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The Cold Storage of Butter and Cheese

By

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During the spring and early summer months the production of butter and cheese and other dairy products is at a maximum, falling rapidly during the autumn to a comparatively low level in the winter. The storage of manufactured dairy products is therefore an important consideration in ensuring a steady supply to the market throughout the year, applying especially to the more perishable products like butter and bulk or unprocessed cheese. In addition Australia and New Zealand export large quantities of butter and cheese to Great Britain. The need for products which will maintain their quality during the period of storage which must elapse in the course of transport and distribution abroad has, especially in the case of butter, strongly influenced the manufacturing practices of these countries. The problems concerned in the storage of butter and cheese are quite distinct and therefore the two subjects are best considered separately.

The Storage of Butter.

Control of Defects due to Bacteria and other Micro-organisms.

Butter is essentially an emulsion of water in fat, the water being dispersed in the form of numerous fine droplets mostly about $\frac{1}{8000}$ inch or less in diameter but ranging up to $\frac{1}{100}$ inch or more. The droplets contain salt (in the case of salted butters), lactose, casein and other milk constituents and micro-organisms (bacteria, yeasts and moulds). In a properly made butter the water droplets are isolated from each other and consequently bacterial multiplication is restricted, occurring to any extent only in the larger droplets. Bacterial deterioration takes place therefore more slowly as a rule in butter than in milk, cream and other dairy products in which there is a continuous water phase. The usual presence of added salt also exerts an inhibiting effect. The physical restrictions to bacterial development do not apply to fungi and filamentous yeasts which under suitable conditions can force their way from droplet to droplet and develop extensively.

Preservation of butter from deterioration due to the growth of micro-organisms is a relatively simple matter as it involves merely the cooling of the product to 32° F. or lower and holding at that temperature. Under commercial cold storage conditions with temperatures well below freezing point defects of microbiological origin do not occur. Where the butter is to be used at once, however, maintenance in a frozen condition during its commercial life is not practicable, as the butter would be too hard for the operations involved in blending and packaging. Handling at temperatures below freezing point would also be too costly for retail distribution and would necessitate a thawing period before butter could be used in the home. In the course of ordinary distribution, therefore, butter is usually held in " cool " stores in which the temperature is from 35° F. to 45° F. Under these conditions some development of micro-organisms can be expected and their accompanying defects may become strikingly evident, especially if undue contamination has occurred during manufacture or if certain specific types of organisms are present.

Storage Defects due to Chemical Changes.

Development of off-flavours and impaired quality due to chemical reactions between the various constituents of butter can be expected to take place in cold storage at temperatures even below —20° F. A large volume of research work has been carried out in most of the larger dairying countries of the world during the past 20 or 30 years on this problem. The principal chemical change which takes place and the one that has received most study is oxidation of the butterfat giving rise at first to stale and oily flavours and progressively to flavours variously described as metallic, oxidised and tallowy. Oxidative changes are catalysed by acidity in the aqueous phase of the butter, traces of heavy metals, particularly copper, and by salt, light and heat. The necessity for a neutral reaction in the butter serum has in particular influenced Australian and New Zealand developments in manufacture. These countries make butter either from sweet cream or carefully neutralized sour cream, and their product is characterized by a mild flat flavour and excellent keeping quality in cold storage. Danish and Continental butter, which can be marketed without delay, is usually made from cream soured under controlled conditions by which means a stronger and more characteristic flavour is imparted. Such butter, however, deteriorates rapidly, due to oxidative changes, even at very low storage temperatures. In Australian factories sour cream is neutralized with sodium bicarbonate or sodium carbonate to an acidity of about 0·08% calculated as lactic acid. This gives a butter serum with a pH of 6·8 to 7·2, a value which has been found to be correlated with best keeping quality. The widespread introduction of stainless steel equipment in the past fifteen years and a more general appreciation of the harmful effect on quality of the slightest trace of copper contamination have also been important developments in the improvement of quality in our export butters. Marked depreciation in keeping quality can be expected if copper content exceeds 0·15 part per million or the iron content 1·5 p.p.m.

Fat-splitting enzymes derived from the original milk, or secreted by micro-organisms may hydrolyse the fat in storage, giving rise to rancidity. This defect is now uncommon as modern pasteurizing temperatures (in excess of 200° F.) completely inactivate lipase and other enzymes.

Conditions of Storage.

Experience has shown that loss of quality in storage is lessened with increasing coldness, but economic factors limit the lowering of storage temperatures. Australian and New Zealand export butters are held between 12° F. and 20° F. on board ship. This is also the usual range of temperature for commercial bulk butter storage in this country, but improved keeping quality could be achieved with lower temperatures.

The lessened rate of deterioration with our good keeping quality butter would not be sufficient to offset the increased cost here, but storage temperatures as low as —20° F. are commonly used in the U.S.A.

The marked tendency of butter and other fatty foodstuffs to absorb foreign odours requires cold rooms for butter storage to be clean and free from mustiness and similar taints. For the same reason butter cannot safely be stored with products like fish and most fruits. The odour of the wooden boxes in which butter is packed may affect its flavour and in the past considerable damage to the quality of Australian export butter has been traced to this cause. Wood taint is now controlled by proper selection of timber and the treatment of the interior of the box with a casein-formalin spray which sets rapidly to a hard impervious varnish-like finish.

Mould growth on butter is a defect which may assume serious proportions at times in butter which has been cold stored. Such growth does not of course take place in cold storage, but appears in the interval between the thawing of the butter and its disposal. The development of mould is favoured by the use of mould-infected boxes and wrapping parchment and the exposure of the butter to a warm moist atmosphere.

Other minor defects appearing in stored butter are "primrose", a deepening of the surface colour of the butter due to evaporation of moisture, and "toppiness", another surface defect characterized by a stale and tallowy flavour due to fat oxidation at the surface of the butter.

The Storage of Cheese.

The variety of cheese most commonly, and almost exclusively, made in Australia and New Zealand is Cheddar cheese. The popularity of this variety, particularly as an export cheese, is due to its firm dry body, its relatively mild flavour, its ability to keep well in storage for comparatively long periods and to withstand rough handling in transport. The following remarks apply particularly, therefore, to Cheddar cheese, though the principles governing the maturation and storage of other hard varieties like Gruyere, Edam, Gouda and Cheshire cheese are not dissimilar.

Hard type cheeses are without cheese character at the time of manufacture. Cheddar cheese must be held for at least a month before it could be said to be acceptable, though much depends on the character of the cheese itself. A high moisture cheese held at a high temperature might ripen more rapidly than this, but would almost certainly be lower in quality. Frequently the cheese may be held from 6 to 12 months with considerable benefit to flavour and quality. The storage of cheese therefore serves a dual function in that it not only serves to equalize supply with demand, but is also an essential feature in the production of a satisfactory marketable product.

Cheese Ripening.

Green or freshly made cheese has a rubbery texture and is devoid of flavour. During maturation or ripening the physical nature of the cheese alters, resulting in the softer soluble condition characteristic of mature cheese, and with this change is the parallel development of the typical cheese flavour. The progressive alteration in physical characteristics is accompanied by an increase of soluble nitrogenous compounds chiefly amino acids, amides, caseoses, peptones and ammonia. These compounds result from the enzymic degradation of casein by natural milk enzymes and the proteolytic enzymes of the rennet added during manufacture. Although the texture of ripened cheese is brought about by the activity of these proteolytic enzymes, the characteristic flavour of Cheddar cheese is produced by the growth of lactobacilli which are naturally present in the original milk and which develop and attain very large numbers in the maturing cheese.

Conditions of Storage.

It will be appreciated that the temperature of storage exerts a very large influence on the changes taking place in the maturing cheese. The usual temperature is about 50° F. Above this ripening takes place at a more rapid rate but is more likely to be accompanied by harsh or even defective flavours. As the temperature is lowered maturation takes place more slowly and the flavour produced is generally milder. Even at temperatures of 25° F. to 30° F. ripening still takes place, though at a very greatly reduced rate. Storage of cheese below this range of temperature with the idea of maintaining it in any desired state of maturity for long periods is likely to result in freezing the product. The slow freezing of cheese has very deleterious effects on its texture. It results in a shattering of the body and tends to give a soapy insipid flavour. Some American experiments have shown that cheese can be "fast-frozen" and defrosted in small lots without injury to quality.

Common Defects of Storage.

The nature of bulk cheese and the normal temperature of storage (50° F.) are such that considerable mould growth can be expected on the surface. This presents an unsightly appearance, increases the rate of moisture loss, and necessitates an increased rind loss when cutting. Mould growth can be controlled to some extent by wiping and cleaning the cheese at regular intervals during maturation, by covering the cheese with a layer of wax, or by controlling the humidity of the cheese maturing room. Optimum conditions for ripening cheese can only regularly be secured in a room with both temperature and humidity control. At low humidities mould growth is greatly decreased, but this condition results in greater weight loss due to drying out of the cheese. A relative humidity of 80% is usually regarded as optimum for control of mould growth with minimum moisture loss. Experiments with ozone and ultra-violet rays in cheese curing rooms for control of mould growth have met with only partial success. Sulphur dioxide is used in some curing rooms.

The waxing of bulk cheese is commonly practised to control mould growth and prevent moisture loss when maturing. It also results in a more attractive finish to the cheese. Waxed cheese owing to its higher moisture content matures more rapidly than unwaxed cheese, but tends to dry out and lose weight more rapidly when it is cut. The waxing of export cheese is prohibited, as it is not favoured on the English market.

Under conditions of neglect maturing cheese readily becomes infected with one or more species of mites belonging to the genus *Tyroglyphus*. These organisms are microscopic in size, white or colourless, and appear at first in the form of a dusty crumbly powder on the surface of the cheese.

Under favourable conditions they are capable of migrating through the cheese and converting it to a powdery mass of cheese mites and their eggs.

Cheese mites do not develop below 35° F. and only very slowly between 35° F. and 40° F. Adequate cooling will check infestation, though of course this is only applicable to mature cheese. Waxing definitely helps to control mite infestation, though control is not complete owing to the invariable presence of cracks and openings in the wax cover. Cheeses should be regularly inspected, wiped and turned during ripening and shelves should be scraped clean and if necessary scrubbed and treated with formalin. Recent New Zealand experiments have shown that treatment of cheese rooms with dichloroethyl ether is very efficient in controlling mites.

Food Technology Course

In 1947 the Sydney Technical College established a Diploma Course in Food Technology. The first three years of this course are common with the first three years of the course for the Diploma in Chemical Engineering. The fourth year of the course introduces the students to some biological subjects; and in the fifth year, which is to be presented for the first time in 1948, some specialized instruction in food technology is given.

The subjects offered in 1948 are the following:

Food Technology I: A treatment of the technology of the canning, the edible fats and oils, and the milk products industries; and of food packaging and the agricultural production of the raw materials for food manufacture.

Food Engineering I: Engineering in the food industries under the headings refrigeration, flow of fluids, heat transfer and design, operation and steam economy in food processing equipment.

Industrial Microbiology II: Advanced general microbiology in preparation for a specialized treatment of the bacteriology of foods in the succeeding year.

Temporary accommodation for teaching Food Technology subjects has been set aside at Sydney Technical College, and members of the Food Technology Association of N.S.W. have supported the course by providing on loan a comprehensive range of small-scale plant and equipment.

It is expected that the classes in 1948 will be composed largely of former graduates of Sydney Technical College, now employed in the food industry, who will be interested in the opportunity of undertaking a refresher course in Food Technology.

Gas-Proofing of Rooms used for Refrigerated Storage of Fruit

By

M. B. Smith.

Introduction.

In the gas-storage of fruit it is necessary to control the percentage of carbon dioxide, and sometimes the percentage of oxygen in the atmosphere of the store, by obtaining the correct balance between the production of carbon dioxide by respiration and the removal of carbon dioxide by ventilation or absorption.

Warm fruit put into a store will be absorbing oxygen and producing an equal volume of carbon dioxide at a high rate which will enable the desired carbon dioxide concentration to be reached fairly quickly. When the fruit has cooled to the storage temperature the rate of production of carbon dioxide, and absorption of oxygen, will be much lower but more uniform. In the absence of ventilation (by ventilation is meant both the known and desired ventilation obtained by the use of ventilation ports, and that due to leakage) the carbon dioxide percentage would continue to increase and the oxygen percentage to decrease, their sum remaining equal to 21%, the percentage of oxygen in the air.

The carbon dioxide concentration can be controlled by allowing some of the internal atmosphere to escape and be replaced by outside air. The sum of the percentages of carbon dioxide and oxygen will still remain equal to 21.

To control the oxygen independently, however, it is necessary to absorb some of the carbon dioxide during its initial production so that the carbon dioxide percentage remains stationary and the oxygen percentage drops gradually to the required figure. When this is reached all that is necessary is to adjust the ventilation to provide oxygen at the same rate as it is being consumed by the fruit and to absorb the equivalent amount of carbon dioxide being produced.

In both cases it is necessary to have control over the ventilation, and in order to achieve this some attempt must be made to limit the ventilation due to leakage to a rate below that required to maintain the conditions in the store.

The desired rate of ventilation depends on the storage conditions required and the loading of the room.

Mechanism of Leakage.

In attempting to calculate the rate of leakage of carbon dioxide from a given room Kidd and others (1927) found that the rate of diffusion through the materials used to gas-proof the room, as determined experimentally, was not high enough to account for the total loss of carbon dioxide. Accordingly they assumed that a large part of the leakage was due to a mass movement of air into and out of the room through fine cracks in the walls and defects in the gas seal. Such a mass movement would be caused by pressure differences set up between the inside and outside of the store, due to temperature fluctuations or the effect of wind blowing across the store.

Gane (1932) found that an air circulation in the store up to a rate of 24 changes per hour did not appreciably affect the leakage rate.

Treatment of Rooms.

(1) *General.*

All the methods so far used for gas-proofing rooms may be divided into two groups: the use of impervious metal sheets joined by welding, soldering, cements or pastes, and the use of paints and similar surface coatings.

Since it has been found that a large part of the leakage from a gas store is due to imperfections in the gas seal it is obvious that the quality of workmanship is of great importance, and that careful planning and attention to details are necessary to obtain a satisfactory barrier to the escape of gas.

It must clearly be realized that anything erected as a barrier to the escape of gas will act also as a barrier to the entry of water vapour. Obviously when considered from this aspect the best place to put the gas-proof barrier is outside the insulation, as this would then prevent water-vapour from affecting the insulation and would also eliminate troubles arising from the condensation of water on the gas-proof barrier itself. This idea presents great difficulties if it is to be used in gas-proofing existing stores but has been used successfully when constructing new stores.

The type of interior surface to be treated in existing cold stores will determine largely the method of treatment to be used. Tongued and grooved boards are very difficult to seal completely with a paint or paste, and the metal lining is the most practicable. Plaster or cement may more easily be sealed with a paint.

In treating existing stores the floor should not be neglected. Any sagging of the floor will tend to break the gas seal, so the floor should be reinforced if necessary. Attention should be paid to the amount of wear to which the floor will be subjected, and if necessary a cover of tongued and grooved boards or wooden slats should be used over the gas seal.

It is advisable to check the condition of the gas-proofing each year. Minute cracks may develop in a painted wall or joints may pull apart due to expansion and contraction in a metal lining. Preferably a trial should be made to determine the leakage rate before the store is used for the next season. Then if necessary further treatment may be given before loading begins. New buildings should be allowed to age for some time, particularly if a surface coating (painting, etc.) is to be used.

(2) *Treatment of Existing Stores.*

(*a*) *Sheet Metal Nailed or Screwed to Wooden Grounds on Walls and Ceiling.* Galvanized or tinned sheet steel of 26-30 S.W.G. has been generally used, although any light gauge sheet metal could be used provided precautions are taken to prevent corrosion of the metal due to condensation of water on the surface facing the insulation. The metal sheets are overlapped two or three inches and vaseline, putty or caulking compound is inserted before the sheets are nailed or screwed down. Large-headed galvanized roofing nails spaced two inches apart have been recommended by Smock and Van Doren (1941). Putty or caulking compounds are preferable to vaseline as they are not as likely to extrude from the joints under pressure, and allow the joints to be painted over when dry. Bitumen-impregnated roofing paper has been used as a backing for the metal (Hardy, 1935), the roofing paper being folded over at the joints and ironed hot on to a bitumen cement.

Stores have been constructed using aluminium foil on both sides of a heavy kraft paper, nailed down on putty (Smock and Van Doren, 1941). By installing several layers spaced ½ to 1 inch apart an efficient heat insulation may be obtained, as well as a gas-proof barrier. These stores have not proved entirely satisfactory after use for a year or two.

Sheet metal may be used on the floor, provided some covering is used to protect the metal from wear.

Sheet metal is generally used to seal doors either by covering the existing door with metal or more commonly by constructing a separate inner door which is not hinged but screwed or bolted to the frame. This may contain an inspection window. Rubber gaskets and vaseline have been used to obtain a tight fitting between door and frame.

(*b*) *Paints or Pastes on Plaster and Cement.* Smock and Van Doren (1941) have given instructions for treating plaster and cement with ordinary enamel paint. Later information indicates that this method often fails to give a surface with lasting gas-proof properties; however it may be usable provided the treatment is repeated each year.

A bitumen emulsion such as "Flintkote" (Shell Co. Aust. Ltd.) has been used (Muntz, 1947; McKenzie, 1941) satisfactorily over cement. A fairly thick layer is normally used which has the advantages that a smooth surface is not as essential as when using paint and the layer is more resistant to wear. This material may also be used on floors and diluted down and applied like a paint to ceilings.

Vaseline was used in some of the early gas storage rooms and gives a good seal but is difficult to use, wipes off easily, and needs a great deal of care to ensure that the layer remains unbroken. One method of use (Gane, 1927) is first to paint the walls with warm vaseline and then to apply ordinary wall paper which has been impregnated by drawing the sheet through a bath of hot vaseline.

3. *Construction of New Stores.*

Apart from the methods given above, which may be used for any new store constructed on conventional lines, there is one method which can only be easily used for a store being constructed—the use of an outside metal covering.

Two types of store using this method are:

(*a*) A patented American store described by Smock and Van Doren (1941) and by American Society of Refrigerating Engineers (1943) of 300 case capacity which used sheets of "galvanealed" metal held down by steel tensioners. The metal sheets have curved edges between which caulking compound is inserted before being screwed down. A disadvantage of this type is that minor defects in the seal lead to ingress of water causing corrosion and, ultimately, breakdown.

(*b*) A large store constructed in South Africa for the gas storage of fruit (Griffiths, 1936). A brief description follows.

The main shell of the store, 108 feet long, 62 feet broad and 24 feet high, is subdivided into four spaces by gas-tight diaphragms. Since the outside temperature varied by 100° F. and the metal shell was outside the insulated space, considerable attention had to be given to expansion. Provision for this was made by designing columns with deep flanges which would flex under the movement of the metal panels, and anchoring the corners of the store so that expansion could be taken up by each column concertina fashion. The roof and floor were similarly constructed to take up the expansion in girders and columns. A cellular concrete which was not liable to decompose or give off foreign odours was used inside the steel shell as insulation. All the seams in the steel shell were electrically welded and the store was completely gas-tight. Self-aligning gas-tight doors were used with a gasket of $\frac{3}{4}$-inch square rubber.

Appendix.

1. *Gas Efficiency.*

In early work carried out by Gane (1932, 1933) on the leakage of carbon dioxide from gas stores it was found that in an empty store the concentration of carbon dioxide was given very closely by the expression

$$P_t = P_0 k^t$$

where P_0=initial concentration of carbon dioxide.
P_t=concentration after "t" days.
k=" gas efficiency " or fraction of initial concentration remaining after one day.

This figure may be obtained by releasing carbon dioxide in the empty, sealed storage room to give a percentage near to that which will be used and making daily estimations of carbon dioxide. It will be a guide to the performance of the store in actual use and will indicate when the need arises to repair or renew the gas-proofing.

2. *Leakage Rates through Coating Materials.*

The following figures given by Gane (1933) show the rates of leakage of carbon dioxide under a pressure difference of 0·5 cm. of water through various substances used in gas proofing.

Material.	*Cub. Ft. CO_2/ 100 sq. ft./24 hrs.*
Bitumen preparations (3 coats)	0·1–0·7
White finishing paint (3 coats)	1·9
Varnish (3 coats)	0·1
Pigmented varnish (3 coats)	0·3
Resin in alcohol (3 coats)	0·3
Raw linseed oil (3 coats)	1·4
Vaseline $\frac{1}{32}$ inch thick	0·3
Water-proof paper and bitumen, 1-ply	0·2
Plywood, $\frac{3}{16}$ inch birch, 3-ply	2·3

Under these conditions bitumen preparations, resin preparations and vaseline have the lowest rates of leakage.

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Peanuts and Peanut Products

The Information Service of C.S.I.R. has prepared a list of 38 selected articles on the subject of peanuts and products from peanuts, which have been published since the beginning of 1940. Copies of this list may be obtained by applying to :

The Officer in Charge,
C.S.I.R. Information Service,
425 St. Kilda Road,
Melbourne, S.C.2,

and quoting No. B.282. Applicants should state clearly why they need the bibliography, as the number of copies is limited.

The Cool Storage of Pears*

By

E. G. Hall.

In the storage of pears a reasonable criterion of success is the degree of realization of the maximum possible storage life for the variety, account being taken of seasonal and locality variations in keeping quality. Storage life is defined as the maximum period for which the fruit can be kept and still ripened satisfactorily after removal to ripening temperatures. Successful storage of pears depends on picking at the correct time, placing in storage without delay, cooling down quickly, maintenance of a uniform temperature of 29-30° F. during the cool storage period, and removal of the fruit at or before the first sign of over-storage.

When to Pick.

For longest storage pears should be picked from the tree as soon as the fruit is fully developed and while it is still hard and green to dark green in colour. There is no single completely reliable criterion of maturity, but it has been found that the best practical guides to maturity are colour of the skin and firmness of the flesh and, for a particular district, calendar date, allowance being made for early and late seasons.

At the correct stage for picking the colour of the skin will have lightened from the deep green of immaturity to a uniform green colour (cosse green, plate 19L5-6 in Maerz and Paul's Dictionary of Colour: McGraw Hill Book Co., N.Y., U.S.A., 1930). At this stage the firmness of the flesh, as measured with a standard United States fruit pressure tester (Allen, 1929) fitted with a plunger $\frac{5}{16}$ inch in diameter, should be between 15 and 22 pounds. Average values for the main varieties are given in Table 1 below. If the skin is deep green in colour and the firmness of the flesh is greater than the maximum values shown in Table I, the pears are likely to be immature and not fit for picking. If the skin shows signs of yellowing to a yellow green colour (more coloured than Maerz and Paul plate 19L4) and the firmness of the flesh is less than the minimum values given in Table 1, it is likely to be over-mature and not suitable for long storage. In the case of russetted varieties the true colour of the skin can be ascertained after gently scraping off the surface layers.

Immature fruit may have a long storage life but is liable to shrivel excessively during storage and will not ripen with good development of juice and flavour. Pears picked after the optimum stage for storage will ripen to excellent quality but their storage life will be relatively short and there will be considerable risk of over-storage with subsequent development of scald and breakdown.

There are certain other indications of maturity which are valuable supplementary aids. At the optimum stage the fruit is easily removed from the tree, the stalk readily separating from the spur. If the fruit on

*This article was also published in the *Agricultural Gazette of N.S.W.* Vol. 59 No. 2, February, 1948, pp 77-81.

the tree has been sprayed with hormone preparations, such as "Clingspray", which are used to prevent pre-harvest drop, the fruit is often difficult to remove from the tree without breaking the stalk, so that ease of removal is of no value as a guide to the maturity of sprayed fruit. The fact that hormone sprayed pears do not drop should not be allowed to influence the time of picking. The use of hormone sprays does not delay maturation and there is some evidence brought forward by Allen and Davey (1946) that they tend to hasten ripening both before and after harvest. Therefore hormone sprayed pears should be picked at the same time as unsprayed fruit, or even a little earlier, and over a shorter period and stored without delay.

At the correct stage for picking the flesh, while still hard, will be showing some development of sugar and juiciness. When a fully developed pear is cut across there will be a slight exudation of juice on the cut surface; if the cut surface remains dry it is probable that the fruit is immature. Changes in the colour of the seeds are not a reliable guide to maturity.

In Victoria it has been found by Tindale and others (1938) that, in a particular district, the most generally reliable guide as to when to pick is calendar date. In investigations extending over several years it was found that the optimum time for picking did not vary from year to year by more than about a week. In New South Wales, however, there appears to be greater variability, perhaps because of greater differences in weather between seasons. Nevertheless, calendar date should be taken into account.

In conclusion it may be said that greatest reliance should be placed on colour and firmness, but the careful grower will consider all factors when deciding whether his fruit is ready to pick.

Quick Cooling.

With pears rapid cooling down to storage temperature as soon as possible after picking is essential to obtain maximum life. For example, it was found by Tindale and others (1938) that the life in air at 32° F. of Williams pears placed in storage 24 hours after picking was 13 weeks and that a further delay before storage of two days at 75° F. reduced the life to five weeks, and also that two days at 65° F. reduced the life to six weeks. The effect of delay is not so severe with later varieties but two days' delay at 65-75° F. would probably reduce the life at 32° F. by a month. Rapid cooling involves not only placing in storage without delay but also picking the fruit when it is coolest and making provision for quick removal of sensible heat after placing in the cool storage room. The aim should be to get the fruit into storage on the same day as it is picked or early the following morning and to bring the pulp temperature down to 45° F. within 24 hours after placing in the cool store.

Useful gains in keeping quality can be made by picking pears early in the morning before the sun has had time to heat the fruit after the cooling effect of the lower night temperatures. When early morning picking is impracticable it is often worth while to leave the boxes of fruit under the trees overnight and collect them early in the morning, thus using the lower night temperatures to remove some of the heat from the fruit and so reduce the load on the refrigeration equipment. It is also important to ensure that the fruit gains a minimum of heat between picking and placing in storage. The field cases should be placed in the shade of the tree as soon as filled by the picker and be kept in the shade or in a well-ventilated shed until delivery to the cool store.

It is an excellent practice to put pears destined for long storage straight into the cool store in the picking boxes, loose and unwrapped; this method is used by the most successful storers of pears and is well worthy of universal adoption. When the fruit has been cooled to storage temperature the cases can be taken out and the fruit graded and packed as quickly as possible and returned to the store without the temperature of the fruit rising enough to affect the storage life appreciably. In some stores the fruit is not graded and packed until it is removed for marketing at the end of the storage period. This is quite satisfactory if the fruit is still in good hard condition, but if it has started to soften, even slightly, handling is likely to cause some blemishing of the fruit. It has been shown by Smith (1946) that the development of skin blemishes on pears graded and packed when cold from the cool store was related to their maturity, and not to the fact that they were cold. It is of interest that the practice of the most successful Victorian growers who specialize in long storage of pears is to size grade, preferably by hand, before storage, and to pack at the end of the storage period, just before marketing.

The first special advantage of putting the fruit into store loose and unwrapped is that cooling is done more rapidly than when it is wrapped and packed. According to Rostos, with loose bare fruit in the standard Canadian bushel case with strawboard linings or in unlined or lined kerosene cases it is quite practicable, in an air circulation or a well designed natural circulation (coiled only) store to reduce the pulp temperature from 70° F. to 45° F. in 24 hours; wrapped and packed fruit, will take about two to three times as long to cool.

Secondly, delay between picking and cooling can be reduced to a minimum. Thirdly, the unavoidable shrinkage due to water loss which takes place in storage, and which is more rapid during cooling, mainly occurs before packing, so that tighter packs can be obtained at the end of storage. A fourth point which is often most important is that full attention can be paid to picking, time spent on packing before storage often means that, with the labour available, the whole of the crop cannot be picked at the correct time. It has often been the experience that packing before storage has so delayed harvesting of part of the crop that the fruit has been past optimum maturity for storage when picked and its keeping quality has been reduced.

Cool store design and management are important in regard to rapid cooling. For the rate of heat removal from warm fruit to be satisfactory there must be ample reserves of refrigerating capacity above that required to maintain steady conditions during storage. This not only means compressor capacity but also adequate cooling surfaces in the rooms or in the batteries.

If possible the rate of intake of warm fruit into the storage room should be no more per day than ten per cent. of its total capacity. It is a definite advantage to distribute each day's intake of fruit in several positions around the room, especially where air circulation is by natural convection only. More of the available refrigeration can then be turned on without danger of freezing in some parts of the room, and there are no big stacks of warm fruit which cool more slowly. Cooling can further usefully be speeded up by the use of auxiliary portable fans.

The usual practice in regard to stacking the cases in the cool storage room is to put them straight on the floor without floor dunnage and to maintain an air space of about one inch on all sides of each column of cases. Our present knowledge, which is rather limited, does not indicate any serious objection to this practice. In order to maintain the stability of the stack without losing the vertical air spaces a number of stores have found the use of vertical dunnage after every third column of cases to be a worthwhile precaution. Horizontal dunnage does not seem to be really necessary at any time, but floor dunnage may be useful when wrapped and packed fruit is being cooled. A space of at least four inches should be left between external walls, and also between any internal walls against a warm space, and the stack of fruit.

Because of likely differences in behaviour, each grower's fruit should be stacked separately, and it is good practice to have, as far as possible, only one variety in a room.

Storage Conditions.

(*a*) *Air Storage.*

In ordinary cool storage the air temperature should be maintained at 29-30° F. ; at higher temperatures storage life is decreased and at lower temperatures there is some risk of freezing. It has been found, particularly with the Williams variety, that the life at 32° F. is significantly shorter than the life at 30° F., and at 34° F. the life may be little more than half that at 30° F. In practice the operator of the store should aim at an air temperature as close to 29° F. as possible while avoiding freezing. This means that the less uniform the temperatures in different parts of the room the more the average temperature must exceed 29° F.

The relative humidity in the store should be high enough to avoid shrivelling during storage ; the optimum level is about 90 per cent. This can only be maintained in a well-insulated store with ample cooling surfaces. In an average store, when well filled, a satisfactory relative humidity of 85 per cent. can be maintained. It should be noted, too, that fruit stored unwrapped will shrivel more than wrapped and packed fruit, and immature fruit will shrivel more than fruit picked at the correct stage of maturity.

(*b*) *Gas Storage.*

Pears, particularly the Williams variety, respond well to gas storage. Storage in an atmosphere containing 5-7 per cent. of carbon dioxide and, correspondingly, 16 to 14 per cent. of oxygen, will considerably increase the life of the fruit. It has been found that the life of Williams pears gas stored at 32° F. can be as much as twice that of similar fruit stored in air at the same temperature. In experimental storage carried out by this Division the life at 32° F. of Packhams has been increased from 4-5 months to as much as 6½-7 months by gas storage, and considerable increases have been observed with other varieties, with the exception of Josephine, which has not responded well to gas storage. A further advantage is that fruit from gas storage ripens more slowly after removal than does fruit from air storage. Gas storage atmospheres containing more than 7 per cent. of carbon dioxide are not recommended because of risk of injury to the fruit. Gas storage as above at a temperature of 31-32° F. is recommended for longest storage, of Williams, Bosc and Packhams particularly. The effects of gas storage at 29-30° F. are not known.

Successful gas storage requires a specially constructed gas-tight room from which the leakage is sufficiently low to enable the required atmospheres to be obtained. It is not practicable to construct completely gas-tight rooms, but the "gas efficiency" of the store should not be less than 0·90. This means that no more than 10 per cent. of an initial content of carbon dioxide, introduced into the empty room, should leak out in a 24-hour period. A continuous metal lining provides the best gas seal, but a room can be satisfactorily gas-proofed by thorough application of a bitumen emulsion such as Flintkote or of crude petroleum jelly. Synthetic enamels such as Dulux machinery finish and also shellac, are useful gas-proofing materials.

Picking at the correct maturity and rapid cooling, as discussed previously, are just as important for gas storage as for air storage. As soon as filled, the gas store should be closed, care being taken that the door is well sealed, and the carbon dioxide concentration allowed to build up to the desired level by accumulation in the store of the gas given off by the fruit. This level is maintained during storage by controlled ventilation as required.

Overstorage.

Pears which have been kept too long in storage fail to ripen normally after removal to ripening temperatures. When overstored, pears commence to turn yellow and may develop scald while still at low temperature. Overstored fruit, when removed, will colour but will not soften or develop juice or flavour; scald and core breakdown develop and the flavour becomes fermented. Typical specimens of scald and core breakdown are illustrated in Figures 1 and 2.

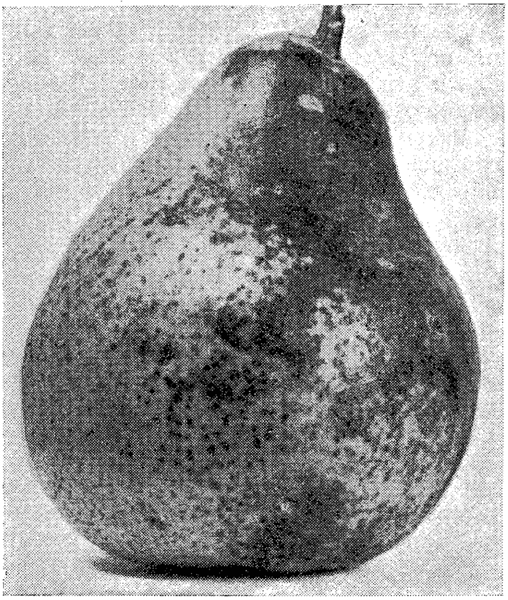
When only slightly overstored, the fruit will soften, but juiciness and flavour will be poor and scald may develop. To avoid overstorage pears should be removed while still hard and while still green to light green in colour. It is a good plan, towards the end of the storage period, to remove small samples at weekly intervals for ripening tests at a temperature of 60-70° F. The first sign of falling off in quality when ripe should be regarded as a warning of approaching overstorage and steps should be taken to market the remainder of the fruit. With Williams this allows a safety period until overstorage of 2-3 weeks and with later varieties about 4-5 weeks.

Ripening.

For best quality pears should be removed from storage while still hard and green to yellow-green in colour and ripened after storage at a temperature of 60-70° F. A temperature of 65° F. has been found to be about the optimum for all varieties tested. Williams pears have only a narrow range of temperatures at which they will ripen, the minimum temperature for satisfactory ripening being 60° F. The minimum ripening temperatures for the other main varieties are Bosc 55° F., Packham 45° F., Josephine, Winter Cole and Winter Nelis 40° F. Although satisfactory, the quality when ripened at these temperatures will be inferior to that of fruit ripened at 60°-70° F.

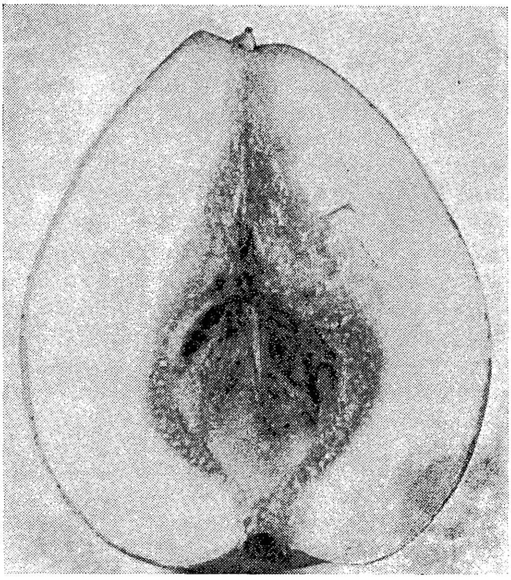
Storage Life.

In Table 1 are given data on the picking maturity and storage life of the main varieties. The data refer to average seasons, and the length of storage life is what could reasonably be expected in an average store.



[Photo, P. R. Maguire.]

Fig. 1. Scald due to overstorage.



[Photo, P. R. Maguire.]

Fig. 2. Core breakdown due to overstorage. It develops after removal from store.

Under the best conditions of handling and storage or in a good keeping season these periods could be exceeded, and in a season unfavourable to keeping quality the life would be somewhat less.

TABLE I.
Picking Data and Storage Life of the Main Varieties.

Variety.	Usual Picking Date in Main Districts.		Firmness at Correct Maturity in Pounds.	Average Safe Commercial Storage Life in Weeks at			
	N.S.W.	Southern Victoria.		30° F.	32° F.	34° F.	Gas at 32° F.
Williams ..	10-20 February.	5-10 February.	17-22	11-12	9-10	7	16
Bosc ..	End February to 1st week March.	End February to 1st week March.	15-19	18	16	13	20-22
Packham ..	Mid March.	End February to 1st week March.	15-19	20-24	16-20	13-17	22-26
Josephine ..	2nd-3rd week in March.	Mid March.	14-17	20-22	18-20	16-18	20-22
Winter Cole	2nd-3rd week in March.	2nd week March.	14-16	24-28	20-24	16-20	28-32
Winter Nelis	3rd-4th week in March.	3rd week March.	17-18	26-30	22-26	20-24	28-32

Acknowledgement.

Mr. G. R. Rostos, of C.S.I.R., Division of Food Preservation, for information on cool store design and management.

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(Copies of this paper are available from the Division of Food Preservation, C.S.I.R., Homebush. They include a coloured chart for use in determining maturity.)

Canned Broccoli

A STUDY OF THE EFFECTS OF VARIOUS PROCESSING PROCEDURES ON QUALITY AND ASCORBIC ACID CONTENT.

By

P. Thompson.

Even in the fresh form, broccoli (*Brassica oleracea*) is not a familiar vegetable in Australia, and canned broccoli as far as is known has not been marketed. In recent years broccoli has been grown more widely in home gardens, and many consumers consider it to be the most palatable of the Brassicas when home grown and home cooked. The fresh vegetable is also known to be high in ascorbic acid content. A small planting (approximately one-quarter of an acre) of green sprouting broccoli by a commercial grower at Toongabbie, near Sydney, N.S.W., presented an opportunity to prepare several laboratory packs and to examine the effects of different canning procedures on the quality and the ascorbic acid content of the canned product.

Raw Material.

Test packs were prepared from three ½-cwt. batches of broccoli from the plot mentioned, picked on May 12th, May 26th and June 8th, approximately covering the period of useful harvest. Normal commercial pickings were made throughout this period.

The first picking was composed largely of primary flower heads, while the second and third pickings consisted mainly of secondary heads.

For ascorbic acid determinations on the fresh vegetable a sample weighing approximately 2 lb. was taken from each batch and divided into the flowers or " curds ", the stalks (diameter not greater than ¾ inch), and the small leaves on the flower stalks. These components were analysed separately for ascorbic acid by the dye titration method and from the relative proportions in the sample a mean ascorbic acid content for the whole edible portion was calculated. A typical ratio of the components was 40% flowers, 50% stalks and 10% leaves.

The first two pickings were about 24 hours old when analysed. With the third picking ascorbic acid losses were followed during a storage period of 120 hours at room temperature (60-65° F.). In this case slight wilting was apparent at 30 hours and at 120 hours severe wilting and yellowing had occurred. The moisture changes in wilting were not followed. The results are set out in Table 1.

The ratio of the ascorbic acid contents of the three components were not uniform in the three pickings and a similar lack of uniformity is apparent in the values determined during the storage of the third picking, although this latter variation may be related to differing degrees of wilting.

In general the fresh leaves and flowers were higher in ascorbic acid than the stalks but showed a greater rate of loss.

The variation in total ascorbic acid values between pickings is noteworthy, e.g. at 24 hours the range is 86·5–138·8. The variation in the components is even greater, notably in the leaves.

TABLE I.
Ascorbic Acid Content of Raw Broccoli.

Picking.	Interval from Picking.	Ascorbic Acid Content (mg./100 g.).			
		Flowers.	Stalks.	Leaves.	Whole Edible Portion. (Calcd.)
1st.. ..	24 hrs.	124·6	135·3	211·0	138·8
2nd ..	24 hrs.	84·3	85·4	110·8	86·5
3rd ..	3 hrs.	180·5	108·8	150·7	129·4
,, ..	24 hrs.	117·2	96·6	119·2	105·0
,, ..	30 hrs.	135·3	90·7	120·7	108·6
,, ..	120 hrs.	59·1	110·2	86·6	94·7

The values determined compare favourably with values previously reported by the following workers:

	Mg./100 g.
McHenty and Graham (1935)	68
Roe (1936)	68–71
Feener, Palmer and Fitzgerald (1937)	113–174
Fitzgerald and Fellers (1938)	67–122
Wheeler, Tressler and King (1939)	114–145
Oser, Melnick and Oser (1943)	95

Canning Procedures.

Fifteen packs of canned broccoli were prepared according to procedures that are included in Table 2. The use of sodium chloride brines for pre-soaking and blanching is recommended by Professor Wiegand, as quoted by Bitting (1937).

The broccoli was weighed before and after blanching in order to assess the increase in weight. This increase was found to vary appreciably around an average of approximately 10%, which is the value used in calculating ascorbic acid losses.

The blanched broccoli was packed in No. $2\frac{1}{2}$ (401×411) S.R. lacquered cans. Eighteen ounces was the standard fill with an addition of 12 ounces of $2\frac{1}{2}$% brine in every treatment except the vacuum pack (No. 13), to which 2·02 ounces of 12% brine were added. All packs were retorted for 30 min. at 240° F. except No. 15, which was retorted for 8 min. at 260° F.

Ascorbic Acid Estimation.

The results of determinations of the ascorbic acid contents of the blanched and canned broccoli in the various treatments are set out in Table 2. The canned samples were opened for inspection 3-6 days after processing.

In Table 2 the figures in the column headed " Initial Ascorbic per Can " have been derived from the ascorbic acid content of 16·2 ounces of fresh broccoli, i.e. 18 ounces of blanched material less 10% gain in water content. The figures in the column " Final Ascorbic per Can " are calculated from the net contents of the can and the ascorbic acid content of the canned product.

Examination of these figures indicates that the greater part (80–90%) of the loss in ascorbic acid content occurs in the blanching operation.

TABLE 2.

Ascorbic Acid Contents of Processed Broccoli.

Code No.	Blanching Treatment.	Fresh. Mg./ 100 g.	Blanch. Mg./ 100 g.	Loss Blanch. %	Canned. Mg./ 100 g.	Initial Asc. per Can. Mg.	Final Asc. per Can. Mg.	Overall Loss %
1[1]	2½ min. in steam ..	138·7	83·5	40	40·0	635	329	48
2	3 min. in 0·5% NaCl at 212° F.	,,	78·5	44	39·2	,,	323	49
3	5 min. in 0·5% NaCl at 180° F.	,,	85·5	38	38·6	,,	314	51
4[2] [4]	3 min. in 2½% NaCl at 180° F.	87·4	58·8	33	29·8	402	245	39
5	3 min. in 2½% NaCl at 180° F.	,,	56·0	36	29·4	,,	242	40
6	3 min. in 2½% NaCl at 180° F.	,,	56·0	36	29·1	,,	243	40
7	3 min. in 2½% NaCl at 212° F.	,,	57·8	34	28·8	,,	241	40
8	3 min. in 2½% NaCl at 180° F.	,,	56·0	36	28·1	,,	228	43
9	3 min. in water at 180° F.	,,	46·9	46	—	,,	—	—
10[3]	3 min. in 2½% NaCl at 180° F.	107·1	—	—	41·8	494	362	27
11	7 min. in 2½% NaCl at 160° F.	,,	72·3	33	37·1	,,	322	35
12	1 min. in 2½% NaCl at 212° F.	,,	71·8	33	41·4	,,	353	29
13	3 min. in 2½% NaCl at 180° F.	,,	—	—	62·2	,,	354	28
14	7 min. in 2½% $CaCl_2$ at 160° F.	,,	75·0	30	40·4	,,	344	30
15	3 min. in 2½% NaCl at 180° F.	,,	77·0	28	40·3	,,	349	30

[1]Codes 1, 2, 3 were picked on May 12th.
[2] Codes 4, 5, 6, 7, 8, 9 were picked on May 26th.
[3] Codes 10, 11, 12, 13, 14, 15 were picked on June 8th
[4] Code No. 4 was presoaked 6 hours in 2½% NaCl. before blanching.

Effect of Storage on Ascorbic Acid Content.

Series of samples were examined after three months and twelve months storage at room temperature and the ascorbic acid contents determined. The results are set out in Table 3 and are expressed on the same basis as the " Overall Loss " figures in Table 2, which are reproduced in Table 3 in the column headed " Initial ".

After one year's storage the canned broccoli retained ascorbic acid contents in the range 20–35 g. per 100 g.

Examinations for Quality.

The experimental packs were also examined for quality in terms of colour, flavour and texture. The test packs were those which had been blanched at low temperatures and closed without an exhaust treatment. Blanching at 212° F. produces unattractive, dull green colour, a soft, mushy texture and a dark, muddy brine.

Blanching for 3 min. at 180° F. gave satisfactory results, and even better results, in improved colour and firmer texture were secured by blanching at 160° F.

TABLE 3.

Storage Losses of Ascorbic Acid.

Code No.	Percentage Loss.			Code No.	Percentage Loss.			Code No.	Percentage Loss.		
	Initial.	3 Months.	12 Months.		Initial.	3 Months.	12 Months.		Initial.	3 Months.	12 Months.
1	48	49 48	— —	6	40	38 39	58	11	35	36 31	48
2	49	44 54	—	7	40	43 41	56	12	29	29 29	42
3	51	46 —	—	8	43	38 50	49	13	28	27 30	—
4	39	30 29	—	9	—	44 37	54	14	30	33 27	51
5	40	44 44	51	10	27	31 29	46	15	29	26 33	—

Samples blanched in $2\frac{1}{2}\%$ sodium chloride brine showed slightly superior colour and less sediment in the brine in the can. The use of calcium chloride did not appear to cause any significant improvement in quality.

Satisfactory vacuums were recorded in cans sealed hot without exhaust, but the use of a steam-jet closure would be preferable.

Conclusions.

Canned broccoli is suggested to canners as a useful addition to the range of vegetables canned in Australia. It is attractive in appearance, palatable, and contains nutritionally important quantities of ascorbic acid.

The following procedure is recommended for the preparation of this canned vegetable:

1. Wash well in water.
2. Blanch 3 minutes in $2\frac{1}{2}\%$ sodium chloride brine at 180° F.
3. Chill immediately in cold water.
4. Pack carefully in S.R. lacquered cans.
5. Add hot $2\frac{1}{2}\%$ brine.
6. Seal immediately without exhaust but with steam jet closure if possible.
7. Retort 30 minutes at 240° F. (for No. 2 and No. $2\frac{1}{2}$ cans).
8. Cool promptly.

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Peeling of Freestone Peaches

By

P. THOMPSON.

In the preparation of freestone peaches for canning one of the essential steps is the efficient removal of the skin of the fruit. This step differs somewhat from the analogous operation with clingstone peaches due to the different texture of the freestone (its tendency towards ragginess) and presence of the coloured pit cavity.

Some freestone varieties are readily peeled by passing through a steam chamber for approximately three minutes, the loosened skins being removed by high pressure water sprays. Another variant of steam peeling often recommended is to lay the pitted halves cavity downwards on cheese cloth and then cover with a single layer of cheese cloth before passing through the steam chamber. The loosened skin adheres to the cheese cloth, and this method gives a very fine appearance to the product.

Clingstone peaches are usually peeled by treating the halved and pitted fruit, by immersion in hot caustic lye. With freestone peaches, particularly those having red pit cavities, a brown discoloration generally develops, and consequently modifications are desirable. Spray treatment of freestone halves with hot caustic lye (2%–5%) with a final wash under high pressure water sprays is satisfactory with some varieties.

A recent American method utilizes a combination of the steam and lye treatments. The procedure involves passing under steam sprays for 15–20 seconds, followed by 5–10 seconds under boiling 2% lye sprays, followed by a reaction period of 15–20 seconds before passing to the high pressure water sprays which remove the loosened skins.

During the 1946 season a number of varieties of freestone peaches were canned in this laboratory using the lye peeling method. The whole fruit was peeled by immersion for 30–60 seconds in boiling 2% lye and then chilled in running water. After a thorough rinse the peaches were halved and the pits removed, and the halves were canned in the normal way. Very satisfactory packs were produced in this way, comparing favourably with standard clingstone packs.

During the 1947 season, when halved and pitted fruit were given the immersion lye treatment, the overall effect was not satisfactory, although the skins were generally removed. The action of the heat and lye on the cut sections of fruit increased the tendency towards ragginess and necessitated, in some cases, additional trimming before canning the fruit.

While it appears that immersion peeling of the whole fruit is desirable, encouraging results have been reported from America with the combination spray methods outlined above, and for large commercial packs of freestones careful investigation of these methods seems desirable, particularly since the general introduction of pitting machines.

With all these methods, however, emphasis must be placed upon uniform maturity of the fruit, and particularly with freestones should attention be paid to selecting the optimal maturity, namely the stage at which the fruit is firm-ripe, with sufficient resilience to withstand ordinary handling.

FOOD PRESERVATION QUARTERLY

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