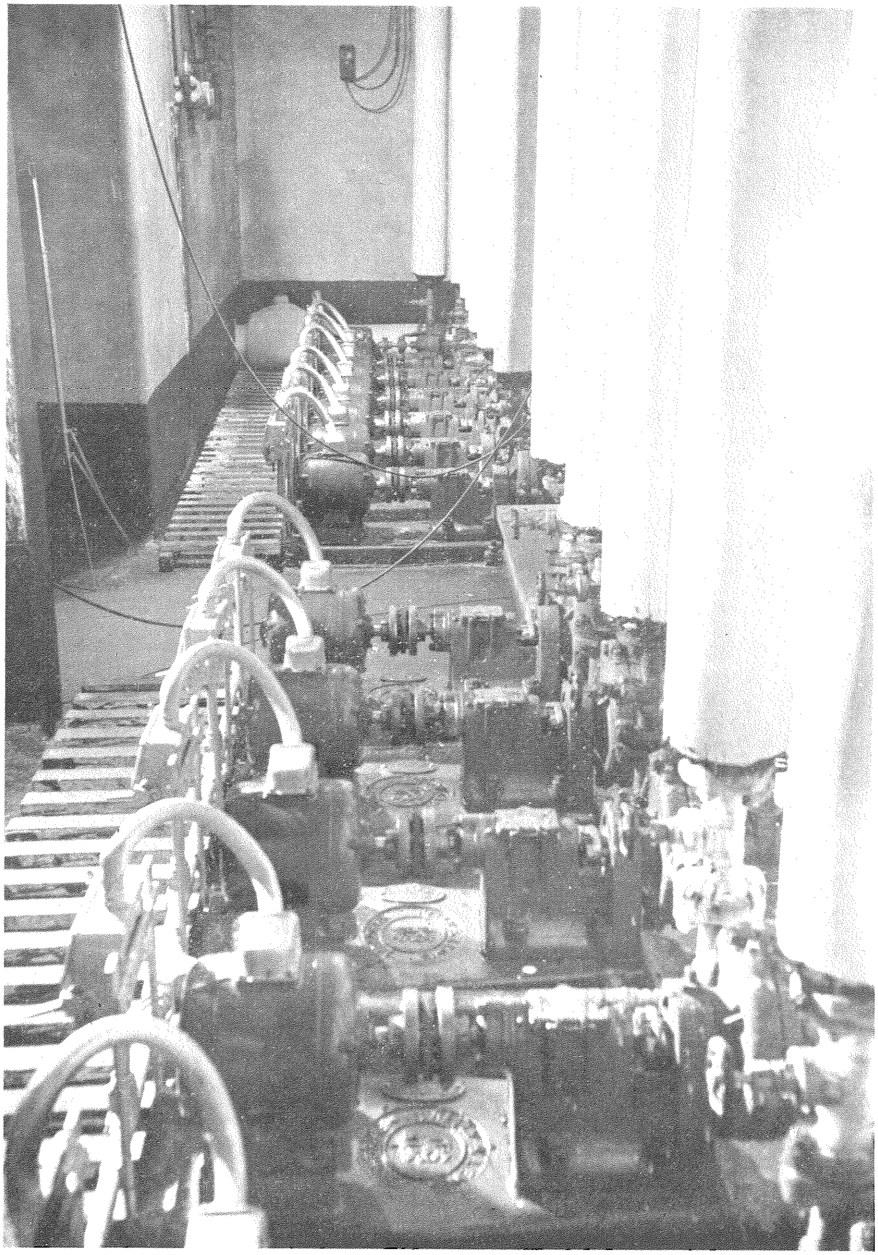
Experiments with developing apples picked at intervals, commencing soon after the fruit was set, showed that as the fruit developed the respiration rate per unit weight decreased considerably but the respiration rate per fruit remained approximately constant. This is consistent with the view that after the first few weeks the increase in the size of the fruit is due to enlargement of existing cells, the amount of cytoplasm—the actively respiring material—in each cell remaining constant.

The respiration of whole Granny Smith apples has been studied during storage at 32° F. and at higher temperatures. The respiration rate after removal to high temperatures declined with increasing periods of storage. This decline was shown to be due to increasing resistance of the skin to oxygen and therefore decreasing availability of oxygen to the tissue. After more than about four months' storage the respiration rate was no longer limited by oxygen supply but by some other factor. Using a special technique, a study was made of changes in the composition of the internal atmosphere of the apple. At picking this atmosphere was little different from the outside air, but as the fruit aged there was a marked fall in oxygen concentration and a small rise in the percentage of carbon dioxide.

The effects of various skin coatings on the respiration and the composition of the internal atmosphere have been studied and it has been shown that coatings considerably reduce the rate of diffusion of atmospheric oxygen into the fruit. The main effects of this are a reduction in the rate of respiration and a retardation of yellowing of the skin. Some coatings also significantly increased the internal carbon dioxide concentrations. The effects of skin coatings were related to their characteristic resistances to the diffusion of oxygen and carbon dioxide.

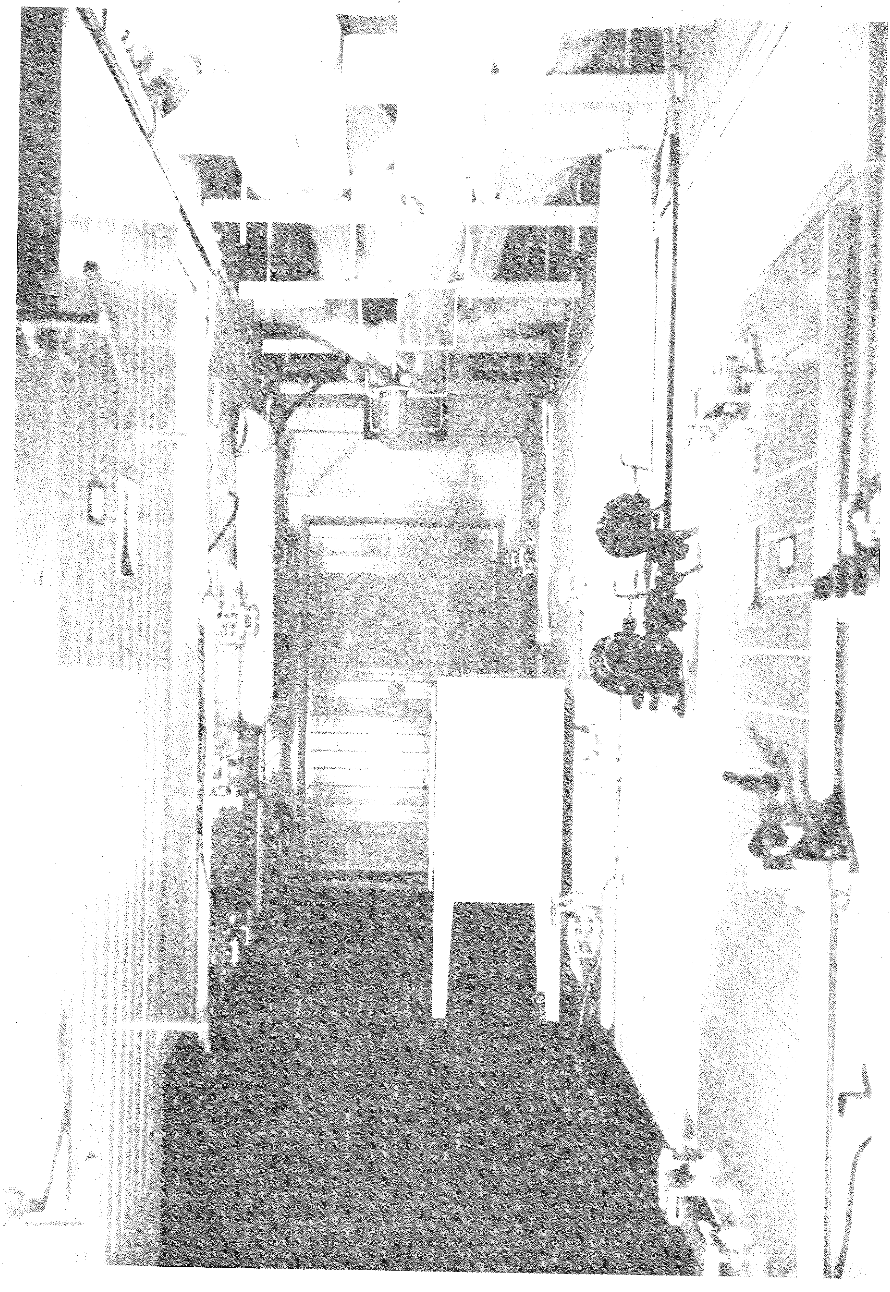
The work with slices of apple tissue was complicated by their instability in water, the uptake of water due to osmotic forces being so

REFRIGERATION EQUIPMENT AT HOMEBUSH.



Brine Pumps.

REFRIGERATION EQUIPMENT AT HOMEBUSH.



Air Lock between Cold Rooms, Ground Floor.

rapid that the cytoplasm became disorganized and respiration rapidly declined. Experiments with solutions of different concentrations indicated wide variations between individual cells so that it is not possible to find a medium isotonic with all cells. The most satisfactory medium for following respiration of the tissue is 0·5 per cent. glucose solution. Work is in progress to correlate tissue respiration with the respiration rate of the whole fruit.

Biochemical Studies on Apples

A comprehensive investigation of the metabolism of Granny Smith apples during cold storage at 32° F. has been carried out and changes in the concentration of a number of substances, including respiratory substrates and possible intermediates, have been followed. It was found that utilization of sugars accounted for about 95 per cent. of the observed output of carbon dioxide and that the respiration rate was not, at any stage limited by the concentration of sugars. Evidence was obtained of the existence of a hitherto unknown carbonyl compound as an intermediate in the formation of carbon dioxide from sugars. There is also good evidence that the Krebs cycle operates in the respiration of the apple.

The total nitrogen content remained constant during storage, but there was an appreciable synthesis of protein which was related directly to the level of respiratory activity. This relationship between respiration rate and protein nitrogen content has been substantiated by a series of analyses on a number of individual fruits picked from the one tree. It has been concluded that the respiration is able to maintain a definite amount of nitrogen in the protein state.

Studies with Carrot Tissue

During the past twenty years a large amount of data has been accumulated by various workers on the absorption of inorganic ions by plant cells from an external solution of inorganic salts. To accumulate ions energy must be expended by the cell and the process is accompanied by an increase in respiration rate which is known as "salt respiration" and which is the source of the necessary energy.

Using carrot tissue, evidence has been obtained in this laboratory on the quantitative relationship between salt respiration and salt accumulation. It has been shown that the number of molecules of salt accumulated is of the same order of magnitude as the number of electrons eliminated in respiration. This work makes an important contribution to fundamental knowledge in this field of plant physiology.

Studies with Peaches

Two seasons' work has been carried out with peaches, and changes in the respiration rate of the whole fruit and in the stability and respiration rate of cut tissue have been followed during development on the tree, and during ripening of the mature fruit. In the early stages of growth the respiration rate of the whole fruit decreased slightly then subsequently increased so that the rate for mature fruit was about twice that of the very young fruit.

The tissue of very immature peaches was stable in water but it became increasingly unstable as the fruit matured. Various solutions were tried with mature tissue, but none increased stability sufficiently for respiration determinations to be carried out satisfactorily.

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