FOOD PRESERVATION QUARTERLY.

Vol. 3. No.4. December, 1943.

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Issued by

DIVISION OF FOOD PRESERVATION

COMMONWEALTH COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

SKIN REMOVAL FROM POTATOES AND CARROTS. - NOTES ON PRACTICE IN U.S.A.

In plants processing root vegetables for canning or dehydration, skin removal probably requires more labour than any other single operation Moreover, considerable wastage of edible material can occur if the methods used are unsuitable or inefficient. It is, therefore, of interest to review the methods of skin removal used commercially in U.S.A.

There are four "mechanical" methods used commercially - abrasion lye, flame, and steam pressure. So far as is known, the boiling brine an radiant heat methods have not so far been used commercially, although considerable experimental work is going on. The operations serve to loosen or remove most of the skin and they must, of course, be followed by hand-trimming, which does not vary greatly in detail from plant to plant.

(a) Abrasion.

Both batch and continuous abrasive peelers are widely used in U.S.A., but there is no clear-cut information relating to the size of output which will justify the more costly continuous peeler. Generally, however, a plant handling more than 4000 lb. of peeled roots per hour will use a continuous peeler.

There can be no doubt that abrasive peeling has the marked advantages of simplicity and of production of a uniformly good product. On the other hand, the peeling and trimming losses obtained are generally much higher than with other methods, and it can be excessively wasteful if care is not taken to grade the roots for size prior to peeling.

The average losses in abrasive peeling and trimming are of the order of 25 to 30 per cent., but the losses vary greatly according to the variety, size, condition, and duration of prior storage, losses as high as 45 per cent. often being experienced with "old", misshapen potatoes and carrots.

One authority states that with the flame, lye, or steam pressure peeling of potatoes there will be a saving over the abrasive method of from 1½ to 2 cents. per lb. in the cost of the dehydrated product, resulting from 6 to 12 per cent. reduction in waste and 30 to 50 per cent. increase in volume of raw material handled per worker per hour. The same authority quotes a figure of 29.8 per cent. peeling and trimming loss in an efficient plant during the preparation of about 1500 tons of U.S. Grade 1, size A potatoes when using abrasive peeling, and he claims that this loss would have been reduced to 10 per cent. (approx.) if either flame or lye peeling were used.

(b) Lye Peeling.

Lye peeling of carrots is very widely and successfully used in U.S.A. Although lye peeling of potatoes is fairly widely used, rather conflicting opinions are held about its efficacy. Most authorities in the

Pacific Coast States favour this method for potatoes, while in eastern U.S.A. it is usually condemned. It is difficult to ascribe this clash of opinion to lack of experience in eastern U.S.A., because lye peeling is widely used there for skin removal from carrots and sweet potatoes. The differing opinions may be due to differences between varieties in reaction to lye, the varieties grown on the Pacific Coast possibly being less readily discoloured. Undoubtedly serious discolouration has been encountered in eastern U.S.A. where lye peeling of potatoes has been tried, and similar troubles are not unknown in California. Provided, however, that certain precautions to be outlined later are observed, lye peeling of potatoes, as carried out in California can be very efficient.

In California a concentration of 15 per cent. sodium hydroxide at 200°F. is mainly used in the lye bath when potatoes are being treated, the equipment being usually the standard lye peeler for peaches. The tank is heated either by immersed steam pipes or by direct gas firing. In both cases, the temperature of the lye is automatically controlled through therm stats. An immersion time of 45 to 60 seconds is used.

In the case of carrots, there is no agreement as to the best strength of lye to be used, the concentration varying in different plants from $2\frac{1}{2}$ to 10 per cent. The temperatures used are usually 200° to 210°F., and the duration of immersion in $2\frac{1}{2}$ to 5 per cent. lye is of the order of $2\frac{1}{2}$ minutes.

After immersion in the lye bath, it is essential to wash the roots very thoroughly to remove the loose skin and adhering lye and to exclude air from the roots after washing.

Thorough washing is obtained by the use of a well-designed tumbler-washer, either the corrugated or the slatted type. Another type favoured by certain large processing plants is similar in design to the slat washer except that the inside of each slat is fitted with a continuous narrow brush running the full length of the washer. In any tumbler-washer, it is essential to use a well-distributed spray of high pressure water at 100 to 120 lb. per sq. inch situated off-centre. The retention time in the washer should be at least $1\frac{1}{4}$ to $1\frac{1}{2}$ minutes.

In order to exclude as much air as possible from the roots, it is preferable to convey them to the cutting machine by water flume, and after cutting into strips or dice to blanch the material without delay.

The only serious difficulty encountered in the use of lye in California occurs in very "old" potatoes, when they tend to absorb excessive amount of lye which it is difficult to remove by water washing. One plant uses an acid dip (0.2N. hydrochloric acid) after washing when it encounters such material, but this practice is not general in U.S.A.

In most plants, the usual practice is to drain off the lye once each week and thoroughly clean the tank.

Certain precautions have to be taken in the disposal of spent lye. Neutralization with acid is probably necessary before it is run into canals or streams or into activated sludge sewage systems.

(c) Flame Peeling.

This method is not widely used in U.S.A. for skin-removal from potatoes and carrots. Nevertheless, there are several very successful installations in certain large processing plants having continuity of operation.

When certain precautions are adopted, flame peeling can be very effective, inexpensive in operation, and result in peeling and trimming losses as low as 13 per cent. The initial cost of the equipment, however, is high and it may not pay to instal it unless it can be worked continuously on root vegetables in quantities not less than 5000 lb. per hour.

When potatoes are being treated, it is necessary first to heat them in a rotary washer for $3\frac{1}{2}$ to 4 minutes at 160° to 170°F. This treatment is vital for "old" potatoes which may otherwise darken badly in the surface tissues after peeling. The hot water treatment probably inactivates the tissue enzymes causing discolouration, whereas, without such treatment, the short period in the flame may be sufficient to raise the surface flesh temperature to a level which will permit discolouration to proceed.

The vegetables to be peeled gravitate through the flame peeler from a bin. The vegetables then tumble direct from the peeler to a rotary slat-type washer having a copious water spray at a pressure of 150 lb. per sq. inch. Immediate quenching and thorough washing of the flame-peeled roots are essential to get thorough skin removal and to prevent the development of a burnt flavour.

A typical flame peeler, having a capacity of 5000 lb. per hour, consists of a cylinder about 6 feet long and with an internal diameter of 18 inches. The ends, each about 9 inches long, are fixed, and the central portion is revolved by a 2 H.P. motor through gearing. The ends and the rotor are heavily lined with special fire-clay which is built up in a spiral fashion in the rotor in order to assist in propelling the vegetable forward. The peeler has two adjacent gas-fired burners, supplied with air from a turbine blower through a venturi mixing device. In dealing with 5000 lb. of potatoes per hour, 9000 cubic feet of producer-gas are used.

It is most essential that the roots be quite free from soil before they go into the flame peeler, as dirt will cause severe binding between the ends and the rotor. Disintegration of the refractory in the peeler and consequent costly renewal is one of its most serious disadvantages. This can, however, be greatly retarded by continuous running of the burners (on low flame) during periods of shut-down (week-ends etc.), thus avoiding the cracking accompanying cooling of the refractory. At one large American plant, such care enabled the management to flame-peel about 2500 tons of potatoes in one machine before renewal of the refractory had to be made.

(d) Steam Pressure Peeling.

This method of skin removal has only recently been developed and details are still rather scanty. It is understood, however, that it is being used very successfully in several processing plants in eastern U.S.A., and there are indications that the method will be adopted very extensively. In its present stage of development, the main disadvantage is that it is a batch method.

The equipment is rather simple and can readily be fabricated in most plant workshops. At one plant, the equipment consists of a steel cylinder 30 inches in diameter and 4 feet long with a screw-secured port, sufficiently large to admit a charge of roots. The cylinder is mounted on a central hollow axle which serves to "bleed-in" steam uniformly over its length, the steam pressure usually used being 50-60 lb. per sq. inch.

The cylinder is first half-filled with roots and then sealed. The steam is bled-in, and, when full pressure is reached, the cylinder is given three complete revolutions in a total time of 1½ minutes. The pressure is then released and the roots are tipped on to a conveyor which takes them immediately to a rumbler-washer.

The loss during peeling is said to be 6 to 8 per cent., with an additional 7 per cent. during trimming. The steam requirements are 1 boiler horse power per 60 lb. peeled (approx.).

In one plant, a cylinder of the size described above and working 20 hours per day was able fully to supply a drying tunnel producing 10,000 lb. of dried, strip potato per day.

(e) Trimming.

The designs of conveyor-belt trimming tables used in U.S.A. are very similar to those commonly used in Australia. One notable feature of American trimming tables is the excellent lighting provided by a continuous bank of fluorescent strip lights.

Where some delays may occur between skin-removal and trimming of potatoes, a tank containing dilute brine is used for holding. In Canada, weak sulphite solution is sometimes used in place of the brine.

The amount of potatoes per hour trimmed by each operator varies from 80 to 140 lb. according to the type of peeling equipment used and the condition of the potatoes. For carrots which have been lye-peeled the output per operator is generally about 125 lb. per hour, but where the crowns and thin roots have previously been removed, the output will rise to about 200 lb. per hour.

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THE CALCULATION OF THE COOLING LOAD FOR FOODSTUFFS.

1. MEAT, FISH, ETC.

Although few accurate figures for calculating the cooling loads for particular foodstuffs are available, approximate values quite adequate for most engineering calculations can easily be obtained for meat, fish, and other non-living materials of high water content, by the method outlined below.

The principle of the method for calculating approximate values is to treat the water and solids content of the foodstuff separately. Where no freezing occurs, we have for each:-

Cooling load (B.T.U./lb.) = Weight of water (or solids) per lb. of foodstuff x specific heat of water (or solids) x change in temperature (°F.).

Since, for meat, etc., the contribution of the water content will be much greater than that of the solids, a fairly rough approximation to the specific heat of the solids will be adequate. A value of 0.35 B.T.U./lb. has been reported for beef solids, and this should be a sufficiently close approximation for all the products we are considering. With materials of low water content, greater accuracy in the estimate of the specific heat of the solids would be necessary.

When freezing occurs, latent heats of fusion must also be taken into account. It can generally be assumed that no changes in state occur in the solids during cooling, and a heat capacity of 0.35 B.T.U./lb. can be assumed for each °F. of the whole range. It may be necessary occasionally, however, to take into account the latent heat of fusion of fats which solidify during the cooling process (e.g. with butter).

Values for thermal constants of water, sufficiently accurate for our purposes are:-

(1) Heat capacity above freezing = 1 B.T.U. per lb. per °F.
(2) Latent heat of freezing = 143.4 B.T.U. per lb.
(3) Heat capacity of ice = 0.5 B.T.U. per lb. per °F.

The latent heat which is given up when water freezes to ice makes a very large contribution to the cooling load if the foodstuff is to be frozen.

The main difficulty in calculating an accurate value for the cooling load for temperatures below 32°F. arises from the fact that complete freezing does not take place at one temperature. Freezing of most foods begins around 30°F. and is not completed at much lower temperatures. The greater part of the water freezes at temperatures above 20°F., and for beef about 80 per cent. of the water content is frozen between 30°F. and 23°F. This means that something less than 80 per cent. of the latent heat of freezing must be removed in cooling to temperatures above 23°F. If it is assumed that all the water is frozen at temperatures a little below 30°F., the value calculated for the cooling load will be too high, especially for temperatures between 20°F. and 30°F.

When freezing temperatures are involved, fairly reliable results are obtained by making use of the values for the cooling load given in the accompanying table. Typical calculations are set out to show the method of application. More accurate date are available for some foodstuffs and temperature intervals, and if these are required for particular purposes, they may be obtained by writing to the Chief, C.SI.R. Division of Food Preservation, Private Bag, Homebush P.O., N.S.W.

Table of Cooling Loads (for water content, 75 per cent.).

The cooling load is given in B.T.U. per lb. of foodstuffs beginning from a temperature of -1°C. (30.2°F.). If the water content is different from 75 per cent. the cooling load can be found approximately from the values in the table by dividing by 75 and then multiplying by the value for the water content.

Temperature, °F.	30.2	29.5	29	28	27	26	25	24	23
Cooling Load B.T.U. per lb.	0	40	48	57	62.5	67	70.5	73.5	76.5

Temperature °F.	22	21	20	18	16	14	12	10	0
Cooling Load B.T.U. per lb.	79	81.5	83.5	87.5	90.5	93.5	96	99	109.5

The above values are derived from measurements on beef muscle. The relation between temperature and the extent of freezing does not vary very greatly between different meat and fish products, so that use of the table for other products should give sufficient accuracy for most purposes. The use of this table for products other than beef muscle will, however, be the main source of error in the method of calculating cooling loads.

Typical Calculations.

A. Beef (18% bones; 25% fat; 57% muscle flesh) of overall water content 52% is to be cooled from 68°F. to 17.6°F. The cooling load for one pound of beef is calculated as follows:

1. Cooling the water content (0.52lb.) from 68°F. to 30.2°F.
   $0.52 \times 1 \times 37.8 = 19.7$ B.T.U.

2. Cooling the solids (0.48lb.) from 68°F. to 30.2°F.
   $0.48 \times 0.35 \times 37.8 = 6.35$ B.T.U.

3. Total cooling load between 68°F. and 30.2°F.
   $19.7 + 6.35 = 26.05$ B.T.U. per lb.

4. Freezing and cooling to 17.6°F. From the table of cooling loads, the value for a water content of 75 per cent. is 88 B.T.U. The cooling load for a water content of 52 per cent. is given by
   88 x 52/75 = 61 B.T.U. per lb.

5. Total cooling load between 68°F. and 17.6°F.
   26 + 61 = <u>87 B.T.U. per lb.</u>

The result can be compared with the value 88 B.T.U. per lb. which was obtained experimentally for the conditions specified above (see reference below).

B. <u>Haddock</u>: overall water content 80% is to be cooled from 68°F. to 17.6°F. Consider the cooling of 1 lb. of fish.

1. Cooling the water content (0.8lb.) from 68°F. to 30.2°F.
   0.8 x 1 x 37.8 = 30.2 B.T.U.

2. Cooling the solids (0.2lb.) from 68°F. to 30.2°F.
   0.2 x 0.35 x 37.8 = 2.6 B.T.U.

3. Total cooling load between 68°F. and 30.2°F.
   30.2 + 2.6 = 32.8 B.T.U.

4. Freezing and cooling to 17.6°F. Correcting the value from the table for a water content of 80 per cent., we have
   88 x 80/75 = 94 B.T.U.

5. Total cooling load between 68°F. and 17.6°F.
   32.8 + 94 = <u>126.8 B.T.U. per lb.</u>

This is lower than the value of 132 B.T.U. per lb. found by experiment (see reference below) for this temperature interval. This can be explained by the fact that slightly more of the water content is frozen than is allowed for in the values given in the table. It will be noted that item 2 in the above calculations makes a relatively small contribution to the total cooling load.

<u>Reference.</u>

Calorimetric Investigation of Foodstuffs. A.Perlick. <u>Food Research</u> <u>3</u>: 155 (1938).

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EXAMINATION OF FOOD CANS.

The need for strict attention to all the necessary precautions required to ensure that metal cans used as containers for heat-processed foodstuffs should be so constructed and handled that the risks of spoilage of the contents due to microorganisms entering the cans after processing are reduced to a minimum is well recognized by those engaged in the food canning industries. At the present time it is particularly important to avoid the wastage of tinplate, manpower, and food due to the use of cans which do not give adequate protection to their contents.

During the past six months, evidence has been obtained in this laboratory which indicates that losses due to leaky cans have frequently been higher than the generally recognized safe upper limit of 5 cans per 1000, while in two specific instances involving the loss of at least 100,000 cans the figures were respectively 300 and 500 per thousand. In the two latter instances the cans were leaky because of faulty soldering of the side seams and cracking of the embossing letters in one group, and because of incorrectly formed end seams at the can-makers end in the other group. Cases of this kind emphasize the necessity for strict attention to the regular examination and testing of cans, particularly by means of leakage-pressure tests and a study of seam dimensions and contours.

Can-making machinery and can-closing machines require frequent and close examinations to ensure the efficiency of their adjustments and operation.

In regard to the sealing compounds used in the ends of double-seamed sanitary style cans, it is advisable to adhere strictly to the recommendations given by the manufacturers of the particular compound in use. In addition to providing a correct dry film weight, it is also necessary to ensure that the compound has been uniformly distributed around the circumference of the end.

An outline of the can-testing methods employed in this laboratory has been given in the Divisions Food Preservation Quarterly, Vol.3, Nos.1 and 2 (1943).

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pH AND SOME OF ITS APPLICATIONS IN FOOD PROCESSING.

The term pH is frequently used in connection with descriptions of various processes employed for the preservation of foods and its significance in relation to the preparation and preservation of foods will be briefly discussed.

A complete understanding of pH requires a knowledge of chemistry and mathematics, but it is intended to present this description in such a form that its essential features will be understood by those with only a limited knowledge of these subjects. The practical food processor will be concerned mainly with the actual meaning of the term pH, which is not so descriptive as other more familiar terms such as acidity and alkalinity. When used in relationship to pH, the point of neutrality is that of pure distilled water which is 7 at a temperature of 22°C (71.6°F); aqueous solutions are acid when the pH is below 7 and alkaline when above 7. In the purest distilled water, which is composed of hydrogen and oxygen, an extremely small amount is ionized or dissociated into hydrogen ions (H) and and hydroxyl ions (OH). The quantities of these two ions are equivalent or of equal molar concentration, and for this reason water is regarded as being neutral. If a substance such as hydrochloric acid is added to water, portion of the acid is dissociated into hydrogen (H) and chlorine (Cl) ions. The concentration of hydrogen ions in such a solution will therefore be greater than in the case of pur water. If a base such as sodium hydroxide (NaOH) which yields hydroxyl (OH) ions on dissociation is added to water, the concentration of (OH) ions of the solution increases and that of (H) ions decreases. From this discussion, a solution will be:-

Neutral if (H) = (OH)

Acid if (H) is greater than (OH)

Alkaline if (H) is less than (OH)

When neutral salts such as sodium chloride (NaCl) are added to pure distilled water there will be no change in pH of the water, since the amounts of (H) and (OH) ions in the water are not altered.

The next step in the explanation of pH can now be put forward by stating that this term, which is really a symbol, refers to the hydrogen ion concentration of the solution, or in other words, its content of dissociated or active hydrogen, expressed as gramme per litre of the solution. Although water contains approximately 111 gramme of hydrogen per litre, only one ten-millionth of a gramme of this hydrogen exists in the dissociated or active form as determined, for example, by measurement of electrical conductivity or the use of the electrical method employing the hydrogen electrode. Why then is the pH of water 7 when its concentration of hydrogen ions (H) is only one ten-millionth of a gramme per litre? The explanation is that pH is a symbol adapted from the logarithmic system. Taking the number 10 as the unit, the logarithms of 10, 100, 1000, 10,000000 are 1, 2, 3, and 7 respectively, since these represent the powers to which 10 is raised to equal the given numbers e.g. 10x10x10 or 10^3 = 1000. In a like manner the logarithms of $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{1000}$, and $\frac{1}{10,000000}$, are minus 1, minus 2, minus 3, and minus 7. The logarithm of the hydrogen ion concentration of pure water, therefore, is minus 7, but in expressing this as pH the minus sign is always omitted.

To quote other examples, the logarithm of the concentration of hydrogen ions (82 thousandth of a gramme) in a litre of solution of tenth-normal hydrochloric acid is minus 1.08 and the pH of the solution is 1.08. Again, the logarithm of the concentration of hydrogen ions ($\frac{1}{15}$ millionth of a gram) in a litre of tenth-normal solution of sodium hydroxide is minus 10.5 and the pH is 10.5. It will be seen therefore that the pH increases as the hydrogen ion concentration decreases. The chief object of the use of the symbol pH is to avoid the use of the very unwieldy figures required to express actual hydrogen ion concentration. When the pH is given, the hydrogen ion concentration can be calculated by referring to tables of logarithms. It is important to remember that the pH or hydrogen ion concentration of a solution is not a measure of its total acidity or alkalinity but is rather a measure of its active acidity or alkalinity. For example, although tenth-normal solutions of hydrochloric acid and of acetic acid are of equal total acidity, requiring equal volumes of tenth-normal alkali for their neutralization, the hydrogen ion concentration of the solution of hydrochloric is considerably greater than that of acetic. This difference is due to the fact that, although the total amount of replaceable hydrogen per litre is similar in each solution, the proportion of hydrogen in the ionized or active form is sixty times as great in the solution of hydrochloric as in that of acetic. From this standpoint, hydrochloric is regarded as a strong and acetic as a weak acid. In a like manner, the strong solution of alkalies are those with high concentration of active hydroxyl ions and low concentrations of active hydrogen ions.

Application of pH in Food Processing.

The approximate pH values of some common canned foods are:- lemon juice 2.4, pineapple juice 3.5, orange juice 3.7, peaches 3.8, plums 3.8, tomatoes 4.3, parsnips 5.0, carrots 5.2, cabbage 5.4, silver beet 5.5, potatoes 5.5, beetroot 5.5, and corned beef 6.0. Although all these foods lie within the acid range of pH, that is below 7.0, there is a wide range in active acidity from the fairly strongly acid lemon juice up to feebly acid substances such as meat. These differences in pH are of great importance in deciding upon the heat processes required to produce canned products which will remain free from spoilage by microorganisms.

The most heat-resistant microorganisms found on foods are bacterial spores which, with one or two exceptions, are incapable of germinating and multiplication in material with a pH lower than 4.5. Therefore, it is well known that the less acid foods with a pH greater than 4.5, such as vegetables and meats, require considerably higher processing temperatures to render them commercially sterile than the more acid foodstuffs, such as nearly all fruits and tomatoes, which have a pH less than 4.5.

Practical application of this relationship is sometimes made by reducing the pH of certain foods prior to canning so that lower heat processes can be safely used. This applies particularly to vegetables such as asparagus and cauliflower in which the texture is adversely affected by the heat processes normally required to sterilize the canned products. The necessary reduction in pH may be obtained by the addition of certain acids such as citric, acetic, or lactic. The amount of acid required can be accurately determined by measuring the pH by any of the known methods such as the use of either hydrogen, or glass electrodes. For less accurate adjustments, use can be made of certain dyestuffs which change colour in the particular zone of pH through which the change is being made. The presence of natural pigments in the tissues, however, often renders the latter method incapable of application.

Jams provide further examples of the advantages of adjustment of pH. The inversion of added cane sugar and the formation of a firm jelly from the pectin are both desirable properties which are dependent upon the actual acidity of the product. The optimum pH range for setting of the jelly is between 3.0 and 3.5. With certain fruits which are naturally of high pH (less acidic) the only possible means for obtaining a jam with good jellying properties is to reduce the pH to the required range. For this purpose citric acid is commonly employed.

Finally, the preservative effect of acetic acid when used in pickles and sauces is partly due to its effect in lowering the pH of these products.

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