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Dr. J. C. Fidler, O.B.E., a noted authority on the storage of fruit and vegetables, visited many parts of Australia last spring. Dr. Fidler is Senior Principal Scientific Officer at the Ditton Laboratory, Kent, England, and has worked in close collaboration with contemporary Australian research workers. Last year he visited the C.S.I.R.O. Division of Food Preservation at North Ryde, N.S.W., and the following is an abridged version of a talk he gave to its research staff on that occasion.

The Work of the Ditton Laboratory

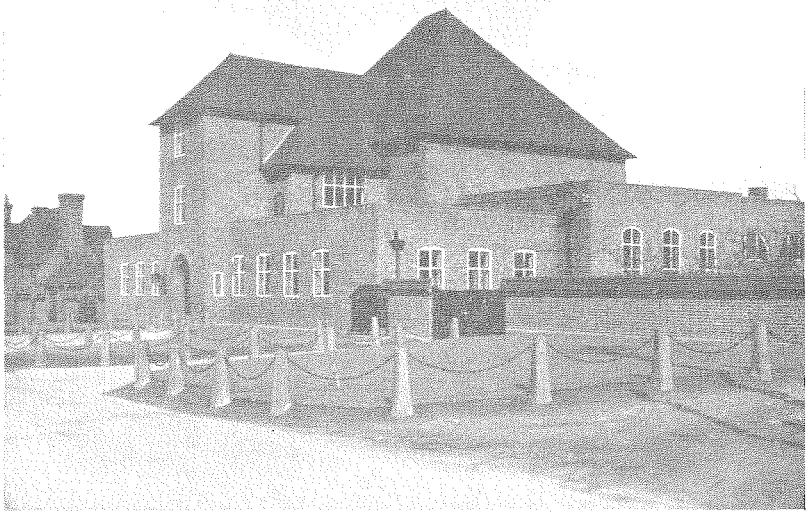
By J. C. Fidler

THE Food Investigation Board was started in Britain in the 1920's to function under the Department of Scientific and Industrial Research. This organization established three research laboratories, one at Aberdeen —the Torry Laboratory—to undertake fish research; a second, the Low Temperature Research Station, Cambridge, whose work was to cover fruit, meat, poultry, and eggs; and lastly, the Ditton Laboratory, Kent, for fruit storage investigations.

The establishment of the Ditton Laboratory, the building of which was finished in 1929, was prompted by the difficulties then being experienced with shipments of fruit from Australia and New Zealand, which included patchy ripeness on discharge and, on occasion, freezing during transport. Although fruit investigations were being made already at the Cambridge Low Temperature Research Station, the facilities were inadequate to permit the experiments, on a semi-commercial scale, which were then envisaged.

The Ditton Laboratory was sited near to the well-known East Malling Fruit Research Station, from where it was intended to obtain and store fruit of known history. In actual fact this has rarely taken place, partly because of the different interests of the two Stations as regards the fruit, and partly because of the need to concentrate on the establishment of correct controlled atmospheres for the varieties of apples and pears grown in England. The funds for building the Ditton Laboratory came from the Empire Marketing Board and, since one of the main objectives of its establishment was a study of temperature distribution in ships' cargoes, the principal feature of the original Ditton Laboratory was a model of a ship's hold, which was full scale in height and width but half scale in the remaining dimension. This hold, which had a capacity of 100 tons of fruit in bushel boxes, could be cooled in a variety of ways—for example with a side or floor to ceiling forced air system, or by grids. Storage space above the hold enabled it to be re-loaded to a variety of storage patterns within a short space of time. Several hundred thermometers placed in the cargo enabled the accurate measurement of cargo temperature distributions. From these measurements the late A. J. M. Smith and J. K. Hardy worked out the principles on which the holds of modern refrigerated cargo ships are now constructed.

Over the years the research workers at the Ditton Laboratory have carried out many fruit storage investigations. Much of this work has been done in close collaboration with the C.S.I.R.O. Division of Food Preservation and other laboratories.



A view of the Ditton Laboratory taken from the south-west. (Crown copyright.)

The principal activities of the Ditton Laboratory at present concern the controlled atmosphere storage of fruit, chiefly apples, work which F. Kidd and C. West initiated in the late 1920s. This work is conducted by the Director of the laboratory, R. G. Tomkins, and by J. C. Fidler.

Satisfactory storage atmospheres have been worked out for most of the varieties of eating apples grown in Britain which, of course, differ from those grown in Australia. Some varieties may be stored successfully in ventilated atmospheres, with no independent control over oxygen, in which the carbon dioxide is allowed to rise to 8–10%. Other varieties, such as the popular Cox's Orange Pippin, are allowed to reduce the concentration of oxygen in the store, and a scrubber employing an absorbent is used to keep the carbon dioxide down to 5%.

It is of interest to record that over the period 1929–32 work was done at Newcastle, in the north of England, on the effect of oxygen concentration on the rate of respiration in apples. Some eight years ago—about the time of the work of D. Martin in Tasmania—attempts were made in the Ditton Laboratory to store apples in low concentrations of oxygen in the absence of carbon dioxide. As an outcome of this work some have stored the variety Cox's Orange Pippin in 2–2½% oxygen in the absence of carbon dioxide (Fidler and North 1961). This is successful, but where fruit is liable to rot through fungal infection better results may be obtained with a 3% oxygen and 5% carbon dioxide atmosphere. This reduces rotting, and the carbon dioxide tends to retard yellowing. The reduction in oxygen helps retain the firmness of the fruit.

For its controlled atmosphere work the Ditton Laboratory has available a very large number of containers of 10–100 lb and ½–1 ton capacity, in which a wide range of controlled atmospheres may be used (Tomkins 1959).

Controlled atmosphere storage of pears is practised in the U.K., but nowadays the building of new stores for this purpose is no longer recommended. Pears are now usually stored in air at 29°F. For success the controlled atmosphere storage of pears was found to depend very much on picking the fruit at the right stage of maturity. This poses a problem for, since no one has been able to develop a suitable index of maturity for field use, it must depend upon the growers' judgment. Graphs of respiration rate, showing the days to climacteric, have been attempted; but by the time the results are available it is invariably too late to apply them in the orchard.

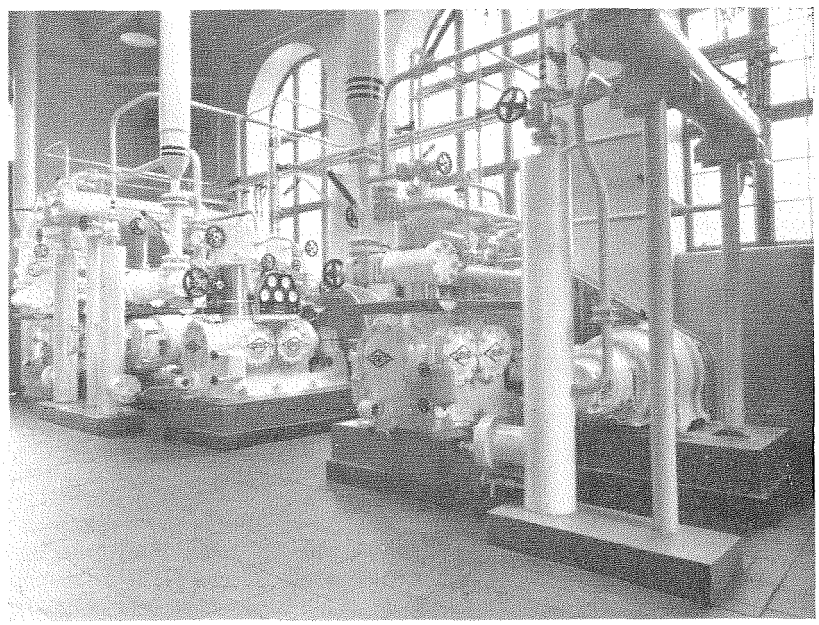
In biological work it is usually unwise to extrapolate results beyond the treatments actually investigated. What happens is sometimes quite unpredictable. For example, if the storage temperature of pears is dropped from 33°F to 30°F one would expect to risk freezing the fruit for a negligible benefit whereas this may, in fact, double its storage life. Likewise if the concentration of oxygen is dropped from 20% to 4% it has little effect on storage results, and as much superficial scald will be found on a susceptible apple variety as when stored in air. Take the oxygen down to 3% and there will be somewhat less scald, but let it drop another fraction to

2% and with U.K. apple varieties the incidence of scald will be negligible. To give another example, this time one which led to a notable advance: if early and late apple varieties, say Worcester Pearmain (which is very early) and the late maturing Bramley's seedlings, are stored together at from 10° to 20°C, the early variety will soon begin to produce ethylene, which induces the climacteric of the late variety, so shortening its storage life. At 10°C there is a sudden and considerable stimulus to ripening; at 7°C there is very little, but at 3°C there is none whatsoever. This discovery has meant growers can safely store together two different varieties of apples, picked at the same time.

The work on control of superficial scald by chemical means which has been carried out at Ditton has not been systematic; the objective has been to find what sort of treatments work and to what extent, if any, they injure the fruit. A number of the American methods of preventing scald, including the use of diphenylamine (D.P.A.) have been investigated. The New Zealand method of formulating the D.P.A.—dissolving it in oil with a wetting agent and emulsifying—has proved very successful. It was found that no damage resulted even if the boxes of fruit were submerged and inadequately drained. Successful treatment by this technique proved possible with 2000 p.p.m. of D.P.A., leaving residues which were well within the U.S. legal limit. This work was in the nature of a sideline to extensive researches into the effect of various factors on the incidence of superficial scald; size of crop, size of fruit, date of picking, delayed storage, weather, irrigation, and composition of storage atmosphere.

To quote one facet of this work: volatiles may be responsible for scald—indeed it seems to be fashionable to believe they are—but so far the workers at the Ditton Laboratory have obtained no convincing evidence. Several methods of removing volatiles from the storage atmosphere have been attempted. The use of activated charcoal, which had been advocated, gave negative results. Even in storage cabinets, where it was possible to reduce the volatiles to a very low figure, this had no effect on the incidence of scald (Fidler 1950). The efficacy of oiled wraps, used earlier with considerable success, was attributed by Brooks, Cooley, and Fisher to their absorption of volatiles but no real evidence for this has been forthcoming.

D. F. Meigh, who has been working on volatiles for some years at the Ditton Lab-

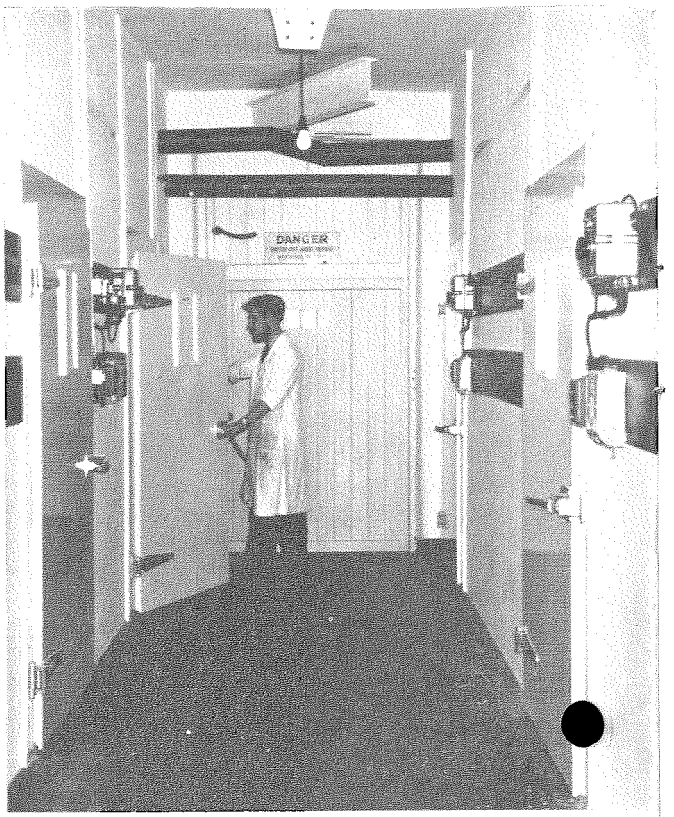


The engine room of the Ditton Laboratory (UDEC copyright.)

oratory, has worked out some elegant ways of identifying and estimating the substances present in apple volatiles in the storage atmosphere. (In this connection tribute must be paid to C.S.I.R.O. research workers in the North Ryde Laboratories who have also developed very effective techniques of estimating minute quantities of ethylene by gas chromatography.) Meigh has been able to detect ethylene inside bananas three or four days before the climacteric of respiration begins. He has also worked on the formation of ethylene by subcellular preparations, but has not found any substrates capable of supporting the production of ethylene. In this work on the constituents of the waxy cuticle he has isolated long-chain fatty acids from C_{13} to C_{22}. These transfer themselves from the fruit to oiled wraps during storage in the expected manner. Virtually the same fatty acids are obtained from the apple skin whether or not the fruit has been treated with D.P.A. (Meigh 1960; Meigh *et al.* 1960; Meigh 1962).

W. G. Burton, working at the Ditton Laboratory, has been trying to ascertain the volatiles which are present in potatoes. Meigh is collaborating with Burton in this work. Burton's earlier work appeared to indicate that nonyl alcohol was produced by potatoes, and was a natural sprout inhibitor. This assumption has been shown to be wrong but valuable, for nonyl alcohol has proved very effective for the purpose and is now used commercially. In spite of their fairly strong aroma, potatoes do not seem to produce much in the way of volatiles. Although some success has been achieved, great difficulty has been experienced in getting rid of moisture vapour on concentrating the volatiles. So far it has proved possible to identify a number of hydrocarbons.

The mitochondrial preparations isolated by A. C. Hulme from the peel and pulp of apples by methods which inhibit inactivation by polyphenols show activities as high as any found in plants. They phosphorylate, and in the electron microscope show a system of double membranes and tubules similar to those in intact cells (Jones and Hulme 1961; Hulme and Jones 1962; Hulme and Wooltorton 1962). A study of the soluble enzymes engaged in $O_2 : CO_2$ exchange has provided a probable explanation of the immediate cause of the respiration climacteric.



Airlock to controlled temperature rooms used for respiration studies.

At the Ditton Laboratory B. G. Wilkinson is carrying out some long-term studies, in collaboration with the workers at the East Malling Research Station, on the effects of manurial treatments on the nutritional status of the tree and the storage properties of the fruit it produces (Wilkinson 1957, 1959). The relation of manurial treatments to the nutrients appearing in the fruit is complicated by the climatic variability of the British summer. One can never be sure if the tree is making use of the current manurial treatment, an earlier one, or both. So far it appears that nitrogen increases the rotting of fruit caused by fungus diseases during storage. The grassing down of orchards, now a fairly common practice in Britain, seems to reduce the tendency of fruit to low-temperature breakdown. From extensive chemical analyses of

the fruit, especially as regards mineral elements, it appears that there may be some connection between magnesium and low-temperature breakdown.

Work at the Ditton Laboratory by W. H. Smith with other fruits such as strawberries and raspberries has yielded results of considerable practical value. Because of the delay in marketing it involves, the precooling of strawberries is not considered worthwhile in Britain. On the other hand, with the better quality raspberries, their precooling in an atmosphere containing 20% carbon dioxide appears to have quite a future. Good quality raspberries grown in Scotland, cooled to 35–40°F and transported in insulated containers containing 20% carbon dioxide, reach the English market in very good condition and usually bring high prices (Smith 1958*a*, 1958*b*, 1959).

Finally a word on coolers (Mann 1960*a*, 1960*b*). Investigations initiated in the Ditton Laboratory have shown the desirability of growers having fully operative coolers. In some cases investigated, what were regarded as large surface coolers were found to consist of a lot of pipe and little actual cooler, which indicated very uneven heat transfer conditions. Looking inside the galvanized casing revealed solid ice for a third of the space, with the rest bone dry. The fitting of deflectors to the air flow through the cooler has resulted in more uniform cooling conditions. Tests have been made as regards the efficiency of materials for the vapour and gas seals of controlled atmosphere stores. A heated probe has been developed which can be inserted into heavy insulation to measure any changes in the thermal conductivity of insulation as it takes up moisture. Expanded polyvinyl chloride (P.V.C.) and polyurethane would appear to be the insulants of the future for controlled atmosphere storage, as they are rigid and can be bonded conveniently to other materials. Being practically vapour and gas proof they are likely to give very good insulation over long periods of time.

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Preservation of Minced Meat with Sulphur Dioxide

By J. H. B. Christian
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Minced meat, like fresh sausage, is an extremely perishable food. While sulphur dioxide is a legitimate preservative for sausages, in only one State is its use permitted in minced meat. Recently, C.S.I.R.O. was asked to examine the effects of sulphur dioxide on the keeping quality of mince, in particular from the viewpoint of the consumer. This article describes some results of the investigation that was carried out.

THE spoilage of minced meat generally results from the growth of very large numbers of bacteria in the mince. It is the action of these bacteria upon some of the constituents of meat which produces the stale, sour, or putrid odours that are indicative of spoilage. The storage life of meat, whether minced or not, depends largely upon two factors: the amount of bacterial contamination, and the rate at which the contaminating bacteria multiply. Contamination reflects the standard of hygiene prevailing, and the rate of multiplication is largely dependent upon the temperature at which the meat is held. Thus in evaluating sulphur dioxide (SO_2) as a preservative it is necessary to examine also the effects on storage life of the number of bacteria initially present, and of the temperature of storage.

EXPERIMENTAL METHOD

As the initial bacterial population of meat is important in determining storage life, surveys of bacterial counts in 27 samples of mince offered for sale were made in Sydney and Brisbane. Temperatures of 24 of these samples were taken immediately after purchase of the mince, since temperature has an important bearing on the storage life.

For the experimental treatments and controls minced steak was purchased from retail butcheries in the Sydney area, but in some cases the meat was purchased as steak and minced in the laboratory in a kitchen mincer which had been cleaned thoroughly with a detergent. Sulphur dioxide was incorporated by dusting a thin layer of mince with an appropriate weight of dry sodium metabisulphite and mixing thoroughly. Sufficient metabisulphite was added to give a dosage equivalent to 3·5 grains of SO_2 per pound. This dosage was chosen because it corresponds to the maximum concentration of SO_2 permitted in fresh sausages under the N.S.W. Pure Food Act, 1962. Over 80% of the added SO_2 was recovered on analysis.

The SO_2-treated mince and the untreated controls were stored in large glass beakers covered with paper or, alternatively, the mince was wrapped in butchers' paper. (Results were similar in both methods.) Storage experiments were performed at 34° and 41°F, and also at 68°F after initial storage for 24 hours at 34°F. The numbers of viable bacteria in the minces were determined daily by the usual methods.

Although an off-odour usually develops in untreated mince by the time it contains about 100 million bacteria per gram, objectionable odours were not readily detected in SO_2-treated mince until the bacterial population reached about 500 million per gram. Hence, as an arbitrary criterion, the storage life of all samples was considered ended when the bacterial count attained the latter level.

RESULTS

Survey of Butchers' Mince

Bacterial Counts.—For the 27 samples purchased in Sydney and Brisbane the geometric average bacterial count was 17·5 million/g. In Sydney the mean was 17·5 million/g, with maximum and minimum counts of 4·4 million/g and 68 million/g, respectively. In Brisbane the mean was 18 million/g, with

extremes of 3·3 million/g and 87 million/g. In mince of this average bacteriological standard, only five successive subdivisions of the bacteria would have to occur to cause spoilage at the defined level.

In contrast, steak bought from a retail butcher and minced in a cleaned kitchen mincer contained less than 10,000 bacteria/g. Sixteen successive subdivisions would have to occur before this population reached the spoilage level.

Temperature.—The temperature of 24 of the mince samples bought in Sydney and Brisbane, measured immediately after purchase, averaged 55°F. For Sydney, the mean mince temperature was 56°F, with extremes of 43° and 65°F; while for Brisbane the mean mince temperature was 54°F, and the extremes 34°F and 83°F. These values may be compared with the maximum temperature of 34°F prescribed for the holding of prepackaged meat in retail premises according to the N.S.W. Pure Food Act, 1962.

Storage Life

Untreated Mince.—The results in Table 1 show the effects of the number of bacteria initially present and of the temperature upon the storage life of mince. High initial numbers reduce the lag (the time taken for growth to commence) but do not affect the rate of growth. However, high temperature reduces the lag and also increases the rate of growth. The effects on storage life are shown in Table 1 and Figure 1. Note that when the initial bacterial count was reduced to one hundredth (e.g. from 100 million/g to 1 million/g), the storage life at 41°F was increased by over 3 days; a similar increase was achieved by lowering the temperature from 41° to 34°F.

Treated Mince.—The incorporation in the form of metabisulphite of 3·5 grains SO_2 per pound of mince substantially increased lags and reduced rates of growth of bacteria at both 41° and 34°F (Table 2). With samples of similar bacterial populations, storage life was increased two to three times at 41°F, and by only 45% at 34°F. A comparison of storage life of mince at 41°F with and without SO_2 additive is given by Figure 1. As with untreated mince, samples of lowest initial count had the longest storage lives. Note also that for samples of similar initial count, the storage life at 34°F for untreated mince (Table 1) was as long as that which had been treated with SO_2 additive and stored at 41°F (Table 2).

TABLE 1

Effects of Temperature and Initial Bacterial Population on Lag, Growth Rate, and Storage Life of Minced Meat without Added Sulphur Dioxide

Initial No. of Bacteria (per g)	Lag (hr)	Growth Rate (Divisions per hr)	Storage Life (hr)
Experiments at 41°F			
63,000	20	0·101	130
750,000	13	0·093	109
4,400,000	12	0·110	80
4,800,000	6	0·096	75
5,200,000	14	0·111	74
Mean		0·102	
Experiments at 34°F			
4,400,000	65	0·066	166
7,500,000	57	0·056	161
Mean		0·061	

Spoilage at 68°F.—To examine the effect of transferring minced meat from low to high temperature, mince was stored for 24 hours at 34°F and then at 68°F. The bacterial population was about 10 million/g at the

TABLE 2

Effects of Temperature and Initial Bacterial Population on Lag, Growth Rate, and Storage Life of Minced Meat Containing 3·5 Grains Sulphur Dioxide per Gram

Initial No. of Bacteria (per g)	Lag (hr)	Growth Rate (Divisions per hr)	Storage Life (hr)
Experiments at 41°F			
600,000	120	0·065	269
3,500,000	70	0·062	186
4,400,000	51	0·063	163
Mean		0·063	
Experiments at 34°F			
4,400,000	108	0·053	231
7,500,000	63	0·055	171
Mean		0·054	

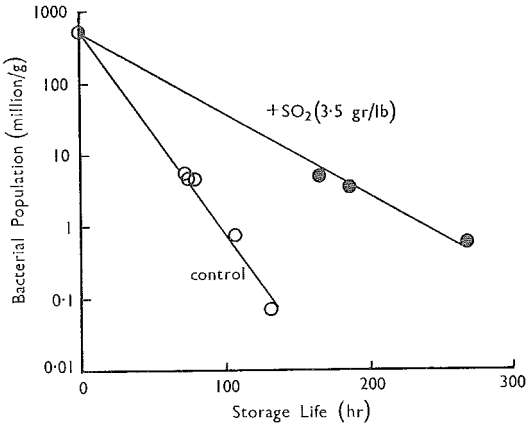

Fig. 1.—Effect of initial bacterial population and sulphur dioxide on the storage life of minced meat at 41° F.

time of transfer. In mince without additive, the number of bacteria doubled in 3 hours and reached 100 million/g in 6·5 hours. When sulphur dioxide was present, the count had not doubled after 9·5 hours at 68°F.

Effect of Sulphur Dioxide on Type of Spoilage

In mince without added metabisulphite, spoiled at low temperatures, the spoilage odour was putrid and the bacterial flora was dominated by gram-negative rods. In contrast, spoilage of SO_2-treated mince was characterized by a sour odour and a flora of short, gram-positive rods. At the spoilage level of about 500 million bacteria/g the sour odour was weaker and less objectionable than the putrid odour.

CONCLUSIONS

Clearly, the number of bacteria initially present, the holding temperature, and the presence of sulphur dioxide all have profound effects upon the storage life of minced meat. From the data reported in the tables, it is likely that mince containing 3·5 grains SO_2 per pound and 100,000 bacteria per gram would keep for up to 16 days at 34°F, and similar mince without the SO_2 additive for up to 13 days at this temperature. From Figure 1 it may be deduced that mince of "average" bacterial count (17·5 million/g) would store for only 2 days at 41°F. Its storage life at the average temperature at which it was being offered for sale (55°F) would probably be less than 18 hours. Thus, any improvement in quality that the butcher can achieve through better hygiene and lower temperatures will benefit the consumer.

For mince of high quality, the raw material must be of low bacterial count. This can be achieved only by restricting handling to a minimum and by ensuring that meat is adequately refrigerated whenever it is not being processed in some way, and that only fresh meat is used. The mincer may be a major source of contamination and should be cleaned thoroughly and frequently.

With regard to temperature, some heating occurs during mincing, but meat which is adequately chilled before mincing and then returned immediately to the chiller will not be adversely affected. It is of interest that nearly all of the mince samples tested for internal temperature were served from some type of refrigerated slab or cabinet, yet the average temperature was some 20°F above the storage temperature stipulated in New South Wales as the maximum for pre-packaged meats.

The similar ranges of temperatures found in the Sydney and Brisbane surveys show that the problem of inadequate refrigeration is not a local one.

The presence of sulphur dioxide completely changed the pattern of spoilage. Not only was spoilage delayed, but a different group of organisms was responsible and they produced a much weaker and less objectionable odour. Thus to some extent, the preservative masked the number of bacteria present in spoiled or spoiling mince. As sulphur dioxide apparently reduces the need for refrigeration, there is a danger of minced meat being stored above 50°F, at which temperature growth of some pathogenic bacteria becomes possible. Which pathogens, if any, are resistant to sulphur dioxide is not known, but any which are would find greatly reduced competition from other micro-organisms.

The demonstration that the additional storage life obtained by adding 3·5 grains SO_2 per pound could also be achieved by a 7°F reduction in temperature emphasizes the importance of adequate refrigeration. Minced meat is a highly perishable food which should be held at as low a temperature as possible, and certainly below 35°F.

Methods of incorporating sulphur dioxide into minced meat present a problem. With sausage mince the legal maximum of 3·5 grains SO_2 per pound is added by incorporat-

ing a suitable salt into the slurry in the silent cutter, and an even distribution usually results. However, it may prove very difficult to obtain in minced meat an even distribution of an accurately defined concentration of sulphur dioxide under commercial conditions.

In summary, the main advantages that might accrue to the consumer if sulphur dioxide were permitted in minced meat are:

- An enhanced storage life of the product, especially at higher temperatures.
- Improved retention of colour.
- A weaker and less objectionable spoilage odour.

On the other hand, the following possible disadvantages must also be considered:

- Standards of hygiene could be lowered yet still give mince of the keeping quality now accepted.
- Holding temperatures could be raised to levels where pathogenic bacteria might proliferate, if resistant to sulphur dioxide.
- Sulphur dioxide inactivates the vitamin thiamin, thus reducing the nutritional value of the product.

The last point is particularly relevant where the food in question is an important source of this vitamin.

Heat Penetration and Rapid Heating Techniques with Canned Foods*

By P. W. Board

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BASICALLY, the success or failure of the canning procedure for the preservation of foods depends, firstly, on the use of suitable containers to prevent microorganisms gaining access to the product after heat processing; and, secondly, on the use of a thermal process of sufficient severity to inactivate contaminating microorganisms, or at least to achieve *commercial sterility* in the canned product.

Commercial Sterility

Commercial sterility differs from total sterility in that some microorganisms may survive the thermal process but, because of the conditions existing within the can, do not multiply or otherwise spoil the product.

If either of these two basic requirements are not fulfilled, i.e. the thermal process is inadequate or the cans are leaky, the risk of the contents spoiling is very great.

If spoilage is caused by microorganisms which survive the thermal process a bacteriological examination of the can contents usually reveals only one type of organism, highly resistant to heat. If, on the other hand, spoilage is caused by microorganisms entering the can through leaky seams then different types of organisms are usually found, including some which are inactivated readily by heat.

Basis for Classification

From the point of view of thermal processing, foods may be divided into two groups on the basis of pH. Those classified as "acid foods", with pH values below 4·5, include most fruit and tomato products and

*Based on a talk given by the author at the Winter School, held at the Hawkesbury Agricultural College, Richmond, N.S.W., August 27–31, 1962.

For additional information on the subjects discussed, see Jackson and Benjamin (1948), Anon. (1953), Ball and Olsen (1957), and Casimir (1961).

require relatively light thermal processes. Processes which bring the temperature of the slowest heating point within the canned food to 190–200°F are usually adequate for commercial sterility. The processes used with many acid foods often greatly exceed what may be needed for commercial sterility, in order that texture or organoleptic acceptability may be improved. "Low acid" foods (which include most vegetables, meat, and fish, having pH values greater than 4·5) require more severe heat processes, often at temperatures of 240°F and higher, to give commercial sterility. This may sometimes cause quality deterioration, but such treatments are needed in order to inactivate heat-resistant spores of microorganisms which are not a problem in acid foods.

Calculation of Thermal Processes

Two kinds of data are required in the calculation of thermal processes for low acid foods: the heat resistance of the spores of potential spoilage organisms, and the temperature history of the slowest heating point in the canned produce. Heat resistance data for any specific kind of food-contaminating microorganism may be applied to thermal processes, but data from *Clostridium botulinum* are often used because this pathogenic spore-forming organism is a source of very dangerous toxins. For the same reason, a very large but ill-defined safety factor is always applied to such data. There are potential spoilage organisms of greater heat resistance than *Cl. botulinum*, but the large safety factor should give adequate protection if their number is small. Hence it is important to minimize contamination by the more heat-resistant types by using proper handling and preparative methods with the food material,

TABLE I
Thermal Inactivation of Spores of Clostridium botulinum

Temperature (°F)	Inactivation Time (min)
220	130·0
230	35·0
240	10·0
250	2·78
260	0·77

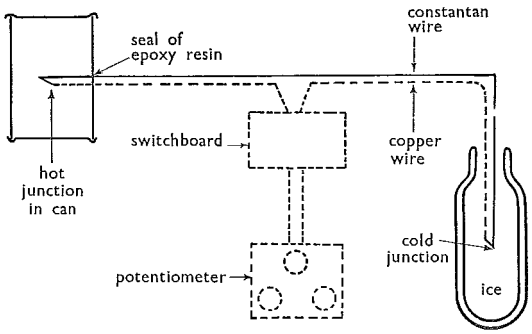

Fig. 1.—Temperature measurements in canned foods by means of thermocouples.

and by maintaining high standards of plant sanitation. Heat resistance data of microorganisms are shown as the time taken to inactivate a specified proportion of the spores in a suspension at a given temperature, assuming the suspension is heated instantaneously to that temperature, held there for the inactivation time, and then immediately cooled to a sub-lethal temperature. Table 1 indicates the thermal inactivation of spores of *Cl. botulinum* based on a reduction in the number of spores by a factor of about 10,000 million. The most noticeable feature of the data is the great decrease in activation time resulting from an increase in temperature.

The second type of information needed to calculate a thermal process is the temperature history of the slowest heating point in the canned product, since this point receives the least severe heat process. The temperature history or heat penetration curve for canned foods is usually obtained with thermocouples. Other methods, including mathematical calculation, may also be used.

Use of Thermocouples

The circuit for measuring temperatures in cans by means of thermocouples is shown in Figure 1. The thermocouple consists of two wires made of different metals or alloys (e.g., copper and constantan, or nichrome and constantan) joined at their ends. One junction is held at a constant temperature of 32°F in a thermos flask of melting ice; the other, the hot junction, being placed at the slowest heating point in the product. When the junctions are at different tempera-

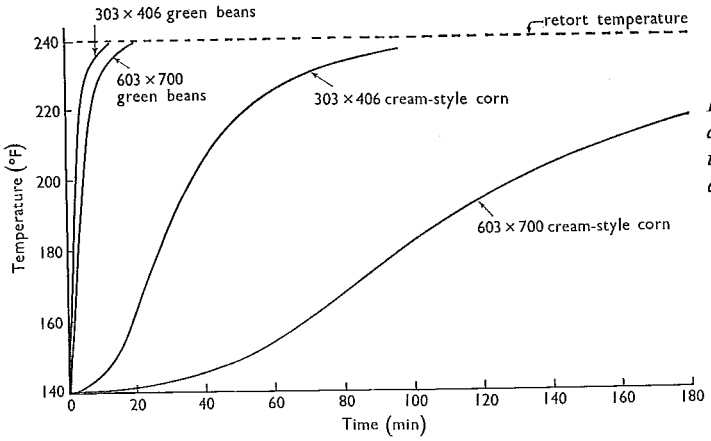

Fig. 2.—Temperature history at slowest heating point in cans of green beans and cream-style corn.

tures the electrical potential set up in the circuit is measured by a potentiometer. By using tables which relate the electrical potential to the temperature difference between the hot and cold junctions, the temperature of the hot junction may be found. A complete temperature history of the product can be obtained by making measurements at intervals throughout the heating and cooling phases of the thermal process. The thermocouples are connected to the potentiometer through a switchboard, since measurements in several cans have to be made at the same time.

Heat Penetration

Typical heat penetration curves for french beans and creamed-style sweet corn are shown in Figure 2.

The most noticeable feature of these curves is the large difference in rate of heating between the two products, which arises from the heat being transferred into the solid cream-style corn mainly by conduction, whereas with the cans of green beans in brine the heat transfer is mainly by convection. It is important to recollect that with many liquid products such as soups and pulps the convective forces may be too weak to cause stirring, which means the heat is transferred mainly by conduction.

TABLE 2

Thermal Processes for Canned Green Beans and Cream Corn

Can Size	Product	Initial Temp. (°F)	Time at 240°F (min)
303 × 406	green beans	140	20
303 × 406	cream corn	140	95
603 × 700	green beans	140	25
603 × 700	cream corn	140	220

The integration of heat resistance data with the heat penetration data obtained from the thermocouple measurements gives a measure of process efficiency in producing a product which is commercially sterile. Several methods exist for integrating the two sets of data but it will suffice to state that the process time required for those products which heat slowly is long, because of the time they take to reach temperatures where the rate of inactivation of the microbial spores is appreciable. Shorter process times are used for products which heat quickly, since high temperatures and high rates of inactivation are attained quickly in all parts of the pack. This relationship is well demonstrated by the thermal process data shown in Table 2 for the products featured in Figure 2.

Factors Affecting Processing

Factors in addition to mode of heat transfer and can size influence the temperature attained and consequently the thermal process required. Table 3 demonstrates the effects of the initial temperature of the product and of the temperature of the retort in processing.

TABLE 3

Thermal Processes for Canned Green Beans and Cream Style Corn in 303 × 406 Cans

Initial Temp. (°F)	Retort Temp. (°F)	Time (min)
Green Beans in Brine		
70	240	21
120	240	20
70	250	12
120	250	11
Cream Style Corn		
140	240	95
180	240	85
140	250	75
180	250	65

The main factors affecting the duration of a thermal process are:

- Heat transfer mechanism. Products which heat by convection require shorter processes than those heating by conduction.
- Can size. Small cans require shorter processing than do larger ones. While the effect of can size is appreciable with products heating by conduction, it is almost negligible with those heating by convection.
- Retort temperature. An increase in retort temperature reduces the processing time required, the effect being greater proportionately with convection packs than with conduction packs.
- Initial temperature. Process time required is reduced by increasing the initial temperature of the product; the effect in this case being greater with conduction than with convection packs.

Although the process time can be reduced by increasing the retort temperature or the initial temperature of the product, there are practical limits to how far these can be raised. It is difficult to maintain initial temperatures higher than 180°F; with large cans high initial temperatures may result in such high can vacua as to cause the cans to panel and "screw" on cooling.

Limits of Retort Temperature

The upper practical limit of retort temperature for conduction-heating packs is about 250°F for small cans and 240°F for large cans. These limits arise from the susceptibility of most foods to heat damage and to the uneven distribution of heat throughout the can. For convection packs, where the temperature distribution is more uniform, the upper limit of retort temperature of about 275°F is based mainly on engineering considerations; for example, the retorts and cans must be capable of withstanding the pressures associated with saturated steam at high temperatures.

High-temperature processes for convection packs should be carried out in continuous retorts, since most of the advantage of the process is lost if a retort takes some minutes to reach the required temperature.

Processing Techniques

The principles used most commonly to reduce process times are the changing of the mode of heat transfer from conduction to convection, and the replacement of natural convection by mechanical agitation and stirring. To apply these principles the following techniques are used:

Strata-Cook.—In this process the different components of the product are filled in the can in such a manner that they remain as separate strata throughout processing. In the case of corn the creamed component, which heats by conduction, is left as a layer on the top of the whole kernels in brine, which heat by convection. By employing this technique a No. 2 can only requires processing for 46 min at 250°F whereas if the components are mixed together, giving a product which heats by conduction only, 74 min would be required at the same temperature.

Vacuum Process.—This involves closing the can under a high vacuum and the use of only a small quantity of brine, which may be as little as 2 oz in a 307 × 306 can. It is used for particular foods such as whole kernel corn and peas. It has been found that the rate of heat penetration in vacuum-packed foods may be increased greatly by agitating the can during processing. What is known as the agitating vacuum process is now in commercial use in the U.S.A.

End-over-End Rotation.—In this process the cans are rotated in a vertical plane about an external point. The movement of the head-

space bubble stirs the contents of the can, thus increasing the rate of heat penetration. Because this form of agitation has not been found amenable to continuous operation, its use in the U.S.A. has been restricted mainly to large cans.

Rotation about a Cylindrical Axis.—A number of the techniques developed differ in the method of rotating and heating the cans.

In the Thermo-Roto machine the cans lie between a series of parallel rollers and are rotated about a horizontal axis. A system of transfer bars moves the cans from one set o rollers to another until they are discharged from the machine. This type of machine, employing hot water as the heating medium, is used for processing acid foods. Attempts to find a suitable liquid with a high boiling point, which could be used for processing low acid foods, have not succeeded.

In another cooker, designed for processing freestone peaches, the cans rotate on a roller between guide bars which are set at an angle to its axis, so determining the speed at which the cans move sideways along the roller to the discharge point.

In a spin cooker developed by the C.S.I.R.O. Division of Food Preservation, an inclined moving belt is used to rotate the cans. The cans which lie on the belt tend to roll down the incline as the belt moves upwards. With this equipment saturated steam at atmospheric pressure is used for processing acid foods. Experimental work is at present in progress using steam under pressure for the spin cooking of both acid and low acid foods. Encouraging results are being obtained with many heat-sensitive foods.

Hot-Air Cooking.—In Europe the use of hot air as a medium for processing spinning cans has received considerable attention. In one type of hot-air cooker, now used commercially with canned milk, the air is circulated at 10 m (about 33 ft) per second at a temperature of 293°F, which results in the temperature of the milk reaching 253°F in 15 min. This particular unit has a capacity of 3200 cans per hour. Work is now at an advanced stage in Europe on the development of flame sterilizers in which cans are spun in gas flames at temperatures of around 1200°F.

Aseptic Canning.—This technique, which involves heat-cool-fill processes, is well established, particularly in the U.S.A. It was first used commercially in 1938 for chocolate flavoured milk. Essentially the process involves sterilizing and cooling the product in heat exchanges, filling it under aseptic conditions into previously sterilized cans, and closing the cans with sterile ends. At present this process is restricted to products which can be pumped. A recent development has been the aseptic canning of tomato products in 44-gal drums. The drums, after being sterilized in a special retort, are filled with previously sterilized and cooled tomato pulp and are closed by remote control prior to removal from the retort for storage.

Other Processes.—What is known as the Smith–Ball process allows the hot fill, close, hold, and cool technique, which is often used for acid foods, to be used with low acid foods. Both the equipment and the operators are located in a pressurized chamber held at 20 lb/sq in, in which water boils at 259°F. The product, after being sterilized at 280–300°F, is cooled to 250–255°F before being delivered to the pressurized room for filling into previously sterilized cans. After closing, the cans are held for a time at the high temperature to inactivate chance contaminating organisms before being cooled and discharged for warehousing. When leaving the pressurized room the operators must spend some 10 min in an airlock for decompression.

Although a great deal of attention has been paid to electrical methods for heating canned foods none have yet reached the stage of commercial application.

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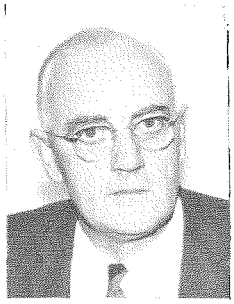

Dr. W. J. Scott graduated from Melbourne University in 1933, and has undertaken post-graduate studies at Cambridge, England, and at Wisconsin, U.S.A. He was initially appointed to the original C.S.I.R. Meat Research Laboratory in Brisbane, and is now Assistant Chief of the C.S.I.R.O. Division of Food Preservation, North Ryde, N.S.W., where he is also Senior Microbiologist. Dr. Scott has made several outstanding contributions to the science of meat hygiene and to knowledge of the growth of psychrophilic bacteria, his present interests being chiefly concerned with the influence of physical environments on the growth of microorganisms important in foods.

Microbiological Hazards in Foods

By W. J. Scott

This article was one of four introducing a Panel Discussion on Public Health Aspects of the Handling and Processing of Foods, held under the chairmanship of Dr. E. Forbes Mackenzie at North Ryde, N.S.W., in September 1961. Contributions by two other members of the Panel, Dr. S. E. Wright and Dr. M. M. Wilson, have already been reported* in previous issues.

THE preparation and serving of foods which are substantially free from microbiological hazards concerns several groups. These include manufacturers or processors, wholesale distributors, retailers, and consumers or caterers serving food to the public; these groups have a joint responsibility for ensuring that the final result is satisfactory. It is proposed, therefore, to say a few words about the part that each can play in ameliorating or aggravating the problem. They are not always the only parties concerned, as producers, and officers of regulatory agencies such as health departments, can also influence the result. For the present purpose it will suffice to concentrate on the groups most regularly involved in the chain from production to consumption.

QUANTITATIVE CONSIDERATIONS

Before passing on to a discussion of the various links in the chain it will be convenient to make some observations on the numbers of microorganisms which we need to consider. In food processing and manufacture we are concerned with large quantities of food and, at times, with very large numbers of bacteria. Many foods which have been heat-processed have very low bacterial contents or are almost sterile. On the other hand, some fresh foods may contain 10 million or more bacteria per gram before we regard them as spoiled. As there are one million grams in a ton, a ton of such food with 10^7 bacteria per gram would contain 10^{13} or 10 million million bacteria, a figure which is already some 3000 times the present human population of this planet. Spoiled food may contain bacteria at more than 100 times this concentration.

This clearly shows that only very small quantities of highly infected or spoiled foods may nevertheless suffice to contaminate very large quantities of uninfected food. An example *par excellence* is in egg bacteriology, where the contents of most hens' eggs are bacteria free, but an infected egg may carry as many as 10^9 bacteria per gram. This is

C.S.I.R.O. Food Pres. Quart. **22** : 85–8; **23** : 1–5.

almost the same number as the number of eggs produced each year in Australia. Consequently, if uniformly distributed, the bacteria in one egg could contaminate the entire Australian production with one bacterium per gram. If the organisms concerned were salmonellae, this single egg could have made 50,000 tons of egg pulp potentially dangerous and bacteriologically unacceptable in some markets.

Another important factor follows from the exponential growth of bacterial populations and the very high rates which are often attained by dangerous disease-producing organisms. For example, bacteria causing food poisoning can divide into two daughter cells every hour at average summer temperatures obtaining in Sydney. Consequently, contamination at the level of one per gram could rise to 10 million per gram in less than 24 hours. Under even more favourable conditions this same increase could occur in 8 hours. The argument applies equally to a single organism which, with a few milligrams of food, could increase to 10 million cells in the same time. This pocket or speck of infection could then be distributed to provide one cell per gram throughout 10 tons of product. Incubation and mixing are, therefore, a very menacing combination.

PRECAUTIONARY MEASURES

Let us now have a look at what can be done to prevent potentially dangerous situations from becoming a reality.

Manufacture

The manufacturer or processor has open to him a number of opportunities for controlling the burden of undesirable organisms in the food.

These include, whenever possible, exclusion of infected material or acquisition of raw materials unlikely to be dangerous. There is nothing to be said for buying trouble, but the realistic processor will appreciate that trouble will, sooner or later, come uninvited. Strenuous efforts should be made to avoid acquiring additional contamination within the factory. Most of the pitfalls are well known, but constant vigilance and the cooperation of staff are needed if lapses are to remain rare. Some of the rules are:

- Whenever possible avoid contact with the hands of employees.
- Staff must observe strict personal hygiene.
- Equipment should be cleaned and disinfected regularly.
- All equipment should be so designed and constructed as to facilitate effective cleaning.
- Foods should not be allowed to remain under conditions which will permit growth of dangerous organisms already acquired. Failure to observe this can cancel the value of all previous measures.

In addition to measures for preventing any increase in the burden of dangerous organisms the manufacturer can frequently use positive treatments to destroy infection already acquired. Terminal heat treatments can very greatly increase the safety of many foods. Even modest treatments which reduce the incidence of infection per unit from say 0·2 to 0·02 could be valuable. The reduction in infected units from one in five to one in fifty would eliminate 90% of the disease incidence.

Manufacturers can further reduce the probability of food-borne disease by ensuring, where appropriate, that the retailers and consumers are properly advised regarding safe conditions of storage. In many cases simple caution labelling is all that is needed—this type of message reaching the consumer as often as he receives the product.

Distribution

Wholesale and retail distributors do not have so many opportunities of influencing the situation. They cannot usually improve the product bacteriologically, but, by providing appropriate storage conditions, they can prevent further deterioration. Products capable of supporting the growth of pathogenic organisms should not be held at temperatures above 40°F. There is probably a need, at all events in Australia, for improved education of food distributors. Some of this would be achieved by more explicit instruction by manufacturers regarding storage conditions and expected shelf life, and by a wider use of stamps to indicate dates of manufacture. Many foods are, in fact, even more perishable

than photographic film even if they are not so sensitive to light.

Food merchandising also presents opportunities for good and bad housekeeping. Careful handling to avoid damage to containers will reduce the opportunities for the subsequent entry of dangerous bacteria.

Consumers

Finally we have the contribution by the consumer, who is always at the receiving end but nevertheless sometimes makes an important contribution to the result. Sometimes he aggravates the situation by providing extended incubation conditions of a product which is only potentially dangerous when purchased. On the other hand, by thorough cooking and destruction of bacteria and their toxins he may correct a dangerous situation. The consumer probably plays his most decisive role when he is also engaged in some manufacturing activity. For instance, a potentially dangerous food is incorporated in another dish, incubated, and fed to a large group of consumers. When there is a suitable combination of circumstances the stage is then set for another outbreak of bacterial food poisoning.

IDEALS AND REALITY

Bacterial food-borne disease will undoubtedly continue as a public health problem. It is, in fact, an inevitable consequence of man's need to store, process, and transport food. The problems, the foods, and the microorganisms, are all real. The people who solve the problem as well as those who need the answers are also real people who want to live and who sometimes get hungry. At present we know *why* most outbreaks of disease occur, but we are less certain of *how* the problems are best solved. Improvements will come gradually, as all concerned become better informed about the hazards and effective control measures. More nearly perfect equipment for processing and packaging would also help, but there are clearly limits to the extent to which the cost of the food can be increased. Food technologists face a continuing challenge to ensure that both new and existing products and processes will meet the combined requirements of safety, palatability, and availability at low cost. Some compromise is likely to be necessary, and the relative importance of some of the opposing considerations is bound to vary from place to place and with the passage of time.

Notes

Advanced Study Course in Food Science

Courses in food science have been conducted jointly in recent years by the Low Temperature Research Station, Cambridge, and the Department of Food Science, Royal College of Science and Technology, Glasgow. The most recent was an advanced study course entitled "Biochemistry and Biophysics in Food Research", which was held in Cambridge from September 23 to 29, 1962. Like its predecessor which took place in Glasgow in 1960, it was supported financially by the North Atlantic Treaty Organisation. Timed to follow the First International Congress of Food Science and Technology (reviewed in the "Food Preservation Quarterly", 1962, Vol. 22, No. 4), the course was attended by about one hundred scientists, the majority being foreign visitors.

About 40 lectures were given in the following six symposia: "Protein Biochemistry", "Laboratory Techniques for the Study of Proteins", "Non-Conventional Food Proteins", "Flavour and Odour", "Water-Binding in Relation to Foods", and "Structural Elements of Vegetable Foods". Present knowledge of the structure and biosynthesis of proteins was presented in the first session, which was extended to cover also the structure of nucleic acids and the nature of the nucleic acid code. In discussing the "Labora-

tory Techniques for the Study of Proteins", the lecturers covered physical methods as well as chemical analyses of proteins and amino acids. The third symposium was concerned with sources of protein, technological and nutritional problems in their use as human foods, and the measurement of their nutritive value. The very interesting Indian multipurpose food was also described. Gas chromatography was one of the techniques given close attention by speakers on research into flavours and odours of such food items as coffee, fruit, meat, and dairy products. "Water-Binding in Relation to Foods" was discussed from a variety of viewpoints, which covered molecular forces, hydration, imbibition, and diffusion, as well as enzymic and microbial activities in foods of reduced water content and activity. The final session was devoted to the chemical composition and physical properties of structural elements occurring in vegetable foods.

This was a most stimulating and concentrated course, dealing with many of the fundamental properties of foods, and it is hoped that the lectures will be published shortly in book form. It was in many ways complementary to the 1960 course held in Glasgow. The latter set of lectures was published in 1962 as "Recent Advances in Food Science" (Butterworth), edited by J. Hawthorn and J. Muil Leitch, in two volumes. This publication is reviewed elsewhere in this issue (see p. 42).

New Food Research Institutes for Britain and Canada

The increasing tempo of food research throughout the world is reflected in recent announcements of reorganization of research activities in both Britain and Canada.

Since 1959 when the British Agricultural Research Council assumed responsibility for research in agriculturally produced foods and set up a Food Research Advisory Committee, it has made a number of far-reaching decisions, some of which will affect research centres with which the C.S.I.R.O. Division of Food Preservation has had close contact for many years.

First came an announcement that (following a recommendation made by Dr. J. R. Vickery) a Meat Research Institute is to be established in close proximity to the Veterinary School of the University of Bristol. Now comes the news of a new Food Research Institute, and of an offer of a suitable site for it at Norwich, by the University of East Anglia.

The Meat Research Institute will continue and extend the work on meat and meat products which since 1922 has been undertaken at the Cambridge Low Temperature Research Station, now to close. The new Food Research Institute is to take over and expand the latter's research in other foods and in the general aspects of food science. The relevant research workers at Cambridge will form the nucleus staffs of the two new institutes and it is planned to complete the transfer of the staffs by 1966.

A new Food Research Institute has also been formed by the Canada Department of Agriculture at the Central Experimental Farm in Ottawa. It is to be under the direction of Dr. R. P. A. Sims, well known for his researches on the composition of oil seeds.

This new arrangement brings under Dr. Sims's administrative charge the Dairy Technology Research Institute, the Food and Processing and Storage Section of the Plant Research Institute, in addition to his own Lipid Section of the Genetics and Plant Breeding Institute. By the time the reorganization is complete it is hoped to have doubled the present staff of 20 scientists now concerned in these studies and to have extended research activities to cover meat and poultry products and investigations on food colours and flavours.

In addition to the work at Ottawa, which will eventually require a completely new Food Research Institute building, research on fruit and vegetable storage and processing is to continue at other Departmental research establishments, including that at Summerland, which was reviewed in our last issue.

To Dr. Sims and his colleagues we extend our best wishes for success in their efforts to ensure that the best possible use is made of the food resources of the Dominion.

New Research Advisory Committee

The Commonwealth Government and the banana industry recently established a Banana Research Advisory Committee, which held its inaugural meeting at Murwillumbah, N.S.W., in January 1963.

The meeting drew up a research programme on post-harvest problems of bananas, and agreed to investigations at three centres: the Food Preservation Laboratory of the Queensland Department of Agriculture and Stock at Hamilton, Queensland; the Tropical Fruit Research Station of the N.S.W. Department of Agriculture at Alstonville; and the C.S.I.R.O. Division of Food Preservation, North Ryde, N.S.W.

The Committee consists of two representatives of the Australian Banana Growers' Council, and one representative from each of the following bodies: the Department of Primary Industry, the C.S.I.R.O. (Mr. E. G. Hall of the Division of Food Preservation), the New South Wales Department of Agriculture, and the Queensland Department of Agriculture and Stock.

The objectives of the Committee are to coordinate present research on banana storage, transport, packaging, and ripening, all of which pose important technical problems in the marketing of bananas throughout the Commonwealth. It will also initiate further research into the problem known as "mixed ripe", which arises in the transport of bananas; the handling and packaging of fruit, especially the use of cartons; precooling as an aid to better transport; techniques of ripening; the control of diseases and other problems associated with good fruit quality.

The Government has agreed to contribute £3000 per annum to a research fund, initially for three years, to match contributions from the banana industry which have been offered for a longer period.

Publications

RECENT ADVANCES IN FOOD SCIENCE*

The short courses in Food Science which were held in 1948 and 1951 at the Low Temperature Research Station at Cambridge, England, stimulated interest in the organization of the then rapidly mounting but somewhat amorphous mass of scientific information on foodstuffs. Hence 1960, being the centenary year of the British Food and Drugs Act, was chosen as an appropriate time for a reappraisal of this information. With the aid of funds from the Office of the Scientific Advisor to the North Atlantic Treaty Organization, a Summer School was held at the Royal College of Science and Technology, Glasgow, Scotland. The papers presented by some fifty contributors, many of high international repute, have been edited and published in two volumes with the above title, the first covering commodities, the second processing.

In a preface to the first volume, Dr. E. C. Bate-Smith, and the two editors, Professor John Hawthorn and Dr. G. A. Reay, state they have tried to preserve the style and approach of the individual contributors. Inevitably this has made for some repetition, and perhaps on occasion incomplete coverage. Nevertheless the reviews are very comprehensive and the presentation adopted should make for easier reading by interested persons, especially those who were unable to attend the course, at which 15 countries as well as the U.K. were represented.

Section 1 of Volume 1 contains five well-presented papers of an introductory nature, "Food Science as a Discipline"; "Teaching and Research in Food Science"; "Food and Microorganisms"; "Effect of Environment on Microorganisms"; and "Pathogenic Organisms in Food". Section 2 deals with animal products, including fish, while Section

* Recent Advances in Food Science, Vols. 1 and 2 (70*s* stg. per volume), 1962. (Butterworths: London.) Obtainable from Butterworth & Co. (Australia) Ltd., 6–8 O'Connell Street, Sydney; 473 Bourke Street, Melbourne; 240 Queen Street, Brisbane.

3 covers "Vegetable Foods". An excellent paper on "Fresh Fruit and Vegetables" by Dr. J. C. Fidler, shows how the upheaval of World War II, changing standards of living, and plant diseases have affected international trade in fruit and vegetables.

Volume 2, dealing with food processing, contains many first-rate contributions in its Sections covering "Dehydration", "Sterilization and Refrigeration", and "Other Processes". Section 4, which consists of miscellaneous papers—"Flavour Testing with Profile Method"; "Trends in Food Science, Technology and Distribution in North America", and "Microbiology, Biochemistry and Food"—leaves one with the feeling that it might have been rounded off with papers covering advances made in other Commonwealth countries, and in Europe.

The papers, nevertheless, provide a fund of authoritative information, well presented and indexed, which is likely to be of value to persons in the food industry with widely different interests. H.H.

CORRECTION: SECOND CENSUS OF FRUIT COOL STORES

As a result of a re-check of the returns obtained in the above census the third and fourth paragraphs of the earlier comment (*C.S.I.R.O. Food Pres. Quart.* **22**:55) require revision and should read as follows:

The census shows an overall increase of 16·1% in cool store capacity over the past two years. New South Wales with 31·5% shows the greatest increase, and Queensland with 8·6% the lowest. The increase of 364,000 bushel capacity for New South Wales is accounted for almost entirely by the rapid development of orchard cool stores. Victoria still has the greatest capacity, 5,156,523 bushel cases, followed by New South Wales with a capacity of 1,512,140 cases; South Australia, 964,550; Tasmania, 416,100; Western Australia, 794,360; and Queensland, 598,200. In Victoria three canneries in the Goulburn Valley have between them a capacity for almost 1,000,000 bushel cases. It is of interest to record that 62 cooperative fruit stores possess 41% of the total cool store capacity in Australia, while 486 growers' stores account for 30%.

In spite of the 1,369,000 bushel increase in total cool store capacity in the last two years the additional storage space is barely keeping up with the increased production of apples, pears, and canning peaches — which are the main fruits cool-stored. E.G.H.

NEWS FROM THE DIVISION OF FOOD PRESERVATION

ELECTRON MICROSCOPE

The Division of Food Preservation has started to install an electron microscope at its laboratories at North Ryde, N.S.W. The instrument, a Siemens Elmiskop I, can magnify 200 to 80,000 times and has a resolving power of 10 Å.

The Division has used the technique of electron microscopy for a number of years, having shared the ownership of an instrument with the Division of Animal Genetics. Fields in which progress has already been made include bacterial cytology, especially the structure of bacterial spores, and the histology of plant cells. In the latter field the electron microscope has been used to trace the changes in ultramicroscopic structure which accompany the development of superficial scald (a storage disorder in apples) and the ripening of pear tissue. In current investigations electron microscopy is being applied to the study of changes in germinating and developing pea cotyledons.

OVERSEAS TRAVEL

Mr. D. J. Casimir, a Senior Research Officer in the Canned Foods Section of the Division, left Sydney on April 30 with his wife and family, to take up a fellowship in the Department of Food Science, Cornell University, under Professor J. C. Moyer.

Mr. Casimir will work at the New York State University Agricultural Experiments Station, Geneva, N.Y., where he will investi-

gate the mechanical harvesting of vegetable crops, especially peas, and study the effect of vining on subsequent processing operations.

The Geneva Experiment Station has been interested in problems of this nature for many years, and growing, harvesting, and processing facilities at the Station are first-class.

Two other members of the Canned Foods Section, Messrs. L. J. Lynch and R. S. Mitchell, worked at Geneva in 1953, when they tested the newly invented pea maturometer under American conditions. Professor Moyer visited Australia in 1954–55, and participated in pea canning investigations in Tasmania.

FULBRIGHT SCHOLARS

The Division has been privileged to have two Fulbright Scholars as guest workers in its laboratories during the last few months.

Dr. R. G. Cassens, a graduate in animal husbandry and biochemistry from the University of Wisconsin, arrived in Sydney on February 27, 1963, to spend about eight months at North Ryde and about four months at the Division's Meat Research Laboratory at Cannon Hill, Queensland.

Dr. Cassens is interested in the cause of the exudate from frozen and thawed beef muscle, known as "drip", which has for a long time been a serious problem in the marketing of frozen beef. At North Ryde Dr. Cassens is investigating the relation of the rate of disappearance of adenosine triphosphate to post-mortem temperature in muscle. At Cannon Hill he proposes to study the depletion of glycogen in different muscles of the same animal during stress.

Another Fulbright Scholar, Professor Noe Higinbotham, head of the Department of Botany in Washington State University, U.S.A., arrived in Australia with his wife on February 28, 1963, and worked in the Plant Physiology Unit of the Division of Food Preservation for three months. He is spending the next six months in the Botany Department, University of Adelaide, with Professor R. N. Robertson.

Dr. Higinbotham and co-workers made some of the first measurements of the intracellular electric potential of cells of higher plants.

RECENT PUBLICATIONS OF THE DIVISION

Copies of these publications may be obtained from the Librarian, Division of Food Preservation, Box 43, P.O., Ryde, N.S.W. (Tel. 88-0233)

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