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Plant Physiology

A KNOWLEDGE OF PLANT PHYSIOLOGY IS OF paramount importance in researches on plants used as food for man or animals, whether the research be designed to increase production or to improve methods of preservation. In spite of this obvious need, the physiology of plants is a neglected science compared with the physiology of man or of domestic animals. The current ignorance of plant physiology, which is the study of the physics and chemistry of plants applied to their living functions, is responsible for many difficulties. We do not know enough about the physiology of our plant crops to be able to predict their behaviour or to exercise satisfactory control, either during growth or in the post-harvest period through which plant products continue to live until they are processed or consumed.

At a recent meeting on fruit and vegetable storage research, senior horticulturists from the Departments of Agriculture in the Australian States pointed out that they frequently faced problems which could not be explained in terms of existing knowledge of the physiology of the plants concerned. Thus the principal problem of apple storage in Western Australia is superficial scald, a physiological disorder which makes the surface of the fruit turn brown. Despite much research, the basic causes of this disorder are imperfectly understood. If the physiology of the disorder were better understood, it might be possible to explain why it is much worse in some districts and in some seasons than in others. It might also be possible to suggest some modifications in horticultural practice which would eliminate the disorder altogether.

An interesting Western Australian example of physiological knowledge overcoming a problem and leading to better production is the change from cincturing currant vines to spraying them with hormones in order to aid fruit-set. For many years it had been known that unless the currant vine was cinctured, i.e. had a fine knife-cut right round the stem, the vines did not set a satisfactory crop of fruits. Since this treatment would temporarily disorganize the passage of foodstuffs from leaves to roots, it is little wonder that there was a progressive decline in the root activity and general vigour of the plant. Physiological knowledge suggested that a better set of blossom, without resort to cincturing, could be achieved by spraying with a hormone at a critical stage. Parachlorophenoxyacetic acid has proved remarkably effective.

It looks as though this treatment will parallel the successful use of a hormone spray in Michigan, U.S.A., and elsewhere. Under normal growing conditions in Michigan, the low night temperatures so retard the growth of the pollen-tube in tomato flowers that the flowers do not develop into fruits. Hormone sprays have the same effect on the fruit (but not on the seeds) as the properly developed pollen-tube, and now all the tomatoes in Michigan are set by a hormone spray which gives satisfactory (though seedless) fruits. In this way has plant physiological knowledge been used to raise crop yields.

PLANT PRODUCTS AND TECHNOLOGY

An outstanding problem connected with plant foods subjected to technological processing is uniformity of yield. High yields are essential, but it is also important that the processor should know what quantity to expect so that he can plan his processing well in advance. It is customary to accept what nature and the farmer supply, but increased knowledge of plant physiology will lead to better prediction and control.

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and Food Technology

A second problem is that of quality in the fresh product as it comes from the plant at harvest, and a third is that of maintaining quality in storage or transport up to the stage of blanching or consumption.

The role of plant physiology in solving the above problems may be illustrated by reference to four investigations now engaging the attention of the Division of Food Preservation and Transport.

Yield and Quality of Peas

In peas, a balance must be struck between increasing yield, represented by the fresh weight, and quality, represented by flavour and succulence. It is necessary not only to know *when* to harvest in order to strike the balance, but also to predict the optimal harvest time a few days in advance. Many will be familiar with the excellent work in this direction which has been done by Mr. L. J. Lynch and Mr. R. S. Mitchell, of the C.S.I.R.O. Division of Food Preservation and Transport. A recent publication by these authors (Lynch and Mitchell 1953) not only defines, but also gives methods for predicting the optimal harvest time.

Recently an examination has been undertaken of pea seeds developing in the pod on the vine, with the object of obtaining physiological knowledge of value to research on pea maturity. In this way perhaps prediction may eventually become still more accurate and quality still better controlled.

If the fresh weight per seed is plotted against days from blossom, we find the usual S-shaped growth curve; the dry weight plotted against time from blossom gives a similarly shaped curve which is much less steep at the beginning. It has been found, however, that after a certain time the dry-weight curve and the fresh-weight curve run parallel. At this stage, as shown by subtracting the dry weight from the fresh weight, no increase in water content is taking place; increase in weight thereafter is due entirely to dry matter. It follows that the quality of succulence, which depends on water, will decrease at this time, and the small increase in yield will be at the expense of quality.

Changes in some of the compounds in the pea have also been investigated. Soluble carbohydrates, which have a marked influence on quality, are a case in point. One of the most spectacular changes in the developing pea is the sudden change in rate of starch formation. In the early stages of development (up to 20 days from blossom in a particular experiment), starch increased only slowly. Then starch formation increased to a new high rate, and continued at this rate until after the normal commercial picking times. During this period of rapid increase in starch content, the soluble carbohydrates, which had previously been increasing more rapidly than the starch, were reduced to a lower level, presumably owing to the rapid starch synthesis. The reduction in soluble carbohydrates would have undesirable effects on both sweetness and water content. About the same time as the increased rate of starch synthesis, the insoluble pectin also began to increase, and it continued to increase for the remainder of the life of the pea. While enough is not yet known about the changes which lead to loss of quality (and make peas so bullet-like), it seems probable that the increase in pectin is an important factor (McKee, Robertson, and Lee 1955).

Greater knowledge of these interrelations may contribute to better understanding of the prediction data on which the work of Lynch and Mitchell depends. Improved knowledge, too, of the physiological changes leading to good quality may help the plant

breeder in selection of varieties with the right physiological characteristics. Looking still further ahead, perhaps some speculation is justified. The period of rapid synthesis depends on energy transferred from the active respiration of the seeds. This respiration rate continues to be high after harvesting, which is why these synthetic reactions continue and peas change in quality after harvesting. The mechanism of this transfer of energy by phosphorylated compounds has been investigated, and one wonders whether it will be possible to control the speed of the synthetic processes so that maturing rates can also be controlled. There is no biological reason why spraying a pea crop with the requisite inhibitor could not hold back the synthetic reactions on or off the vine, and thus prevent the peas from maturing. This may seem remote as a practical possibility, but it is not less reasonable than causing tomato plants to bear fruit by using a hormone spray.

Fruit Size and Low-temperature Breakdown in Apples

The second investigation chosen is concerned with the search for physiological understanding and control of low-temperature breakdown, a cool-store disorder that has been one of the principal factors working against successful long storage of fruit grown in Tasmania. The late W. M. Carne and Mr. D. Martin had shown that low-temperature breakdown was greater in large fruits than in small, and that the fruits from light-crop trees were much more susceptible than fruits of the same size from heavy-crop trees. Carne and Martin based their storage recommendations on these facts. When about eight years ago Mr. Martin and the author came to discuss collaborative work, it was agreed to determine first the physiological meaning of size in these fruits.

Since apples consist of a large number of small cells (about 40 million per fruit in the Granny Smith variety), the variation in fruit size may be due to variation either in cell number or in mean cell volume, or to a combination of both. Following leads from work done in Britain, it was demonstrated that both cell number and cell size could be important in control of fruit size. When Martin came to examine the difference between light-crop and heavy-crop fruit, he found that the light-crop fruit were larger because they had larger mean cell volume. This was an important clue, which led to the conclusion that if fruits are large because of large mean cell volume, they are susceptible to low-temperature breakdown. Thus, to grow fruit of good keeping quality and satisfactory size, cell number must be increased and mean cell volume controlled (Martin and Lewis 1952).

Martin's work has been concerned with this problem. Earlier work by various authors had shown that in most varieties of apple the cell division period is confined to the first three to four weeks after blossom; thereafter, division having ceased, the apple grows entirely by enlargement of the cell. Martin, using the blossom thinning sprays which have found favour elsewhere in recent years, caused some of the blossoms to fall before the cell division period was too far advanced, and the decreased competition between the young fruits remaining resulted in an increase in cell numbers. Fruits from trees thinned in this way are therefore large but are not susceptible to low-temperature breakdown. The plans laid eight years ago have therefore been justified: a physiological investigation has led satisfactorily to results of economic importance.

Phenate and Green Mould in Oranges

This investigation illustrates how a knowledge of physiology has led to satisfactory treatments for oranges which during storage or transport develop a disease, green mould, due to a fungus, *Penicillium digitatum*. This disease has frequently been the cause of considerable loss, particularly in New South Wales coastal areas, where in a bad season losses may be as high as 10 per cent. of the fruit going through the packing-houses. Much of the work of the Citrus Wastage Research Laboratory, controlled by C.S.I.R.O. and the N.S.W. Department of Agriculture cooperatively at Gosford, N.S.W., has been concerned with the control of this disease. In the course of testing a number of substances which might be effective against the fungus, it was found, following South African and American suggestions, that one of the most promising compounds was sodium orthophenylphenate. At first it was found that this compound injured the skin of the fruit, making it brown and most

unattractive. In Florida, it had been found possible to mix the orthophenylphenate with hexamine to form a complex which yielded, in solution, a low concentration of the orthophenylphenate which was high enough to control the fungus without injuring the fruit. The mixture was not satisfactory for Gosford oranges. For some reason which is not understood, their skins are evidently more sensitive than those of Florida oranges. Injury of the skin would result only if the substance penetrated the skin cells and tissues. Physiological observations on a wide range of plant tissues show that ionized substances like sodium orthophenylphenate do not penetrate cells rapidly. The explanation is that they are excluded partly by the types of substances which constitute the cell surfaces and partly by ionized compounds which occur in the cells themselves. Un-ionized compounds, however, penetrate readily. Mr. J. K. Long and Mr. E. A. Roberts of the N.S.W. Department of Agriculture realized that the injurious component was probably the small amount of the undissociated molecule, orthophenylphenol, which accompanied the orthophenylphenate and hexamine at the pH of the mixture (11·5). When, even in the absence of hexamine, the pH was raised to 11·7-11·9, the concentration of the undissociated molecule was reduced. While the compound was still effective against the fungus, it no longer injured the skin of the fruit. The control of the pH was achieved by addition of caustic soda, using indicator paper as a guide. This method was so successful that it was used by a packing-house having trouble with mould in February 1954, and in this first commercial trial in Australia, 20,000 cases of fruit were treated with complete success. Since then the treatment has been accepted as standard practice by several packing-sheds with good results at a cost amounting to only a fraction of a penny per case. In this instance, therefore, physiological knowledge of the behaviour of the skin of the orange in the presence of a weak electrolyte at varying pH levels has led to a new method of controlling a fungal disease (Long and Roberts 1954).

Injury and Off-flavours

The fourth example shows how an increase in physiological and biochemical knowledge can explain an old observation. For a long time it has been known that plant products such as fruits and vegetables develop off-flavours if they are injured and kept for any time before processing. These off-flavours are frequently associated with the development of acetaldehyde and ethyl alcohol—substances characteristic of anaerobic conditions—in the plant product. Under anaerobic conditions, the production of these compounds is the result of the specific enzyme reactions of glycolysis, breaking down sugar and liberating carbon dioxide. In healthy tissue, this process of glycolysis is the same under both aerobic and anaerobic conditions, producing pyruvic acid. Under aerobic conditions the pyruvic acid is completely broken down to carbon dioxide and water by the enzymes of the mitochondria—the very small particles present in all cells. If, however, as has been discovered in recent years, cells are injured, the mitochondria and the organization of their enzyme processes are completely destroyed unless special precautions are taken. The mitochondria are specially sensitive to acid, which is liberated by most plant cells on injury. When the mitochondrial organization is destroyed, the pyruvic acid, which is still produced by the glycolytic enzymes, is converted to acetaldehyde and ethyl alcohol instead of to carbon dioxide and water, with a consequent increase in off-flavours.

CONCLUSION

An increase in plant physiological knowledge may be expected to lead to more rational and effective methods of handling plant products. Many gaps in our knowledge persist, largely owing to lack of investigations. Funds for fundamental research in the agricultural and food industries are not great compared with the large investments in research in physics and the medical sciences. Some of the reasons may be mentioned. Good fundamental research in biological science is difficult. Agriculture, depending as it does on tradition and experience, seldom calls urgently for new ideas and methods, and when it does call on science, the few investigators available are overwhelmed with solving day-to-day problems. Finally, it is generally accepted that crop failures and losses in storage are to be expected and are beyond our control, so we

are resigned to the defeatist view that we cannot manage our agricultural and food production with the precision of a manufacturing process. Difficult as the latter task may be, we shall not be able to dismiss it as impossible until we have greatly extended our knowledge of plant physiology.

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Beef Export Industry Conference

The Division recently arranged a Beef Industry Conference which was held at the Shell Theatrette, Ann Street, Brisbane, on March 22 and 23, 1955.

The main purposes of the conference were:

- To enlist the help of the industry in defining the more important scientific and technological problems facing the meat export industry.
- To acquaint the meat industry with recent advances in the science of preservation as applied to the beef export industry, with particular emphasis on the results of the more recent investigations carried out by the C.S.I.R.O. Division of Food Preservation and Transport.

About 90 delegates were present at the conference. The majority were from the industry, while both Commonwealth and State Departments were also well represented. Interest in the conference was stimulated by the publicity given early in March 1955 to the difficulties encountered by the Australian beef export industry, particularly in the United Kingdom market, where de-rationing and reversion from bulk buying to private trading have caused some upsets in meat distribution.

The first day and a half of the conference was devoted to the presentation of papers, each of which was followed by a discussion.

The conference was opened on the morning of March 22 by Dr. S. H. Bastow, Executive Officer of C.S.I.R.O. Dr. Bastow was also chairman of the opening session. At this session papers were presented by Dr. H. L. Webster and Mr. A. Howard from the Brisbane Branch of the Division. Dr. Webster summarized recent Australian and British investigations on frozen beef and Mr. Howard presented two papers, one on the comparison of frozen and chilled beef and the other on proposed investigations on the freezing and storage of beef.

In the afternoon, when Mr. J. L. Shute, Chairman of the Australian Meat Board, was in the chair, papers on chilled beef were presented by Dr. J. R. Vickery, Chief of the Division, and by Mr. W. J. Scott, also from Divisional Headquarters at Homebush, N.S.W. Mr. Scott summarized present knowledge of chilled beef, and Dr. Vickery spoke on proposed investigations.

On the morning of March 23, the chair was taken by Mr. T. G. Hope, Chairman of the Queensland Meat Industry Board. Papers were presented by Mr. E. W. Hicks, of the Division's Homebush laboratories, and Mr. K. R. Ross, of Thomas Borthwick and Sons (Australasia) Ltd. Mr. Hicks discussed some physical aspects of the cooling, freezing, and storage of beef, and Mr. Ross spoke on some engineering aspects of the design and operation of beef chillers, freezers, and stores. During the afternoon delegates inspected the Branch Laboratories of the Division at Cannon Hill, Brisbane, where all aspects of the work being undertaken were explained. Delegates also saw the Division's new blast freezer, in full operation for the first time.

The conference officially ended on March 23, but the following day many delegates accepted the invitation of Thomas Borthwick and Sons Ltd to inspect the operations of loading chilled beef on S.S. *Ixion*.

General view of exhibit by the Division of Food Preservation and Transport.

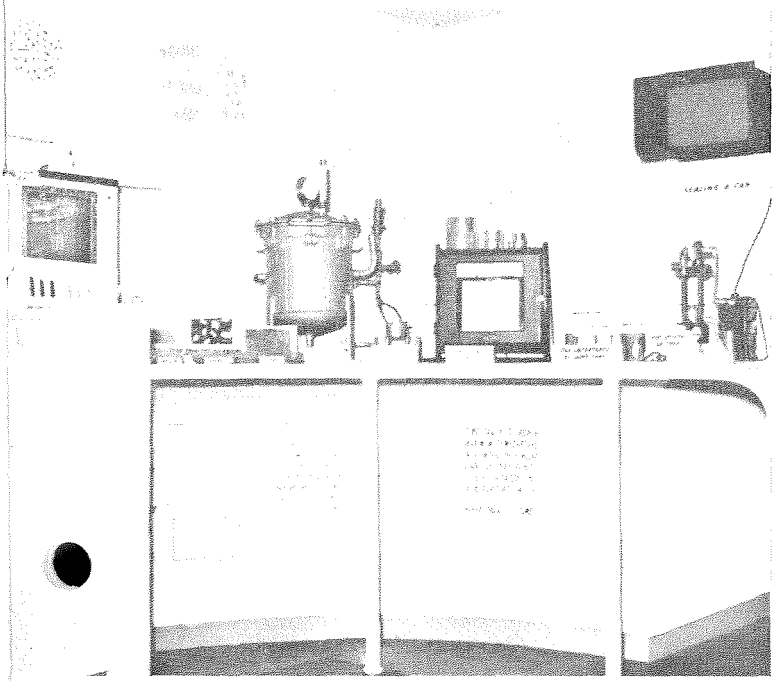
BETTER FOOD EXHIBITION

THE DIVISION OF FOOD PRESERVATION AND Transport participated in a Better Food Exhibition in Melbourne from January 26 to February 5, 1955. The Exhibition, which was sponsored by the Food Technology Association in Victoria, occupied most of the spacious and venerable Exhibition Building.

The C.S.I.R.O. exhibit, which bore a banner "Food Research in C.S.I.R.O.", was arranged by the Dairy Research Section and the Division of Food Preservation and Transport. The former's exhibit included a large freeze-drier for drying starter-cultures for cheese making, a fraction collector used for investigations on the flavour chemistry of milk, and meringues made from an egg-white substitute derived from non-fat milk by a C.S.I.R.O. process.

The Division of Food Preservation and Transport featured the part played by research in making canned foods safe. Equipment and charts were arranged to demonstrate the determination of the temperature and time required to kill heat-resistant food spoilage organisms, the measurement of the penetration of heat into various types of cans and foods, and the function of the modern hermetically sealed can in protecting its contents against spoilage organisms. The public showed keen interest in the exhibit, particularly the sealing of the can, which was demonstrated on a hand-sealer, by means of a short film which ran continuously, and on a modern can-closing machine capable of closing 300 cans per minute.

Tasting tests were carried out at intervals on different types of prepared milk and 3700 opinions were collected from the public during the 10 days of the exhibition. The results showed that pasteurized milk is preferred to reconstituted or evaporated milks, but it is an open question whether the preference is a natural one or the result of habit.



A demonstration of the part played by research in making canned foods safe.

MOISTURE AND

Earlier articles in this series appeared in the **Food Preservation Quarterly,** *Volume 13 (1953), pages 3-8 and 21-31, and Volume 14 (1954), pages 8-18, 26-31, 46-52, and 74-6.*

MOISTURE CONTENT AND ITS CONVERSE, TOTAL solids content, are frequently specified for canned foods in official regulations, in standards of quality, and in requirements for satisfactory storage life.

OVEN DRYING

One group of methods for determining moisture or total solids in foods depends on the direct removal of water. The water may be removed at room temperature under reduced pressure in the presence of a desiccant, but more usually it is removed at elevated temperature in a drying oven. It is misleading to attach absolute significance to moisture contents determined by oven drying, because of the operation of such factors as loss of other volatile constituents, partial decomposition of heat-labile constituents, uptake of oxygen by oxidizable constituents, and the presence of so-called "bound" water (Joslyn 1950; Common 1951; Willits 1951). Drying methods are therefore empirical procedures in which the weight loss occurring under narrowly specified conditions of temperature, pressure, and time is recorded as the moisture content. For this reason it is highly desirable for an analyst reporting moisture or total solids contents to state briefly the method by which the determinations were made.

The Association of Official Agricultural Chemists (U.S.A.) prescribes vacuum oven drying as the official method for moisture determination in most foods. Thus, drying at 95-100 °C with a vacuum at least 26 in. Hg is specified for meat products, and drying at 70 °C with a vacuum 26 or 28 in. Hg for fruit and vegetable products which may contain labile sugars. The conditions laid down provide for the admission of air to the vacuum oven through a drying train, at a rate of at least two bubbles per second, in order to reduce the water vapour pressure in the oven.

The preferred containers for samples are flat-bottomed cylindrical aluminium dishes, with closely fitting lids. Dishes not less than five centimetres in diameter and not more than four centimetres deep are recommended for meat products etc. where the sample weight is 2-5 grams. The National Canners' Association Research Laboratories (Townsend *et al.* 1954) suggest dishes nine centimetres in diameter and two centimetres deep for fruit and vegetable products where the sample weight may range up to 20 grams. In any series of determinations it is important that the dishes used should be uniform in size and weight, and each dish and lid should carry an embossed code number.

Samples for moisture determination, to be truly representative, must be taken from a homogeneous bulk sample. The product under examination is therefore comminuted in a suitable device which may be a mortar, mincer, or mechanical blender, and then thoroughly mixed. These operations should be performed rapidly to avoid loss of moisture and the well-mixed bulk material transferred immediately to a stoppered container. Samples should also be weighed expeditiously to the nearest milligram. An inert spreading agent, such as sand, asbestos, or filter paper, may be added to foods subject to "case hardening", creeping, or spattering.

Cheftel, Frichet, and Estang (1951) also favour vacuum drying at 70 °C, with filter paper or sand as a spreading agent. Many cannery laboratories, however, are not pro-

Critical comments on the procedures described, and suggestions for modified or alternative methods found to be useful in practice, will be welcomed.

SOLIDS CONTENT

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vided with vacuum ovens, and in these circumstances overnight (16-18 hours) drying in an air oven is a satisfactory alternative procedure for many foods. The air oven is preferably provided with forced air circulation. The drying dishes should be placed directly on the metal shelves of the oven and well spaced. The lids are placed in the oven with the dishes. The oven should be tested for reproducibility of results between dishes in different positions.

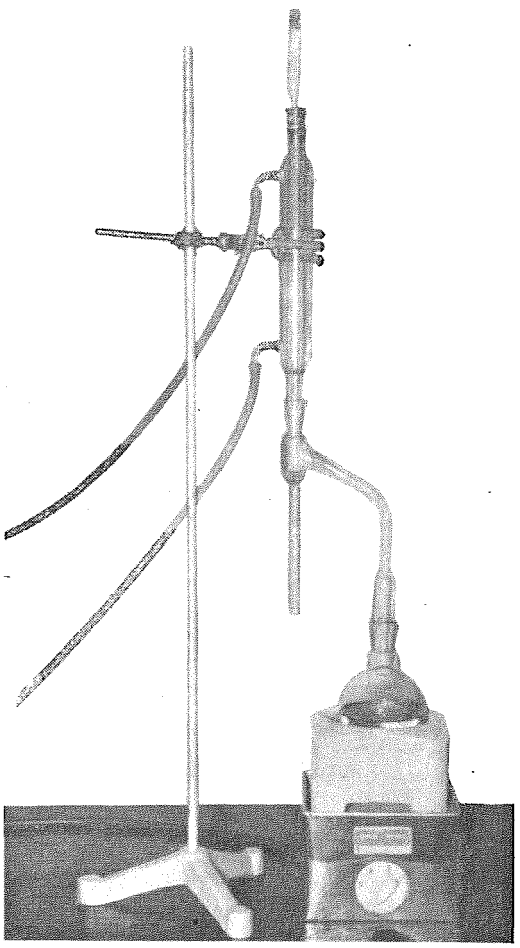
Recommended procedures may require samples to be dried for a stated time, found by experience to be adequate, or to "constant weight", i.e. to the stage where successive weighings do not differ by more than 2-3 milligrams. The dishes are covered while still in the oven, then cooled in a desiccator containing fresh, active desiccant, and weighed as soon as they are cool.

SPECIFIC CANNED FOODS

The procedures officially recommended by the Association of Official Agricultural Chemists (A.O.A.C.) and the Royal Australian Chemical Institute (R.A.C.I.) for the determination of moisture or total solids in canned foods are now outlined. The original sources (A.O.A.C. 1950; R.A.C.I. 1952) should be in every cannery laboratory, and should be consulted for operating details (see also Joslyn 1950; Townsend *et al.* 1954).

Meat Packs, including Meat Pastes

The sample consists of the entire contents of one can comminuted and thoroughly mixed (A.O.A.C. 1950*i*). With meat pastes, thorough mixing of the sample is sufficient preparation, and with canned sausages the determination is made on the sausages



Moisture determination by entrainment-distillation.

scraped free of external fat (R.A.C.I. 1952*d*).

The A.O.A.C. (1950*f*, *i*) recommends vacuum drying to constant weight at 95-100 °C a sample representing about two grams of dry material, or alternatively, drying to constant weight over sulphuric acid in a vacuum desiccator (A.O.A.C. 1950*h*). Windham (1953) (cf. Anon. 1954), however, examined these procedures critically and found that drying over sulphuric acid required at least one week, and even then gave erratic results. He recommends vacuum drying at 95-100 °C for approximately six hours in dishes with the lids slightly open, except for high fat products subject to spattering. As alternative procedures Windham recommends drying in open dishes for 16-18 hours at 100-102 °C in an air oven, preferably with forced circulation, or drying to constant weight (2-4 hours) in a forced-circulation air oven at 125 °C. In the latter procedure it is necessary to avoid excessive drying, and the dried sample is not suitable for subsequent fat determination.

The overnight air-drying procedure is essentially the same as that prescribed by the R.A.C.I. (1952*b*) for beef and mutton products. For pork products, however, the R.A.C.I. recommends vacuum drying to constant weight at 95-100 °C.

Belanger (1952) compared three methods of moisture determination in meat products and found that forced air drying at 102 °C gave results 1-1·5 per cent. higher than those by vacuum drying at 95-100 °C and 0·5-0·75 per cent. higher than those by air drying with natural convection at 105 °C.

Meat Extracts

The product under examination is prepared by thorough mixing, with slight heating if necessary, care being taken to incorporate any sediment in the container. A sample is weighed into a flat weighing bottle, then taken up in water and transferred to a tared dish containing ignited sand, asbestos, or pumice stone. The bottle is rinsed, and the rinsings also added to the dish. Most of the water is removed on a steam bath, then drying is completed in a vacuum oven at 95-100 °C as for meats (A.O.A.C. 1950*j*; R.A.C.I. 1952*c*).

A rapid method for moisture in meat extract is based on the determination, by hydrometer, of the density of a standard dilution. Riddle (1944, 1945) described procedures for constructing curves relating the moisture content, by oven drying, to the density of diluted extracts. The method is reliable when used with a calibration curve appropriate to the extract tested. Curves relating to extracts prepared from beef muscle tissues are applicable to extracts from mutton muscle tissues or mixed muscle material, but not to extracts prepared from bones, offal, and trimmings.

Yeast Extracts

Yeast extracts may be examined in the same way as meat extracts, with the additional provision that the dissolved sample may be absorbed on strips of filter paper rolled into the dish (R.A.C.I. 1952*f*).

Processed Cheese

The sample consists of a slice or core taken from the canned product. The A.O.A.C. (1950*d*) recommends vacuum oven drying at 100 °C or, as a rapid screening method, partial drying on a steam bath, followed by $1\frac{1}{4}$ hours at 130 ± 1 °C in an oven with forced air circulation.

The R.A.C.I. (1952*a*) prescribes overnight air drying as for meat packs, or a rapid method in which the cheese is mixed with asbestos, by means of an ebonite or glass rod which is weighed with the sample, and dried to constant weight (approximately 3 hours) at 105 °C.

Condensed Milks

For the determination of total solids in condensed milks, the R.A.C.I. prescribes the A.O.A.C. official methods (1950*a*, *b*, *c*). The products are made homogeneous and diluted with water and the diluted samples are partially evaporated on a steam bath. Drying is completed in an air oven at 98-100 °C for unsweetened milk, or in a vacuum oven at 100 °C for sweetened milk in the presence of sand or asbestos.

Soups

The R.A.C.I. (1952*e*) procedure for moisture in canned soups is as follows: Weigh five grams of a homogeneous sample in a glass or porcelain dish. Dry on a water bath to a thick consistency, then

complete the drying in an air oven at 100-102 °C for three hours.

Vegetables, including Tomato Products

The sample may consist of the entire contents of a can or the drained solids following a drained weight determination, comminuted and mixed thoroughly. Products already comminuted may be shaken in the can, emptied out, and mixed thoroughly.

The official method of the A.O.A.C. (1950*m*) for total solids content involves vacuum drying at 70 °C to apparent dryness at 18 in. Hg vacuum, then complete drying at 26 in. Hg vacuum. The preliminary drying at low vacuum is, however, tedious, and the National Canners' Association Research Laboratories (Townsend *et al.* 1954) recommend partial drying on a steam bath, hot plate at low heat, or infra-red heater, while a gentle current of air is blown over the dishes with a fan.

The sample weight must be calculated from the area of the dish and the approximate solids content of the sample, so as to meet the requirement that the amount of dry residue shall not be less than nine milligrams nor more than 12 milligrams per sq. cm. of drying surface.

Fruits, Jams, and Marmalades

Canned fruits are sampled in the same way as canned vegetables. Jams and marmalades are comminuted and thoroughly mixed. Sample weights up to 20 grams are required to give the 3-4 grams of dry residue specified, and nine-centimetre dishes are suitable.

If insoluble solids are present, the sample is distributed evenly in the dish, diluted with water if necessary, and dried to constant weight (± 3 mg) at 70 °C and 26 in. Hg vacuum (A.O.A.C. 1950*e*).

If no insoluble matter is present, the sample is spread on pumice or quartz sand and dried at 70 °C and 28 in. Hg vacuum (A.O.A.C. 1950*e*, *l*; Cheftel, Frichet, and Estang 1951). More usually, however, such samples are examined for solids content by indirect methods, to be described in Part VIII of this series.

Peanut Butter

The R.A.C.I. follows the A.O.A.C. (1950*k*), which prescribed vacuum oven drying at 95-100 °C.

ENTRAINMENT-DISTILLATION

Another method for moisture determination in foods involves the direct removal of water by distillation and entrainment in an immiscible solvent, the condensed water being collected in a graduated trap. Fetzer (1951) has reviewed and illustrated a variety of forms of apparatus which have been devised for this determination. Moisture contents determined by distillation are subject to the same strictures as those determined by oven drying as regards their relation to "true" water content, and the possibility of incomplete recovery of water from the solvent is an additional source of error.

Entrainment-distillation is an official method (A.O.A.C. 1950*g*) for moisture in stock feed, but not for moisture in foods. It is, however, generally used in the author's laboratory for products having moisture contents less than 30 per cent., mostly candied fruits and fruit cakes (cf. Joslyn 1950). Although it may take several hours to reach the end point, the procedure occupies very little of the analyst's time. It is customary to reflux the sample with the solvent throughout one day and to read the water level next morning.

Toluene (b.p. 110·8 °C) is the solvent most widely used in this determination. However, Overbeek and Mossel (1951), Mossel and Reith (1951), and Mossel, Mossel-Hens, and Reith (1951) made a very thorough study of entrainment-distillation for the determination of moisture in foods, and they recommend *iso*octane (2, 2, 4-trimethylpentane, b.p. 99 °C) as the most suitable entrainer on the grounds of time to reach a constant reading, low solvent power for water, and minimum decomposition of samples.

CHEMICAL METHODS

Brief mention should be made of moisture determination in foods by procedures which depend upon chemical reactions with water. The best-known procedure of this type, the Karl Fischer titration, makes use of a reagent consisting of sulphur dioxide and iodine in solution in pyridine and anhydrous methanol (Mitchell and Smith 1948). It has found no special application to canned foods, but satisfactory results were obtained for moisture in condensed milks (Fosnot and Haman 1945).

The reaction of water with calcium carbide to produce acetylene has also been utilized for moisture estimation, e.g. in cheese (Shemin and Wagner 1947) and sweet corn (Williams, McComb, and Washauer 1950). The sweet corn was mixed with calcium carbide, salt added to control the rate of reaction, and the weight loss measured after approximately 10 minutes. Moisture contents so calculated agreed satisfactorily with vacuum oven drying. Joslyn (1950) and Belanger (1952) mention calcium carbide moisture testers for foods, in which the pressure of acetylene generated is recorded on a gauge calibrated directly in moisture content.

Another method included here, although it depends upon desiccant action rather than chemical reaction, is that of Potter (1951). The food sample is blended with anhydrous methanol and filtered first through glass wool, then through a weighed sintered glass crucible with a layer of "Drierite" (soluble anhydrite, $CaSO_4$). The crucible is washed with methanol and ether, heated 5 minutes at 140 °F to remove the solvents, and reweighed. This method showed satisfactory agreement with vacuum oven drying.

Finally, Launer and Tomimatsu (1952) made a novel approach to moisture estimation in foods, including some canned foods, by completely oxidizing the organic matter with standard dichromate in hot sulphuric acid. The dichromate consumed was estimated after an electrometric back titration and moisture was calculated by difference.

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Based on a lecture delivered at the New South Wales University of Technology on November 9, 1954.

Internal Protection of Tin-plate Food Containers

By E. G. Davis

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CANNED FOODS MAY BE BROADLY CLASSIFIED as "sulphur-staining" or "acid", according to their effect on the tin-plate container. In each class, the attack may be slight and of no commercial significance, or it may be so severe that the tin plate requires additional protection. The methods used for the protection of containers are generally different for "sulphur-staining" and "acid" products.

Sulphur staining, which occurs mostly with low-acid, high-protein foods such as meat, fish, crustacea, and some vegetable products, is a light brown to blue-black film which adheres firmly to the tinned surface and usually follows the pattern of the tin crystals. The mechanism of the staining reaction is not thoroughly understood, but it is usually attributed to the breakdown of the proteins during the heat processing of the pack, liberating sulphide ions which react with the tin to form tin sulphide. If iron is exposed where the tin coating has been fractured, as at the seams or around the expansion rings and bead on the ends, black iron sulphide may be formed as a loose deposit which may become detached and contaminate the product. While tin and iron sulphides in a can constitute no health hazard, they may detract seriously from the appearance of the can and its contents.

Acid corrosion is a much graver problem in the canning industry than sulphur staining. In mildly corrosive fruit and vegetables, such as peaches, pears, apricots, tomato products, and beans, normally packed in plain cans, some corrosion of the container is tolerated, and is often essential for the retention of a desirable light colour. For instance, pineapple, grapefruit, peaches, and pears packed in lacquered cans develop unattractive dark colours (Lueck and Brighton 1944*a*, 1944*b*, 1944*c*; Anon. 1946). In plain cans, the reducing conditions at the tin-plate surface maintain a light colour through a bleaching action. These reducing conditions, however, are not desirable for products containing anthocyanin pigments, since they lead to bleaching of the natural colour.

INORGANIC PROTECTIVE FILMS

Several methods of producing invisible, chemically passive films on tin-plate cans, for the prevention of sulphur staining, have been described (Crosse and Blackwell Ltd. and Sumner 1938; Crosse and Blackwell Ltd. *et al.* 1938; Sumner 1940; Anon. 1940; Kerr 1940). These methods were tested in this laboratory (Kefford and Lynch 1941), and found to reduce sulphur staining effectively.

The method known as the "Protecta-tin Process" (Kerr 1940; Lowinger and Kerr 1941) was most readily applicable to cans commercially. This method as later improved (Kerr 1946) involves immersion of the tin plate or cans for 10-60 seconds in a bath at a temperature of 70-80 °C, followed by rinsing in water. The bath is made by dissolving the following in one litre of water:

Trisodium phosphate (cryst.)	20 g
Sodium chromate	8 g
Sodium hydroxide	20 g
Wetting agent	3 g

Suitable wetting agents include "Teepol" and "Dispersol" L. The treatment can be

applied to the cans themselves, or to the tin plate before manufacture of the cans. In the latter case, removal of solution residues during the rinsing operation is easier, and both external and internal protection is given to the made-up cans.

More recently, Britton and Angles (1954) described a process for the treatment of tin-plate cans in which the time of immersion is reduced to three seconds at 90-95 °C. The solution is made by dissolving the following in one litre of water:

Sodium hydroxide	10 g
Sodium chromate	3 g
"Teepol"	2-3 ml

Other suitable wetting agents include "Lissapol" LS, "Perminal" BX, "Calsolene" Oil HS, and "Lubrol W". After immersion in the solution the cans are rinsed and dried. The exact nature of the film applied by alkaline chromate solutions is not known; evidence indicates that it is not simply tin oxide, but contains chromium in a chemically bound form.

In a series of canning trials using mulligatawny soup as the test product, the treatment gave a satisfactory resistance to sulphur staining on cans treated after fabrication, but was less satisfactory on cans treated before fabrication. The performance in both cases was better than the untreated control cans. In addition, some degree of protection against external corrosion was achieved.

ORGANIC COATINGS

Protection against both sulphur staining and acid corrosion is more commonly achieved by the use of organic protective coatings, or can lacquers. These linings function as chemically resistant barriers between the can contents and the metal surfaces of the can. They are applied to the flat sheets of tin plate by roller-coating, and dried by stoving at temperatures about 400 °F. A good can lacquer must therefore have the ability to withstand the operations of can manufacture; it must have good flexibility, hardness, and strong adherence to tin plate.

Lacquers resistant to sulphur staining are known as sulphur-resistant (S.R.) lacquers. This resistance is commonly achieved by incorporating finely-ground zinc oxide in the lacquer in amounts representing 10-15 per cent. of the solids. The zinc oxide preferentially reacts with sulphide ions to form white zinc sulphide, and thus prevents discoloration due to the formation of tin and iron sulphides.

Lacquers used for protection against acid corrosion are known as acid-resisting (A.R.) lacquers. In practice, A.R. lacquers are required mainly to aid colour retention in products such as beetroot, berries, berry jams, and cherries—all of which contain anthocyanin pigments—and to prevent metallic taints in flavour-sensitive foods, such as fruit juices. It should be pointed out that the use of internally lacquered cans may lead to severe localized corrosion at discontinuities in the lacquer film, followed by hydrogen swelling or perforation of the can.

There are four main types of lacquers used for protecting tin-plate containers: vinyls, phenolics, oleo-resinous types, and epoxide types. Each type, with the exception of the vinyls, can be given a wide range of properties by varying the chemical constitution.

Vinyl Lacquers

Vinyl lacquers are made by the copolymerization of vinyl chloride and vinyl acetate to form linear polymers. In contrast to the other types, these polymers do not crosslink during the stoving operation, and are thermoplastic. Vinyl lacquers will dry in the air, but may be given a low-temperature bake, which serves to remove the solvent and promote adhesion.

The vinyls have good chemical resistance and tooling properties, and freedom from taint and odour, but they are not widely used because they will not withstand high-temperature processing conditions. They have a low film build, and do not adhere well to tin plate. Vinyl lacquers are, however, used overseas on flavour-sensitive products such as canned beer, and for some post-lacquering operations such as side seam striping.

Phenolic Lacquers

Phenol formaldehyde lacquers are made by the acid or alkaline condensation of a phenol with formaldehyde. Polymerization is arrested at an early stage so that the resultant polymer remains soluble, and can be easily applied to tin plate. The stoving operation promotes further polymerization

and cross-linking between polymer molecules, to give an insoluble thermosetting film.

Phenolic lacquers have good chemical resistance and can be used as S.R. lacquers without the addition of zinc oxide. They are used on meat products, particularly sausages, where adhesion of the sausage skins to the lacquer film presents a problem with many other lacquers. Phenolics, however, have two serious disadvantages: they may impart a phenolic taint to foods, and they lack flexibility except at low film weights.

Oleo-resinous Lacquers

Oleo-resinous lacquers constitute the most widely used group of can lacquers. They are characterized by good tooling properties, ease of application, fairly good chemical resistance, and low cost. A wide range of raw materials, both synthetic and naturally occurring, is available for their manufacture.

Oleo-resinous lacquers are made by reaction between a suitable resin and an oil which can be polymerized by heat. Resins commonly used include naturally occurring resins such as kauri gum, congo gum, rosin, and various modifications of these, or synthetic resins such as oil-modified phenolics, and coumarones. Oils which may be used are: tung, dehydrated castor, oiticica, and perilla. The initial reaction between the resin and oil, as carried out by the lacquer manufacturer, results in chemical combination of the resin and oil to a polymer which is still soluble. After application to tin plate, the lacquer is again subjected to heat treatment, which brings polymerization to a stage where the film possesses the desired chemical and physical properties.

Epoxide Lacquers

The epoxide lacquers are the most recent addition to the range of can lacquers available to can makers. The basic resin for the manufacture of these lacquers is made by the reaction of epichlorohydrin and diphenylol propane (De Trey Frères S.A. 1946). This resin has a linear structure possessing a reactive epoxy group at each end of the molecule and reactive hydroxy groups at widely-spaced intervals along the chain. The basic resin is supplied to lacquer manufacturers in this form, and because of the reactive groups it is capable of being modified in a large number of ways. Other resins such as phenolics, alkyds, and urea-formaldehyde resins may be linked to the epoxide resin. The most useful can lacquers have resulted from a combination of epoxide resins with phenolics, the hydroxy groups in the epoxide resin forming ether linkages with the phenolic resin. The absence of ester linkages renders the resultant polymer more resistant to the action of alkalis and acids.

Epoxide lacquers have been tested in this Laboratory on a number of products and found to be as good as or better than existing oleo-resinous lacquers. With citrus juices, epoxide lacquers show no tendency to strip or peel, as do the oleo-resinous types. With cheese, the lacquer does not show any tendency to strip from the can or adhere to the product. The resistance to sulphur staining is very good even when zinc oxide is not included in the formula. This means that epoxide lacquers may serve as universal coatings, eliminating the necessity for canners to hold stocks of A.R. and S.R. lacquered cans. Their resistance to abrasion during fabrication of the cans is also very good.

Epoxide lacquers have, however, several disadvantages which will need to be overcome if they are to be widely used in the canning industry. Firstly, they have a high critical stoving temperature: the optimum stoving temperature is 420 °F and the minimum 385 °F (Hughes 1954). Below this temperature cross-linking between resin molecules does not take place, and the resultant film does not possess the properties of a correctly stoved film. Secondly, they have a low solids content, so that in most cases two roller coats must be applied to make up the desired weight of film. Finally these lacquers are more expensive than the oleo-resinous types.

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ANSWERS TO INQUIRIES

SMOKED EELS

A demand for smoked eels has arisen in Australia, particularly among migrants from continental Europe. As directions for preparing them are not readily obtainable in English, the following notes have been compiled, mostly from foreign literature, in response to a number of inquiries.

The eels should weigh from 9 to 14 ounces, have a bright appearance, and be alive at the commencement of processing. It is best not to use eels caught in muddy waters, for they may have an unpleasant taste. Two methods are used to remove mucus from the surface of the eels. One procedure is to cover them with fine salt for three hours, then brush them vigorously, and rinse in clean water. A quicker method, which does not affect the quality of the fish, is to place them in a tub and cover with a one per cent. solution of ammonia (1 pint of ammonia to 100 pints of water), which is later rinsed off with plenty of clean water. The live fish may be made less slippery to handle if each one is covered with sawdust.

After the eels have been transferred to the cleaning bench, the workers may dip their hands in dry salt to reduce slipping. The eels are opened and cleaned, care being taken to remove all blood along the backbone, and then washed thoroughly.

Salting in 10 per cent. brine (40° salinometer) gives a more tender and more delicately flavoured product, but at this concentration there is risk of deterioration in hot weather. Ice is sometimes added to the brine to cool it, but more frequently concentrated brine (100° salinometer) is used or the fish are stretched and laid parallel in dry salt. Salting requires 5-24 hours according to the market for which the eels are intended. After salting the fish must be washed thoroughly, as over-salting leaves a white bloom on the skin after smoking.

For smoking the eels are hung on long hooks which pierce the fish from the throat to the back of the neck. Tenterhooks fitted on wooden rods are better for large eels, and S hooks are used for very large ones, which are attached to the hook by means of wire fixed around the body above the anus. When they are on the hooks the eels are dipped for a few seconds into a vat of

boiling water until the sides of the body open out. Large fish are placed in the centre of the smoke house, and smaller eels to the outside.

Hot smoking is in two stages. In the first stage (in Europe) chips of dry oak, birch, beech, or chestnut are burnt to give clean hot flames. (In Australia most hardwoods are unsuitable for smoking, but light hardwoods such as she-oak give good results. Sawdust and buzzer chips suitable for smoking fish can be obtained from furniture manufacturers.) The flames reach a height of 8-10 inches and the temperature rises quickly to 248-257 °F. This is kept up for 5-10 minutes, during which time the fish cooks and loses part of its oil and water. The flames are regulated by means of fire doors.

In the second stage the flames are smothered with chips and sawdust, and the smoke outlet and fire doors are almost closed. Thick smoke arises, and the temperature is maintained at around 104-122 °F. Small eels will be smoked in about 90 minutes, big ones in 2-4 hours. Export fish (in Europe) are smoked for 8-12 hours.

The fish are well smoked when the flesh at the level of the anus is easily detachable without the appearance of fat or drops of water along the backbone. The eels are cooled off in the smokehouse, given a light brushing of edible oil on the outside to improve the appearance, and wrapped in transparent cellulose film. From 4 to 33 pounds of fish are packed in long narrow cases.

A hundred pounds of fresh eels yield about 60 pounds of the hot smoked fish, as the loss in gutting is about five per cent. and in smoking about 30 per cent.

The simplest smokehouse is a large barrel with a large hole in each end, placed over a hole in the ground which serves as a hearth. A wet bag is used as a cover to keep heat in the barrel and regulate the loss of smoke. A larger smokehouse is usually made entirely of bricks. The bricks comprising the roof are supported on a timber frame, and those in the floor are set with the long axis vertical. Dimensions are approximately 3 feet wide, 6 feet long, and 6 feet high. The door has an iron frame and is divided into three sections to control the smoking. Above the door is a sheet-metal hood which communicates with the chimney and helps to let out the smoke. The chimney is 6-8 inches in diameter and can be opened and closed. About six inches below the roof there is an angle-iron running along the side walls to support the smoke rack on which the eels are hung.

TAINTING OF FOODS

How can one test whether off-flavours in food have been derived from the enveloping carton?

Samples of the following materials used in making the carton should be obtained from the manufacturer:

Unprinted board.
Newly printed board.
Board printed some time before.
Transparent plastic (cover) with some of the adhesive (if any) used to attach it.

A sample of each of these packaging materials should be put into a separate closed jar or tin for some time with a shallow dish or tin containing a thin layer of fresh butter. Butter is chosen for the test because it is more sensitive to tainting than most other foods.

As a control, one jar should contain a dish of butter but no packaging material. After 12 to 24 hours a little butter is scraped from the surface exposed in each jar and examined by a panel of 6 to 12 tasters, preferably of proven ability. Advice on the conduct of tasting tests may be obtained from the Division of Food Preservation and Transport or from the C.S.I.R.O. Dairy Research Section, Box 20, P.O., Highett, Vic.

CORRIGENDUM

VOLUME 15, NUMBER 1

Page 13, second column: *For* ml *read* degrees Brix.

NEWS from the Division of Food Preservation and Transport

WORK OF THE CANNING SECTION

Most of the work of the Canning Section is carried out at the Divisional Headquarters at Homebush, where there are six Research Officers, two Technical Officers, and five Technical Assistants; one Technical Officer and two Technical Assistants are located at the Tasmanian Regional Laboratory of C.S.I.R.O. in Hobart, Tas.

The Section is interested in all methods of improving the quality of canned foods. Since it is axiomatic that canned fruits and vegetables cannot possess better quality than the raw material, studies are being made of the relative suitability of varieties for processing. Particular attention is being paid at the present time to peaches, apricots, tomatoes, and peas. Stress is laid on the stage of maturity at which these products are harvested. Possible modifications of processing procedure are being investigated. Various aspects of the container are being studied. A long-term investigation has been commenced into the effects on each other of the electro-tinplate can and the product it contains and into the need for protective coatings on the tin plate.

A fundamental investigation of the problem of bitterness in canned citrus juices was begun about five years ago. It is hoped that the precise chemical constitution of the bitter principle (limonin) and its related compounds will be elucidated shortly, when the project will be terminated. It is planned to begin another fundamental chemical investigation on the deterioration of colour (anthocyanins) which occurs during the processing of a number of pigmented foods.

Work at the Section's Tasmanian Laboratory is concerned with the development of methods for improving the quality of canned solid-pack apple, berries, and berry pulp. The programme is based essentially upon varietal selection, fruit maturity, and process modification.

Senior officers of the Section devote a considerable amount of time to advisory work by personal interview, visits to plants, and investigation of problems as they arise. Contact with industry has proved valuable in the selection of applied problems undertaken by the Division. The food industry has given generous support to the work of the Canning Section by the provision of facilities for large-scale plant and field tests and has, from time to time, made direct contributions in cash and kind in appreciation of services rendered.

PERSONAL

Dr. R. N. ROBERTSON, Senior Principal Research Officer of the Division, has been awarded the W. B. Clarke Memorial Medal by the Royal Society of New South Wales. The medal is awarded annually for distinguished research in the natural sciences in Australia or its territories. Dr. Robertson's award was in recognition of his researches in plant physiology, particularly on salt accumulation in the plant cell and its relation to respiration and on the physiology of fruit development.

Mr. E. W. HICKS, Senior Principal Research Officer, left Sydney on May 21, 1955, for a six months' tour overseas. Mr. Hicks will have the distinction of being the first officer from the Division to visit the Central Food Technological Research Institute at Mysore in southern India, where he will discuss problems of interest to the two institutions. In the United Kingdom and Europe, and probably also in the United States and Canada, Mr. Hicks will visit food research laboratories and study the refrigeration and transport of food. In September Mr. Hicks will be Australia's senior delegate to the International Congress of Refrigeration in Paris.

Professor A. N. Bose, Professor of Food Technology and Director of the Food Technology Laboratories (Research) at Jadavpur College of Engineering and Technology, Calcutta, was a guest worker at the Homebush laboratories during the month of April. On April 15 he gave an illustrated lecture to the scientific staff on the food industry in India. Professor Bose returned to India at the end of April.

PUBLICATIONS BY STAFF

Fish Handling and Processing in U.S.A. *W. A. Empey. Fish. Newslett. Aust.* **12** (7): *8*, (8): *13*, (9): *15*, (10): *15*, (11): *13*, (12): *11* (*1953*); **13** (*1*): *11*, (*3*): *15*, (*4*): *9*, (*5*): *15*, (*6*): *8*, (*7*): *8*, (*8*): *9*, (*9*): *13*, (*10*): *13*, (*11*): *12* (*1954*).

Mr. Empey, who visited the United States recently to study preservation methods for fish, described in this series of articles a modern fish pier and its equipment; containers used for fish; the freezing of fish; the canning of salmon, tuna, Californian sardines (pilchards), Maine sardines, and mackerel; canned fish flakes from haddock or cod, or a mixture of both; and canned fish roe. He deals also with the handling, freezing, and canning of shrimps, crabs, lobsters, oysters, clams, and other shellfish. The fish-meal and fish-oil industries are described, also glue and isinglass production, and salt curing and smoking of fish. In conclusion, the organization of research on fish preservation is outlined briefly.

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Fish Handling and Processing in Canada. *W. A. Empey. Fish. Newslett. Aust.* **13** (*12*): *10*.

The author had less opportunity for study in Canada than in other countries. He gives a brief account of fish processing and research on preservation by the Fisheries Research Board of Canada.

* * *

Isolation of Mucic Acid from Fruits. *E. F. L. J. Anet and T. M. Reynolds. Nature* **174**: *930* (*1954*).

Mucic acid has been recorded only twice from natural products, namely in putrefied blood and in the diffusion juice from sugar beet. Pure mucic acid has now been isolated from sound ripe peaches and pears by displacement chromatography on anion-exchange resins. The methods used make it appear certain that the acid was present in the free state in the fresh fruit.

* * *

Water-soluble Constituents of Fruit. I. Some Observations on the Occurrence of Free Galacturonic Acid in Fruit. *A. S. F. Ash and T. M. Reynolds. Aust. J. Biol. Sci.* **7**: *435-43* (*1954*).

T. H. Harris, using a colorimetric method, had in 1948 (*J. Ass. Off. Agric. Chem. Wash.* **31**: 501) detected free uronic acid in juice from rotten apples and from different varieties of sound apples. Dr. Ash and Dr. Reynolds, by using paper chromatography, have detected a free uronic acid in several varieties of pears after ripening at 20 °C, but not in green or tree-ripened pears. Similar results were obtained with freestone peaches. No free uronic acid was detected in apricots whether ripened on the tree or at 20 °C. Chemical tests applied to the free uronic acid in pears, after elution from paper chromatograms, indicated that it was galacturonic acid.

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The Tenderization of Peas During Vining. *J. C. Moyer* (*Department of Food Science and Technology, Cornell University, Geneva, New York*), *L. J. Lynch, and R. S. Mitchell. Food Tech., Champaign* **8**: *358-60* (*1954*).

In the course of an investigation at Geneva, U.S.A., in 1953, the effect of viner speed on the physical condition of peas was studied, using the maturometer to measure the changes in texture. The amount of injury was shown to vary directly with the beater speed. The rate of change in maturometer values was independent of variety and maturity, and identical for a commercial and experimental viner. The results obtained emphasize the need for careful control of beater speed, in order to avoid losses due to split skins in processing lines and to prevent unnecessary texture deterioration in the finished product. Operational control of viners should have as its target the maximal though not necessarily the total recovery of peas from the pod, since damage to peas is an economic factor of primary importance.

THE SURVIVAL OF AIRBORNE MICROORGANISMS. III. EFFECTS OF TEMPERATURE. *A. D. Brown. Aust. J. Biol. Sci. 7: 444-51 (1954).*

Two earlier papers in this series have already been summarized (*Food Pres. Quart.* **13**: 84-5). The rate of death of cells dispersed in air of different relative humidity was measured at 10 °C for one strain of *Escherichia coli*, *Achromobacter* sp., *Micrococcus* sp., and *Pseudomonas* sp. (the last three being low-temperature organisms). Some measurements were also made at 5 °C and 15 °C. The results show marked effects on the death rate of these organisms due to relative humidity (40-90 per cent.), the temperature of the atmosphere, and the age of the cells.

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

FOOD SCIENCE ABSTRACTS

COLORIMETRIC ESTIMATION OF FAT PEROXIDES IN MEAT. *L. Hartman, C. N. Hooker, and H. E. Watt. N.Z. J. Sci. Tech. B 35: 307-10 (1954).*

The dichlorophenolindophenol method of Hartman and Glavind (see *Acta Chem. Scand.* **3**: 954 (1949)) for determining peroxides is modified for the estimation of fat peroxides in meat by using a mixture of *n*-propyl alcohol and xylene to extract fat from the wet meat, and calibrating the colorimetric determinations against results obtained by the ferric thiocyanate method of Loftus Hills and Thiel (see *J. Dairy Res.* **14**: 340 (1946)). Phosphatides do not interfere with the method.

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"BILGY" FISH. *C. H. Castell. Fish Res. Bd. Can., Progr. Rep. Atlantic Coast Stas. No. 58, 27-31 (1954).*

Certain fish may develop a very bad odour, resembling that of bilge water. This odour diminishes on exposure to air, and is not accompanied by increased pH or accumulation of trimethylamine in the muscle. The relationships between acidity and bad odour are the same for bilge water and for these "bilgy" fish; however, bilge water does not cause the contamination. Absence of air and the presence of suitable bacteria (which are found in the gut and on dirty pen boards) are responsible for this putrefaction, which is worst in the first-caught fish. It can be avoided by: (1) taking great care in separating the first-caught fish from the pen boards and from each other by a layer of ice, thus ensuring that air is present, (2) having clean surfaces (preferably of non-corrosive metal) free from slime, and (3) careful degutting to ensure that the fish are not contaminated with their own faeces. "Bilgy" fish are unfit for human consumption.

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