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TEMPERATURES IN NON-REFRIGERATED STORES FOR PROCESSED FOODS.

BY

E. W. HICKS.

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EFFECTS OF TEMPERATURE OF STORAGE ON THE LIFE OF FOODSTUFFS.

While processed foods are generally not perishable in the sense that most fresh foods are, they will not remain in good condition indefinitely. Mould growth, bacterial attack, and most enzymic changes are eliminated by efficient processing and packing, but some chemical changes go on slowly, leading to flavour changes, loss of vitamins, corrosion of cans, etc. These changes may be called ageing reactions.

There are many products in which the ageing reactions are so slow that no appreciable change is likely to occur during five years or more under average Sydney conditions, e.g., canned corned beef. There are other products which suffer serious deterioration in six to twelve months' storage at average Sydney temperatures, e.g., dried milk, dried egg, dried vegetables, citrus juices. There are other materials with storage properties intermediate between these extremes, e.g., many canned fruits and vegetables suffer appreciable deterioration if stored much longer than twelve months under Sydney conditions. The practical importance of storage temperature depends, therefore, on the properties of the goods being stored.

These ageing reactions increase in rate with increasing temperature according to an exponential law. The rates of most of them are approximately doubled for each 18 deg. F. rise in temperature. Slower rates of increase in the ageing reactions are rare but higher rates are not uncommon.

The rate of ageing of foodstuffs will, therefore, vary considerably with the temperature of storage. In non-refrigerated stores the temperature will depend on the geographical location and the design of the store. Considering ideal stores in which the average temperature is equal to the average outside air temperature, the effects of differences in climate between different parts of Australia are indicated in the following table:—

	Average temperature °F.	Rate of ageing of foods.
Melbourne	58.5	1.00
Sydney	63.2	1.20
Brisbane	68.9	1.49
Cairns	76.5	2.00
Darwin	82.6	2.53

In this table the averages are taken over a whole year and average Melbourne conditions are adopted as a reference standard. These figures imply that if a commodity has a life of fifty weeks in Melbourne it will have a life of forty-two weeks in Sydney, thirty-four weeks in Brisbane, twenty-five weeks in Cairns, and twenty weeks in Darwin. When goods are stored for less than a year it is, of course, necessary to take seasonal variations into account.

The average temperature in a shed is often considerably higher than that of the outside air. The worst conditions likely to be experienced in a shed not heated by proximity to boilers, etc., is an average temperature about 10°F. above the average outside air temperature. This temperature-excess would result in increasing the rate of ageing by about 50 per cent. It is, however, fairly easy to design a shed in which the average temperature is within 2°F. of the average air temperature, i.e., rate of ageing increased by not more than 8 per cent.

CONDITIONS IN SHEDS.

General.

The most usual cause of relatively high temperatures in sheds is heating by radiation from the sun. The amount of incident radiation can be large; in inland areas it is often sufficient to raise the temperature of a store and its contents 20°F. in one day, assuming all of it to be absorbed. In actual sheds a large proportion of the incident radiation is not absorbed by the goods in store. Much of it is reflected by the roof and walls and a large part of the remainder transferred to air flowing over or through the shed.

The difference between the average temperature, day and night, over a considerable period of time, and the average outside air temperature, is a satisfactory index of the efficiency of a shed from the temperature point of view. There are generally appreciable variations in average temperatures in different parts of a shed; the tops of stacks often average about 5°F. above the centres. Consequently it is desirable to consider also the average temperature for the hottest part of stacks as well as for the whole stacks in assessing the efficiency of sheds.

The variation of temperature between day and night is not in itself of great importance in the storage of processed foodstuffs. In particular, the maximum temperature reading in a shed during the afternoon is not a satisfactory index of its efficiency.

Storage Spaces in Big Buildings.

On the lower floors of big buildings there is very little heating by solar radiation. Stores in such positions are often very slow in responding to changes in outside conditions. They feel, and are in fact, cool on hot afternoons, but this may give a misleading impression since they are correspondingly warm on cool nights. In such stores the average temperature may be expected to be very close to average outside air temperature with very little variation from point to point or between day and night.

Galvanized Iron Sheds.

In a galvanized iron shed which is not painted a fair average figure for the proportion of solar radiation reflected is probably 25-30 per cent. This means that if high average temperatures are to be avoided a large quantity of heat must be transferred to air flowing over or through the shed.

Calculations, necessarily rough because of the need for making many assumptions, indicate that in a fairly large shed which is completely unventilated average temperatures about 10°F. above the average outside temperature may be expected in clear summer weather. An average wind speed of 10 m.p.h. was assumed in this calculation. Measurements in an actual, poorly ventilated shed showed an average temperature-excess of 7.3°F. with an excess of 14.5°F. in the hottest part. In well-ventilated sheds average temperatures about 1°F. above average outside temperature with an excess of about 2°F. in the hottest parts have been observed.

Ventilation of galvanized iron sheds is, therefore, of very real importance. The main need is a relatively high rate of air flow between the roof and the tops of the stacks, but air flow over the inside of walls exposed to the sun is also important. Air flow through the stacks themselves is not of great value from the temperature point of view.

The size of the openings necessary to provide adequate ventilation depends on the average wind speeds, the amount of roof overhang, and other factors so that it is impossible to state rules which will be satisfactory everywhere. It is suggested, however, that in most locations openings about two feet in depth should be provided between the tops of the walls and the roof and at floor level there should be openings equivalent to a six-inch gap. The openings may be covered with wire gauze. In tropical regions where wind speeds are very low, larger openings are desirable; in such areas it is often wise to have the sides of sheds completely open, or covered with wire mesh only.

Whitewashing the outer surfaces or paintnig them white has a considerable effect since it increases the proportion of solar radiation reflected. Clean white paint or whitewash surfaces will reflect about 80 per cent. of the incident radiation.

The installation of a ceiling will have a considerable effect on the temperatures of the top faces of stacks and on the comfort of men working in the store, but its effect on the average temperature over the whole of the stacks will generally be quite small. In some locations a ceiling may be almost essential to prevent excessive dust accumulation on the stacks of food. Good ventilation between the ceiling and the roof is very necessary in such circumstances.

Asbestos Cement Sheds.

Asbestos cement sheets have some insulating value and this results in the transmission of less of the heat absorbed from solar radiation to the goods in store. This effect is, however, relatively small, so that the amount of ventilation necessary in an asbestos cement shed is not much less than in a galvanized iron shed.

Open Versus Close Stacks.

From the point of view of average temperature conditions there is little advantage to be gained from the use of an open stowage for processed foods except, of course, where goods are at a relatively high temperature when put into store. Open stowage has, however, real advantages where drying out of cases etc. during storage is necessary.

Making Use of Low Night Temperatures.

In a well-insulated store the average inside temperature will generally be very close to the average outside air temperature. If, however, the store is unventilated during the day and well-ventilated during the night average temperatures below the average outside temperature can be achieved. Information on the amount of cooling which has been achieved in actual stores by this method does not seem to be available but it is worth while considering what is theoretically possible. Griffith may be taken as a representative Australian inland region. In January the average daily maximum temperature is 89.1°F. and the average minimum 61.9°F. The overall average temperature is therefore approximately 75.5°F. Between midnight and dawn the average temperature is probably about 65°F. Consequently in a perfectly insulated store it should be possible to maintain an average temperature of 65°F. by rigorous ventilation between these hours, i.e., a gain of about 10°F. is theoretically possible. With insulation equivalent to two inches of cork and efficient shielding from solar radiation the temperature rise during the day in a store filled with canned foods would probably be of the order of 1°F. so that the practical achievement of a temperature lowering within a few degrees of 10°F. in mid-summer is probably feasible. At other seasons the temperature difference would be less.

THE EXTRACTION AND USES OF PECTIN.

BY

F. E. Huelin.

* * *

1. Introduction.

Pectin, the jellying principle of fruits, has received considerable attention in this laboratory over the last three years. Work on this subject began as an investigation into the possibilities of preparing solid jams to conserve tinplate. For this purpose large quantities of pectin would be required. Imported pectin has been in short supply during the war, but large quantities of citrus residues have been produced by juice-processing plants. These residues are largely a waste product, which has involved considerable cost in disposal, and an economic method of utilisation would be of great value. In addition, considerable quantities of apple residues have been available from juice and dried apple plants.

This article is primarily a critical review of the available literature in the light of the writer's experience, together with brief accounts of some of the experimental work carried out in this laboratory. On many points the information available in the literature was so indefinite that laboratory investigation was necessary to determine the most suitable procedure. Some aspects of the problem have already been mentioned in this Quarterly.*

A brief account of the chemistry of pectin is given here before considering the technical aspects. Pectin is a complex colloidal substance, occurring in the cell wall of fruits and vegetables and is largely responsible for their jellying properties. The presence of acidic carboxyl groups wholly or partly esterified with methyl alcohol is characteristic of pectin. Treatment with dilute alkali demethylates the pectin to pectic acid which readily forms an insoluble gel. The pectic acid gel is, however, weak and unstable, and quite different from the characteristic pectin gel (used in jam and jelly making) which requires for its formation 60 per cent. or more of sugar and a suitable range of pH. Further hydrolysis of pectic acid produces galacturonic acid, which is regarded as the basic structural unit of pectin.

The pectin in fruits occurs both as soluble and insoluble forms. The former can be extracted with cold water, but is usually of poor jellying power and is generally rejected. The insoluble pectin appears to be combined with calcium, cellulose or other constituents of the cell wall and requires treatment with acid or heat or both to convert it into a soluable form. During ripening a large proportion of the insoluble pectin is converted into soluble pectin of low jelly grade, and for this reason ripe fruits are commonly poorer in jellying properties.

2. The Source of Pectin.

Pectin can be obtained from:—

(*a*) Citrus skins and rag from juice-pressing plants;
(*b*) apple pomace from juice-pressing plants, and
(*c*) apple skins and cores from dehydration or canning plants.

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* Food Preservation Quarterly (1943)—3: (No. 2) 30, (No. 3) 34.
Food Preservation Quarterly (1944)—4 Nos. 2/3: 18.

Fresh citrus residues may contain about 2 per cent. of pectin (on a 100-grade basis) and apple residues about 1-1.5 per cent. The wet material deteriorates rapidly and must be extracted almost immediately. Practically all the pectin in citrus residues can be destroyed within 24 hours at room temperature. (The method of evaluating pectin will be described in a subsequent section). Wet residues can be preserved for a limited period (maximum about one week) by mixing with sodium metabisulphite to give a sulphur dioxide content of 1000-1500 parts per million.

If it is necessary to keep the residues for an extended period, they can be dried at 60-65°C. to a moisture content of about 15 per cent., which is approximately in equilibrium with the atmosphere. Dried citrus and apple residues have been kept for a period of six months in this laboratory without any loss of pectin.

A fair amount of apple pomace has been dried in America in kilns. This is a comparatively slow process, requiring about 12 hours. A more efficient procedure is that using the rotary steam tube drier (19),* which has come into use more recently. Only small-scale drying of (*a*) orange residues—shredded skins and minced skins and rag—and (*b*) apple skins and cores has been carried out in this laboratory. Using a vertical circulation through three inches of material, drying has been completed at 60-65°C. in about two hours.

With citrus residues, a preliminary leaching and pressing before drying has been customary in the United States. A recommended procedure is to grind the citrus residues to pieces about half an inch in diameter and add to three parts of boiling water. The temperature is maintained at 90°C. for 5-7 minutes to inactivate enzymes. Cold water is then added, and the residues leached further in cold water, pressed and dried. This residual product is known as "crude pectin". It dries more readily than unleached material, as there is much less tendency to sticking. Also it is more convenient for extraction of pectin as it does not require any preliminary leaching. Experience in this laboratory indicates that it darkens much less readily in storage than unleached material.

3. The Extraction of Pectin.

Before extraction, citrus or apple residues are leached with cold water. This is conveniently carried out in a tank with a perforated false bottom above the outlet. The material is first covered with water. Dry material is allowed to soak for thirty minutes before leaching. The water is then allowed to drain away slowly while fresh water is poured on the top to keep the material covered. Rooker (18) recommends leaching until the specific gravity of the drainage water falls to 1.005. By this means sugars, soluble pectin of low jelly-grade, and other extraneous material are removed.

The material is then extracted by heating with a dilute acid solution and the extract pressed out. The weight of solution used is 2-2½ times that of the fresh residues or 8-10 times that of the dry residues. If the whole extract is to be added to food products, only citric or other acid permitted under the Pure Foods Act can be used for extraction. If the pectin is to be subsequently purified by precipitation, the cheaper hydrochloric acid is quite satisfactory.

A wide range of conditions during extraction is suggested in the literature. Rooker (18) recommends heating with 0.2 per cent. citric or lactic acid for 30-40 minutes at 100°C. or 60-80 minutes at 88°C. (With apple residues this gives a pH of 3.0-3.5 during extraction). Myers and Baker (12) compared the

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*Numbers in parentheses refer to the table of literature cited, which is given at the end of this article.

effect of time, temperature, and acidity over a wide range and obtained the most efficient extraction after sixty minutes at 70°C. and pH 1.5. Wilson (20) extracted citrus residues with one per cent. sulphurous acid at 80°-90°C. (which should give a pH of about 2.4). The present tendency in the United States is to use lower temperatures and higher acidities (lower pH) for extraction. Baker and Woodmanse (4) have found recently that polyphosphates, e.g., sodium hexametaphosphate, reduce the time of extraction by half and give maximum efficiency at about pH 3.0.

With apple residues, suitable extracts have been prepared in this laboratory by boiling with 0.1 per cent. citric acid for 30-40 minutes. This gives an extract of about pH 3.5. Altering the pH of extraction between 2.0 and 4.0 does not seem to affect appreciably the concentration of pectin in the extract. Heating for longer periods at 85-90°C. does not give any better extraction.

Extracts of citrus residues have been prepared over the range of pH 3.0-4.0, using citric, lactic, and mineral acids. Boiling for 45 minutes gives approximately maximum extraction in this range of acidity. There was a tendency for more efficient extraction at pH 3.0 than 4.0 (approximately 10 per cent. more pectin at the lower pH). Approximately 0.5 per cent. citric acid or N/50 hydrochloric acid will give a pH of extraction between 3.0 and 3.5. More pectin can be extracted at pH 2.0 and below, but the writer has found serious disintegration of the material at the high acidity, rendering pressing and subsequent filtration much more difficult. The difficulty in filtration is due to the much greater quantity of suspended material resulting from the disintegration of the residues and not to the viscosity of the extract, which is actually less at the lower pH.

Unless carefully controlled, the higher acidity can cause appreciable demethylation of the pectin. This change will be discussed in a subsequent section. It is not advisable to use more acid than necessary, particularly as most of it has to be neutralised subsequently.

4. The Preparation of Powdered Pectin.

The preparation of powdered pectin from the original extract may require—

(*a*) removal of starch by enzymic hydrolysis;
(*b*) treatment with activated carbon;
(*c*) filtration;
(*d*) preparation of solid by spray drying, or precipitation with alcohol or aluminium.

Starch is removed from extracts of apple pectin to avoid cloudiness in jellies. This can be accomplished by incubation with a suitable enzyme preparation (usually obtained from *Aspergillus oryzae*). Baker (1) has shown that hydrolysis is best carried out at 30°C. and pH 3.2-3.6 to avoid destruction of pectin which may occur at higher temperatures and pH. In this laboratory it has been shown that extracts of apple pectin can be incubated wtih an enzyme extract for thirty minutes at 30°C. and pH 3.5 without loss of jellying power. This treatment is sufficient to hydrolyse starch to dextrin (indicated by a brown colour with iodine). The extract should then be heated immediately to 80°C. to inactivate the enzyme.

A disadvantage of this treatment is that the dextrins and sugars produced by starch hydrolysis are still retained in the extract. Baker (1) has proposed enzymic treatment of the original pomace. The pomace is heated for five minutes at 80°C. to gelatinise the starch, cooled to 30°C. and treated with the enzyme. Subsequently the pomace is leached and soluble products of starch hydrolysis are removed as well as the original sugars. This method has been tried successfully in our laboratory.

To decolourise pectin extracts, Rooker (18) recommends treatment with 0.3-0.8 per cent. of activated carbon at 80°C. for 35-60 minutes before filtration. This treatment is certainly not necessary for citrus pectin.

Filtration is readily carried out at 50°-60°C. using 1-2 per cent. of filter aid. Wilson (20) proposes filtration through paper pulp, but the writer has not found this very satisfactory. It is claimed by Platt (15) and confirmed by us, that more rapid and efficient filtration is obtained at a fairly low pH (approximately 1.5). The recent tendency in America is apparently to make both extraction and filtration at pH 2 or less. In this laboratory we have been unable to avoid serious disintegration of the material during extraction at a low pH. The extracts contain considerable fine suspended material and are rather difficult to filter under any conditions. Extracts prepared at pH 3.0-3.5 (with less suspended material) and subsequently adjusted to pH 1.5 have filtered very rapidly.

The filtered extract can be concentrated in a vacuum pan to a viscous product containing about 5 per cent. of 100-grade pectin. This is sometimes marketed as "liquid pectin." Solid pectin can be produced by spray drying, but apparently the process is not very satisfactory and gives a somewhat impure and hygroscopic product. The alcoholic precipitation method of Poore (16) is extremely convenient. By concentrating to a thick paste and adding alcohol to a final concentration of 60 per cent., the pectin can be precipitated as a granular mass which is readily separated and dried.

The method of aluminium precipitation can be used without any previous concentration. As described originally by Wilson (20), the method involved adding calculated amounts to aluminium sulphate and ammonia to form colloidal aluminium hydroxide which precipitates the pectin. Baker and Goodwin (3) have shown that pectin can be precipitated by aluminium at a fairly acid pH (4.0-4.5). By adding a concentrated aluminium chloride solution (containing about 20 per cent. of $AlCl_3.6H_2O$) and adjusting to pH 4.0 with ammonia, the pectin can be precipitated quantitatively without loss of jelly grade. Baker and Goodwin recommend adding a quantity of aluminium salt equal to 3 per cent. by weight of the pectin. This may not always be adequate, as we have had to add aluminium equivalent to about 8 per cent. of the pectin to obtain complete precipitation. The pectin is precipitated in clumps by this method, and is readily filtered or otherwise separated. The aluminium can be removed from the separated precipitate by washing with alcohol containing about 3 per cent. of hydrochloric acid.

Powdered pectin is commonly standardised to 100 or other jelly grade by mixing with a suitable diluent, e.g., glucose. Powdered pectin readily clumps when mixed with water to disperse it, and the use of various substances to reduce clumping has been the subject of numerous patents. Sodium chloride, sugar, acetone-dicarboxylic acid, and salts of aluminium, copper, iron, nickel and chromium have all been proposed for this purpose. The time of setting of pectin jellies has received considerable attention, and a number of patents propose controlling this property by treatment with acid or alkali.

5. The Jellying Properties of Pectin.

Pectin may be estimated chemically in solutions and extracts by the calcium pectate method of Carré and Haynes (6) or the volumetric method of Hinton (9). In the former the pectin is precipitated by alcohol, redissolved and demethylated to pectic acid by dilute alkali. The solution is then made slightly acid and the calcium pectate precipitated by adding calcium chloride. The precipitate is filtered off in a Gooch or sintered glass crucible, dried, and weighed.

In the volumetric method, the pectin is first separated with alcohol or acetone, redissolved, demethylated by dilute alkali, and adjusted to pH 7.5, using a suitable indicator. The free acidic groups are then estimated by adding an excess of 0.1 N hydrochloric acid, filtering off the precipitated pectic acid, and back-titrating. An equivalent weight of 250 is assumed for the pectin.

Chemical estimations of pectin are, however, of no value in assessing the jellying power of extracts, as samples of purified pectin may vary enormously in this respect. The jellying power under standard conditions is regarded as primarily a function of the molecular weight or degree of polymerisation of the pectin (13). Pectin from different sources may vary considerably in jelly grade, and excessive heat treatment may largely destroy the jellying power.

The jelly grade of powdered pectin is expressed in terms of the quantity of sugar it will jelly, i.e., 1 lb. of 100-grade pectin will form a satisfactory jelly with 100 lb. of sugar. The jellying power of extracts is commonly expressed in terms of 100-grade pectin, i.e., an extract is equivalent to 4 per cent. pectin when it will form a jelly under standard conditions similar to that given by a 4 per cent. solution of 100-grade pectin.

In this laboratory we have prepared jellies under standard conditions with different concentrations of American 100-grade pectin, and determined the jelly strength in each case. This gives a curve of concentration against jelly strength which can be used for estimating the pectin equivalent of unknown extracts.

At concentrations of pectin and sugar suitable for jellying, the jelly strength changes characteristically with decreasing pH. From practically nil at about pH 3.5 it increases sharply to a maximum and then falls off more gradually with further lowering of pH. Increasing either the pectin or sugar concentration tends to raise the optimum pH. In a jelly containing one per cent. of pectin the optimum pH is approximately 3.0 for 70 per cent. sugar, 3.2 for 65 per cent. sugar, and 3.4 for 70 per cent. sugar. This type of relationship has been reported by many workers, but Olsen (14) claimed that the fall in jelly strength below the optimum pH is really due to premature jellying, and avoided this by pouring the pectin-sugar mixture into acid. Under these conditions he obtained little effect of pH over a wide range. Hinton (9) obtained an increasing jelly strength with lowering of pH right down to 2.0. However, as this author prepared his jellies with 65 per cent. of glycerine his results may not be completely applicable to pectin-sugar jellies.

The pH of pectin jellies may be controlled:—

(a) by adjusting the extract with acid or alkali, or

(b) by adding a suitable buffer.

Pectin extracts are largely unbuffered, as most of the fruit buffers are removed in the preliminary leaching. Only small amounts of acid or alkali are required for adjustment. The use of a buffer probably makes conditions more comparable to commercial jams and jellies made from whole fruit or juice. The effect of pH on jelly strength has been determined in this laboratory, using both methods of adjustment, and in most cases very similar results have been obtained. But extracts prepared under fairly acid conditions, which are probably partly demethylated, gave an optimum pH of about 2.5 in unbuffered jellies and 3.2 in buffered jellies. Baker and Goodwin (3) reported that the optimum pH of gelation of non-buffered pectins decreases with decrease in methoxyl content. These variations, however, appear to be much less in buffered jellies.

In this laboratory, the jellying power of extracts has been estimated under conditions which approximate fairly closely to commercial jams and jellies. The standard jelly contains 70 per cent. of total sugar (40 per cent. cane sugar, 30 per cent. invert sugar) and is adjusted to pH 3.2 with a citrate-phosphate buffer. The buffer is incorporated in a 75 per cent. invert syrup prepared as follows—Dissolve 285 grams of cane sugar and 15.8 grams of crystallised citric acid in 115 mls. of boiling water. Heat until the sugar is dissolved and continue heating in a boiling water bath for 30 minutes to invert the sugar. Then add 17.7 grams of disodium phosphate ($Na_2HPO_4.12H_2O$).

In the case of concentrated extracts (equivalent to 3 per cent. or more of 100-grade pectin) mix 10 grams of the extract with 20 grams of buffered invert syrup and heat to boiling. Add 20 grams of cane sugar and heat until the sugar is dissolved. Then allow to cool and set. The jelly strength is preferably tested next day. In preparing jellies from more dilute extracts, a greater quantity of the extract is required, and the excess water (above 10 grams) should be boiled off rapidly before adding the cane sugar. This can be done by attaching an arm to a balance pan which can be heated by a burner underneath. The jelly mixture is stood on this arm which is suitably counterpoised and heated until the requisite weight of water has been boiled off.

A variety of instruments for determining jelly strength are described in the literature. They usually measure the breaking strain, i.e., the force required to break the surface and force a plunger into the jelly. In Baker's (2) improved Delaware tester, the plunger of a hypodermic syringe is used for this purpose. The pressure applied to the plunger is gradually increased by delivering mercury into a closed space, and the breaking pressure is registered on a manometer. This apparatus is quite suitable for jams and jellies of the usual consistency, but is not satisfactory for strong jellies as the syringe tends to leak under high pressure. In the apparatus of Kizevetter (11) a vertical spindle, which moves freely in a sleeve, is connected at its lower end to a plunger which rests directly on the jelly. At its upper end the spindle carries an open cylinder, into which shot is poured until the plunger is forced into the jelly. The shot is then tipped out and weighed. This equipment is not suitable for weak jellies, as the weight of the spindle and attachments is sufficient to break the jelly without any added shot.

Reedman (17) has recently described a simple apparatus which is suitable for a jelly of any strength. The jelly is placed on one pan of a counterpoised balance and just touches the bottom of a stationary plunger. The weight on the other pan is gradually increased, and the jelly is forced against the plunger until it is broken.

Campbell (5) describes an absolute method of determining jelly strength. He defines it as the work done in turning a vane of standard size through an angle of 30 degrees when inserted in the middle of the jelly.

Cox and Higby (7) measure instead the elastic deformation of the jelly under its own weight. The jellies are prepared in glasses of standard dimensions which are fitted with cardboard strips to enable filling above the top of the glass. After setting, the top of the jelly is sliced off level with the glass, and the jelly then tipped out. The "percentage sag" is determined with a micrometer gauge.

6. The Effect of Heat on Pectin.

It is commonly known that high temperatures degrade pectin, with loss of jellying power. However, the minimum temperature at which serious degradation can occur has not been clearly defined. Hinton (9) found that 30 minutes at 100°C. reduced the jellying power of pectin solutions by about half. The effect was independent of pH between 2.5 and 3.0 Loss of jellying power was only slight at 80°C.

In the experiments carried out in this laboratory the loss of jellying power has been much less than in Hinton's experiments. Thirty minutes at 100°C. has resulted in practically no loss of jellying power in crude extracts and solutions of commercial pectin. Even 60 minutes at 100°C. had only a slight effect. Serious loss of jellying power only occurred at 105°C.

7. Uses of Pectin.

In addition to its use in jams and jellies, pectin has found extensive application as an emulsifying agent in a wide range of food products. Hartman and others (8) have found recently that pectin solutions after suitable treatment can be injected to maintain blood volume in cases of wound shock. For this purpose the pectin requires a prolonged heat treatment (15-18 hours at 90-100°C.) to reduce the molecular weight.

Baker and Goodwin (3) have shown recently that demethylation of pectin can be controlled at a low temperature and pH (approximately 50°C. and pH 1.5), and by this means pectins of practically any methoxyl content can be obtained. The methoxyl content of pectin is usually about 11 per cent., but demethylated pectin can be prepared containing about 4 per cent. of methoxyl. These will form jellies with calcium in the complete absence of sugar, and can be used in jellied products which contain no sugar or only a low concentration. Kaufman and others (10) give formulae for preparing tomato and other vegetable jellies with demethylated pectin and calcium phosphate.

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A NOTE ON THE STORAGE OF PEACHES AND PEARS FOR CANNING.

BY

E. G. HALL.*

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The canning of clingstone peaches and Williams pears is an important industry in New South Wales and Victoria. It is generally necessary to hold considerable quantities of fruit in cool storage to extend the canning season so that the canneries can handle as much as possible of the fruit available. With pears cool storage offers other advantages. Williams pears will not ripen to good quality on the tree, and best quality is only attained after a period of cool storage followed by ripening at a suitable temperature. Moreover, pears ripen more uniformly after removal from cool storage than when ripened off the tree.

For a number of years experiments have been carried out on the storage of peaches and pears and in one year this was followed up with commercial scale canning trials of fruit from the storage experiments. It is considered that the results of this preliminary work will be of interest to canners because of the importance to them of cool storage. It will be necessary, however, to carry out further investigations to confirm the tentative recommendations given hereunder.

Peaches.

Storage experiments have been conducted with the Golden Queen and Phillips Cling varieties and the canning tests were carried out with Golden Queens only. In the canning trade the maturity of cling peaches is usually described as either "canning" or "off canning," the latter being less mature than the former. Fruit of these two maturity classes was obtained from the Murrumbidgee Irrigation Area and stored in the experimental cool storage rooms at the Food Preservation Laboratories, Homebush.

The "off-canning" fruit was slightly harder on arrival at the laboratory than the fruit picked at the "canning" stage, had a slightly higher acidity and when ripened immediately at 65° F. had a poorer flavour than the more mature fruit. Usual figures for firmness on arrival and as measured on peeled fruit with the standard U.S. pressure tester fitted with a 5/16 inch diameter plunger were—"off canning" 10 to 13 lb., "canning" 9-11 lb.

In the storage tests as judged by condition of the fresh fruit, the life at 32° F. was three weeks for both maturities of Golden Queens and 1 to 2 weeks longer for the Phillips Cling variety. The storage life was not affected by maturity but was reduced by one week when the storage temperature was raised to 34° F. In one year a storage temperature of 30° F. was also used with both J. H. Hale and Golden Queen varieties and better results were obtained than at 32° F.

The Effect of Storage Treatments on the Yield and Quality of Canned Peaches.

For this experiment Golden Queen peaches were picked at Griffith on 11/3/40 and separated into "off canning" and "canning" grades. The fruit was received at this laboratory on the following day and samples were placed in air storage at

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30° and 32° F. and in 5 per cent. CO_2, 16 per cent. O_2, and 10 per cent. CO_2, 11 per cent. O_2 at 32°F. Samples of the "off canning" grade were also delayed for one and two days at atmospheric temperatures before being stored in air at 32° F. Bushel lots of fruit stored without delay were removed after two, three, four and five weeks from air storage at 30° and 32°F. and canned under commercial conditions. Only one removal after five weeks was made of delayed and gas-stored fruit. The fruit was canned as halves to local pack standards. The normal yield in canning for the local trade is about 64 per cent. of the fresh weight, losses being due to peeling, pitting, trimming and rejection of inferior fruit. In the experimental lots pieces were rejected as being unsuitable for canning if they had dark centres, ragged edges, bruises or other blemishes. The amount of fruit involved was only about 40 lb. and consequently the figures obtained must be regarded with caution. The yield of the various lots is recorded in Table 1.

Table 1.—Canning Yield of Stored Golden Queen Peaches.

Sample.	Percentage of Fruit Canned.
R 2 weeks at 30°F.	48
G 2 „ „ 30°F.	51
R 2 „ „ 32°F.	41
G 2 „ „ 32°F.	56
R 3 „ „ 30°F.	50
G 3 „ „ 30°F.	54
R 3 „ „ 32°F.	47
G 3 „ „ 32°F.	54
R 4 „ „ 30°F.	35
G 4 „ „ 30°F.	58
R 4 „ „ 32°F.	19
G 4 „ „ 32°F.	25
R 5 „ „ 30°F.	37
G 5 „ „ 30°F.	39
R 5 „ „ 32°F.	24
G 5 „ „ 32°F.	all bruised.

R = Canning maturity. G = Off canning maturity.

The yield in all cases was lower than the 64 per cent. usually obtained commercially but the experimental fruit was somewhat riper than that normally canned and was handled much more with resultant increased bruising and other trimming losses. Fruit removed from air storage after five weeks and examined before canning was pale in colour, slightly mealy with discolouration round the stone and had an off flavour.

There was not a sufficient quantity of delayed or gas-stored fruit available to determine yields of the canned product, but after five weeks' storage this fruit was discoloured and had an off flavour and very little of it was of canning quality. It will be observed from Table 1 that both maturities were fairly satisfactory after three weeks' storage, but after four weeks the only satisfactory lot was the off-canning maturity at 30° F.

Samples of the canned fruit were stored at 65° F. and examined for appearance and palatability after nine months and sixteen months' storage respectively.

The results of the first examination can be summarised as follows:—

(1) The colour was good in all samples and the colour of the earlier removals of the "canning" stage fruit was particularly good, being an attractive golden yellow.

(2) G2-30, G2-32, R3-30, G3-30, R3-32 and G3-32 were better than commercial standard.

(3) R2-30, R4-30, G4-30, G4-32, G5-30, R5-32 and G5-32 were of commercial standard.

(4) The other air-stored lots were not equal to commercial standard, being generally too soft and somewhat stale in flavour due to over-ripeness.

(5) The gas-stored fruit, particularly that from 10 per cent. CO_2, was unsatisfactory because of poor texture and the presense of off flavours.

(6) The air-stored fruit was generally considered to be superior to the usual commercial product in colour and flavour but softer in texture. Some people preferred the softer texture.

At the second examination it was observed that the quality of most samples had deteriorated since the first examination seven months previously. This applied particularly to samples R2-30, G2-30 and R2-32. The more rapid deterioration of this fruit which was stored for the shortest time and the fact that at the earlier examinations it was inferior to similar lots stored for three weeks was probably due to the fact that the first removals from store were held for ripening at room temperature for a few days before canning. This resulted in these lots being slightly over-ripe when canned. The later removals were sent in to the cannery as soon as they were removed from store.

At this examination the following samples were still good and equal to commercial standard:—

G2-32, R3-30, G3-30, R3-32 and G4-30.

The following lots were of fair quality and still quite palatable:—

R2-30, G2-30, G3-32, R5-32 and possibly G5-32.

The remaining samples were of poor quality, being too soft and stale or off in flavour.

Summary of Canning Trials.

(1) Fruit at the "off canning" stage stored better than that at the "canning" stage; the later fruit, however, had the better flavour and colour.

(2) Three weeks' storage of "canning" stage fruit or four weeks' storage of "off canning" fruit at either 30°F. or 32°F. was satisfactory.

(3) Storage at 30°F. was better than storage at 32°F. as, in the later removals, there was less wastage, giving a greater yield, and the canned fruit was fresher in flavour.

(4) Gas storage was unsatisfactory, resulting in an off flavour quite distinct from staling due to over-ripeness.

Pears.

The storage life of Williams pears is greatly influenced by the maturity at picking, and by delay before storage. The life is also considerably affected by the temperature of storage and varies somewhat according to seasonal conditions.

Pears for storage should be picked when still quite green but not until they start to loosen on the spur when the colour is a paler green than the deep green of immature fruit; the fruit should be hard with a firmness of 16-20 pounds as measured with the standard U.S. pressure tester fitted with the 5/16-inch diameter plunger. The fruit should be placed in storage without delay and cooled down to the storage temperature as rapidly as possible.

At 30°F. the life of Williams pears picked at the correct stage and stored without delay should be 10-12 weeks; it will be about a fortnight less at 32°F. and at 34°F. the life will only be about 6-8 weeks. Pears respond well to gas storage and the storage life of Williams pears gas stored at 32°F. in an atmosphere containing 5 per cent. carbon dioxide and 16 per cent. oxygen should be of the order of four months.

The Effect of Storage Treatments on the Quality of Pears for Canning.

The fruit for this experiment was picked on 20th January, 1940, at Orange and placed in storage at 30°F., 32°F., and in 5 per cent. CO_2 at 32°F. on 21st January, 1940. Samples of each lot were removed for canning after four, six, and eight weeks' storage. Half of each lot was ripened at room temperature (A) and half at 65°F. (C). One lot was ripened at room temperature on arrival and then canned (Ao).

The yield was in most cases quite satisfactory; in the two or three cases where it was low this was due to the fruit being ripened too long before canning.

All canned lots were satisfactory, being well up to commercial standard. In some cases the fruit after canning was somewhat too soft and in some cases the flavour was only fair. These departures from the general good standard were not the result of over-storage but were due to difficulty in getting some lots canned at exactly the right stage of ripeness, owing to pressure of work at the cannery and also to the fact that sometimes the optimum stage of ripeness was attained during a week-end.

The members of the Department of Agriculture who examined the fruit reported that, on the whole, the pears were in very good condition, the best being lots cold stored for six and eight weeks, which had good appearance and texture and very good flavour. When examined at Homebush, the fruit had deteriorated in quality as it was then almost eighteen months since it was canned. Most lots had a "tinny" off flavour as a result of some corrosion of the tinplate. However, even then, all compared quite favourably with commercial samples recently purchased which were rather hard in texture and weak in flavour, apparently due to being canned before the fruit was sufficiently ripe. There was no apparent improvement in quality as a result of ripening at 65°F. instead of at ordinary room temperature, although average room temperatures were of the order of 77-80°F.

From these results it seems that, provided there is no delay between picking and storage, W.B.C. pears can safely be stored for eight weeks before canning. In this experiment there were no differences between the three storage conditions but under commercial conditions it would be safer to store at 30°F. instead of 32°F. if gas storage is not available.

Conclusions.

(1) It is recommended that Williams pears and peaches intended for canning should be held at a temperature of 30°F. if storage is required.

(2) Provided that William pears are picked when still green and hard and placed in cold storage without delay, they should keep quite satisfactorily for canning for ten weeks at 30°F.

(3) Golden Queen peaches should keep quite satisfactorily for three weeks and Phillips Cling peaches for four weeks.

(4) Peaches picked at the "off canning" stage will sometimes keep slightly longer than fruit picked at the "canning" stage. The canning yield of "off canning" fruit after storage will generally be somewhat greater but the quality will not be as good as that of the more mature fruit.

NOTE.—An interesting point arising out of these investigations with peaches and pears is that most of the experimental samples were canned in a riper state than is usual commercially. This resulted in fruit with more flavour and better colour but with a softer texture than the usual commercial lines. The pieces of fruit were sometimes slightly ragged and the juice sometimes slightly cloudy. *In spite of the poorer appearance of such fruit, tasting tests by two different* panels indicated the strong probability of a consumer preference, on the score of superior palatability, for fruit canned riper than usual.

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