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Mould Wastage in Stored Fruit

By

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Wastage of fruit by moulds is a very common experience and we have all observed the typical lesions which occur in various fruits under household conditions.

In commercial storage also the aggregate losses due to the ravages of moulds are very large and, as a general rule, attack by moulds sets the limit to the permissible storage period.

It is worthwhile, therefore, to consider some of the general principles which are involved.

Relation Between Mould and Host

Firstly it should be recognized that the growth of mould on fruit is an example of an interaction between two living organisms. The pathogen or mould grows at the expense of the living tissues of the host. The mould is able to do this by virtue of its pathogenicity or invasiveness which enable it to attack the host. The host tissue in turn manifests a measure of resistance to the fungus. The attributes of pathogenicity on the one hand and resistance on the other both have a measure of specificity. For example *Penicillium expansum* commonly causes rots in apples but not in oranges. A closely related mould *Penicillium digitatum* causes rots in oranges but not in apples. We can say that *P. expansum* is pathogenic for apples but not for oranges. We can say with equal justification that apples are susceptible to attack by *P. expansum* but that oranges are resistant to this fungus. Very often we are unable to say whether the pathogenicity or the resistance is the important factor. The occurrence of a lesion, however, is evidence of the fact that, under the conditions prevailing, pathogenicity has been sufficient to overcome resistance.

Both the pathogen and the host have certain requirements in common. They are both organisms needing oxygen for respiration and producing carbon dioxide. Storage in atmospheres of reduced oxygen content or with an increased level of carbon dioxide cannot, therefore, be used to inhibit growth of the mould without risk of injury to the fruit. Some fruits are, in fact, sensitive to carbon dioxide and adequate ventilation of the storage space is necessary to prevent breakdown of the tissues. The activity of both the host and the pathogen are also markedly influenced by temperature, but often the host tissue is damaged when cooled to temperatures which still permit mould growth. Some apple varieties can be stored successfully at 32° F., others not below 36° F. Minimum temperatures which avoid cold injury are several degrees higher for citrus and stone fruits and as high as 53° and 58° F. for bananas, the actual temperature being dependent on the variety. Tropical fruits

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are generally very sensitive to injury by cold. It is clear, therefore, that each fruit imposes a lower temperature limit to the conditions of storage and so prevents the use of storage temperatures which would arrest mould growth entirely.

How Lesions Develop

Before a rot or lesion develops the fungus has three tasks to perform. Firstly it has to come in contact with a susceptible fruit. Secondly it has to gain entry into the tissues of the fruit, and thirdly it must grow and advance through the tissues. If the fungus fails at any one of these three stages no visible lesion results.

In considering the original infection of the fruit it is important to know when this occurs. In some disorders it has been established that fruit becomes infected on the tree from spores carried in the air or in raindrops. In others infection occurs after harvesting, by contact with infected surfaces or from neighbouring fruits on which lesions have developed. Some fungi produce more than one type of spore, and only one of these may have the capacity to initiate infections. In all cases the extent of infection is likely to affect the incidence of lesions. A heavy infection may lead to a large number of lesions on each fruit, or it may simply increase the probability that one of the spores alighting on the fruit will be successful in causing a lesion.

Actual penetration of the fungus into the tissues may be achieved in three ways. Firstly there may be a direct penetration through the cuticle of the fruit. Proof of this has been clearly established by experiments on banana anthracnose which were carried out in Queensland by J. H. Simmonds. The fungus spore forms a body in very close contact with the surface of the fruit, which is then penetrated by a very fine tube or infection thread. Growth may then proceed throughout the deeper tissues. Only a few organisms are believed to possess this ability to penetrate the intact surface. A second method of penetration is through natural openings in the skin. Some of the rots in apples always have one of these openings or lenticels as the centre of the lesion, thus indicating that the fungus enters at this point. Thirdly it is well established that many fungi can only gain entry when the fruit surface has been damaged, as may occur by mechanical injury. Gross injuries undoubtedly predispose to attack by moulds, but much more work is needed before one can assess the importance of minor injuries. A great deal obviously depends on the size of the damaged site and on any changes which may occur in it prior to the arrival of a fungus spore. Whatever the method used for gaining entry into the host, the fungus requires time to do it, and certain combinations of temperature and availability of water may be vital for successful penetration. The deposition of dew or periods of rainy weather may, for example, have a large effect on the chances of infections becoming established.

After penetration has been completed there is still no visible lesion and further growth is necessary before the rot is apparent. In this connection it may be noted that the food requirements of the moulds are generally fairly simple and would be satisfied by all kinds of fruits. If, therefore, the fruits were simply inert reservoirs of nutrients the moulds would grow without hindrance immediately after penetration. This, however, is not always the case. In some disorders growth subsequent to penetration may be long delayed. Fruits so infected but not showing lesions are commonly described as carrying latent or hidden infections.

Latent infections are fairly common and their importance has been demonstrated by Wardlaw and his colleagues working in Trinidad, and in this country by Adam in South Australia, by Kiely in N.S.W., and by Simmonds in Queensland. Infections may remain dormant for only a few days or the period may extend over several months. It is presumed that the advance of the fungus is dependent on certain changes in the host tissue which render it susceptible as the fruit advances in maturity. The nature of the changes which are important to the fungus have, however, not yet been established. They could be due to an increase in the availability of nutrients, or to a decrease in the concentration of fungal inhibitors in the fruit tissue. An additional possibility is that the fungus tissue itself undergoes changes which result in enhanced invasiveness after a period of dormancy.

The actual advance of the fungus is conditioned by characteristics of the pathogen, by the nature of the host tissue and by the environment. Some moulds have an inherent capacity to grow rapidly under favourable conditions. Species of *Rhizopus* and *Sclerotinia* which cause rots in stone fruits may be cited as examples of fungi which grow rapidly. On the other hand a fungus such as *Gloeosporium album* which causes " target spot " in apples is a slow-growing organism. The ability of a fungus to secrete toxins which destroy the host cells may also affect its rate of advance. There is abundant evidence that the state of the host tissue is important. Experimental inoculation of immature fruits may not result in the development of lesions, but similar inoculations on more mature fruit are followed by rotting. In some cases it has been shown that the rate of fungal advance increases with increasing maturity. There are also marked differences in the rates at which a fungus can grow in different varieties of the same fruit. Experimental work in England has also shown that certain manurial treatments have a bearing on the rate of fungal advance in apples. Of the environmental factors temperature is by far the most important. Apart from the obvious benefit of reducing the rate at which the fungus grows, the use of low temperature delays the maturation of the fruit and, in the absence of cold injury, prolongs the period during which the fruit will manifest a useful resistance to attack. It is probable that the effect of low temperatures in delaying the maturation of the fruit is often of paramount importance.

There may be advantages of another kind from storage at low temperatures. For example in dry rot of potatoes the lesions remain small at low temperatures as the defence mechanism of the host seals off the fungus and prevents its advance into healthy tissue. At high temperatures the rate of growth of the fungus enables it to overcome the defence reaction of the potato, and to invade the whole tuber.

Control Measures

Some of the methods used for controlling mould wastage may now be considered. Firstly we have the general method of preventing infection or reducing its incidence. Depending on the manner in which the fruits become infected, this may involve revised horticultural practice, orchard sanitation or precautions against infection during and after picking. Penetration into the host may be reduced by anti-fungal sprays before harvesting, by avoidance of injury, or the application of anti-fungal treatments after picking. Anti-fungal chemicals should have a greater toxicity to the fungus than they have to the fruit, and

this requirement reduces the number of available substances to a very low number. They should be capable of application in a form which will ensure intimate contact with the fungus and some degree of permanence is desirable for continuing protection. The substances must not be toxic to man in concentrations that may persist on the edible portion of the fruit. Some of the substances which have been useful in controlling some rots have been diphenyl, o-phenyl-phenol and iodine. These all have an appreciable vapour pressure at ordinary temperatures, and this is doubtless important for securing contact between the fungus and the chemical when the latter is incorporated in wrapping papers. Boric acid and borates have also been used widely for controlling green mould in citrus fruits. The fruits are treated by washing in a bath of the solution. In general it may be said that suitable anti-fungal compounds may be very valuable when they are applied before the fungus has penetrated into the fruit. They then have an opportunity of contact with the fungus, and of preventing germination of the spores or of killing the spores during their germination. Application of anti-fungal treatments after the fungus is established in the host is usually without any beneficial effect. In some instances it has been found harmful. For example in Trinidad citrus fruits carrying certain latent infections have had wastage by these fungi substantially increased by application of iodized wraps and also by boric acid dips. The presumption is that the fungi were protected from the chemicals as they were already established in the skin of the fruit. The treatments, however, caused some damage to the fruit tissues and enhanced wastage resulted. In this country similar boric acid dips have given useful control of green mould in citrus, and iodized wraps have been valuable for controlling the same disorder in oranges from Israel.

The most important generally applicable means of controlling mould wastage is by reducing the temperature of storage to the minimum permissible for the type and variety of fruit. This reduces the activity of the fungus to the lowest level possible, and, at the same time, retards the changes in the fruit which tend to diminish its resistance to attack. Control of relative humidity in the store is without much effect on the moulds as the effective humidity for the fungus is determined mainly by the composition of the tissues in which the fungus is located. Gas storage in mixtures of air and carbon dioxide can be useful when the mixture is tolerated by the fruit. As with low temperatures the carbon dioxide will tend to reduce the respiration of both the fruit and the mould and benefits will ensue for both reasons.

Finally the method of enhancing the resistance of the host tissues may be mentioned. A matter of considerable practical importance is harvesting the fruit at the correct maturity. Over-ripe fruit is very susceptible to mould attack, and picking at the correct maturity makes an important contribution to a reduction in mould wastage. With our present knowledge there is little that can be done to exalt the resistance of the host above its normal value. It is not impossible, however, that horticultural methods could be altered to bring about such a change. The ideal solution would be the use of varieties which are resistant or immune to mould attack. Progress in this direction may be slow, but it will come when we have acquired greater knowledge of the mechanical, morphological and chemical factors which lead to enhanced resistance.

It is obvious that a great many factors are operative in determining the probability that a certain fruit will be attacked by moulds within a

specified time. In many instances we find evidence of a system in a rather delicate state of balance. A small change in one factor may favour the mould, another change may favour the host. The scientific and commercial problem is to discover new and more effective ways of tipping the balance in favour of the fruit.

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The Fruit Juice Industry in Europe

At a meeting of the Council of the Federation Internationale des Producteurs de Jus de Fruits, held in Stuttgart on June 21st, 1952, some interesting observations were made on the fruit-juice industry in Europe.

Straight apple juice appears to be declining in popularity, while orange, pineapple, tomato, apricot and berry juices are finding increased acceptance.

In several countries attempts have been made to develop new beverages based on apple juice. France prefers a " soft " cider ; in Switzerland carbonated apple juice blends, made up from concentrates and flavoured with orange, grapefruit, lemon, and raspberry, are being made in thirty factories and marketed under the common brand " SU-SY ", and in Germany, the strong competition from widely-advertised aerated drinks has been met by developing " Appel-Kola ".

The Influence of Rootstocks on the Quality of Canned Orange Juice*

By

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I. INTRODUCTION

Quality improvement in canned orange juice has been the subject of investigations in this Division for a number of years. One outstanding quality defect is a bitterness which appears in some canned juices immediately after processing. This bitterness is due to the presence of various members of the limonin group of bitter principles which are not yet completely characterized chemically, but which are known to be different from, for instance, the bitter glucosides of grapefruit.

The bitter principles are located in the white tissues of the intact orange—in the albedo and segment walls (Camp *et al.* 1932 ; Samisch and Ganz 1950), but they pass into the juice during the operations of juice extraction. Even then the bitterness is not immediately apparent ; at room temperatures it requires four to eight hours to develop, but at the usual processing temperatures, around 200° F., it appears almost instantaneously.

Not all canned orange juices are bitter : a number of factors determine whether a particular sample of fruit will give a bitter juice.

(i) *Maturity.*—Disappearance of the bitter principles from oranges is one of the normal processes of ripening. Thus immature fruit always give bitter juices, but with advancing maturity the bitterness decreases and may eventually cease to be detectable.

(ii) *Variety.*—Some varieties of orange reach normal eating ripeness about nine months after blossoming. They are the early-maturity varieties such as Washington Navel and the Shamouti orange of Palestine. But in these early varieties the process of removal of bitter principles does not keep pace with the processes of sugar increase and acid decrease which lead to normal ripeness. The result is that Navel oranges yield bitter juices even when they are apparently mature. On the other hand, the late varieties of orange, such as the Valencia, are generally free from bitterness at normal eating ripeness.

The potentially bitter character of Navel oranges was recognized in the early years of the Californian citrus juice industry, and since that time it has been generally accepted that it is not possible to make satisfactory canned juice from Navel oranges (Marsh and Cameron 1950).

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(iii) *Rootstock.*—It is well known that the rootstock can affect the character and composition of oranges in a number of ways (Sinclair and Bartholomew 1944; Marloth 1950), but the specific effect of rootstock on bitterness in orange juices was discovered only recently.

II. Investigations on Navel Oranges

In 1950, Marsh and Cameron, of the University of California, published a brief account of observations over two seasons on the effect of rootstocks on the quality of Navel orange juices. Their observations are summarized in Table 1.

Table 1

Effect of Rootstock on Quality of Navel Orange Juice

Stock	Bitterness	General Quality
Grapefruit	Almost none at commercial maturity.	Good.
Trifoliata	Disappears within a few weeks of commercial maturity.	Excellent.
Sweet Orange		Good.
Sour Orange	Disappears only in late season.	Fair.
Navel Cutting		Fair.
Rough Lemon	Never disappears.	Poor.

The American work stimulated Australian interest in the rootstock question. Investigations were initiated in this Division in 1950 and continued through the 1951 and 1952 seasons. There was some difficulty in locating suitable test material where the effects of rootstocks were not complicated by other variables such as soil, climate and cultural practice. The aid of the New South Wales Department of Agriculture was enlisted and three orchards were found in the Richmond-Windsor district where there were uniform plots of Washington Navel oranges on a number of rootstocks.

(i) *Procedure.*—Fruit was taken from the orchards at intervals through the season and brought to Homebush for processing. There the halved fruit was hand-reamed on high-speed reamers; the juice was screened, filled into cans, sealed under steam-flow and heated for two minutes in a spin pasteurizer.

At the time of extraction the yield of juice on a weight basis was assessed. Subsequently the juice was analysed for acidity, soluble-solids content and ascorbic acid content, and examined for bitterness. Scores for bitterness were allotted by panels of at least 10 tasters who were selected for sensitivity and consistency. Finally the peel from the oranges was dried and its bitter principle content was determined by benzene extraction.

(ii) *Results.*—Nine rootstocks were represented, drawn from three plots (Hawkesbury Agricultural College, Cornwallis, and Wilberforce) during two seasons (1951 and 1952).

In comparative bitterness tests on juices from fruit picked on the same day, Trifoliata was least bitter, with Tangelo and Cleopatra Mandarin not very different; Parramatta, Sweet Orange and East Indian and Sweet Limes were intermediate in bitterness; and Rough Lemon and

Kusae Lime were most bitter. The bitterness scores varied between the seasons and between plots but the relative positions of the stocks remained very nearly the same.

The additional influence of maturity on bitterness was studied by taking successive picks of fruit through the season. In the present season the maturing of fruit on a number of stocks is being followed but for the 1951 season results are available only for Trifoliata and Rough Lemon, the two stocks of greatest commercial interest.

In the normal ripening processes leading to increasing soluble-solids content and decreasing acidity, the two rootstocks behaved similarly. But there were marked differences in the bitterness of the juices. Juice from Navels on Trifoliata was only slightly bitter at the earliest pick and this bitterness decreased to zero with advancing maturity. On the other hand, juice from Navels on Rough Lemon showed marked bitterness in the early picks and some bitterness persisted throughout the period during which the fruit remained on the tree.

With respect to these two rootstocks, the results are in complete agreement with the American findings (Table 1) that Navels on Trifoliata lost bitterness early in the season but Navels on Rough Lemon never lost it.

In these rootstock comparisons attention was concentrated on bitterness, partly because it was the primary problem, and partly because it showed fairly clear-cut effects. In the other aspects of juice quality examined the effects of rootstock were not so marked, but Navels on Trifoliata appeared to run consistently higher in juice yields, solids content and acidity. There were no obvious trends in ascorbic acid values. The bitter principle contents of the peels ran approximately parallel with the bitterness scores for the juices.

III. Investigations on Valencia Oranges

The effect of rootstocks on the quality of canned juice from Valencia oranges has also been investigated. The American workers did not report studies on Valencia juices but they mentioned in passing the superior quality of Valencia fruit grown on Trifoliata stock. This effect of Trifoliata on general fruit quality is well known in this country (Hall 1943; Kebby 1950*b*; Benton *et al.* 1950).

(i) *Procedure.*—The trials on Valencias were restricted to three stocks: Trifoliata, Sweet Orange and Rough Lemon. In the 1950 season fruit was drawn from Hawkesbury Agricultural College, Cornwallis and Dooralong and in 1951 from these plots again and also from Wilberforce and Leeton.

(ii) *Results.*—There were rather marked differences in the bitterness pattern in the different localities. But it was generally true that juice from Valencias on Rough Lemon was appreciably bitter up to an advanced stage of maturity, whereas juices from Trifoliata and Sweet Orange stocks were virtually free from bitterness at normal maturity.

The tasting panels were asked to record preference ratings for the Valencia juices as well as bitterness scores. In all cases Trifoliata was rated best and Rough Lemon worst, with Sweet Orange in between. This preference for Trifoliata was due not only to its lack of bitterness but also to a distinctive aromatic character which greatly increased its attractiveness.

IV. Discussion

The results indicate strongly that Trifoliata is an excellent stock for oranges for processing. Both Navels and Valencias on Trifoliata stock have given canned juices free from bitterness and outstanding in character. By contrast, Rough Lemon, the common stock in the New South Wales coastal area, had a most unfavourable influence on juice quality. Sweet Orange stock falls in an intermediate position in its influence on the general quality of the juice and on the rate of disappearance of bitterness.

At the present time a high proportion of the recent plantings of oranges in New South Wales are worked on Trifoliata stock (Kebby 1950*a*). In future seasons the fruit from these orchards should produce a marked improvement in the quality of processed orange products.

V. Acknowledgements

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New Canned Milk Holds Fresh Flavour*

A new process now makes it possible to can sterile milk without the pronounced cooked flavour that characterizes products preserved by present-day retort-processing. Several companies are already producing single-strength sterile milk, and many more large operators are conducting investigations on a pilot-plant scale. Results indicate that the next few years will see a great increase in the acceptability of canned milks, and a resultant increase in the market for full-strength and concentrated products.

A method of using high-speed continuous sterilization and canning, perfected by Dr. William McKinley Martin of the James Dole Engineering Company of Redwood City, California, has shown great promise in both pilot plants and in full-scale installations. The Martin Aseptic Fill Method is designed to sterilize, cool, and can milk in seconds, as contrasted with the conventional methods of canning milk which require half an hour for sterilizing and cooling the milk after it has been canned.

Since the milk is only exposed to high temperature for an extremely short period of time, the canned product retains a natural sweet flavour.

Fundamentals of Process

Essentially, what Dr. Martin has done is to apply the principles of high-temperature short-time pasteurization to the sterilization and canning of milk. However, since these products are to be kept without refrigeration for an indefinite period of time, a number of problems are encountered which are not involved in the pasteurization of milk for bottling.

Milk must be raised to a temperature of about 300 ° F., and even higher temperatures are needed for some other dairy products. However, with instantaneous heating and immediate cooling, there is little change in flavour.

While sterilization on a pilot-plant scale is not too difficult, and highly satisfactory products have been prepared in experimental operations, something more elaborate than the conventional heat exchanger is required to do the job properly.

One promising type of sterilizer is the "Votator" agitating heat exchanger. In the early work done by Dr. Martin at Dole's Dade City plant, it was found that this unit is capable of heating dairy products to high temperatures without caramelization of milk sugars or burn-on of the product.

Rapid heating of the product in a thin film is obtained in this type of equipment by using a mutator, similar to the scraper in an ice cream freezer, which spreads the product in a thin film over the heated cylinder wall of the unit.

Another satisfactory way to heat the product without excessive burn-on is by forcing it through small-capacity tubes at high velocities.

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Because of the difficulty in cleaning small tubes, solid-core heaters have come in for a great deal of consideration. Experimental work done by the United States Department of Agriculture with heaters of this type has provided valuable data on the performance and advantages of such units.

The product is forced through the heater at high speeds and pressures. Homogenizers, or other high-capacity positive-displacement pumps, are used for this purpose.

Cans and covers are washed and sterilized in special equipment designed by Dr. Martin. With special steam superheating equipment, temperatures approaching 600° F. are attained. Temperatures in the cover sterilizer may run as high as 635° F.

The most important step in the entire process is that of filling and sealing the sterile product in sterile cans. This is done in an atmosphere of superheated steam under positive pressure to eliminate the possibility of contamination by air-borne bacteria.

Automatic Supervision

High-speed, continuous processing leaves no room for mistakes, and the Martin process includes elaborate precautions to prevent temperature variations during any of the vital steps in sterilizing the product, cans, or covers. If, in spite of these precautions, variations do occur, additional safeguards are provided to divert either cans or product and, if necessary, to shut down the equipment until the condition is corrected.

A single electronic strip chart recorder integrates on one chart the records from the can sterilizer, the filler, the seamer, the cover sterilizer, and the super-heated steam supply. An auxiliary pen on the instrument is interlocked with the filler control to show the times of starting and stopping canning operations.

Any time the operation of the equipment is interrupted, a large light on the main control panel flashes on. This signal to the operators ensures that any unsafe operating conditions will be promptly corrected. Smaller lights on the panel aid in locating the source of trouble.

Heat Exchanger Control

The electronic instrument used to control the milk sterilizer also functions as a thermal-limit controller. The temperature-sensitive element of this instrument measures the final temperature of the sterilized milk, and a pneumatic control unit in the instrument operates a diaphragm motor valve to adjust the flow of steam to the heat exchanger. The control unit incorporates automatic reset, so that it automatically corrects for any change in the temperature of incoming milk or variation in steam quality.

Unless these changes are unusually large and sudden, the controller will keep the temperature of the milk leaving the heat exchanger within a fraction of a degree of the set point. However, if the temperature of the milk should drop below the minimum for complete sterilization, the instrument functions as a thermal-limit controller, operating a flow diversion valve to prevent unsterilized milk from reaching the filler.

A non-indicating controller also measures product temperature. If this temperature should drop to a point slightly above the predetermined minimum, a contact in this device closes and flashes a warning

light. If the deviation is not immediately corrected and the product temperature drops below the sterilization point, the controller stops the movement of cans through the filler.

Sterilizing and Filling Cans

Cans are washed and then sterilized by superheated steam as they pass through an insulated tunnel to the filler. The time of exposure to the superheated steam is controlled by the speed of the conveyor to provide a wide margin of safety over a minimum required for complete sterilization.

Covers are processed in a similar unit. The temperatures of both operations are recorded on the multipoint instrument, and minimum-temperature alarms are provided on both pieces of equipment.

Standard can-filling and sealing equipment has been specially adapted to prevent the possibility of contamination of the product at this important stage of operations. Both the filler and the sealer are enclosed, and an atmosphere of super-heated steam is maintained in the filler, the closing machine, and the interconnecting conveyor system. A slight pressure is maintained so that any leakage will be out rather than in. This is done to eliminate the chance that air-borne bacteria might contaminate the product.

Temperatures in the filler and sealer are recorded, and low-temperature alarms are provided for extra protection.

Continuous versus Batch Methods

Some of the advantages of the Martin process will be obvious to milk processors who are familiar with the comparative merits of thirty-minute-holding and high-temperature short-time pasteurization. However, some understanding of conventional sterilization methods used in the evaporated milk industry is needed for full appreciation of the benefits offered by the new technique.

At the present time, the basic piece of equipment used to process concentrated milk is a pressure retort equipped with a revolving reel which permits the cans to be agitated somewhat for more rapid heating. Since the consistency of the milk is fairly thick and its viscosity consequently high, heat penetrates the cans slowly despite this agitation.

In order to be sure that the milk has been sterilized through to the centre when batch methods are used, it is necessary to overheat the milk nearest the can wall. This results in the extreme cooked flavour that characterizes evaporated milk.

With batch methods, the larger the can the longer the processing time. While smaller sizes may be heated and cooled in about half an hour, the time required for large cans is considerably longer.

All of these disadvantages of the batch method are eliminated by the Martin process. Since the milk is sterilized in a thin film as it passes through a continuous heat exchanger, the development of a cooked flavour is minimized. It is practicable to fill cans of any size because the milk is completely sterilized before canning. The speed with which the milk can be heated or cooled is not a factor.

Time required for processing is reduced considerably. Although continuous versions of the agitating retort have been developed to do away with the disadvantages of batch operation, these still require the

same amount of time to heat and cool a can of milk through the required cycle.

Because of the excellent quality-control job that has been done by the evaporated milk industry, this product has for many years been accepted as a standard ingredient in infants' foods. It is to be expected that these same processors will continue to exercise the same care in the preparation of concentrated milks which are to be sterilized by the new continuous process.

So far as actual sterilization is concerned, the margin of safety provided by the new process is greater rather than less than that provided by batch methods. Remember, all of the milk is heated to the same temperature. There is no localized overheating. This makes it possible to process milk at a higher temperature and for a longer time than the minimum safe limit, so that the sterilization treatment can be several times as stringent as the minimum requirement without affecting quality.

As designed at present, the Martin process requires that the product be liquid or semi-liquid at sterilizing and filling temperatures. The list of products which could conceivably be handled in the equipment would therefore include most full-strength or concentrated milks, flavoured milks and other dairy drinks, cream, and some types of cheese.

Established Trends

On the basis of work that has already been done, it seems probable that milk will eventually be put on the market in several more convenient forms. These will serve to supplement rather than replace present fluid milk deliveries, and may do much to put our surplus milk production into use.

Whole milk, processed by aseptic-fill methods, can be stored for an indefinite period of time, and shipped for great distances without seriously affecting flavour or food value.

A tremendous sum of money is spent annually on soft drinks sold from automatic vending machines. Until now, milk had a difficult time competing for this business because of its perishable nature. Both "white" and flavoured milks, canned by the Martin process, can be dispensed by automatic machines. This will give consumers a better chance to utilize surpluses of fluid milk and non-fat milk solids.

Heat-processed concentrate, probably three-to-one or four-to-one, will have a slightly over-pasteurized flavour to the critical palate. There may be some objection on the part of consumers to its use as a fluid drink, but it is sure to find ready acceptance for cooking, in infants' foods, as coffee cream, and for flavoured drinks.

At the same time, the increased production of concentrates will provide a larger, more profitable market for milk producers. The use of concentrated milk instead of cream in coffee and on cereals will help to eliminate our current skim-milk surplus. The sale of skim-base flavoured drinks will help even more. And the other new products made possible by new processes may boost the sale of milk by making it available in a more convenient form for additional uses.

Answers to Inquiries

Canned Tongues

Question : What is the procedure for canning tongues ?

Answer : This depends on the tongues to be canned, ox tongues being treated differently from sheep or lamb tongues.

Processors of canned meats for export from Australia should study the specifications laid down by the Commonwealth Department of Commerce and Agriculture and by importing countries. The standards for the products to be marketed within Australia depend upon the requirements of the individual States of the Commonwealth.

(*a*) *Canning of Ox Tongues*

After removal from the heads, the tongues are cleaned by hosing with running water, and if necessary by brushing. Some trimming may be carried out at this stage as well. The treatment then proceeds as follows :

(i) *Scudding*, or removal of the skin, is usually done on the slaughter floor but could be carried out later, if necessary. This is done by hanging the tongues on hooks around the inside of barrels containing water at about 145° F. The tongues are immersed for about three minutes, then removed, the surface skin and membranes pulled off by the fingers, and finished by scraping with a metal scraper. While awaiting removal to the pickling room the tongues are held for 2-3 hours in iced water.

(ii) *Pickling*.—The pickling or curing process may be carried out by immersion of the tongues for 9–10 days in a 40° F. salt brine containing nitrate and nitrite. Another method is to first inject the pickling fluid and then immerse the tongues for about three days in brine containing nitrite.

The approximate composition of a pickle suitable for curing tongues in 9–10 days at 40° F. is as follows :

Brine—40° Salinometer (approx. 15 lb. salt to 10 gal. water).

Sodium or potassium nitrate—6 oz. in 10 gal. water.

Sodium nitrite—$\frac{1}{4}$ oz. in 10 gal. water.

In the early stages it is necessary to apply a weight such as a grating to keep the tongues under the surface of the brine.

In the second method of pickling the tongues are first injected through the arterial system, or at two or three other points, with a pickling fluid of the following composition :

Brine—55° Salinometer.

Sodium nitrite—1 oz. in 10 gal. water.

Sodium nitrate—4 oz. in 10 gal. water.

The pickle is injected at 40° F. at 50–60 lb. per sq. in. by means of a pressure pump. It should add about 10 per cent. to the weight of the tongue ; this should be checked by weighing since it is difficult to avoid

loss of some of the fluid during injection. After injection the tongues are transferred to a pickle of the following composition :

Brine—40° Salinometer.

Sodium nitrite—$\frac{1}{3}$ oz. in 10 gal. water.

The tongues are held in this solution for 3 days at about 40° F.

Where supplies are small and intermittent the general practice is to build up stocks in frozen storage. In this case the scudded tongues are transferred to the freezing rooms after immersion for about two hours in ice-cold water. Frozen tongues which are to be pickled by immersion may be partially thawed in running water ; but they require to be fully thawed if the pickle is to be injected.

(iii) *Pre-cooking.*—The tongues are removed from the pickle, drained, immersed in boiling water, and pre-cooked for about $2\frac{3}{4}$ hours. Tongues which have not been skinned are boiled for $3\frac{1}{4}$ hours.

(iv) *Trimming and Packing.*—The tongues are trimmed while hot and weighed into cans containing some agar. The agar used is sometimes in the dry strip form, but more frequently as a jelly of appropriate strength. Some processors press the tongues in a metal press, such as a tincture press, before placing them in the cans, to remove excess fat and water. The tongues are always pressed after canning, and the top surface of the pack is dried with a clean stockinette wiper.

(v) *Processing in the Can.*—Ox tongues are commonly packed in 6 lb. and 2 lb. cans. The 6 lb. cans are usually retorted at 220° F. for five hours after the temperature has been reached in the retort. This time at 220° F. is insufficient to meet the requirements of a National Canners' Association safe cook ; nevertheless it is commonly employed by canners who find that more severe heating unduly softens the texture of the tongues. The salt and curing ingredients exert a protective effect against the growth of surviving bacteria in the canned tongues. A full NCA process for cylindrical cans of 6 lb. size would be about 4 hours at 240° F. A 2 lb. can (508 × 212) would require about $2\frac{1}{2}$ hours at 240° F. 12 oz. flat cans of sliced tongue containing about $1\frac{1}{2}$ oz. of agar jelly should require 80–90 minutes at 240° F.

(*b*) *Canning of Sheep and Lamb Tongues*

After removal from the heads the sheep or lamb tongues are washed in water to remove food particles, blood, etc. Re-washing is done on the cannery floor.

(i) *Scudding* is not usually done with sheep or lamb tongues but it is recommended for tongues showing severe grass staining. The operation is carried out by immersing the tongues for about one minute in water at 140–145° F., and then scraping off the skin with a knife. The skinned tongues are cooled by immersion in fresh water.

(ii) *Pickling.*—The tongues are usually cured or pickled in a salt brine containing nitrite and nitrate (saltpetre)—although nitrate is not considered an essential curing ingredient. The curing process is completed in 2–3 days at 38–40° F. (See Table 1).

Ten gallons of pickle is sufficient for about 80 lb. of tongues. Provided that its temperature is not allowed to rise about 40° F. the pickle can be safely used once again, after restoring the salt and nitrite concentrations to their original levels.

(iii) *Pre-cooking.*—After pickling the tongues are drained, and pre-cooked in boiling water. Cooking times, which range from 20 minutes for small lamb tongues to 45 minutes for large sheep tongues, are calculated from when the water containing the tongues commences to boil.

(iv) *Trimming and Packing.*—After draining the tongues are trimmed free of excess fat, blood clots, fibrous tissue, glands, etc. Sheep and lamb tongues are usually packed in 12 oz. flat cylindrical cans. A small amount of agar jelly is added. A 12 oz. can may contain 10½ oz. of tongue meat and 1½ oz. of agar jelly (made by boiling 1 lb. agar in 4–7 gal. water).

TABLE 1

Pickling of Sheep or Lamb Tongues

Pickling Time (Days)	Composition of Pickling Fluid		
	Salt Concentration (° Salinometer)	Sodium Nitrite (oz. per 20 gal. water)	Sodium Nitrate (oz. per 20 gal. water)
2	48	1⅓	2
3	42	1⅓	3

Sometimes it is necessary to make up the weight of tongue meat with a half tongue, obtained from a whole tongue by cutting lengthwise from tip to root. The average number of tongues required to make up the 10½ oz. of meat in a can will be between three and four, depending on the age of the animals, the season, and especially on the amount of trimming and shrinkage during pre-cooking.

(v) *Processing in the Can.*—Cans may be vacuum closed or heat exhausted before retorting. During heat exhaust care should be taken to avoid condensation on the tongues from the steam exhaust box, for example, by clinch covering the cans before exhaust.

12 oz. cans (401 × 116) containing 10½ oz. tongue-meat and 1½ oz. agar jelly should be retorted for 85–90 minutes at 240° F., depending upon the temperature of the can contents at the time of retorting.

(vi) *Yield.*—The yields of canned product, including agar jelly (approximately one-eighth of the can contents by weight) range between 58 and 70 per cent. of the raw fresh weight, and are mainly influenced by the degree of trimming and the intensity of pre-cooking before canning.

News from the Division of Food Preservation

Citrus Wastage Research Laboratory

The Citrus Wastage Research Laboratory, which is at Gosford, about 50 miles north of Sydney, was set up by the C.S.I.R.O. Division of Food Preservation and the New South Wales Department of Agriculture. It was officially opened on October 25, 1948.

The Central Coast Area of New South Wales, in which the laboratory is situated, grows about 1¼ out of the 6 million or so bushels of citrus fruits which Australia produces annually. However, experience in the trade has been that the keeping quality of a high percentage of New South Wales coastal oranges is inferior to that of oranges grown in other districts of the State (Murrumbidgee Irrigation Area, Narromine district, Murray Valley). It has also been claimed that the keeping quality of coastal oranges was higher prior to 1939 than in later years.

With these considerations in mind, the C.S.I.R.O. Division of Food Preservation and the N.S.W. Department of Agriculture agreed to establish a laboratory to investigate the problems of keeping quality of citrus fruits, with special reference to those from the Coastal Area. The Sungold Co-operative Limited (a Gosford growers' co-operative society) agreed to lease portion of their citrus packing house for the purpose.

Equipment at the Laboratory includes a complete pilot-scale citrus washing and dipping plant, capable of treating 30 bushels per hr., together with other necessary facilities. The Laboratory functions under the aegis of the Advisory Committee on Fruit Cool Storage Investigations in New South Wales, which has the advice of its sub-committee, the Citrus Wastage Research Committee. Both committees have on them representatives of the N.S.W. Department of Agriculture and the C.S.I.R.O. Division of Food Preservation.

Investigations

The investigations being carried out at the Laboratory are primarily concerned with the effective control of wastage due to *Penicillium digitatum* (Green Mould). It has been shown that green mould wastage can be greatly reduced by the use of a process consisting essentially of a borax dip. (An account of this work was given in an article by E. G. Hall and J. K. Long in the Food Preservation Quarterly, 1950, Vol. 10, pp. 48–54).

Another type of wastage under investigation is stem-end rot caused by *Phomopsis citri*. Under certain conditions, stem-end rot can be serious in oranges, but the great interest in this rot is due to its occurrence in lemons which are stored over the winter period The use of a post-harvest dip consisting of the plant hormone 2,4-D (2 : 4 dichlorphenoxy-acetic acid) has given outstanding results.

The nature and aims of the investigations in progress at the Laboratory may be summarized as follows:

(i) *General Handling and Processing.*—(*a*) To test, on a pilot scale, promising handling and processing treatments for use by both centralized packing houses and growers. (*b*) To guide recommended methods through to successful commercial operation.

(ii) *Lemon Storage.*—To investigate methods of reducing wastage in lemons and of extending their storage life.

(iii) *Fungicides.*—To investigate the efficiency and adaptability of fungicides and fungistats against green and blue mould, stem-end and other post-harvest rots of citrus fruits.

(iv) *Spore Load Investigations.*—To investigate the relationship between surface contamination of citrus fruits with spores of *Penicillium digitatum* and subsequent wastage.

(v) *Detergents, Waxes and Wraps.*—To investigate the use of detergents, waxes and wraps on citrus fruits.

(vi) *Characteristics of a Good Keeping Orange.*—To determine whether keeping quality, with special reference to resistance to green mould, can be correlated with physical or physiological characteristics of orange rind.

(vii) *Handling and Transport.*—To investigate methods of packaging and transporting citrus fruits.

Personal Pars

Several officers of the Division of Food Preservation and Transport are members of Commissions of the International Institute of Refrigeration.

Dr. J. R. Vickery, Chief of the Division, has been re-appointed a member of Commission VIII (Refrigerated transport by water).

Mr. E. W. Hicks has been re-appointed a member of Commission II (Transfer of heat. Thermal properties of materials. Instrumentation. Insulating materials), and of Commission VII (Refrigerated transport by land and by air).

Mr. W. A. Empey has been appointed consultant member of Commission IV (Applications of refrigeration to foodstuffs and agricultural produce).

Recent Publications by the Staff

(1) A New Paper Chromatography Solvent for Amino Acids. By F. Bryant and B. T. Overell (1951).—*Nature* 168: 167.

Mesityl oxide with formic acid and water as a solvent for the paper partition chromatography of organic acids gives a wide distribution of R_F values. Heating of the ninhydrin-sprayed sheets brings up discrete spots in characteristic colours which should lend themselves well to quantitative studies.

(2) Studies in the Metabolism of Plant Cells. 9. The Effects of 2,4-Dinitrophenol on Salt Accumulation and Salt Respiration. By R. N. Robertson, Marjorie J. Wilkins and D. C. Weeks (1951).—*Aust. J. Sci. Res.* B 4: 248–264.

2,4-Dinitrophenol, while increasing the respiration, inhibits the accumulation of ions by carrot cells. Further investigation is necessary

to determine whether the inhibition is due to a direct effect of the dinitrophenol on the mechanism or whether the dinitrophenol indirectly prevents the mechanism from operating by causing some disorganization within the cell, possibly in the mitochondria. If the assumption that dinitrophenol inhibits phosphate transfers is justifiable, hypotheses of salt accumulation might require modification to allow for the participation of energy-rich phosphate. This would suggest that the Lundegardh mechanism may be part of a more complex mechanism.

(3) The Chemistry of Bitterness in Orange Juice.

2. The Ketone Group in Limonin and the Product of its Reduction—Limonol. By B. V. Chandler and J. F. Kefford (1951).—*Aust. J. Sci.* 14 : 24.
3. Infra-red Spectra of Limonin and Some Derivatives. By J. F. Kefford, B. V. Chandler and J. B. Willis (1951).—*Aust. J. Sci.* 14 : 55–56.

(4) The Cooling of Fruit.

1. Fruits as Living Organisms. By R. N. Robertson (1952).
2. Fruit in the Cool Store. By E. G. Hall (1952).
3. The Control of Storage Conditions. By G. M. Rostos (1952).—*Refrig. J.* 5 : (9) 28, 30, 32 ; 32, 34–36, 38, 40 ; (10) 34, 36–38.

This symposium was presented at a meeting of the New South Wales Division of the Australian Institute of Refrigeration. Dr. Robertson described the respiration of fruit and the effects of low temperature upon it. Mr. Hall gave details of the effects on fruit of variations in temperatures, concentrations of gases in the atmosphere, and humidity. He discussed recent experimental work and future trends. Both these speakers stressed the variability of this living material which makes its storage so much more difficult. Mr. Rostos spoke on the need for setting reasonable aims for the control of conditions in stores for fruit. From information gained by a survey of fruit cool stores undertaken by the Division of Food Preservation in New South Wales, Victoria and Tasmania, he was able to show the effects of (i) temperature variations within a store, (ii) rapid initial cooling of fruit coming in, (iii) gas storage, and (iv) the relation of weight losses to relative humidity.