Food Preservation Quarterly

Published by

DIVISION OF FOOD PRESERVATION, COMMONWEALTH COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

Vol. 6. Nos. 3 and 4. September/December 1946.

*K 124 44560—*a*

Food Preservation Quarterly

Vol. 6, Nos. 3 and 4. September/December, 1946.

CONTENTS

Published by

DIVISION OF FOOD PRESERVATION
COMMONWEALTH COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

PROTECTION OF WALLS OF COLD ROOMS AGAINST DAMAGE BY MOISTURE.

By

M. C. Taylor.

The condensation of moisture inside the walls of cold rooms may lead to one or more of the following troubles:—

1. Impairment of insulation value so that heat is conducted more easily. This puts an increased load on the refrigerating plant, and makes it more difficult to control temperatures.
2. Mechanical breakdown of the structures due to swelling and rotting.
3. Spoilage of stored commodities due to dripping of water from walls and ceiling.

The losses due to any one of these troubles make it desirable to protect the walls against the ingress of moisture by suitable methods of construction.

Before specifying the general methods of construction to be followed, it is desirable to discuss briefly the underlying theory which leads to an intelligent choice and use of building materials.

It is well known that the atmosphere consists of a mixture of several gases of which water vapour is the only one condensable at ordinary temperatures. Whereas most of the gases occur in nearly constant proportions, the amount of water vapour present in a given space is very variable. The maximum amount of vapour which may be present in the space without the possibility of condensation depends on the temperature, and the amount increases as the temperature is raised. The pressure exerted by the vapour varies in the same way (referred to as the partial pressure of the water vapour to distinguish it from the total pressure of the atmosphere). If the amount (or pressure) of the vapour is less than the maximum value (saturation value), the percentage relative humidity is used to express the amount. Knowing the temperature and the relative humidity it is possible to calculate the pressure and amount of water vapour in any given space by referring to a table which gives values for saturation. Table 1 of the Appendix gives some values for the partial pressure of water vapour expressed in pounds per square inch for various degrees of saturation and for some temperatures met with in cold storage work.

Water vapour, as such, does not often cause serious trouble in refrigerated rooms, but, as the temperature is lowered with any given concentration of vapour, a temperature (dew-point) is reached which corresponds to saturation and the vapour may begin to condense either as liquid or as frost. As the water, or frost, is less harmful in some positions than in others, efforts should be made to control the location and extent of the process. This can be done by making use of the fact that the refrigerating coils are at the lowest temperature of the system and arranging that condensation takes place only at the coils.

Water vapour will inevitably be introduced to the room by air leakage and diffusion from outside and by evaporation from stored produce. If a commodity is of high water content, it may lose a large quantity of water by evaporation and transfer to the refrigerating coils, but this source is not likely to contribute an appreciable quantity of water to the walls unless they contain materials of a hygroscopic nature. The outside air then remains as the important source of troublesome water vapour, and under normal conditions there is a continuous flow of vapour from outside the room to the refrigerating equipment.

The water vapour may be brought into the room by either of two methods. The more obvious way is by the movement of air through doorways or cracks, but this transfer is usually less harmful as far as insulation is concerned. The process of transfer by diffusion must be studied to gain an appreciation of the reason for the penetration of water into the insulation. Diffusion of a vapour is due to the ceaseless activity of the constituent molecules, and if the vapour pressure is not uniform, a net transfer of vapour tends to take place to regions of lower vapour pressure.

The vapour pressure on the cold side of walls is almost always lower than that on the hot side, and in warm humid weather the difference may be around ½ lb. per square inch. The difference in vapour pressure will cause diffusion of water vapour into and through the insulation unless there is an absolutely impermeable water vapour barrier on the hot side of the insulation. Various water vapour barriers are used to reduce the penetration of water vapour, but few, if any, of these materials are completely impermeable. Some of them are, however, so good that they will transmit less than 1 lb. of water per square foot during 100 years under average conditions. (See appendix 1.)

The position in the wall of these special barriers is very important. Since the wall is primarily constructed as a barrier to heat flow, it follows that there is a temperature gradient as well as a vapour pressure gradient through the wall. The actual values of the temperature and vapour pressure at any point in the wall, which determine whether condensation will take place or not, depend on the nature and location of the barriers to heat flow and to vapour flow. A sheet of material which is an excellent barrier to water vapour may be a good conductor for heat, and vice versa. These properties make it possible to adjust the values of temperature and vapour pressure throughout a wall by the choice and location of suitable materials of construction.

If the thermal conductivity of the insulation is above a certain value, condensation will occur on the outer face of the wall in warm humid weather. This is often objectionable in itself and is generally an indication of inadequate insulation, i.e., it generally pays to use insulation thick enough to prevent condensation on outer walls at any time. To meet the danger of condensation at points within the wall, the vapour pressure must be kept below the saturation value which is determined by the temperature at these points. This implies that the main barrier to water vapour should be on the side of higher vapour pressure, i.e., the warm side. If the wall is completely sealed on the cold side only, there is almost certain to be condensation within the insulation next to the seal. This condition occurs with insulated cold metal ducts, such as refrigerant pipes, which pass through warm, humid air. Unless the insulation is completely sealed on all sides, it is preferable to leave it comparatively open on the cold side so that any vapour which does penetrate the wall can escape to the room. (See appendix 2.)

The use of hygroscopic materials for heat insulation leads to further complications in design. When the relative humidity of the air in contact is high, such materials tend to absorb an appreciable amount of water which impairs the insulation and may lead to troubles from fungal growth. Such materials should be well protected on the inside wall also, but care should be taken to ensure that the outside seal is the more effective. For further protection, each unit slab of insulation may be sealed on all sides by dipping in hot bitumen; in some applications the insulation is thoroughly dried out and the slabs are then hermetically sealed in sheet metal. The sealing of each slab of insulation is also useful when a cold room is allowed to warm up for short periods at intervals. Moisture from the warm air admitted to the room is likely to penetrate and quickly saturate the cold insulation unless it is protected in this way.

A severe limitation to the design of insulation for cold rooms is the inadequacy of data on materials available for construction. Although permeability figures are given for many materials (1, 2) these figures are not always applicable to apparently similar materials or to the same materials with different methods of construction. In addition more needs to be known about the ageing characteristics of materials. At present it is difficult to forecast whether the life of an installation is going to be five, ten or twenty years, although this would be possible if the effectiveness of the vapour barriers was known throughout their life. It might also be mentioned that an installation which proved satisfactory for one type of service might not be satisfactory in another application. A bad installation usually shows up after the first summer, but the deterioration may not be very severe till the second summer.

The discussion leads to two main principles which should be applied when designing the walls of cold rooms.

1. The thickness of insulation (barriers to flow of heat) should be sufficient to keep the temperature of the outside face of the wall above the dew point of the external air under normal summer conditions. This ensures that the outside walls will not "sweat."

2. The barriers to the diffusion of water vapour into the insulating material should be as effective as possible, and in addition the most effective barrier should be placed on the warm side of the wall. Any vapour which does penetrate the wall is then unlikely to build up the concentration to the condensation point.

It must be emphasised that the selection of suitable materials for a building does not complete the application of these principles. The methods of construction must be directed to the same ends, and in particular it must be ensured that the vapour barriers are properly sealed so that there are no breaks.

Appendix.

Estimates of Performance of Some Walls.

1. The Refrigerating Data Book (2) gives the permeability of heavy roofing sheets as 0.03 grains per sq. ft. per day per mm. of Hg. By combining this sheet with other moisture proofing materials we might expect to realise a permeability rather less than 0.01 grains per sq. ft. per day per mm. Hg. If the vapour pressure difference is taken as 10 mm. Hg. (= 0.19 lb. per sq. inch), the amount of water transferred in one year $= \frac{0.01 \times 365 \times 10}{7000} = 0.0052$ lb. per sq. ft., i.e., it would take more than 100 years to transfer 1 lb. of water through each sq. ft. of this barrier under the conditions stated.

2. Many materials which are commonly used for protecting insulation have a much higher permeability than the above figure, possibly 200 times as much. This means that sufficient water to damage the insulation could be transferred in one year or less, so that if condensation takes place at any point in the wall, rapid deterioration of the installation is possible. If the major part of the vapour resistance is concentrated on the warm side of the wall, condensation may not take place in the insulation, but any hygroscopic materials are likely to show deterioration due to the absorption of water from the moist air in contact with them. As the thermal conductivity generally increases with increasing water content, the breakdown is progressive and condensation may occur in the wall within a fairly short period of time.

As an example of a poor installation we may consider a room insulated with sawdust (which is hygroscopic) between a half inch thickness of wood on each side. The permeability of the wood to water vapour can be taken as 100 grains per sq. ft. per day when the pressure difference is 1 lb. per sq. in. Take the air conditions on the hot side of the wall as 80° F. and 50% R.H., and on the cold side 35° F. and 90% R.H. Then the temperature on the warm side of the sawdust will be 77.5° F. approx., and on the cold side 39.25° F. approx.*; and the difference of vapour pressure across the wall is (0.253 — 0.090) = 0.163 lb. per sq. in. Since the barriers have equal resistance, the vapour pressure within the sawdust will tend to approach the value 0.171 lb. per sq. in. which is mid-way between the values on either side of the wall. This means that condensation is likely at points in the sawdust where the temperature is less than 49°F. When condensation begins near the inner face, the rate of diffusion through the outer barrier will correspond roughly to a vapour pressure difference of (0.253 — 0.118) = 0.135 lb. per sq. in. Under these conditions the amount of water vapour diffusing into the sawdust per year will be $\frac{100 \times 365 \times 0.135}{7000} = 0.7$ lb. per sq. ft. of wall surface. Some of this, probably about 20%, will diffuse through the wood on the inside to the air of the cold room and the rest will be absorbed in the sawdust. If the sawdust is about four inches thick, this would correspond to nearly 15% increase in water, which is sufficient to make a noticeable difference in the performance of the installation.

It is interesting to see what happens when the resistance of the vapour barrier on the outside wall is increased 100 times by covering the wood with a good building paper. The temperature distribution will be much the same as realised with the original installation in its new condition, but the vapour pressure in the sawdust will now tend to be only 0.092 lb. per sq. inch compared with 0.171 previously possible. The lowered value corresponds to a relative humidity just under 80% at the coldest part of the sawdust (39.25° F.), so that there is no danger of condensation. The water content of the sawdust is likely to increase till it comes into equilibrium at a higher relative humidity, but there should be no severe rotting even at the point of highest relative humidity (80%). The amount of water vapour diffusing right through the wall will be about one hundredth of the previous amount. This result could be achieved by increasing the resistance of the inside barrier, but in this case there would be rapid condensation within the sawdust making it worthless as an insulating material.

Table 1.—Partial pressure of water vapour in lb. per sq. in. as a function of temperature and relative humidity.

Temperature, degrees F.	Relative humidity, per cent.					
	100.	90.	80.	70.	60.	50.
100	0.9487	0.854	0.759	0.664	0.569	0.474
90	0.6980	0.628	0.558	0.489	0.419	0.349
80	0.5067	0.456	0.405	0.355	0.304	0.253
70	0.3628	0.326	0.290	0.254	0.218	0.181
60	0.2561	0.230	0.205	0.179	0.154	0.128
50	0.1780	0.160	0.142	0.125	0.107	0.089
40	0.1217	0.109	0.097	0.085	0.073	0.061
35	0.1000	0.090	0.080	0.070	0.060	0.050
30	0.0808	0.073	0.065	0.057	0.048	0.040
20	0.0505	0.045	0.040	0.035	0.030	0.025
10	0.0309	0.028	0.025	0.022	0.018	0.015
0	0.0185	0.017	0.015	0.013	0.011	0.009

Example: External atmosphere, 80°F. at 50 per cent. R.H. Internal atmosphere, 35°F. at 90 per cent. R.H.

Then the differential of vapour pressure across wall forcing water vapour inwards = (0.253 — 0.090) = 0.163 lb. per sq. in. The dew point of the external atmosphere is fairly close to 60°F. which corresponds to a saturation pressure of 0.2561 lb. per sq. in. It follows that no point in the wall to which vapour can penetrate easily should be at a temperature lower than 60°F.

References.

1. Woolley, H. W. (1940)—Moisture Condensation in Building Walls. Building Materials and Structures Report BMS 63. U.S. Dept. of Commerce, National Bureau of Standards.

2. American Society of Refrigerating Engineers (1943)—Refrigerating Data Book, Fifth edition, p. 154, New York.

*The thermal resistances expressed as hr. x sq. ft. x °F./B.T.U. used in deriving the above temperatures are as follows:

Air to outside surface, 0.17.
Air to inside surface, 0.61.
½" thickness of wood, 0.5.
4" thickness of sawdust, 10.0.
Total resistance of wall = 11.78.

AIR TRANSPORT OF CARGO.

THE use of aeroplanes for the carriage of agricultural products is a post-war development which is arousing considerable interest at present. An excellent review of the subject, "Air Transportation of Primary Products: Possibilities and Implications," by K. O. Campbell appeared in "Review of Marketing and Agricultural Economics," v. 14, No. 6, June, 1946, pp. 193-200, which is available from the Department of Agriculture, New South Wales.

Mr. Campbell points out that the extensive use of aircraft for transport of freight during the war period has focussed attention on the possibility of transporting a greatly increased volume of civilian goods by air in future. Perishable agricultural products appear to be one class of commodities which have potentialities as air freight. Such an advance in marketing technology, if it becomes a reality, is likely to have a marked effect on the production and distribution of perishables.

Several research agencies, conscious of possibilities in this field of transportation, have been conducting investigations during the past few years. Air transportation of primary products is, however, no longer in the blue-print stage. Large scale shipment of fruit and vegetables have already been made on a commercial basis. In the latter months of 1945, a regular service carrying 60,000 lb. of perishable produce per week operated between California and Eastern United States using seven freight planes. Small shipments of fruit and vegetables have also been made in Australia.

The chief advantage of air transport for foods and flowers is that speed and reduction of handling enable the produce to reach its market in better condition. Fruits can be harvested at full maturity, which improves flavour and nutritive value. Highly perishable berry and tropical fruits can be marketed much farther from their growing place than was previously possible.

Air transport may alter existing agricultural practices by encouraging the cultivation of some attractive varieties which are at present unpopular with growers because of poor carrying qualities. Proximity to markets may cease to be important, and the location of growing areas may, in future be governed only by suitability for cultivation of the crop.

The use of aircraft for cargo will depend more than anything else on the cost. At present the rates are 20-25 times greater than railway rates in Australia, but in U.S.A. air-freight rates have dropped sharply, sometimes to as low as 50% of the pre-war rate. This may be due to the acquisition of surplus war planes at low cost, which would not be available to the same extent in Australia. The existing air-freight services and passenger services in which foods would make up a small part of the mixed cargo do not seem to be the most economic method. Such services follow set routes and may have scheduled stops. The goods could be carried at lower cost by a contract carrier plying directly between producing district and the market, particularly if a supply of agricultural products is available from nearby areas throughout the year, and cargoes of manufactured goods from the cities are carried on return journeys.

Correct packaging for air shipment may make the difference between making and losing money by the use of air transport. As handling is less severe lighter containers may be used and freight charges thus reduced. Containers that afford some insulation are particularly good, as temperature changes on air journeys are often great. A feature of the commercial development of air transport of fruit and vegetables in America has been the use of packages containing the quantity of produce commonly bought by the housewife. For example spinach has been washed, sorted, and removed from the stems and packed ready for use in 10 oz. bags, with a saving in weight of about 50%. Fruits are packed in 1 lb. cartons with cellophane windows for inspection. The American housewife is already accustomed to buying quick-frozen fruits and vegetables in such packages. The use of these containers and their carriage direct from grower to retail store may be found essential to the success of air transport of foods.

Mr. Campbell concludes that air transport will not, in the near future, absorb any significant proportion of the total traffic in agricultural produce at present carried by surface traffic, but it will supplement surface carriage and may make possible the marketing of commodities which cannot be conveyed under existing conditions. He also discusses briefly the possible future competition between air-borne and quick-frozen fruits and vegetables.

Another review "Air Transport of Agricultural Perishables" has been issued by the United States Department of Agriculture as Miscellaneous Publication 585 (January, 1946). The opportunities for air transport seem greater in America, where many of the large cities are in a zone with a severe winter, and must have all their fresh fruit, vegetables and flowers brought, for a large part of the year, from distant areas. In addition to discussing potential volume of goods traffic by air and freight rates, this publication deals in more detail with the aspects treated in Mr. Campbell's article, and also discusses briefly types of planes, airports and other handling facilities.

CHEMICAL PRESERVATIVES IN FOODSTUFFS.

PART 2.

By

M. R. J. Salton, D. I. Annear and D. F. Ohye.

1. Benzoic and Salicylic Acids.

During the earlier part of this century there was a great deal of controversy concerning the desirability of sodium benzoate as a foodstuff preservative. Wiley (1917), a worker in the United States and the chief antagonist to its use contended that it was a poison and should be prohibited. The referee board appointed by President Theodore Roosevelt to investigate the possible toxicity of sodium benzoate concluded that the daily dosage necessary to incur any hazard to health was far in excess of the amounts likely to be ingested from preserved foodstuffs. Folin, who was concerned in these investigations, stated further that of all the chemical preservatives then in use, sodium benzoate was probably the least harmful to human beings.

To-day, benzoate is one of the most widely used of the chemical preservatives. So also is salicylic acid, which, incidentally, Wiley regarded as less objectionable than benzoic acid. Both of these acids are permissible preservatives in all States of Australia. The foodstuffs in which they are permitted and the concentrations above which they are prohibited vary from State to State. Their use is restricted entirely to fruit and vegetable products and they find their greatest application in fruit juices, cordials, fermented drinks, temperance drinks, tomato sauce and tomato chutney. The concentrations allowed vary, in the case of benzoic acid, from 0.002% to 0.1% and in the case of salicylic acid from 0.002% to 0.014%.

It has been known for many years that the inhibitory activity of weak acids such as benzoic and salicylic towards microbial growth is influenced by the hydrogen ion concentration of the medium. This effect is quite separate from that of the hydrogen ion itself which also has a strong influence on the growth of micro-organisms. Cruess (1932) drew attention to past reports of sodium benzoate failing to prevent spoilage in commercially packed foods of low acidity whereas little difficulty had been encountered with acid food products such as fruit juices. Working with a number of strains of yeasts, moulds and bacteria, Cruess found that the concentrations of sodium benzoate and sodium salicylate necessary to inhibit the growth of these organisms in fruit juices and laboratory media was significantly greater in the range pH5 to pH9 than in the range pH2 to pH4.5. Such marked variations were not obtained with inhibitory substances such as formaldehyde or sodium chloride in high concentration. At pH7 a 4% concentration of sodium benzoate was necessary to prevent growth of most of the fermentation organisms studied whereas at pH3.5-4, the range for most fruit juices, only 0.06% to 0.1% was needed. One strain of *Penicillium* grew vigorously in a 10% concentration of sodium benzoate near neutrality. *Clostridium botulinum*, the causative agent of botulism grew and produced toxin in asparagus juice of pH7.4 and with a sodium benzoate content of 0.8%. Cruess stressed the danger of attempting to preserve non-acid foods with sodium benzoate because of this potential risk of the growth of *Cl. botulinum* under these conditions. His findings for a wide variety of naturally contaminated foodstuffs were essentially the same as those for experimentally inoculated mediums. This author believed that it was the undissociated molecules of these weak acids and not their ions that were the preservative agents.

Rahn and Conn (1944) placed this reasoning on a firm basis when they demonstrated that the inhibitory concentrations of benzoic and salicylic acids at all acidities represented a constant amount of undissociated acid. Further observations by Huntington and Rahn (1945) showed that this held true for a wide range of weak acids.

An interesting application of benzoic acid as a preservative was that described by Tarr and Bailey (1939). These workers tested ice made from a 0.1% solution of benzoic acid in tap water as a preservative for freshly caught fish but found that the keeping quality of the fish in this medium as judged by bacterial counts and trimethylamine tests was little better than that of the fish stored in ice made from tap water alone. They do point out, however, that benzoic acid ice is practically a sterile ice, bacteriologically, and may be useful in fish cleaning and handling processes where ice is manufactured from water with a high bacterial content.

Recently Wyss and Poe (1945) investigated the germicidal properties of a wide range of substituted benzoic acids and the salts of these acids. Substitution in the *ortho* position was, generally speaking, superior to that in either the *meta* or *para* position. Of the group of compounds tested, o-hydroxy benzoic acid was the most active against the two test organisms, *Bacterium typhosum* and *Staphylococcus aureus*. It is possible that this work may yield suitable and more effective food preservatives than benzoic acid.

2. Sulphur Dioxide.

Sulphur dioxide is used chiefly in the preservation of fruit juices, fruit cordials, syrups and certain unfermented and fermented beverages in concentrations from .5 to 2 grains per pint. Its use is permitted in all States of the Commonwealth in the above-mentioned products, as well as in sausage meat, potted meat, pressed meat and brawn. Doubt exists as to its effectiveness as a preservative in the latter-mentioned products, but the addition improves the colour imparting the appearance of fresh meat. Apart from nitrates and nitrites used in the curing of meats, sulphur dioxide is the chief inorganic substance employed as a chemical preservative.

Rahn and Conn (1944) have shown that sulphurous acid like benzoic and salicylic acids is nearly one hundred times more efficient as a preservative in strongly acid solutions than in neutral solutions. Sulphur dioxide forms the dibasic sulphurous acid of which the SO_3-ion is without effect. The HSO_3-ion inhibits the growth of bacteria but not yeasts. Bacteria which are more sensitive to inhibitory concentrations can tolerate as much as ten times the lethal concentrations for yeasts, before they are killed. The effect on yeasts is due to the undissociated H_2SO_3 molecule of which a very low concentration prevents multiplication. At high acidities SO_2 is a good disinfectant and the effective principle is the undissociated H_2SO_3 molecule. According to these workers the difference in efficiency of undissociated molecules and ions of the same acid may be explained by the fact that it is difficult for ions to permeate living cell membranes.

The results of Cruess, Richert and Irish (1931) also show that it is the undissociated H_2SO_3 molecule, the HSO_3 ion or possibly the anhydride SO_2 which exerts the toxic action.

The following table gives the concentration of SO_2 (in parts per million), required to prevent the growth of various organisms at different pH levels.

	Saccharomyces ellipsoideus.	Mucor mould.	Penicillium mould.	Mixed bacteria.
pH Value	ppm.	ppm.	ppm.	ppm.
2.5	200	200	300	100
3.5	800	600	600	300
7·0	above 5,000	above 5,000	above 5,000	1,000

The marked influence the pH value of the medium has on the effectiveness of the preservative, can be seen from this table.

It has been found that certain substances reduce the effectiveness of SO_2. Cruess, Richert and Irish state that sulphur dioxide combines with sugar and other compounds in fruit juice and that the combined form has very little preserving power. This is important in such products as concentrated syrups where the sugar content is high.

Sulphur dioxide is used in the wine industry to prevent the spoilage of the grape juice by wild yeasts. The yeast culture used for fermentation is less susceptible to the effect of sulphur dioxide and the growth of contaminants is thereby controlled.

Work carried out on fermented cider showed that three factors influenced the preservative action by sulphur dioxide namely, alcohol, nitrogenous matter and sugar content. Should these three factors be thrown out of balance the control of the growth of yeasts is not effective at a given concentration of sulphur dioxide.

3. Boric Acid.

Boric acid and borates were used extensively until recent times in such products as cream, butter, liquid egg, potted meats and some beverages. It was also permitted for the preservation of hams and bacon imported into England. When so used it was dusted over the product. In Australia some States permit its use in products such as concentrated milk, cream, rennet, junket tablets and essence.

According to Rost, boric acid exerts only feeble action on bacteria and must be used in large amounts to be effective. Tomkins (1937), on investigating fungicides suitable for food preservation showed that the retarding effect of borax was much more pronounced in alkaline than in acid solutions and suggested that it might be more profitable to allow the borax to act in lower concentration in an alkaline medium than in higher concentration in an acid medium.

It is generally accepted that boric acid is poisonous when taken in large doses. Wiley stated that boric acid or borates when administered in small amounts for a long period, or in large quantities for a short period created disturbances of appetite, digestion and health. He, therefore believed that its use should be prohibited in foods.

References.

Cruess, W. V. (1932).—Ind. Eng. Chem. 24: 648.

Cruess, W. V., Richert, P. H. and Irish, J. H. (1931).—Hilgardia. 6: 295.

Huntington, G. I. and Rahn, O. (1945).—J. Bact. 50: 655.

Rahn, O. and Conn, J. E. (1944).—Ind. Eng. Chem. 36: 185.

Rost. As quoted by Tanner, F. W. The Microbiology of Foods. 2nd ed. Garrard Press, Champaign, Illinois (1944) p. 10.

Tarr, H. L. A., and Bailey, B. E. (1939).—J. Fish. Res, Bd, Canada 4: 327.

Tompkins, R. G. (1937).—Trans. Brit. Mycol. Soc. 21 : 126.

Wiley, H. W. (1917).—Foods and Their Adulteration, 3rd ed. J. and A. Churchill, London (P. Blakiston's Son & Co., Philadelphia).

Wyss, A. P., and Poe, C. E. (1945).—Proc. Inst. Food Technologists p. 21.

MATURITY OF SWEET CORN.

To ensure that sweet corn is canned at the stage of maturity which will yield the most attractive product it is necessary to be able to predict the date of its maturity. Investigations have been carried out at the Homebush laboratory of the Division of Food Preservation on the prediction of maturity from the date of sowing and the weather. A more precise prediction can be made by determining the rate of moisture loss of the developed cob during the last ten days or so prior to picking, depending on the time of season at which the cob matures. Moisture loss in general has been found to vary between 1.75 and 1.79 per cent. per day. These data, combined with the known fact that sweet corn should be picked when its moisture content is in the range 66-71 per cent., enable the canner to arrange picking times with a satisfactory degree of precision. A quick and simple means of determining the moisture content of the corn is needed to make use of these findings. An excellent correlation has been found to exist between the refractive index of the grain mash and its moisture content. Maturity testing by means of the refractometer has been described by G. C. Scott in "The Canner," Convention Number, pp. 80-82, 1939, and by Scott and others in "Food Industries," v. 17, No. 9, pp. 1030-1032, 1945.

More recently A. Kramer of the University of Maryland and H. R. Smith of the National Canners Association Research Laboratory (U.S.A.) have designed a new instrument the "Succulometer," which they describe in "The Canner," v. 102, No. 24, pp. 11-13, 1946. This apparatus measures the amount of juice expressed from a known weight of corn under a certain pressure. It has been used successfully for moisture determination in raw corn, and also in canned corn, whole-kernel style.

Another simple piece of apparatus of interest to those canning corn is the "Adams Consistometer" which may be used for measuring the consistency of a number of foods. It is described by M. C. Adams and E. L. Birdsall in "Food Industries," v. 18, No. 6, pp. 844-846, 1946. It is a round plate marked with concentric circles, on which the corn or other food to be tested is deposited from a container in the form of a truncated cone open at the ends. The circle to which the corn has spread after a certain time is a measure of its consistency.

ONION VARIETIES FOR DEHYDRATION.

By

T. M. Reynolds.

Dehydrated onion is an attractive product with many potential uses both in the home and in industry. Considerable quantities of onion and garlic were dehydrated in America before the war and small quantities of onion were dehydrated in Australia. Production was expanded enormously in both countries during the war and the experience gained should assist in the establishment of a stable peace-time industry.

The processing of onions is relatively simple and the quality of the product is mainly dependent on the variety of onion used. A wide range of onion varieties has been studied in this laboratory over the past two seasons and this investigation is still in progress. At least one more season's work will be necessary before the results can be published in full but the main effects are already clear. This work has been carried out in co-operation with the Division of Plant Industry of C.S.I.R. and the onions have been grown under irrigation at Canberra. The growing conditions were very different from those obtaining in the main onion-producing districts of Victoria, but were satisfactory for the initial investigation of varietal characteristics. In the coming season onions grown in at least one Victorian district will be studied.

The work done so far has made it possible to define the characteristics required for dehydration. These may be summarised as follows:—

(1) *Weight.* The weight of most of the bulbs should be between 6 and 14 ounces. A high average weight will lessen handling costs and trimming losses but very large bulbs are difficult to handle.

(2) *Shape.* This should be spherical or slightly elongated. Flattened types are more difficult to trim particularly if either the upper or lower surface is at all depressed.

(3) *Dry Bulb Scales.* To be ideal these should be few in number, thin, and easily removed. There is some doubt whether these characteristics are compatible with a long storage life of the fresh onion and some compromise may be unavoidable.

(4) *Neck Formation.* The neck should be raised and well-filled to facilitate trimming.

(5) *Colour of Fleshy Scales.* These should be white or yellow, with a preference for pale yellow. There should be no red or purple pigmentation because this usually becomes dull or discolored in the dehydrated product.

(6) *Storage Life.* The fresh onion should be capable of being stored for several months with little deterioration so as to prolong the processing season.

(7) *Twinning.* The variety should be free from a tendency to form twins or multipliers in order to facilitate trimming.

(8) *Solids Content.* The fresh onion should have a high total solids content so that it will give a high yield of dehydrated material. The solids content should be at least 12 per cent.

(9) *Pungency.* The main use of dehydrated onion is as a flavouring agent so that the fresh onion must be very pungent. The volatile sulphur content should be at least 150 p.p.m. on the fresh basis.

(10) *Reducing Sugar Content.* The reducing sugar content should be low and should not exceed 3.5 per cent. on the fresh basis. A high percentage of reducing sugar increases the tendency to scorch during dehydration.

A rating system has been devised on the basis of the ideal set out above and used as a means of assessing the quality of the varieties studied. Twenty-two varieties were grown in each of the two seasons but only eleven varieties were grown in both seasons, and of these only five were grown from the same seed line. The general quality of the bulbs was better in the second season except that there was a greater occurrence of twins or multipliers. The solids contents were of the same order in both seasons, but the volatile sulphur contents were lower in the second season. In cases where the same variety was grown in both seasons the agreement between the ratings was generally good, and where any discrepancy occurred it was not such as to alter the overall rating of the variety.

Both in these investigations and in similar work carried out in America it has been found that very pungent varieties of onions have a high solids content whilst the weak salad types have a low solids content. These studies have also shown that pungent onions have a low reducing sugar content, whereas weak onions have a high reducing sugar content. Thus the combination of properties required for dehydration, namely, high pungency and solids and low reducing sugars is that which normally occurs. On the basis of their chemical composition the varieties studied may be grouped as follows:—

(a) Highly suitable for dehydration—Australian Brown (also known as Brown Spanish), Ebenezer, Brown Globe Western District, and one line of White Spanish.

(b) Satisfactory—Danver's Yellow Globe and Southport Red Globe.

(c) Borderline—Early Golden Globe, Imperial White Spanish, Pukekhoe and Red Wethersfield.

(d) Not suitable—all salad types.

All of the other varieties fell in between those classed under (c) and (d).

Consideration of the characteristics of the onion bulbs can be confined to the varieties in group (a) because none of the varieties in groups (b) or (c) has any outstanding feature which would cause it to be preferred to the more pungent types. Australian Brown scored well on shape, size and neck, but there was a fair amount of twinning and the dry bulb scales were thick, many in number and difficult to remove. Of the four lines grown in the second season two had 70 per cent. of bulbs with some purple, fleshy scales, and two had 30 per cent. All lines of Australian Brown stored well with respect to rotting and sprouting, but they developed a bitter flavour which was intensified by dehydration. Ebenezer stored well and had yellow and white fleshy scales and good dry bulb scales. However, it was smaller, and twinning was very bad. The line of Brown Globe studied, was very similar to Australian Brown and stored better than is usual for this variety. The White Spanish line scored well on shape, size and colour, but it was a poor keeper and was given low scores for dry bulb scales and percentage of twins.

It is obvious that none of the varieties studied is ideal for dehydration, and the information available about other varieties does not suggest that there are any more suitable alternatives. Since Australian Brown and Brown Globe are so widely grown no good purpose would be served by introducing other varieties which would be better in some respects but less satisfactory in others. The best procedure at present would be to select from material offering of these two varieties the lines with least pigmentation, and to keep the storage period before processing to a minimum.

Work aimed at improving onion varieties for dehydration will lie along two lines, namely, breeding to produce a variety with the desired characteristics, and selection from Australian Brown to obtain lines free from red and purple pigment. It seems probable that a variety more nearly approaching the ideal could be obtained by breeding, but it would take many years to reach this objective. More rapid results should be obtained with a selection programme for Australian Brown. This variety was taken to America from Australia, and in 1935 a strain was released which had 100 per cent. lemon-coloured flesh. It has been found possible to maintain this standard by careful roguing. Some progress has already been made by the Victorian Department of Agriculture in the selection of lines of Australian Brown with relatively low percentages of coloured bulbs.

A complete list of the varieties studied during the past two seasons follows:—Australian Brown (Brown Spanish), Babosa, B.B. Hybrid, Bathurst Brown, Brown Globe Western District, California Hybrid Red No. 1, Colorado No. 6, Crystal Grano, Crystal Wax, Danver's Yellow Globe, Early Flat White, Early Golden Globe, Early Grano, Ebenezer, Extra Early Brown Globe, Hunter River Brown, Hunter River White, Imperial White Spanish, Maitland White, Odourless, Pukekhoe, Red Wethersfield, San Joaquin, South Australian Late White Globe, Southport Red Globe, Stockton G36, Stockton Yellow Globe, Sweet Spanish, Sweet Spanish Utah, Sweet Spanish Valencia, White Bermuda, White Pearl, White Spanish, Yellow Bermuda.

Food Preservation Quarterly

INDEX TO VOLUME 6. (1946.)

Sydney: Thomas Henry Tennant, Government Printer—1946.