FOOD PRESERVATION QUARTERLY

Vol. 26 Nos. 2-4 December 1966

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

Drying and Storing Peanuts

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In 1962 about 15,000 tons of peanuts (ground-nuts) were harvested in Australia, and annual production seemed likely to increase. Accordingly, more reliable means of drying the product to a suitable moisture level seemed desirable than the traditional field drying in stooks and wind-rows. The following article by Dr. O. Myklestad provides an elegant example of how such a problem lends itself to systematic investigation along scientific and engineering lines. As a result of this preliminary study, drying equipment was constructed that allowed maximum utilization of both the natural drying environment and artificial drying means, thereby resulting in maximum economy.

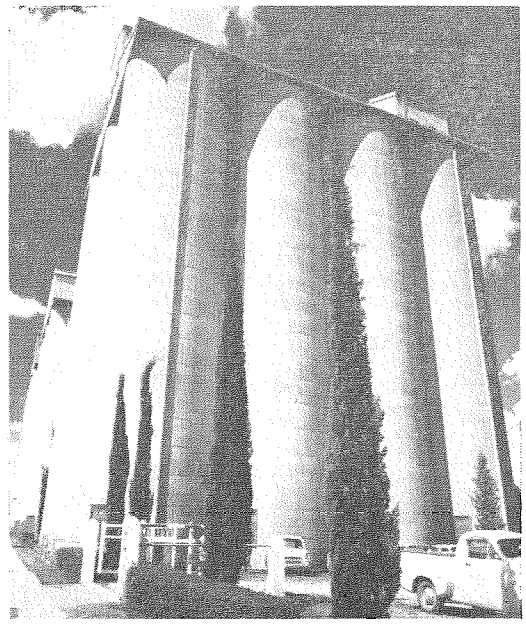
THE PEANUT, *Arachis hypogaea*, thought to be a native plant of Brazil (Robbins 1931), is today grown extensively in Africa, the Americas, the Far East, the Near East, and Europe, the total annual world production being about 15 million tons. About 25 thousand tons per year are now grown in Australia, whose main centres of production are Kingaroy, Rockhampton, and Atherton, all in Queensland.

Peanuts after harvesting are generally dried in the field, threshed, and stored in tall silos. Field drying poses a number of problems for the preservation, storage, and marketing of this perishable crop, particularly during rainy harvests, when losses are very high and quality tends to be inferior. These are some of the reasons why artificial drying is now being considered seriously in the more-developed countries.

DRYING PRINCIPLES

Resistance of the Peanut to Heat Transfer and Drying

Because of lack of homogeneity of its structure, the peanut offers more resistance to the transfer of heat and moisture during the drying process than do the majority of agricultural products. Its total resistance is composed partly of three boundary layer resistances, comprising the resistance at the interface of the outside shell surface and the surrounding air, that at the inside shell surface and the internal air, and that at the kernel surface and the internal air. There are also three other resistances that are inversely proportional, respectively, to thermal conductivities through the shell, through the internal air gap, and through the kernel. The thermal conductivity of the air gap is low, as also are those of the shell and the kernel, for the shell consists mainly of hemicellulose and fibres (Radhakrishnamurthy and Srinivasan 1961), and the kernel contains a large proportion of fats and proteins (Milner 1962), all of which are good insulators.



The Peanut Marketing Board's silos for the bulk storage of dry peanuts at Kingaroy, Qld.

An interesting feature of the peanut shell is its white inner surface, which provides protection against solar radiation immediately after harvesting. Some time after maturity, however, this surface gradually becomes darker and so loses its effectiveness as a radiant shield.

Sorption Isotherms

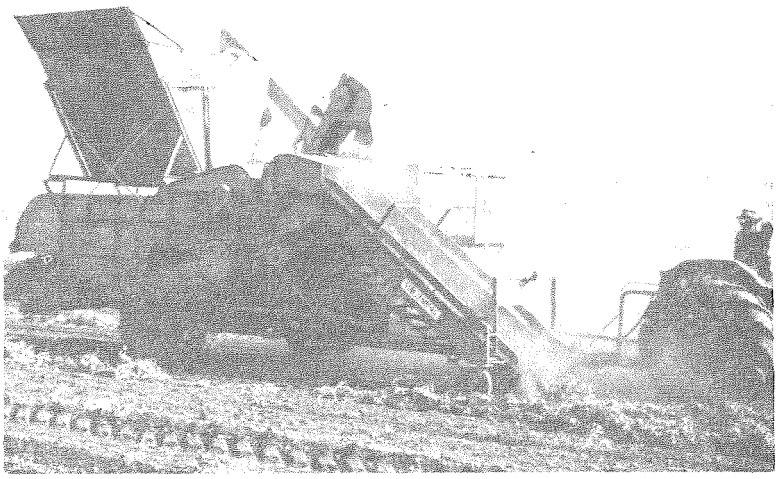
Sorption isotherms indicate to which moisture content materials will dry when exposed to air at constant temperature and various relative humidities (R.H.). Isotherms at 25°C for Virginia-type peanuts and their composite parts have been determined by Karon and Hillery (1949) and Myklestad (1965), who have between them established equilibrium moistures of this type of peanut over the range 11–99% R.H. This information is particularly useful for predicting the success of field drying, since it may, for example, be concluded that during the final stage of successful drying (reduction of peanut moisture content to 9–12%) the air humidity should be maintained at a value not exceeding 75% R.H.

DRYING METHODS

Field Drying

Most of the peanuts grown in Australia are dried in stooks or wind-rows on the open field.

Stooks are conically shaped heaps of the harvested peanut plants and, when properly made, protect the crop against ground dampness, rain, and strong sunshine. Generally carried out manually, stooking is no longer profitable in a number of mechanized countries, mainly because qualified farm labour is becoming very expensive for this time-consuming operation. Mechanization of the stooking operation has been attempted, and semi-automatic stookers are in operation in Australia, but these machines are complicated and difficult to operate, and have not found wide application in the local peanut-growing industry.



Mechanical harvester picking up and threshing the partly field-dried peanut crop.

Drying in wind-rows lends itself readily to mechanized harvesting equipment, however, and is more suitable for large-scale production of peanuts. This method is therefore generally preferred in developed countries, in spite of the poor protection afforded against damp weather or excessive sunshine.

The damage to peanuts being dried in the field, particularly during wet harvests, ranges from dark brown or black discoloration of the shell to destruction of both shell and kernel. This degradation of the nut is not confined to the field, but may continue during storage in bins or silos where, given favourable conditions, dormant spores of fungi may also be activated.

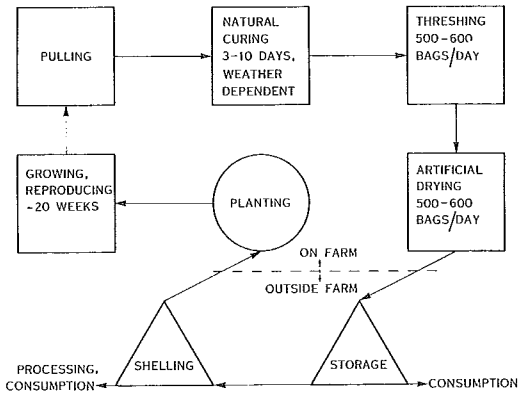


Fig. 1.—Flow diagram indicating the sequence of operations from planting when artificial drying is used.

The development of fungi on stored grains and other produce causes a special post-harvest problem when it is associated with the production of dangerous toxins (Burnside *et al.* 1957; Forgacs and Carll 1962). There was thus considerable concern when it was reported recently (Diener *et al.* 1963) that aflatoxin was observed in stored peanuts contaminated with the fungus *Aspergillus flavus*. Mycotoxin was earlier known to be produced by *Penicillium rubrum* (Burnside *et al.* 1957) but at a technical meeting in Washington, D.C., in April 1965, sponsored by the National Peanut Council, it was reported to be produced also by *Aspergillus parasiticus*, *Penicillium islandicum*, *P. puberulum*, and *P. rubrum*.

Artificial Drying

Artificial drying of peanuts is generally carried out by exposing the crop (in bag or in bulk) to a current of warm air. While this drying method requires facilities for heating and moving air, it is expected that capital and operational costs may be offset by increased yield and by improved quality of the peanuts processed, mainly because growers would be able to collect their crop from the field about one week after harvest instead of, as in particularly bad seasons, several weeks to months later. The accompanying flow-sheet diagram (Fig. 1) indicates how artificial drying may be employed in the entire production schedule.

The drying requirements of peanuts in the main growing area of Queensland (Kingaroy) were first investigated by the Division of Food Preservation (Myklestad 1965) in 1963, when pilot-plant experiments were carried out under various conditions which made it possible to establish design specifications and economy of full-scale machinery. The preliminary findings of 1963 were confirmed in 1964, when performance tests of a semi-industrial bin dryer (Fig. 2) capable of processing 7 tons of wet material per day were carried out using air heated to about 100°F.

Observations made during the testing of this 8-ft-tall bin dryer were that:

- Temperatures at various levels in the central axis differed considerably during the first half of the drying period, but the total maximum difference during the second half of the drying period was 10 degF and at the end of 24 hr was only 3 degF.
- Moisture contents of the peanuts at various levels of the load varied according to a similar pattern, and at the end of 24 hr the maximum moisture difference measured between any two points was about 3%.

Chemical Changes

It is reasonable to ask if intensive artificial drying of peanuts would cut short a necessary open-air maturing period, and thus adversely affect the quality of the product. This question was looked into by Pickett and Holley (1960), who discussed the possibility of chemical changes in peanuts dried under

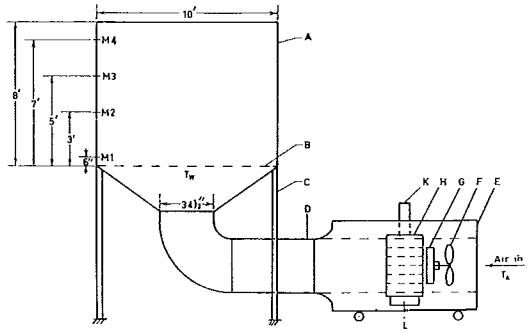
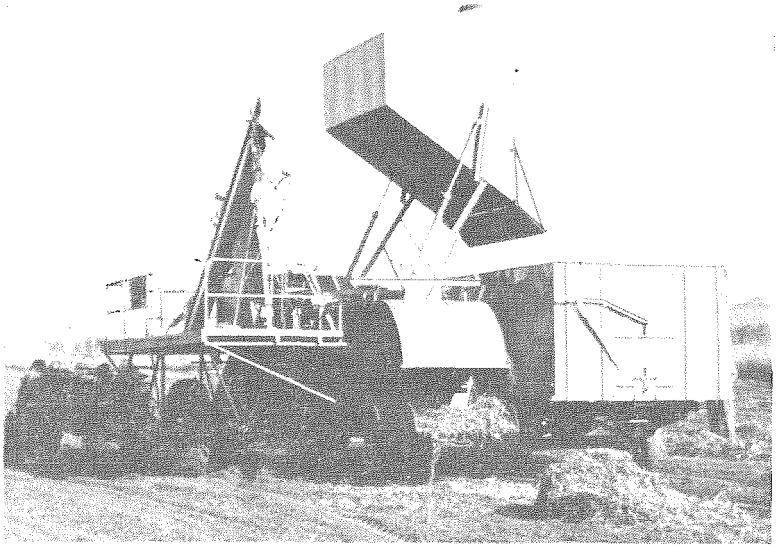


Fig. 2.—A semi-industrial bin dryer for peanuts.
A *Dryer* B *Perforated floor* C *Support*
D *Air duct* E *Aerator* F *Fan*
G *Fan motor* H *Heat exchanger* K *Exhaust*
L *Oil burner* M *Sampling points*
T_A *Temp. of atmosphere* T_W *Temp. of warm air*



After threshing, the peanuts are transferred from the thresher's bulk bin to a field bin, for transport to the drying bins, which are located in a central position on the farm.

various conditions. No consistent change in amino acids, for example, was detected whether drying was carried out in wind-rows or artificially at 120°F or 160°F. The amount of phytin — a reserve of phosphorus — was found to increase as the peanut matured, but it remained unchanged during artificial drying at 140°F. The amount of sugar does not seem to be affected by the method of drying, the apparent increase in sweetness of the dried nuts being due to increased sugar concentration as a result of water removal.

Constant values of the iodine numbers indicated no manifest changes in double bonds on unsaturated oils when peanuts were dried at various temperatures, but it was found that when drying was carried out at temperatures above 100°F, oxidation of the oil was retarded. This fact may be taken advantage of for peanuts intended for oil production, where delaying the onset of rancidity is of importance. Since high-temperature drying causes off-flavours and affects viability, it is not recommended for peanuts intended for eating or replanting.

STORAGE OF PEANUTS

The main requirements for preservation of peanuts during prolonged storage are properly dried peanuts and controlled conditions (temperature and humidity) of the storage space. The difficulty of storing poorly dried peanuts, indicated above, will first be discussed in some detail.

Physical Aspects

Before peanuts are admitted to silos at the storage depots, analyses of moisture contents of random samples from individual loads are carried out. Because of the limited number of samples which may possibly be checked, wet spots within loads could pass undetected, and if allowed into storage silos these wet peanuts would form centres of infestation.

Slow aeration of silos has been suggested to overcome this problem, but this is not the complete answer. A reason for this is that wet peanuts pack more densely, collect dirt and debris more readily, and consequently offer greater resistance to air flow than do other portions of the load. This results in the anomalous situation that wet spots, which would require more efficient drying, actually get less aeration than the rest of the load.

Biological Aspects

Even uniformly dried peanuts are subject to storage damage, which may start in isolated colonies of insects and microbes and be aggravated as the colonies enlarge.

Insects.—A number of serious insect pests, such as *Cadra cautella* (Walker), *Oryzaephilus mercator* (Fauvel), *Plodia interpunctella* (Hübner), and *Tribolium castaneum* (Herbst),

have been reported from South Africa (Lochner 1963) and from Queensland (Champ 1965) to infect peanuts. Respiration of the insects is accompanied by the evolution of carbon dioxide, water vapour, and heat, which creates an upward motion of warm, water-laden air. The warm air gradually cools during its ascent in the silo, and if its temperature falls to its dew point, water starts to condense from it onto the peanuts. Water so condensed in the higher regions of the silo activates dormant spores present there, so that, before long, mould colonies develop in this region.

Microorganisms.—Even in the absence of insects, colonies of fungi and yeasts may develop in localized regions where environmental conditions stimulate the activation of spores. Thus during prolonged periods of high humidity mould is frequently observed in stored peanuts in the top layer of the load, this layer being in direct contact with atmospheric air.

Other locations likely to stimulate mould growth are colder sections of the silo walls, because air in the neighbourhood of these regions acquires a higher relative humidity through being cooled.

Chemical Aspects

Considerable attention has been given to the possibility of changes in constituents during the storage of peanuts. Stansbury and Guthrie (1947) experimented with the storage of unshelled peanuts maintained at various temperatures in closed containers and carried out analyses for total nitrogen, sugars, oil content, iodine number and free fatty acid concentration of the oil, and protein solubility. At the end of 2 years of storage at temperatures below 1°C no change in these constituents was found. At room temperature (25–28°C) a slight increase in free fatty acid concentration was observed.

Studies of diene conjugation of the oil in peanuts during storage at various temperatures have been carried out by spectrophotometric techniques by Pons *et al.* (1948), who measured extinction coefficients at wave lengths of 227–234 mμ. At the end of a storage trial lasting for over 4 years, it was observed that extinction coefficients had average values of 0·33, 0·45, and 1·09 at storage temperatures of −18°C, 1°C, and 27°C, respectively. These indicate that diene conjugation can be considerably retarded in peanuts stored at temperatures below 0°C.

CONCLUSIONS AND RECOMMENDATIONS

Field drying of peanuts should be limited to the initial drying stage, when the crop loses water readily and evaporative cooling prevents overheating due to the sun's rays.

Drying to an even moisture content (9–12%) is part of the answer to successful storage of peanuts. Provision for hygienic storage facilities and control of storage atmosphere are other prerequisites.

Finally, in spite of these precautions it might be necessary to apply insecticides, a large number of which are marketed to suit individual needs.

Typical silo-type drying bins being loaded. Bulk handling without forced-air drying is not encouraged.

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Principles and Practice of Heat Sterilization in Canning*

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In an earlier article† Mr. Board discussed some of the problems and techniques of sterilizing canned foods. In the present article attention is focused on a number of practical aspects of thermal processing that are often overlooked. Readers seeking a more comprehensive discussion may refer to Circular 7-P (1965) published by the Division of Food Preservation and obtainable from its librarian.

FOODS when packed into cans by conventional filling and can-closing operations contain viable microorganisms, and unless special preventive measures are taken, these may multiply during storage and spoil the product. The unit process known in the industry as 'cooking', 'retorting', or 'thermal processing' is designed essentially to inactivate contaminating organisms inside the can and so bring the canned food to a condition of '*commercial sterility*'.

Commercial sterility differs from total sterility in that in the former some organisms may survive the heat treatment but are unable to grow or spoil the product because of the conditions that exist in the can — for instance, the presence of a growth-inhibiting substance or the absence of substances essential to growth.

* Based on a talk given by the author at the Winter School held at Hawkesbury Agricultural College, Richmond, N.S.W., August 5–9, 1966.

† BOARD, P.W. (1963).—Heat penetration and rapid heating techniques with canned foods. *CSIRO Fd Preserv. Q.* **23**, 33–7.

Failure to apply a thermal process sufficiently severe to produce commercial sterility in a can of food increases the risk of spoilage caused by surviving organisms. Such spoilage is frequently accompanied by the production of gas that causes the can to swell and eventually burst. However, more important than the risk of losses due to swelling of the can and spoilage of the food is the health hazard to consumers when canned foods are inadequately sterilized. For example, in under-processed canned foods survival of the organism *Clostridium botulinum* may result in contamination of the food with a toxin that is lethal to humans. Spores of this species of bacillus do not produce the toxin themselves, but they have high heat resistance, and under favourable conditions (which frequently coincide with those in a sealed can) the surviving spores may develop into the vegetative form that produces the toxin.

It is worth noting that toxin production of this kind may occur in a can even though no swelling of the can is evident, and even though the food may show no obvious signs of contamination.

SEVERITY OF STERILIZATION PROCESSES

There are several factors to be considered in determining the severity of the sterilization processes required.

The influence of pH

A measure of the hydrogen ion activity of the components of a food is its pH, and this is perhaps the most important single criterion for determining how severe the heat treatment must be to ensure commercial sterility of the food. 'Acid' foods (i.e. with pH less than 4·5) include most fruit and some tomato products, and these products can be sterilized by bringing the temperature of the slowest-heating point within the can to about 200°F before cooling. Somewhat lower temperatures are adequate for highly acid foods such as passionfruit juice.

Because rates of inactivation of micro-organisms are greater at low pH, and because the concentration of hydrogen ions in acid foods is high enough to prevent the growth of any heat-resistant organisms that do survive the heat treatment, such foods may be given a relatively mild thermal process of the type just mentioned, sometimes called a pasteurizing process.

'Low-acid' foods such as vegetables, meats, and fish are those having a pH greater than 4·5 and require more severe heat treatment than the acid foods. They are usually processed at 240 or 250°F to inactivate heat-resistant sporing organisms. The processing time is calculated to give commercial sterility with as little damage as possible to the product through overcooking. Suitable time–temperature schedules for the process are determined by the rate of heating and cooling of the slowest-heating point within the can, and by the resistance of likely spoilage organisms to inactivation by heat.

Heat Resistance of Spoilage Organisms

The calculation of retort processing schedules for low-acid foods is usually based on the heat resistance of a large population of spores of *Clostridium botulinum*. This species is not the most heat-resistant of potential spoilage organisms, but for the reason previously mentioned is the most dangerous from the point of view of public health. Because of this danger, a large but ill-defined safety factor is embodied in the calculation of retort processing schedules.

It is convenient to think of the heat resistance of microorganisms in terms of the time required to just inactivate all of a known population of spores at a given temperature, it being assumed that the population instantly attains this temperature and is held there for the required time before being cooled instantly to a non-lethal temperature.

Figure 1 shows the relation between temperature and the time taken to inactivate a suspension of about a thousand million spores of *Cl. botulinum*. The figure shows that the time taken to inactivate the spore population decreases markedly as the temperature increases. If the population of spores were lower than that stated above, the corresponding line in Figure 1 would be parallel to, but beneath, the line shown, indicating that the smaller population could be inactivated by a less severe process.

A process sufficient to inactivate a large population of *Cl. botulinum* spores is usually severe enough to inactivate organisms that are even more heat-resistant, provided their

number is small. Hence it is essential when using a thermal processing schedule based on *Cl. botulinum* to maintain high standards of sanitation and to use raw materials having a low bacterial count. These safeguards will ensure that the thermal process used will also adequately control any more heat-resistant organisms that may be present in the food.

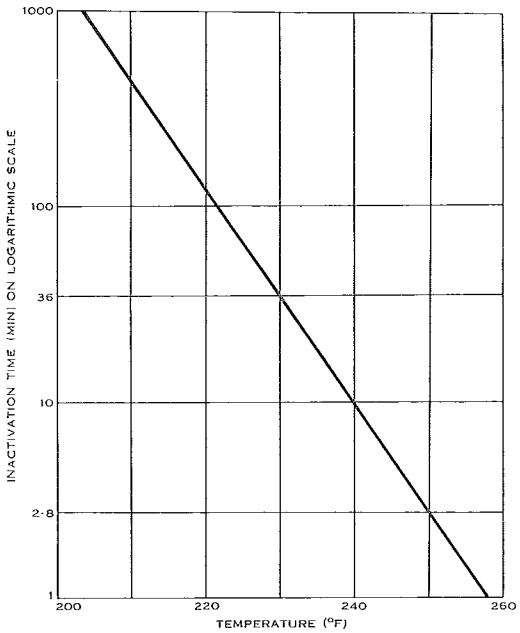

Fig. 1.—Relation between thermal inactivation time and temperature for Clostridium botulinum.

The severity of a thermal process is conveniently measured in terms of F_0 values. The F_0 value of a retorting process is defined as the time in minutes at 250°F that produces an equivalent inactivating effect to the particular retort process. As an example, data from Figure 1 show that processes of either 10 min at 240°F or 36 min at 230°F are equivalent in inactivating effect to one of 2·8 min at 250°F; accordingly, each process has an F_0 value of 2·8 min. Here again it is assumed that in each case the contents of the cans instantly attain the specified temperature, that these temperatures are maintained for the times stated, and that cooling is instantaneous.

Thermal Characteristics of the Can

Since the rate of inactivation of organisms increases with temperature, and because in practice the contents of a can do not instantly attain retort temperature or cool instantly, the temperature attained by the slowest-heating point in the can must be known before a safe schedule for the retort process can be decided upon. The rate at which heat penetrates to the slowest-heating point in the can under given processing conditions varies with the size of can and the nature of the product. The most convenient way of determining the temperature history of a can during processing is by means of suitably located thermocouples (Board 1963, 1965).

Figure 2 shows typical heat penetration curves for 303×406 and 603×700 cans of French (green) beans and cream-style corn. For beans, the can temperature quickly rises to the region where contaminating organisms are rapidly inactivated. In contrast, the cans of cream-style corn show only a slow rise in temperature: even after prolonged heating of the larger 603×700 can, its temperature remains within the region where the rate of inactivation is slow.

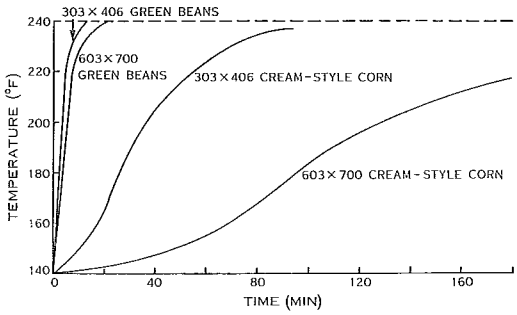

Fig. 2.—Temperature at slowest heating point in cans of green beans and cream-style corn during processing at 240°F.

Several methods that take into account the temperature history of a product are available for calculating the total inactivating effect, or F_0 value, of the retort process. Retort processes for most low-acid canned foods have F_0 values in the range 4–8 min, but more severe processes may be needed if the products are likely to be heavily contaminated with heat-resistant organisms.

PRACTICAL ASPECTS OF RETORTING

Canneries encountering spoilage in canned foods often send samples of the cans to the laboratories of the Division of Food Preservation for examination. Sometimes the spoilage is caused by contamination after processing, through leaks in the can seams. Occasionally, spoilage is caused by the use of processes that do not impart to the particular product an adequate level of sterility. But just as frequently the cans spoil because of incorrect application of processes that would be adequate if accepted retorting practices were followed.

Table I

Effect of Initial Temperature and Packing Conditions on Processing Time at 240°F for 303 x 406 Cans of Some Low-acid Foods*

Product	Initial Temp. (°F)	Time (min)
Green beans in brine, green	70	21
or wax, whole or cut	120	20
Cream-style corn	140	95
	180	85
Asparagus, white spears	70	25
processed with tips down	120	23
Asparagus, white spears	70	27
processed with tips up	120	26

* Data from National Canners' Association (1962).

As already indicated, correct processing conditions for a given product in any given size of can are expressed in terms of time of processing at a specified temperature. The actual duration of a satisfactory process varies with the initial temperature of the product, and for some products, such as asparagus, packing conditions are also important. Table 1 shows some typical data where these factors are taken into account. In each example cited, the duration of processing is timed from the moment when the retort reaches operating temperature, and the initial temperature given is that of the coldest can in the retort at the beginning of the process.

DESIGN AND UTILIZATION OF EQUIPMENT

Unsatisfactory design and installation of processing equipment may be the cause of inefficient processing. For instance, steam-heated cookers operated at atmospheric pressure are frequently used for processing acid foods, and these cookers are sometimes designed with an inlet port at a point some distance below the outlet point. Such an arrangement may, by its chimney-like action, induce a draught of air into the machine and so cause the loss of large volumes of steam from the unit and consequent under-processing of the cans.

Two other examples of unsatisfactory performance due to faulty cooker design may be cited. One was encountered during an investigation by the Division of Food Preservation into the spoilage of canned pears. In this case it was found that the temperature in an older type of reel cooker was only about 190°F, despite the fact that clouds of steamy vapour were issuing from the can discharge port. The other example is provided by a similar but smaller commercial machine, in which steam entered the cooker through a series of jets spaced along a pipe running the length of the unit. These jets so directed the steam across the interior of the cooker that a vortex formed and sucked air into one end of the cooker, a mixture of air and steam being discharged from the other end. In both instances cited, under-processing was frequent until appropriate modifications in design eliminated the chimney effect in the first machine and vortex formation in the second.

Installation

Precise specifications are available for the installation of cannery retorts (National Canners' Association 1955, 1962), but many retorts in commercial operation in Australia fall short of these specifications. It is essential that the steam supply system should have sufficient capacity to displace air from a retort within a few minutes and bring the retort to operating pressure within the next few minutes. An inadequate steam supply causes 'venting' and 'come-up' operations to be unduly slow and hence reduces retort output; moreover, the cans are exposed to steam for unnecessarily long times under

conditions which make only a small and indefinite contribution towards inactivating heat-resistant microorganisms that may be present within the can.

Instrumentation

Retorts should be fitted with a mercury-in-glass thermometer of limited range, say 170–270°F. This type of thermometer should be regarded as the primary reference instrument, and although many retorts are fitted with dial thermometers operating on the Bourdon gauge principle, these should not be regarded as a substitute for the mercury-in-glass thermometer. The mercury-in-glass thermometer used as reference instrument should be checked for accuracy at least once a year.

Table 2
Effect of 3 degF Errors in Retort Temperature on F_0 Value of Heating Phase of Typical Processes for 303 x 406 Cans

Product	Initial Temp. (°F)	Process Time (min)	Retort Temp. (°F)	F_0 (min)
Green beans in brine	120	20	237	2·0
			240	3·0
			243	4·7
Cream-style corn	140	95	237	3·2
			240	4·4
			243	6·2

In a survey of retort thermometers in two canneries it was found that some thermometers were as much as 3 deg F in error. Table 2 shows the effect such an error has on F_0 values of typical retort processes, these data applying to the heating phase of the retort process only. Complete instrumentation to control separately the operations of venting, come-up, processing, and cooling is seldom warranted, but retorts should be fitted with automatic temperature controllers and recorders. The steam supply to the retort should include a bypass system that allows the retort to be rapidly vented and brought almost to operating temperature with high-pressure steam while permitting steam of lower pressure to be supplied to the steam valve of the automatic controller when the bypass is subsequently closed. (Detailed specifications for installation of retorts have been published by the National Canners' Association and other organizations and may be found in several of the references appended to this article.)

Efficient Venting of Retorts

Many of the spoiled cans submitted by industry for examination in the laboratories of this Division have been found to be under-processed as a result of inadequate venting of the retorts. Venting is an operation that aims to displace all air in a retort by steam before the retort is brought to operating temperature and pressure.

Specifications for vent design and venting procedures have been set out in detail by the National Canners' Association (1962) and others (Reed 1948; Bock 1957). One essential requirement is that vents should be as remote as possible from the steam inlet, thus ensuring that the steam travels across the retort before finally escaping through the vent valve, which should be fully open. The volume of steam flowing through the retort must be sufficient to enable steam to swirl across all parts of the retort and around all cans in the retort baskets, thereby sweeping out all air.

Retort baskets and spacers should be designed with due regard to the danger of their impeding the free flow of steam in a retort and thus increasing the risk of faulty venting. For satisfactory venting, the vent must not be closed, nor must pressure be allowed to build up in the retort in any other way, until all air has been removed. Air left in a retort tends to form an insulating layer around the cans, particularly those near the centre of the retort baskets, and the cans therefore receive less heat than may be needed for the attainment of commercial sterility.

Any lack of agreement between the temperature actually indicated and that expected from the observed pressure in a retort indicates inadequate venting, although the presence of air in a retort may not always be detected in this way. Temperatures of less than 200°F have been found in inadequately vented commercial retorts when the pressure was 10 lb/sq in, a pressure which for saturated steam corresponds to approximately 240°F. Cans processed under these conditions spoiled and the canneries concerned suffered heavy losses.

Although cannery retorts should be fitted with bleeders or pet-cocks (usually about $\frac{1}{8}$ in. in diameter), these are sometimes erroneously regarded as if they were substitutes for vents. Bleeders should be left open during venting and also during the come-up period and while processing. Their function is to maintain movement in the steam inside the retort and to permit the removal of traces of air that may enter the retort with the steam.

Stacking and Loading of Cans

In our visits to canneries we have sometimes seen cans stacked in columns in retort baskets (that is, one can directly above another). Stacking in this manner may restrict or prevent free access of steam to the ends of the cans, and so cause underprocessing.

A more satisfactory method of stacking cans is to arrange them so that one layer is offset relative to the layer beneath, thereby ensuring that all surfaces are accessible to the steam. This point is particularly important with squat cans, for a large part of the heat entering such cans enters through the ends. Similar considerations apply to the packing of rectangular cans in retorts.

Instances have been investigated where cans have been found to be swelled when removed from the retort immediately after processing and cooling. This condition may arise when there is a considerable delay between closing the cans and commencing thermal processing. Cans are sometimes held up for long periods before they are processed, and might during this time be kept at temperatures that permit active growth within them of viable organisms capable of producing gases, thus causing the cans to swell. The delay between closing and retorting should not be greater than 1 hour, and care must be taken to ensure that the occasional basket-load of cans is not pushed aside and forgotten somewhere between the closer and cook-room. It is a wise precaution also to mark each basket-load of cans with a heat-sensitive material, such as autoclave tape, the appearance of which will indicate whether the basket has or has not been heat-processed. In this way the risk of unprocessed cans being sent to the warehouse is minimized. Cans of unknown status found outside retort baskets in the cannery or cook-room should be destroyed.

Cooling

As quickly as possible after processing, cans should be cooled to an average temperature of the contents of 100°F. It must be emphasized that the average temperature is not the centre temperature, which, in solid foods particularly, will be much greater than 100°F when the desired average temperature is reached. At an average temperature of 100°F there is sufficient residual heat in the product to dry the outside of the can and so prevent rusting. In addition, the risk of stack-burning and of spoilage of the product from the growth of thermophilic organisms that have survived the retort process is minimized.

Many of the practical points discussed above are illustrated in a set of slides prepared by the National Canners' Association for training retort operators. The Division of Food Preservation has a set of these slides which may be borrowed from the librarian by interested people in the food industry.

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Pesticides on Apples and Pears— The Problem of Spray Residues

By E. G. Hall

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The successful prosecution of the continuing chemical warfare against plant pests and crop disorders involves frequent and efficient application of insecticides and fungicides, acaricides and nematocides, and weedicides and growth regulators to soils or crops. Without at least some of these aids there would frequently be no worth-while crop to harvest, but at all times special care is required to ensure that man himself does not become a victim of the treatment.

THROUGH the large-scale cultivation of food plants and fodder crops, man's principal food resources are being rendered increasingly vulnerable to attack by insect pests and disease. In consequence, poisonous chemicals are being used on an ever-increasing scale in order to protect crops and food supplies. This in turn has increased the need for special precautions to ensure that no dangerous residues are left on the produce.

The use of pesticides is today essential to fruit production, and the big increase in the production of apples and pears since World War II has been due largely to the much better control of pests and diseases. This has been accomplished through selective use of the wide variety of complex organic insecticides and fungicides produced by the modern agricultural chemicals industry over the last two or three decades.

Before the War only a few simple materials were in general use for spraying fruit on the tree. Lead arsenate was used to combat codling moth and other chewing insects, nicotine sulphate was used for aphids, petroleum oils and sulphur preparations were used for mites (red spider), and Bordeaux mixture and lime–sulphur were used for black spot, mildew, and other fungus diseases. These materials have now been almost entirely replaced by organic chemicals. Though very much more effective than the preparations used earlier, the new chemicals are frequently less specific in their action, and are as likely to kill useful insects that prey on more harmful species as to kill the parasites against which they are directed.

Many modern pesticides are also potentially more dangerous to users in the field and to consumers of harvested fruit than were the earlier preparations. The use of these modern materials is thus fraught with risks which must be understood as clearly as their great advantages. Precautions must always be taken to prevent operators from being exposed to the pesticides. Also, while proper care must clearly be taken to avoid the application of pesticide formulations and the like in amounts that could injure the trees or the fruit, it is equally desirable that they leave no unsightly or dangerous residues on the produce at harvest.

SPRAY RESIDUES ON POME FRUITS

The problem of spray residues on apples and pears is a continuing one. In order to ensure the effectiveness of spraying as a means of controlling pests or disease, the crop must in the first instance be adequately covered by the active ingredient. Moreover, while the crop develops and matures in the field this cover must be adequately maintained, generally by periodic renewal. Each spray application must therefore be thorough, and several applications, spaced throughout a season, are generally necessary. Inevitably the fulfilment of these requirements results in spray residues on or in the fruit at harvest time.

On harvested fruit the presence of spray residues that are readily visible can give rise to problems even when the residues are not toxic. Spray formulations, particularly those based on wettable powders, frequently

include inert filler or carrier materials as well as wetting or emulsifying agents. Such inert additives commonly form a considerable part, and sometimes most, of the visible residue. When a residue is visible it not only detracts from the appearance of the fruit but, more serious, invites a more rigorous examination of samples by health authorities, so that there is an increased likelihood of a consignment being impounded pending a full analysis. The serious disturbance to normal trade that follows when a consignment is impounded for this reason is particularly unfortunate if the analysis of the residue shows that it is in fact harmless.

In contrast, situations may arise where residues of certain materials may be present in amounts that exceed accepted safety levels even though the residues may not be visible. These clearly constitute a dangerous health hazard. Certain pesticidal chemicals, such as demeton and those comprising compounds of mercury, may present an even more difficult problem in that they can be absorbed to a significant degree by the skin of the fruit, and even penetrate into the flesh, without being apparent on the surface of the fruit at harvest.

TOXICITY OF PESTICIDES

Pesticides vary greatly in toxicity. Some are highly poisonous to a wide range of living things, including man, while others are much less poisonous to higher forms of life, though effective against particular pests or disease microorganisms. Some chemicals are initially poisonous, but are rapidly broken down to less toxic or even harmless substances after they have been applied by spray. When correctly used, these are safe. Other toxic chemicals, however, such as aldrin and dieldrin, persist in their original form for very long periods and must be used with great caution on edible crops.

Authorities all over the world are concerned about possible undesirable side effects resulting from the widespread and prolonged use of pesticides. There is already some evidence that wild life has suffered lethal effects, and there are serious misgivings about the possible consequences to all forms of animal life exposed for long periods to even very small amounts of many pesticidal chemicals now in common use. Some of these problems have been highlighted in Rachel Carson's book 'Silent Spring', first published in 1962. Research into the long-term effects of the use of pesticides is therefore being greatly expanded.

For the adequate protection of our food supplies we must perforce continue to be heavily dependent on the use of pesticides in the foreseeable future. Scientists, governments, manufacturers, sellers, and users of pesticides and the like are therefore under a strong obligation to see that health risks are reduced as much as possible, that the public is made fully aware of what risks are involved, and that stringent precautions are taken at all times.

DEFINING SAFE TOLERANCE

A major part of the responsibility for safeguarding human health has been accepted by health and food authorities in many countries, and these authorities are continually checking the amounts of pesticides left on fruits, vegetables, and other food crops after harvest. Based on rapidly accumulating knowledge of toxicity tolerances of humans to foreign chemicals in foods, and of what constitute safe amounts, levels are being defined and, as far as possible, enforced. This is an enormous task, enforcement particularly being extremely difficult.

To provide a clear understanding of the basis for setting residue tolerances, the Plant Production and Protection Division of the Food and Agriculture Organization of the United Nations has defined the relevant terms as follows:

Residue.—A pesticide chemical, its derivatives and adjuvants in or on a plant or animal. Residues are expressed as parts per million (p.p.m.)* based on the fresh weight of the sample.

Food Factor.—The average fraction of the total diet made up by the food or class of foods under discussion.

Acceptable Daily Intake.—The daily dosage of a chemical which, during an entire lifetime, appears to be without appreciable risk on the basis of all the facts known at the time. 'Without appreciable risk' is taken to mean the practical certainty that injury

* The meaning of parts per million can be illustrated by a particular example, such as 1 oz of salt in 62,500 lb of sugar, this proportion corresponding to 1 p.p.m.

will not result even after a lifetime of exposure. The acceptable daily intake is expressed in milligrammes of the chemical, as it appears in the food, per kilogramme of body weight (mg/kg/day).

Permissible Level.—The permissible concentration of a residue in or on a food when first offered for consumption, calculated from the 'acceptable daily intake', the 'food factor', and the average daily food consumption per kilogramme of body weight. The permissible level is expressed in p.p.m. of the fresh weight of the food.

Tolerance.—The permitted concentration of a residue in or on a food, derived by taking into account both the range of residues actually remaining when the food is first offered for consumption (following good agricultural practice) and the permissible level. The tolerance is also expressed in p.p.m. It is never greater than the permissible level for the food in question and is usually smaller.

It can be seen that a high safety factor is an integral part of the setting of tolerances for residues of pesticides in food.

Most countries now have regulations governing the maximum amounts of spray residues permitted on fruit and are enforcing them more strictly. The Food and Drug Administration of the United States has established tolerances for residues of most of the common pesticides used on most crops. These vary from 0 to 100 p.p.m. fresh weight, according to the relative toxicity of the chemical concerned. For example, the tolerance for parathion, a potent organic phosphorus insecticide, is 1 p.p.m., while that for the fungicide captan is 100 p.p.m.

Because of their high toxicity and danger to consumers the use of some very effective pesticides on food crops is not recommended at all. Thus, though mercury in its compounds is a potent fungicide, it is also a potent persistent poison and accordingly mercury has in the U.S.A. a 'zero' tolerance. In Australia the recommended tolerance for mercury is now 0·01 p.p.m.

AUSTRALIAN INVESTIGATIONS ON SPRAY RESIDUES

In Australia there is now considerable activity relating to spray residues on crops, particularly through the National Health and Medical Research Council, the Australian Agricultural Council, and the Commonwealth Departments of Customs and of Primary Industry, and through State Departments of Health and of Agriculture. Manufacturers and distributors of pesticides, and CSIRO also, are playing their part.

An Apple and Pear Spray Residue Committee was set up in 1957 by the Australian Agricultural Council through the Standing Committee on Agriculture. Its continuing task is to examine levels of residues in apples and pears, particularly in relation to export, and, as necessary, to develop adequate methods of analysis; to develop satisfactory methods for the removal of residues from these fruits; and to advise generally on the problem. Funds for the research directed by the Committee are provided by the Commonwealth Treasury. While the work is largely concerned with safeguarding the export industry by advising on ways and means of preventing contamination of fruit with spray residues whose presence would interfere with the marketing of Australian apples and pears overseas, the Australian consumer is also being protected.

The investigations are being carried out by several bodies in close cooperation. The New South Wales Department of Agriculture is responsible for the greater part of the analytical work and chemical investigations, including the checking and development of methods for the accurate analysis of residues. The Department of Customs and Excise examines samples of export apples and pears from all States, analysing them especially for lead arsenate, DDT, and mercury. The CSIRO Division of Food Preservation has been charged primarily with undertaking investigations aimed at developing simple, effective methods for the removal of residues without harm to the fruit. Other State Departments of Agriculture cooperate as required, and the Commonwealth Department of Primary Industry, being responsible for inspection of all export fruit, is actively concerned in all aspects of the investigations.

CSIRO Investigations on Residue Removal

The removal of spray residues has been a problem for a long time. The first experiments in Australia were carried out about 30 years ago, following the setting of toler-

ance limits for lead arsenate on fruit exposed for sale. At that time lead arsenate was universally used to control codling moth in apples and pears. The residues on the fruit at harvest were frequently heavy and were incompletely removed by brushing, so that commonly in the stem and calyx cavities there remained amounts in excess of the tolerance.

It was found that washing the fruit in a bath of dilute hydrochloric acid effectively removed lead arsenate residues. However, the treatment was not fully satisfactory, because the skin of the apples was frequently injured by soluble arsenic compounds accumulating in the wash water, and because varieties with an open calyx, such as the variety Cleopatra and some types of Delicious, were damaged through penetration of the washing solution into the core.

In recent years the use of lead arsenate has greatly declined, but pesticidal residues in general have become more of a problem, so that methods of removal are being studied more widely.

Dry Brushing.—Most apples are brushed before they are packed, and brushing units for cleaning and polishing the fruit are now part of the equipment in most packing sheds. The Committee prompted studies on the effectiveness of dry brushing in removing residues from apples, and these studies have revealed that no brushing units currently available in Australia are capable of removing residues from the stem and calyx cavities.

As brushing is a simple operation which greatly improves the appearance of the fruit, it has a permanent place in preparing apples for market. Pears, however, have a more tender skin and cannot usually be brushed with safety. Spray residues on pears thus constitute a more difficult removal problem. The Committee is currently investigating the design of brushes and brushing units, with the object of improving their efficiency. It is likely that brushing with improved equipment will be satisfactory for light powdery residues such as those from carbaryl (Sevin) and dicofol (Kelthane), both widely used.

Washing and Wet Brushing.—The alternative to dry brushing is washing, either alone or combined with brushing. Because of the difficulty of dry brushing the calyx and stem cavities, and because certain residues are resistant to dry brushing, some form of washing may be necessary. It has been established that the mere spraying, rinsing, or soaking of the fruit with or in solutions of acid, alkali, or detergents, even when these are heated, will remove only certain residues. Using a specially designed experimental spray-type washing machine, the need for an acid wash to remove lead arsenate has been confirmed. A double wash, first in acid and then in alkali, more effectively removed residues of a number of pesticides, such as thiram (TMTD), demeton (Systox), captan, and dinocap (Karathane). For residues of ziram and carbaryl two successive alkaline washes were most effective.

It was further shown that the best means for removing most kinds of residues was wet brushing. Wet brushing involved either passing the fruit over revolving brushes under sprays of an acid, alkaline, or detergent solution, or soaking it in the solution and then brushing it under sprays of clean water. (In any washing procedure the fruit must finally be rinsed with clean water.)

Development of a cheap and efficient wet-brushing unit is under consideration. Though washing is more expensive than dry brushing, and more suited to larger sheds, it would in fact fit in well with the new methods of gently emptying apples from bulk bins by floating them out in a tank of water. Some form of washing will probably be necessary to meet the developing demand for completely clean fruit.

Chemical analyses have revealed that treatments which removed visible residues also as a rule effectively removed the active pesticide. However, even the best treatments were ineffective in removing DDT, mercury compounds, or dicofol, all of which are partly translocated into the skin and flesh and so cannot be more than partly removed by washing. Residues of dicofol have nevertheless all been well below the tolerance and so do not constitute a serious problem.

Analytical Investigations

N.S.W. Department of Agriculture.—Satisfactory determinations of spray residues require precise and extremely sensitive methods of analysis, and highly skilled analysts. Because of the chemical complexity of many of the pesticides and the need for the accurate determination of very small amounts of the compounds concerned, it has been necessary

to test thoroughly, and in some instances to modify, the recommended methods of analysis. Even with modern laboratory instruments some of the methods are very involved and time-consuming. This is especially true for mercury, which must be precisely determined in amounts of only 1 part in 100 million. As a result of chemical research, satisfactory methods of analysis are now available for most of the pesticides commonly used on apples and pears. Investigations to develop simpler and more sensitive methods of analysis for all important pesticides are continuing.

When present investigations were commenced by the N.S.W. Department of Agriculture there was practically no information on the levels of pesticide residues, other than lead arsenate, on and in Australian apples and pears at harvest and after storage. Accordingly, surveys were carried out of residual levels attained after various numbers of spray applications had been made on fruit in different districts. These studies included residues from experimental applications in excess of normal use. The surveys revealed the very satisfactory position that residues of 17 of the total of 20 different pesticides studied did not in any instance exceed official tolerances established by the United States Food and Drug Administration. In fact, the residues at harvest were generally well below the allowable safe limits.

The three pesticides that gave excess residues were lead arsenate, DDT, and the organic mercury compound phenyl mercuric chloride (PMC). Residues of the first two only occasionally exceeded their tolerances. Residues of mercury constitute a serious problem, as any detectable amount must be regarded as a health risk. Mercury is a powerful cumulative poison and mercury compounds are readily translocated into the flesh of fruits and do not gradually decompose as do most organic pesticides. Although mercurials are extremely effective fungicides, their use on food crops must be closely restricted in the interests of the safety of consumers.

The results to date from many analyses indicate that mercury compounds may be safe only when used on apple and pear trees after the crop has been harvested (as an eradicant spray for black spot) but the evidence strongly suggests that they should not be used on the growing crop at any stage. Mercury residues are receiving major attention in the current research programme.

Department of Customs and Excise.—For some years the Department of Customs and Excise has been analysing random samples of export apples and pears for lead and arsenic. Over the last few years only a very small proportion of the 100 or so samples analysed each season has exceeded the British tolerance of 3 p.p.m. for lead and 1 p.p.m. for arsenic. In 1964 and 1965 many samples were also analysed for DDT and mercury. In all samples, DDT residues, when present, were well below the British tolerance of 5 p.p.m. Small amounts of mercury were present in some samples but in no instance was the Australian tolerance of 0·1 p.p.m. exceeded.

Through its subcommittee on pesticide residues in foods the National Health and Medical Research Council is exercising a close watch on pesticide residue problems. Its primary task is to advise on the safety of pesticides and to recommend safe maximum levels for residues of such as are permitted. In the light of the new information now available the whole question of the safety of mercury residues is being re-examined.

PRECAUTIONS IN USING PESTICIDES

Toxicity may either be acute, with a quick and drastic effect from a single exposure, or chronic, with slowly developing insidious effects from repeated small doses or low-level exposure. In using sprays the possible toxic effects of the solvent, wetting agent, or diluent must also be considered. Pesticides may be absorbed directly through the skin, or by inhalation, or through being ingested with food or drink. Organic phosphates are very readily absorbed in all three ways. Accordingly, the more toxic ones, of which parathion is the most dangerous, must be used with special care. Some precautions for users are indicated below:

- Treat all pesticides as dangerous.
- Read labels carefully and follow instructions exactly.
- Do not allow pesticides to drift to other crops or to cause contamination of water supplies.

- Immediately return unused stocks to a locked store.
- Wash out thoroughly and safely dispose of all used containers, e.g. by burning or burying.
- Wear protective clothing as advised on the labels.
- Immediately the spraying job is completed, thoroughly wash exposed parts of the body with soap and water.
- *Never* eat or smoke before washing hands and face.
- *Never* apply sprays later than the recommended safe periods before harvest.

Precautions for Consumers

If there is any sign of foreign material on the surface of the fruit (or vegetables), always thoroughly wash or wipe them before they are eaten or cooked.

THE FUTURE

While production of more and more food becomes more and more urgent, we shall continue to depend primarily on chemical methods to control pests and disease. Therefore more research and increased vigilance are needed to protect people from pesticide residues on food crops. All must play a part, but research workers and manufacturers must seek safer and more effective chemicals and improved formulations and methods of application, so as to keep to a minimum the amounts applied. Greater care must be exercised in using pesticides, and simple and effective removal methods must be developed and used. There must be an expanded, continuing monitoring of levels of toxic chemicals in all our foods. Efforts to develop alternative methods of pest and disease control, such as biological control, irradiation, and breeding for resistance, must be increased.

It is clear, then, that the work initiated by the Apple and Pear Spray Residue Committee must continue and be expanded. It is equally clear that as a result of the investigations already carried out, the consumer can be assured that Australian apples and pears are wholesome and safe to eat. They must be kept so.

FURTHER READING

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A Small Freeze Dryer for Industry

By J. D. Mellor

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THERE IS nowadays an increasing demand for a suitable freeze-drying unit that can be used in the laboratory and in the pharmaceutical and food industries for the preservation of labile products, especially those of biological origin. Freeze dryers are used to dry frozen products by converting the ice within the products directly into vapour under vacuum and eliminating it from the system. The advantages of freeze drying, particularly for solid foods, are considerable; for besides the fact that freeze-dried products can be stored and transported without refrigeration, they can also be rehydrated readily. Hence freeze-dried foods can instantly be prepared for cooking when required.

To meet the physical requirements of freeze drying and to provide a conveniently sized unit for developmental work on freeze-dried products in laboratories and factories throughout Australia, officers of the Division of Food Preservation recently designed a portable freeze dryer suitable for commercial manufacture. The unit, one commercial

Fig. 1.—The self-contained freeze-drying unit.

model of which is being used successfully in a pharmacological laboratory, and another in a food research laboratory in Queensland, incorporates self-contained facilities for refrigeration, heating, and vacuum pumping, and can freeze-dry 15 lb of frozen product at each batch.

The freeze dryer (Fig. 1) consists of an insulated cylindrical drying chamber 16 in. int. diam. by 24 in., mounted horizontally on top of a cabinet (2 ft 8 in. long, 3 ft 6 in. wide, and 2 ft high) which can be moved about on rubber-tyred swivel castors. One end of the chamber has a flanged opening, to which is fitted a swing cover similarly flanged but with a self-retaining O-ring vacuum seal. The cover also has a viewing window.

Heating and cooling systems, essential for the freeze-drying process, are located inside the chamber (Fig. 2). The heating system consists of a bank of four blackened radiant heaters (22 in. long, 10 in. wide) in the central region of the chamber. These are electrically heated. Three perforated metal trays to hold the product slide between the heaters, which are spaced $2\frac{1}{2}$ in. apart. The cooling system consists of 32 ft of $\frac{3}{4}$-in.-diam. cooling coil running along the length of the chamber in zig-zag fashion, with the nearest surface of the coil $\frac{1}{2}$ in. from the inside wall. The space between the heating and cooling systems is shielded in such a way as to reduce heat exchange between heaters and coil while still allowing water vapour to pass through it.

The vacuum pump and mechanical refrigeration compressor are housed in the cabinet beneath the chamber, and pipe-lines from them run to the cooling coil through special seals in the back of the chamber. The vacuum pump is a single-stage air-ballasted type with a displacement of 5 cu ft/min (which gives a pressure of 0·2 mmHg), and the refrigeration compressor is a $1\frac{1}{2}$-hp (R502 refrigerant) single-stage unit with sufficient capacity to reduce the coil temperature to −40°F under full load.

Temperature of the heaters is controlled by means of a transistorized electronic device, and the vacuum pressure is measured by a Pirani gauge. The instruments and controls are all panel-mounted, and the electrical leads to the back of the chamber are connected to demountable electrical lead-in seals.

The freeze-drying unit is being manufactured by Cutler Refrigeration Pty. Ltd., of Sydney.

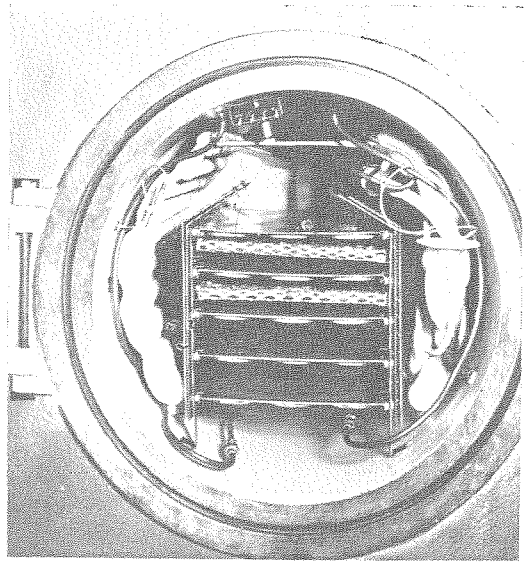

Fig. 2.—Interior view of the freeze-drying chamber when the swing cover is opened. (Photo: courtesy Department of Pharmacology, University of Sydney.)

Prevention of Non-enzymic Browning

By D. L. Ingles
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The prevention or inhibition of undesirable colour and flavour development associated with 'browning' reactions that occur during the processing of many foods is of great technical importance in the food processing industry. In this article Dr. Ingles, who has been engaged for a number of years on a detailed study of the complex chemical reactions involved in the browning of foods, indicates some of the underlying reasons for the remarkable inhibitory action of sulphur dioxide on this type of browning.

BROWNING is a common accompaniment of many organic reactions that are promoted by heat or dehydration, and is of particular importance when such reactions occur in foods.

Browning may be undesirable in some foods and advantageous in others. For instance, the yellowing of a sugar syrup when it is heated or concentrated may detract from the appearance of a food product in which it is used, but in the production of caramel a brown colour, and the associated changes in flavour that accompany the browning, are actually desired. One type of browning, arising from the action of enzymes, occurs more or less spontaneously on cut surfaces of many fresh fruits (bananas, apples, etc.). It can, like non-enzymic browning, be inhibited by exposing the fruit to sulphur dioxide, but the chemical reactions involved, in both the development and the inhibition of this type of browning, differ from those associated with non-enzymic browning. It is with non-enzymic browning reactions and their prevention that this article is concerned.

Non-enzymic browning in foods is the consequence of complex chemical reactions in which sugars and their derivatives play an important part. Sugars readily brown when they are heated, more so when acids or alkalis are present. Browning occurs even more rapidly when sugars are heated with amines or amino acids (a reaction known as the Maillard reaction). Consequently, when amino acids and sugars are both present in a system, as they are in many foods, several kinds of non-enzymic browning reactions can occur simultaneously during heating, or even storage, of the food.

INHIBITION OF BROWNING BY SULPHUR DIOXIDE

When browning detracts from the quality of a food and is therefore not desired, it is common practice to prevent its development by the use of sulphur dioxide, as in the sulphuring of portions and slices of fruit (apples, apricots, etc.) that are to be dried. In some instances sulphur dioxide may be applied to a food in the form of one of its salts (e.g. bisulphite), which is added in limited quantity before processing or prolonged storage.

Two reviews on the use of sulphur dioxide as a browning inhibitor appeared in 1954 (Joslyn and Braverman 1954; Gehman and Osman 1954). Although these were concerned mainly with methods of utilizing sulphur dioxide for the purpose mentioned, they drew attention to two main basic problems:

- The mechanism whereby sulphur dioxide exerts its protective action in foods.
- The fate of the sulphur dioxide in a stored food (since the sulphur dioxide gradually disappears and is 'lost' as storage time is prolonged).

Despite the variety and complexity of non-enzymic browning reactions in different food systems and the different reactive intermediates that may be formed during processing or storage, sulphur dioxide appears to be an effective inhibitor of this type of browning. Clearly, in order to understand why this should be so, and in order to provide satisfactory answers to the questions posed above, much had to be learned about the

nature of the chemical changes taking place during browning reactions. In particular, information was required about reactions that can occur between sulphur dioxide, or its salts, and sugars or sugar derivatives, so that sulphur dioxide could be usefully applied to particular food systems in which browning was not desired. Such reactions have been studied at the CSIRO Division of Food Preservation for a number of years, and in what follows an attempt will be made to outline some of the conclusions arising from this and related work.

REACTION OF SULPHUR DIOXIDE WITH SUGARS

Sulphur dioxide is a highly reactive substance, whether in the form of the free gas, in combination with water (i.e. as sulphurous acid), or in the form of its salts. Besides being a powerful reducing agent (which accounts for its bleaching properties), it is capable of forming addition compounds with aldehydes and ketones, and under appropriate conditions can bring about sulphation or sulphonation of unsaturated compounds. The course of the reactions which it undergoes with a given substance frequently depends on the pH of the system, and so it is with sugars.

Reactions at pH 4.0

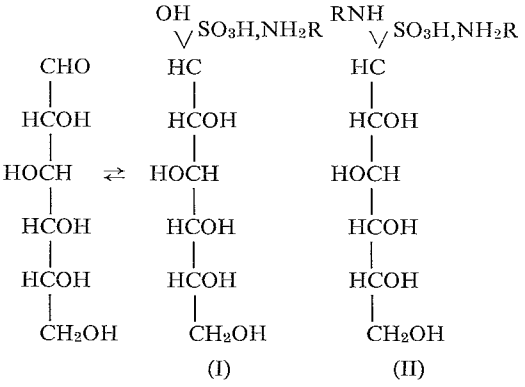
At pH 4·0 sulphur dioxide in solution exists mainly in the form of the bisulphite ion, which determines the types of reaction that can occur with sugars under these conditions. Some of these reactions are considered below.

Formation of Bisulphite Addition Compounds with Aldose Sugars.—Braverman (1953) was the first to isolate a crystalline glucose–sodium bisulphite addition compound, though there was already much indirect evidence suggesting the existence of such compounds. Later, it was shown (Ingles 1959*a*) that aldose sugars such as glucose, galactose, mannose, xylose, and arabinose reacted readily with potassium bisulphite to yield crystalline addition compounds. The reaction may be written:

$$RCHO + KHSO_3 \rightleftharpoons RCH\begin{matrix}<^{OH}\\ _{SO_3K}\end{matrix}$$

where R represents the aldose residue. This reaction is reversible, and dissociation of the addition compound is favoured under alkaline conditions.

Reaction of aldose sugars with amine bisulphites (Ingles 1959*b*) also gave crystalline bisulphite addition compounds. Two types of compound (I and II, as represented below) were formed.



D-glucose Amine bisulphite addition compounds

Formation of addition compounds from aldose sugars and amine bisulphites.

Formulae of Addition Compounds.—Bisulphite addition compounds have also been isolated (Ingles 1961*a*) from glucosone, glycerosone, reductone, 3-deoxy-glucosone, and dehydroascorbic acid, which are sugar compounds that have been implicated in various browning systems (Hodge 1953). These addition compounds were found to be unstable in alkali but relatively stable in cold acidic solution (Ingles 1959*c*). The sulphur dioxide contained in them could be recovered during the Monier–Williams sulphur dioxide estimation (Shipton 1954), and would not therefore be 'lost' in the analytical sense.

Disproportionation Reactions of Sulphur Dioxide.—The term 'disproportionation' is used to connote mutual interaction between the molecules of a particular compound such that the end products are dissimilar but mutually related (e.g. oxidant and reductant arising from self-oxidation of a molecular species). Under the influence of light or heat, sulphur dioxide undergoes a slow disproportionation reaction which results in the oxidation of some of the sulphur dioxide to sulphate, with simultaneous reduction of an

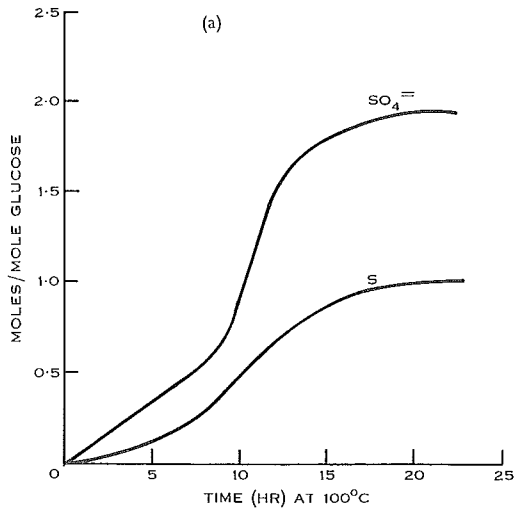


Fig. 1(a).—Formation of sulphate and sulphur from the reaction of glucose (1 mole), sodium bisulphite (4 moles), and water (25 g/100 g solids).

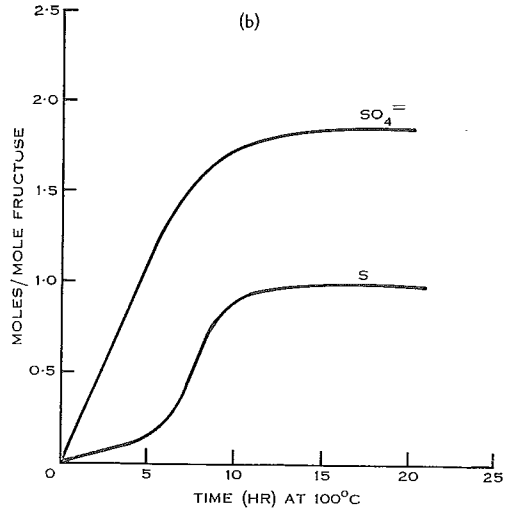


Fig. 1(b).—Formation of sulphate and sulphur from the reaction of fructose (1 mole), sodium bisulphite (4 moles), and water (25 g/100 g solids).

equivalent quantity of sulphur dioxide to elemental sulphur. This kind of reaction was studied by Toland (1960), who observed that sulphur-containing compounds in one state of oxidation catalysed the disproportionation of similar compounds in another state of oxidation. Thus sulphides and thiosulphates catalyse the disproportionation of bisulphites.

Reducing sugars are also effective promoters of the disproportionation of bisulphites, as has been found by workers interested in the sulphite process for paper pulp manufacture. Thus Hägglund, Johnson, and Urban (1930) reported that when sugars were heated with bisulphites at 140°C considerable disproportionation of sulphite occurred. This reaction was studied at lower temperatures by the author (Ingles 1960*a*) and found to occur at significant rates even at 25°C. The effects of glucose and fructose in promoting disproportionation of bisulphite to sulphate and sulphur are shown in Figure 1, and the effects of a number of browning intermediates in Table 1.

Sugars that promote the disproportionation reaction are themselves affected, being both

Table 1
Yields of Sulphate and Sulphur per mole of Reducing Sugar at 50, 37, and 25°C

Reaction mixture: Reducing sugar (0·01 mole), sodium bisulphite (0·04 mole), and water (25 g/100 g solids)

Time of heating	10 weeks at 50°C		16 weeks at 37°C		24 weeks at 25°C	
Compound Oxidized	Yield					
	Sulphur (g-atoms)	Sulphate (moles)	Sulphur (g-atoms)	Sulphate (moles)	Sulphur (g-atoms)	Sulphate (moles)
Glucose	—	—	0	0·10	0	0·11
Fructose	0·60	1·4	0·06	0·21	0	0·12
Ascorbic acid	0·80	1·3	0·75	1·4	0·09	0·54
1-Deoxy-1-glycino-fructose	0·21	0·62	0·08	0·29	0	0·12
Sorbose	—	—	0·07	0·34	0·03	0·27

oxidized and sulphated during the reaction. For instance, from the reaction of glucose and bisulphite both gluconic acid and glucose-6-sulphate were isolated and identified (Ingles 1960*b*). Indeed, it was possible to account quantitatively for all the bisulphite and sugar reaction products formed when glucose was boiled with sodium bisulphite (Table 2).

Table 2

Products of Reaction of Glucose (0.1 mole), Sodium Bisulphite (0.1 mole), and Water (25 g/100 g solids) at 100°C for 8 hr

	(moles)		(moles)
Glucose recovered	0·064	Sulphur	0·025
		Sulphur dioxide evolved	0·009
		Sulphur dioxide released on cold alkaline hydrolysis	0·009
Gluconic acid	0·008		
		Sulphate (inorganic)	0·039
Glucose-6-sulphate	0·019	Sulphate (as glucose-6-sulphate)	0·019
Total	0·091		0·101
Percentage recovery (mole basis)	91		101

Reactions at and above pH 6.0

At pH 6·0 or higher, disproportionation of sulphur dioxide occurs only to a slight extent. At these pH values one is concerned mainly with the reactions of the sulphite ion, since at pH 6·5 the sulphite ion occurs in equimolecular proportions with the bisulphite ion, and at pH 9·6 it is in great excess.

Formation of Sulphonic Acid Derivatives.— When glucose and sulphite are heated at pH 9·6, a substantial loss of sulphur dioxide as sulphite still occurs (Fig. 2), even though negligible amounts of sulphate and sulphur are formed. However, it was found that β-sulphopropionic acid could be isolated from the products of the reaction (Ingles 1961*b*). Clearly, this could result only from sulphonation and fission of the sugar molecules. Although the loss of free sulphite under these conditions is thus accounted for, the detailed mechanism of the reaction resulting in the formation of the sulphonic acid is still not clear.

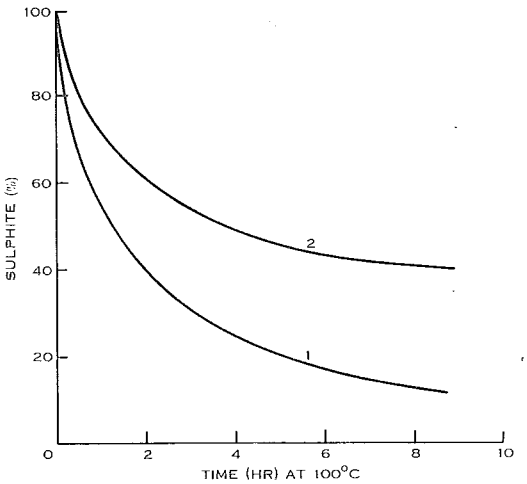
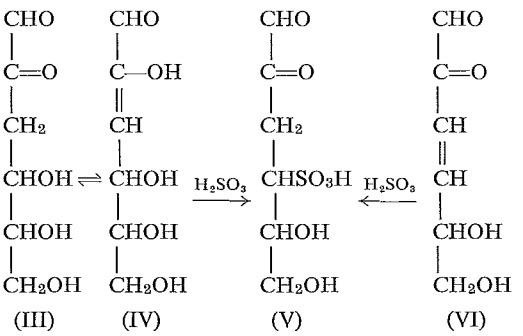


Fig. 2.—Rate of loss of sulphite upon heating glucose (1 mole) and sodium sulphite (1 mole) at 100°C in water. Curve 1, free sulphite; curve 2, free and combined sulphite.

When a similar mixture of glucose and sulphite is caused to react at pH 6·5, fission of the sugar molecule does not take place, although here also a sulphonic acid is obtained. This sulphonic acid, which is represented by (V) below, was thought to arise either through substitution in 3-deoxy-



Formation of sulphonic acid derivatives.

glucose (III) or through addition to the unsaturated osone (VI); both of the mechanisms proposed (Ingles 1962) have since been verified by Anet and Ingles (1964) and Lindberg, Tanaka, and Theander (1964). The two reactions are of especial interest because the compounds (III) and (VI) have

both been isolated as intermediates from browning systems.

The reaction of browning intermediates with bisulphites in the manner described above provides a clear explanation of why these intermediates are precluded from taking a further part in the browning reactions. The sulphonic acid derivatives formed are very stable compounds. They do not release their combined sulphur dioxide in either acid or alkaline systems, nor do they release it in the Monier–Williams distillation used for the estimation of combined sulphur dioxide. For practical purposes, therefore, the sulphur dioxide bound in the form of sulphonic acids during storage of a sulphured food can be regarded as 'lost', and the intermediates, also, are inactivated.

MECHANISM OF INHIBITION BY SULPHUR DIOXIDE

It remains now only to summarize the reactions of sulphur dioxide with sugars and to point out their implications for the inhibition of browning reactions.

When sulphur dioxide is added to a food at about pH 4·0, bisulphite addition compounds are formed rapidly. The sulphur dioxide in these addition compounds is not lost in the analytical sense because it can be readily recovered and estimated; also, because it is still available in the system, it provides a latent reservoir of sulphur dioxide in the food. However, on storage of the food, or after it is heated, the available sulphur dioxide is diminished, because under these conditions of pH the sulphur dioxide can undergo disproportionation to sulphate and free sulphur. Concurrently, the sugars may undergo oxidation and sulphation (i.e. formation of sulphate esters, not sulphonation).

In foods with higher pH values than those considered above, losses of available sulphur dioxide also occur, but for a different reason. These losses are due to the binding of sulphur dioxide in the form of sulphonic acid groups attached to sugar molecules or their derivatives. The types of sulphonic acids formed, and the mechanisms of their formation, have already been indicated above.

With regard to the non-enzymic browning of foods, the important point is that through the formation of stable derivatives from highly reactive intermediates the normal sequence of browning reactions is interrupted. Sulphur dioxide, sulphites, and bisulphites thus exert their inhibitory effect by breaking the chain of chemical reactions that leads to the formation of brown pigments.

Although much more has yet to be learned of the fate of individual sugars and intermediates in a given food system, and of the details of the reaction mechanisms involved in browning and its inhibition, it is apparent that enough is now known about these to provide broad solutions of the two problems posed at the beginning of this article. Perhaps with further advancement of our knowledge it may be possible to devise more efficient means for the control of non-enzymic browning in foods.

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Influence of Blanching Time on the Storage Life of Frozen Peas

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IT HAS LONG BEEN KNOWN that most vegetables, prior to freezing, require blanching in hot water or steam to prevent the development of off-flavours during storage at 0°F (Haslacher 1928; Birdseye 1934; Tressler and Evers 1957).

Adequacy of blanching has normally been determined by tests for residual activity of the enzymes catalase and peroxidase. A variety of methods have been developed for this purpose (Joslyn 1949; Walker and Shipton 1962), but different methods often give divergent results and, in addition, are subject to interference by reactions involving non-enzymic components of the vegetable tissue. The ultimate standard against which the residual enzyme tests must be judged is, of course, the retention of organoleptic quality and colour by the frozen product during storage.

Since an entirely acceptable quantitative relationship between residual enzyme activity and storage life of frozen peas has not yet been established, one might consider the alternative of standardizing the blanching time. Kertesz (1933) found that a blanching time of about 20 sec in boiling water was adequate for quality retention by size 3 peas. Joslyn (1949), quoting unpublished data of Joslyn and Bedford, reported that the flavour of peas was equally well retained when they were blanched for 30 or 60 sec, whereas blanching for 2 or 3 min had a deleterious effect.

These findings suggested to us that it would be useful to establish the minimum time necessary for the blanching of peas, as well as to ascertain to what extent this value could be exceeded without causing impairment of quality. Accordingly, ungraded commercially vined peas were washed and cleaned, blanched in boiling water for 15, 30, or 60 sec, frozen, and subsequently stored at 0°F. For use as control samples in the tasting tests, an additional quantity of peas was blanched for 60 sec and stored at −35°F.

Samples for organoleptic assessment of quality were removed after storage periods of 0, 4, 8, 16, and 24 months. Twice on each such occasion separate groups of samples were presented in random order to a taste panel of 16 members. The tasters were asked to score the peas on a 10-point scale for colour, skin texture, cotyledon texture, and flavour.

The mean taste test scores are given in the table. The only significant effect of blanching time was the development of off-flavour and slight colour deterioration in the samples blanched for 15 sec.

The results indicate that when boiling water is used, a blanching time of 30 sec is adequate for the retention of quality in frozen peas during storage at 0°F, and that this time can be extended to 60 sec without adverse effects. Under commercial production conditions the longer blanch would be preferable, since it provides a greater safety margin.

Mean Tasting Test Scores*

Characteristic Assessed	Blanch Time (sec)	Storage Time (months) 0	4	8	16	24
Colour	15	7·6	7·6	7·6	6·8	6·4
	30	7·8	7·7	7·7	7·3	7·7
	60	7·5	7·5	7·9	7·3	7·5
Flavour	15	5·9	4·8	5·1	5·6	4·9
	30	6·5	6·6	6·7	6·7	7·0
	60	6·9	6·8	7·0	6·5	6·9
Skin texture	15	6·0	5·9	6·2	6·1	6·0
	30	6·3	6·5	6·6	6·6	6·2
	60	6·1	6·3	6·6	6·1	6·5
Cotyledon texture	15	4·9	4·4	4·7	4·0	4·4
	30	5·1	5·0	4·8	4·7	4·4
	60	5·0	5·1	4·9	4·3	4·9

* Characteristics were assessed on a 10-point scale, 0 (lowest score) to 10 (highest score).

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Notes

DETINNING PROBLEMS IN CANNED FOODS—THE ROLE OF NITRATE

At a Technical Day organized by the Comité International Permanent de la Conserve (C.I.P.C.) in Parma on September 28, 1965, it was reported that the incidence of certain types of rapid detinning in canned foods appears to have increased over the past 3 to 5 years. Nearly all of the outbreaks have been in packs of tomatoes, tomato products, carrots, green beans, or sweet potatoes, which have extensively detinned their containers within 3 to 8 months after canning, a rate 5 to 10 times as rapid as normally expected. Characteristically the detinning is scattered widely throughout the pack; it seldom falls into a recognizable pattern within individual cannery operations, but it sometimes seems to be associated with a geographical area.

Many foods contain oxidizing agents or depolarizers that corrode tin by direct chemical attack without evolution of hydrogen. When sufficient quantities of these substances are present, detinning may proceed at a rapid rate without loss of vacuum, and only when virtually all of the tin in the container has been dissolved does the unprotected steel begin to corrode very rapidly, with a vigorous evolution of hydrogen. A strong metallic flavour may quickly develop in the contents, and the container fails owing to the formation of a hydrogen swell.

Unusually high levels of inorganic nitrate have been suspected as a possible cause of

detinning in canned foods more acid than about pH 5·4 (Strodtz and Henry 1954). The nitrate may come from vegetables as a result of fertilizer treatments, or from some natural waters, or from cured meat ingredients in formulated packs.

Unfortunately, nitrate is chemically reduced during the course of the detinning action, and little or no nitrate may remain in a detinned container even though it may have been the agent responsible for the corrosion. Ammonia may result as one of the products of the reduction.

American Experience

Considerable presumptive evidence existed that inorganic nitrates were intimately connected with many of the detinning problems encountered in recent years in America. The problem was recognized as a matter of industry-wide concern, and a research programme under the general guidance of technical men from the tinplate producers, the can manufacturers, and the canning industry was undertaken by the National Canners' Association in cooperation with seven universities.

The primary object of the first year's work was to determine whether or not accumulated nitrates in edible plant tissues could shorten the shelf lives of the canned products. An experimental programme was designed to investigate three different levels of application of nitrate fertilizers to four vegetables: tomatoes, green beans, carrots, and spinach. Throughout the storage period, changes in nitrate and ammonia content in the canned products were followed, while the extent of corrosion was determined by analysis for tin. Reporting to the C.I.P.C., R. P. Farrow and I. I. Somers, of the National Canners' Association, said that on the basis of the first few results available it would be premature to make other than casual observations. The universities were not successful in accumulating nitrates in the experimental vegetable packs in every instance, but when success was achieved internal can corrosion appeared to be correlated with the level of inorganic nitrate initially present.

South African Experience

In South Africa a specific problem of rapid detinning in tomato paste has been encountered. Until 1960 tomato paste producers obtained a shelf life of 24–30 months in plain cans made from hot-dipped tinplate (1·25 lb/base box). In 1962, however, about 20% of Transvaal production became hydrogen swells within 6 months, while in the Cape Province shelf life remained normal.

Factors previously reported to promote detinning in tomato paste were nitrate, heat damage due to delayed cooling, high storage temperature, and cold breaking of the tomatoes. South African investigators first examined the possible significance of these factors in relation to their problem, but decided that none appeared to be responsible for a reduction in the shelf life of plain cans. Moreover, poor shelf life could not be shown to be due to abnormal properties of the tinplate, and rapid failure was as liable to occur in cans made from 1·25-lb hot-dipped tinplate as in those of 1-lb electrolytic tinplate.

Looking round for other possible explanations of the detinning problem, they found that in the Cape Province, where tomatoes were railed to the factories and converted into paste at least 36 hr after picking, no detinning problem had arisen. In the Transvaal, paste produced from tomatoes grown in fields adjacent to the factory gave rise to rapid detinning, while paste produced from the same tomatoes processed 48 hr after picking at a factory some distance away did not. Moreover, a further detailed study of the detinning problem in one factory showed that the percentage of hydrogen swells developing in each day's production depended upon the relative proportions of tomatoes received each day by road from local farmers and by rail from distant growers. Looking back, it was realized that there had been no detinning problem when there were no tomato paste canning factories in the growing areas. At that time all tomatoes were processed a day or two after picking.

In an account to the C.I.P.C. of investigations involving tin dissolution experiments, G. G. Knock, of the Metal Box Company of South Africa, stated that juices prepared from Roma tomatoes held for periods up to 72 hr after picking became progressively less active in dissolving tin.

During the maturation of Roma tomatoes there are changes in consistency, pH, and malic to citric acid ratio, and the nitrate content drops by as much as 30%. While the drop in nitrate content is probably a

significant factor, it is believed that the interrelationship of these variables is of major importance in regulating the rate of detinning, and that the ratio of malic to citric acid influences the anodic relationship of tin to iron. Further experimental work is being undertaken in the hope of elucidating the mechanism of this detinning reaction.

Japanese Experience

From Japan there has appeared a report confirming the harmful effect of nitrate in accelerating detinning in canned foods. An orange drink in plain cans was suspected to be the cause of food poisoning and was found to contain 400–500 p.p.m. of tin shortly after processing. Analysis of the well water used in preparing the drink revealed the presence of nitrate (7–25 p.p.m. nitrate N). Canning trials with various levels of added nitrate led workers at the Toyo Institute of Food Technology to recommend that water for addition to canned foods should contain not more than 1 p.p.m. nitrate N (Horio, Iwamoto, and Oda 1966).

Another curious effect of nitrate is to produce a petroleum-like taint in canned foods sweetened with sodium cyclamate. The odorous substance was identified as cyclohexene formed by reduction of cyclamate by nitrite, which in turn was produced by reduction of nitrate in contact with tinplate (Sawayama *et al.* 1966).

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J. F. K.

DETERMINATION OF TIN BY THE DITHIOL METHOD

In an article that appeared in a previous issue of this Quarterly*, an analytical method was outlined for the estimation of tin based on spectrophotometric readings at 485 mμ on the tin–dithiol complex.

Although spectrophotometric readings at 485 mμ will give satisfactory results, higher sensitivity is obtained at 530 mμ. Accordingly, the latter wavelength is now recommended for routine use.

* BOARD, P. W., and ELBOURNE, R. G. P. (1964).—The laboratory examination of canned foods. XXI. New methods of determining tin and iron. *CSIRO Fd Preserv. Q.* **24**, 53–6.

PECTIC SUBSTANCES IN FRUITS AND VEGETABLES

The author of this informative booklet* was formerly in charge of the biochemical department of the Institute for Research on Storage and Processing of Horticultural Produce (I.B.V.T.), Wageningen, The Netherlands, where much of his work was devoted to research on pectins. He is now Professor of Food Science at the University of Stellenbosch, South Africa.

The booklet is a valuable up-to-date review, and the subject is covered very thoroughly in only 125 pages of text (excluding list of contents, literature references, and index). Much of the author's own work is included, but each topic is treated critically, with due regard for differing views of other workers. The value of the review is increased considerably by the inclusion of 538 literature references.

Chapter 1 is concerned with the nomenclature and structure of pectic substances. The author discusses thoroughly the problem of the structure of protopectin, defined as the water-insoluble parent pectic substances in plants from which soluble pectic substances can be produced. Chapter 2, covering some important characteristics of pectic substances, deals with coagulation, swelling, solubilization, and related phenomena, and concludes with some notes on oxidative degradation. Jellying phenomena are adequately considered, in separate sections for high- and low-methoxyl pectins. The stability of pectic substances in acid solution (below pH 4) and in low-acid (pH 4–7) and alkaline solutions

* Pectic substances in fresh and preserved fruits and vegetables. By J. J. Doesburg. I.B.V.T. Commun. No. 25 (1966). Institute for Research on Storage and Processing of Horticultural Produce, Wageningen, The Netherlands. 152 pages; 56 figs. Price $US3.00 (Europe Dfl.10.-).

is discussed, and recent work on the trans-elimination reaction at high pH is included. Chapter 3 deals with the detection, determination, and characterization of pectic substances, the major alternative methods of chemical determination and also the determination of jellying properties being considered. Chapter 4 is concerned with pectic enzymes, i.e. depolymerizing enzymes and pectinesterases, and their use and production.

Chapter 5 covers pectic substances in living fruits, which include stored intact fruits, and in this chapter the relation of pectic substances to firmness, the changes occurring during development and ripening, and their relation to enzymes are discussed, as well as the effect of ionizing radiations. Chapter 6 covers applications of direct interest to the food technologist, namely: the influence of pectic substances on texture and firmness of preserved products containing parenchyma tissues; preservation with sulphur dioxide and by freezing; pickling; the influence of heating; the firming of heat-processed and frozen products; rehydration of dehydrated products; jellying power of fruits; the use and inactivation of pectic enzymes in fruit juices; and raw materials for pectin production.

The booklet is well illustrated with photographs, diagrams, and graphs, has a good index, and is printed clearly on paper of good quality.

F. E. H.

Financial Contributions, 1965-66

THE ANNUAL BUDGET for the Division of Food Preservation is now close to $1\frac{1}{4}$ million dollars. In the year ended June 30, 1966, it amounted to $1,208,200, of which $1,049,100 was provided by the Commonwealth Treasury. The balance was in the nature of contributions for specific researches from the following Government departments and statutory bodies within Australia.

Australian Meat Research Committee
Research on the quality, processing, storage, and transport of beef
Australian Apple and Pear Board
Apple and pear storage investigations
Australian Dried Fruits Association
Investigations on dried tree fruits
Australian Egg Board
Investigations on packaging of egg pulp
Australian Meat Board
Investigations on the mechanical skinning of sheep
Department of Primary Industry
Fruit fly sterilization investigations*
Metropolitan Meat Industry Board, Sydney
Muscle biochemistry investigations

* Central funds made up of contributions from the Commonwealth, Queensland, New South Wales, Victoria, and the citrus industry in New South Wales and Queensland.

New South Wales Department of Agriculture
Fruit storage investigations
The Rice Marketing Board for the State of New South Wales
Investigations on the drying of rice grain

Financial support has also been forthcoming from international sources: the U.S. Department of Agriculture has continued to contribute to the cost of investigations on the chemical structure of ovalbumin and S-ovalbumin, and on cyclopropenoid compounds. The presence of the latter in poultry feed has adverse effects on hens and causes disorders in stored shell eggs.

In addition to the above the Australian food industry and its associated industries, such as packaging, have contributed the highly creditable total of $21,887, which is a record. These valuable contributions have enabled the Division to carry out a number of specialized investigations for the food industry, and to purchase equipment for its work. The Division is also grateful for the assistance rendered by industry in providing facilities for experiments.

It is pleasing to find a growing number of companies and organizations willing to support the Division, and it is with sincere pleasure and gratitude that we acknowledge our indebtedness in these pages.

Contributors to General Donations Account, 1965-66

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NEWS FROM THE DIVISION OF FOOD PRESERVATION

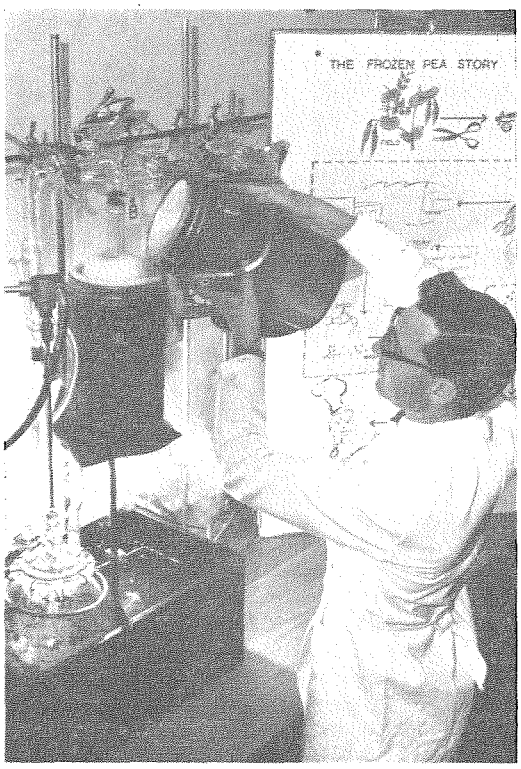
OPEN DAYS

A series of open days was held at the North Ryde laboratories of the Division on Thursday, Friday, and Saturday, August 4-6. On the first day nearly 600 visitors from the food and related industries, from government departments and institutions, and from the universities inspected the laboratories and the scientific and food processing equipment used in the Division's research and investigations. On the second day 280 secondary school children were taken on conducted tours, and Saturday afternoon was given over to members of staff and their relatives and friends. An illustrated brochure on the work of the Division was produced for the occasion.

Many visitors stated that they found the exhibits very interesting and informative. One large laboratory had been set aside exclusively for exhibiting samples, diagrams, and special testing equipment used in meat research being conducted at the Division's branch laboratory at Cannon Hill, Brisbane, as well as at North Ryde.

Among other exhibits were specimens of freeze-dried strawberries, prawns, mushrooms, and even beefsteaks. These and similar foods can now be freeze-dried much more rapidly (e.g. up to 30% less time than formerly) by utilizing the new 'cyclic' freeze-drying process invented by Mr. J. Mellor of the Division and now the subject of a CSIRO patent application (see page 37).

In the post-harvest physiology section, exhibits showed how experiments on bananas were being carried out to study the biochemistry of ripening processes. Working in association with officers of the fresh fruits and vegetables section, the post-harvest physiology group has recently established that the onset of ripening in bananas can be delayed by as much as 6 months if the composition of the storage atmosphere is suitably controlled, and that such bananas can subsequently be induced to ripen normally when required to do so.



On display during the Division's recent Open Days at North Ryde was apparatus used in the various stages of a method developed by the Division for concentrating minute quantities of volatile flavours from peas (50 kg of stored, unblanched peas yields 0·5 ml of highly concentrated flavour and off-flavour essence).

The photograph shows Dr. F. Whitfield topping up a liquid-air cool-trap used to condense an initially crude fraction being distilled from a mash of 6 kg of peas subjected to refluxing under reduced pressure.

HONOUR FOR CHIEF

Dr. J. R. Vickery, Chief of the Division, received the 1966 Australian Award of the Australian Section of the Institute of Food Technologists. The award is for meritorious contributions to the advancement of food technology in Australia.

Dr. J. R. Vickery, Chief of the Division.

Dr. Vickery was also chosen by the Food Group of the Society of Chemical Industry, London, to deliver the first International Lecture to this Group on September 21. Dr. Vickery left Australia on August 16 to attend the Second International Congress of Food Science and Technology, which was held from August 22 to August 27 in Warsaw.

GUEST WORKERS

Dr. Mary Clegg, a lecturer in food science from the University of Strathclyde, Glasgow, has exchanged positions with Mr. K. A. Harper, of the Food Technology Section at North Ryde, for a period of one year. Dr. Clegg, who arrived in Sydney on September 23, 1966, is undertaking research on chemical problems in the processing of foods.

Mr. B. B. Mohamed, of the Sudanese Department of Agriculture, Khartoum, took up duty in the Division on October 4, 1966, for a period of 6 months. Mr. Mohamed, who is a graduate of the Universities of Khartoum and Strathclyde, holds a United Nations Fellowship. He is seeking experience in food technology, especially techniques for drying foods.

OVERSEAS VISITS BY STAFF

It is highly desirable that from time to time research workers should have the opportunity of attending international conferences and meeting or even working for short periods with overseas scientists engaged in their special field of research. Several members of the staff of the Division have been overseas recently.

Mr. J. J. Macfarlane left Sydney at the beginning of June to attend an International Symposium on Food Irradiation at Karlsruhe, Germany. During an eight-week visit to continental Europe, Britain, Canada, and the United States, he visited many centres carrying out investigations on the irradiation of foods.

Dr. F. Grau, the Senior Bacteriologist at the Division's Meat Research Laboratory at Cannon Hill, left Sydney in mid June on a 3 months' overseas trip to visit meat laboratories in Europe, Britain, the U.S.A., and New Zealand. He attended the Summer Conference of the Society of Applied Bacteriology at Durham (England), a Botulinum Symposium and the International Microbiological Congress in Moscow, and the twelfth meeting of European Meat Research Workers at Sandifjord (Norway).

Under the auspices of the U.S.D.A. PL480 grant, Dr. A. R. Johnson, leader of the Animal Products Section, visited laboratories and research institutes overseas. He also attended the Seventh International Congress of Nutrition in Germany, the Thirteenth World Poultry Congress in Moscow, the Second International Congress of Food Science and Technology in Warsaw, and an International Symposium on Gas Chromatography and a Symposium on Gel Filtration, both of which were held in Italy. Finally he attended a Symposium on 'Recent Advances in Tracer Methodology' in U.S.A., and read a paper to a meeting of the American Oil Chemists Society which was held in Philadelphia, Mass., from October 3 to October 7.

Other members of the Division's staff who attended the Second International Congress of Food Science and Technology (these being overseas either on recreation or study leave at the time) were Dr. O. Myklestad, Mrs. W. Szulmayer, Mr. J. D. Mellor, and Mr. K. A. Harper.

Mr. J. D. Mellor delivered two papers at the Second International Congress of Food Science in Warsaw in August, and visited firms and research establishments in Britain, U.S.A., Germany, Italy, and France before returning to Australia in September. Mr. Mellor had been invited to France as a guest speaker for the Fifth International Freeze Drying Course, a 10-day course held in Lyon and Dijon in mid July and sponsored jointly by the International Institute of Refrigeration and the International Association of Biological Societies.

Mr. K. A. Harper left Sydney towards the end of June to spend about a year on research at the Department of Food Science, University of Strathclyde, Glasgow. He visited laboratories in Budapest and Prague to observe research on anthocyanins, and attended the Second International Congress of Food Science in Warsaw.

Recent Publications of the Division

Copies of these papers are available from the Librarian, Division of Food Preservation, Box 43, P.O., Ryde, N.S.W. (Telephone 88 0233.)

ANDERSON, LOUISE A., and SMILLIE, R. M. (1966).—Binding of chloramphenicol by ribosomes from chloroplasts. *Biochem. biophys. Res. Commun.* **23**, 535–9.

CASSENS, R. G., and NEWBOLD, R. P. (1966).—Effects of temperature on post-mortem metabolism in beef muscle. *J. Sci. Fd Agric.* **17**, 254–6.

CHANDLER, B. V., KEFFORD, J. F., and LENZ, F. (1966).—Absence of bitterness in Navel oranges from rooted cuttings. *Nature, Lond.* **210**, 868–9.

CHANDLER, B. V., and KEFFORD, J. F. (1966).—Chemical assay of limonin, the bitter principle of oranges. *J. Sci. Fd Agric.* **17**, 193–7.

DAVENPORT, J. B. (1966).—Structure of complex phospholipids. *Nature, Lond.* **210**, 198.

GIOVANELLI, J. (1966).—Oxalyl-coenzyme A synthetase from pea seeds. *Biochim. biophys. Acta* **118**, 124–43.

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HALL, E. G. (1966).—Precooling of fruits and vegetables: a review. *Fd Technol. Aust.* **18**, 322–3, 325, 327, 328, 331, 442–3, 445, 447, 449, 451.

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KAESS, G. (1966).—Bildung von Eiskristallen in Muskelgewebe. *Kältetechnik* **18**, 111–13.

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MONTGOMERY, W. A. (1966).—Processing and canning abalone. *Aust. Fish. Newsl.* **25**(6), 23–5.

SCOTT, K. J., and ROBERTS, E. A. (1966).—Polyethylene bags to delay ripening of bananas during transport and storage. *Aust. J. exp. Agric. Anim. Husb.* **6**, 197–9.

WHITFIELD, F. B., and SHIPTON, J. (1966).—A procedure for concentration of flavour volatiles from frozen peas. *Chemy Ind.* **1966**, 1038.

WHITFIELD, F. B., and SHIPTON, J. (1966).—Volatile carbonyls in stored unblanched frozen peas. *J. Fd Sci.* **31**, 328–31.