Paper Wrappers and Their Effect Upon Physical and Chemical Properties of Horticultural Products
Michigan State University Agricultural Experiment Station
Technical Bulletin
H.D. Brown, Horticulture
Issued January 1928
29 pages

Oakley Lardie

Technical Bulletin No. 87 January, 1928

Paper Wrappers and Their Effect Upon Physical and Chemical Properties Of Horticultural Products

By H. D. Brown

AGRICULTURAL EXPERIMENT STATION
MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

HORTICULTURAL SECTION

East Lansing, Michigan

ACKNOWLEDGMENTS

Special acknowledgment is due the Kalamazoo Vegetable Parchment Co. of Kalamazoo, Michigan, this firm having furnished funds for the investigation and cooperated in every possible way, particularly through their representatives Dr. G. F. Des Autels and Mr. E. C. Stoll. The assistance given by Professor V. R. Gardner and Dr. John W. Crist was valuable and much appreciated.

PAPER WRAPPERS AND THEIR EFFECT UPON PHYSICAL AND CHEMICAL PROPERTIES OF HORTICULTURAL PRODUCTS*

By

H. D. BROWN

Although the making of paper from rag fibers was a well-established industry in China at the dawn of the Christian era, it was not until after the invention of a crude paper making machine by Louis Robert in France in 1799 that paper was produced on a scale such as to warrant its extensive use in the agricultural industries. By 1830, improved paper making machines were employed for the production of great quantities of paper, but the machines that would generally be classed as more or less modern were not perfected until about 1889. Prior to 1860, practically all paper was made from rag fibers. The discovery of the process of making pulp from wood permitted a great expansion of the paper industry.

Even before the supply of paper became abundant, it was used occasionally in connection with horticultural practices, as is indicated by a statement of Worlidge in 1683, "Some anoint the stems of their Trees with Tar, to prevent the Ants from ascending them, but then it is best to bind Paper about the stems and anoint the Paper, for Tar is apt to injure the Bark of your Tree." (28).

In 1837, John Turnbull (25) used papers, which he oiled for protecting dahlias from frost. He states, "For protecting fruit trees when in blossom oiled paper frames have been long in use—. I have been very successful in growing cucumbers and melons under oiled paper frames—. These frames will protect the plants (dahlias) from perpendicular frost until the roots are ripe."

Paper was employed for preserving seeds in 1842 (23). Previous to that time seed was kept in vials, tin cases, and earthen jars but probably not in paper packages (27).

Paper was apparently used for packing and displaying fruits as early as 1847, as is indicated by a statement regarding displays, "We have known a thin sheet of tissue paper to occasion the loss of a medal" (18).

In 1856 brown paper was used to separate layers of pears in barrels (2) and paper was used also around grape bunches packed in bran, in order to preserve their bloom (3). One box of oranges shipped from Australia to England in 1879 was wrapped with paper but the paper proved inferior to sawdust (4). Paper was used for packing figs and peaches in 1879 (13). After this period and in conjunction with the development of the fruit shipping industry, paper was more commonly employed in this branch of horticulture. The use of paper for protecting vegetables in transit came somewhat later and its use for cucumbers and tomatoes was not reported until 1899 (8).

*Adapted from a thesis submitted to the Faculty of Michigan State College in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

As early as 1848, W. Deans (15), in England, employed papers impregnated with tobacco extracts for fumigation purposes in greenhouses although he reported that plants were injured by the fumes. Paper was used previous to 1845 for drying plants for the herbarium (1). According to Slingerland (22), paper collars were first employed to protect cabbage plants from the attacks of root maggots in 1887 and grape clusters were enclosed in paper bags to protect them from disease and insect pests as early as 1882 (7).

Tebb's traveling flower pot made of stout brown paper was introduced in 1880 (5). Soft tissue paper seems to have been used extensively for packing flowers as early as 1880 (29).

Though paper was employed for blanching celery for exhibition as early as 1881 (6), it did not come into general use for this purpose until about 1922 (10). Within the past few years paper has been used for mulching pineapples (26).

The influence of wrappers and containers on the succulence, flavor, color, and on undesirable contaminations of foodstuffs, varies greatly with the materials that are used. Very little is known concerning the effects of papers of different kinds on the quality of horticultural products. Sando (21) found that tomatoes, ripened off the vine with diminished ventilation due to paper wrappers, had a high acid content and a low soluble carbohydrate (sugars) content, while well ventilated tomatoes contained relatively more sugar and less acid and possessed a flavor more nearly like that of fruits ripened on the vines.

He concluded that, "Commercially ripened green fruit, wrapped with one paper, showed an increase in acid of approximately 102 per cent and a sugar decrease of nearly 5 per cent compared with corresponding tests of vine-ripened tomatoes. The results of wrapping with three papers were less marked and are difficult to explain. The data seem to justify the conclusion that wrapping probably modified the course of ripening to such an extent as to account for marked changes in taste and flavor."

The difference in acidity and sugar content is not so great in green tomatoes ripened under different conditions. It is interesting to note that three paper wrappers apparently cause less acidity than one wrapper. He also states that although the reaction was decidedly acid, the general flavor was insipid. He concludes that lack of ventilation retards ripening. Duggar (16) states that lack of oxygen inhibits the development of the red color of tomatoes.

McKay, Fischer, and Nelson (20) found that wrappers interfere with the cooling of cantaloupes placed under refrigeration and that the wrappers, by retaining the moisture condensed on the melons after their removal from refrigeration, favor the spread of diseases.

Apple scald, found by Brooks and Cooley (11) and others to be caused by the volatile products of the apple, may be prevented by wrapping each fruit in oiled paper or by distributing shreds of this paper uniformly among the fruits in the packages.

Some papers are, therefore, desirable for certain purposes and undesirable for others. It is evident that a careful selection of the right types of paper is necessary to insure the desired results. The investigations herein described were undertaken to determine the limitations and the value of papers of different kinds in the packing of flowers, nursery stock, and a number of the more common fresh vegetables. In some instances, value is measured in terms of appearance; in some, of keeping or shipping quality; in others, in terms of the various factors that constitute quality; and in still others, in terms of insulation against heat and cold.

Materials and Methods

Kraft, tissue, waxed (paraffined) paper, vegetable parchment, and a special water-indestructible paper sold under the trade name of "whalehide" were used in different ways in the course of the experimental tests reported in this paper.

Kraft paper is made principally from coniferous woods by the sulphate (sodium sulphate) process. Its great strength is due, in part, to the length of fibers, to mild cooking, and to the presence of resins and fats (24).

Parchment paper is usually prepared by treating paper for a few seconds with 78 per cent sulphuric acid. The acid is adsorbed by the cellulose to form a series of adsorption compounds, accompanied by swelling and peptonization. When the paper is plunged into water after the short acid treatment this process is stopped and a gelatinous hydrate is formed (24). Parchment papers may be made from most kinds of paper but only that made from the most refined and purified papers should be used in wrapping food such as butter and meats. Parchment papers do not decompose in water but they are readily permeable to both air and water.

Dry waxed paper is lightly impregnated with paraffin, while self sealing waxed paper is not only impregnated but is coated on both sides with sufficient paraffin so that the paraffin will make a practically moisture proof union when melted by the application of the proper degree of heat. The coating of paper with paraffin is accomplished by dipping the paper into melted paraffin, after which it is hardened in cold water. Waxed papers (30 pound basis and above) afford almost complete protection against the entrance of water vapor but they quickly decompose in water. This is due to the fact that the paper is never completely coated with paraffin. Paper fibers thus exposed and those exposed where the paraffin cracks absorb water like wicks and the paper becomes wet throughout, resulting in its tearing. Self sealing waxed papers are used for preserving foodstuffs (especially cereals) in packages against moisture fluctuations. The packages are wrapped and sealed by machinery.

Papers of several different thicknesses or weights were employed during the tests. By "basis weight" is meant the weight of one ream of standard size and standard number of sheets adopted by the trade. The standard size of wrapping paper, such as used in these experiments, is 24 x 36 inches and generally 500 sheets constitute a ream. (Waxed papers come on the basis of 480 rather than 500 sheets to the ream). Thus 500 sheets of 24 x 36 inch paper weighing 20 pounds would be rated 20-pound paper. Papers used in the tests ranged from 13-pound tissue to 90-pound kraft.

Most of the tests were designed to determine the effects of papers, when used in different ways, upon the quality of the different vegetables and fruits. Tests for light penetration and insulation were also conducted. To check the value of the laboratory results, practical shipping tests were made. Questionnaires were sent to grocerymen and commission merchants in order to get their opinions concerning certain aspects of the problem.

Tests of quality were made, after the removal of the various lots from storage, by taste and by a determination of the losses in weight. Refractive indices and freezing point depressions were secured from the extracted sap, compared with the data obtained from carbohydrate analyses and other quality tests, and used as an indirect measure of quality. Catalase determinations also were made to ascertain, if possible, any correlation between the activity of the enzyme and the changes which were taking place.

Most products were kept under four environments: (1) In a Frigidaire refrigerator where the temperature was kept at about 32° F. and the relative humidity at approximately 87 per cent; (2) In an ordinary ice-cooled refrigerator where the temperature was about 50° F. and the relative humidity approximately 70 per cent; (3) In a nearly air tight chamber where the temperature was about 80° F. and the relative humidity approximately 81 per cent; (4) In a laboratory where the temperature was about 80° F. and the relative humidity about 32 per cent, but where both temperature and humidity fluctuated with weather conditions.

A sample of each lot was extracted in an oil hydraulic press, immediately centrifuged, and filtered. The centrifuge was run at 1900 revolutions per minute, the radius of the centrifuge head was 16 centimeters. The filtered sap was then tested for refractive index, freezing point depression, and acidity. Total solids were determined by direct readings on an Abbe-Spencer refractometer at 20° C. A cryoscope of the Hortvet type was used for determining the freezing point depression. The colorimetric method for determining the pH values was used almost entirely but supplemented with the calomel electrode for the determination of the values for grape juice. Titratable acidity, when measured, was determined by titrating 5 c.c. of the extract with $\frac{N}{20}$ NaOH, using a suitable indicator to determine the end point. All operations for any one lot were usually completed the same day. The extracted juice, when not in use, was kept at 32 ° F.

If carbohydrate analyses were desired, 40 to 100 gram samples were preserved by covering with sufficient hot (75° C.) 95 per cent alcohol to insure a concentration of 75 per cent and heating at 75° C. for one hour. Chemically pure calcium carbonate was added (.25 gr.). The samples after being sealed and allowed to set for some time were then extracted with 80 per cent alcohol and the filtrate made up to volume (500 c.c). The residue was dried at 60° C., ground to pass a 60-mesh sieve, and 1-5 aliquots weighed out for analysis. Dry weights were calculated from 1-10 portions of the extract and 1-5 aliquots of the residue. The 1-5 aliquots were extracted with water (30°-40° C.) and in the case of grapes combined with the alcohol extract to make sure that all the sugar was secured. The water extract of the residue was not combined in the case of corn and peas as the filtration proceeded too slowly. The solutions were clarified with neutral lead acetate and deleaded with sodium carbonate in the usual manner. The sugars were inverted by adding 5 c.c. of concentrated HCl to 50 c.c. of the neutral sugar solution and heating for 10 minutes at 70° C. The solution was then cooled, neutralized, made up to volume, and 25 c.c. samples of the filtered solution used for sugar determinations. For starch the residue was treated with taka-diastase at 38° C. for 24 hours. The products of the digestion, with 150 c.c. of water used as washings, were then acidified with 8 c.c. of concentrated HCl and refluxed for 2.5 hours. The product was then cooled, neutralized, clarified, and deleaded. Sugar determinations were then made. The residue from the taka-diastase digestion with 70 c.c. of water as washings and 4 c.c. of concentrated HCl was refluxed for 2.5 hours for acid hydrolyzable material. After neutralizing, clarifying, and deleading in the usual manner had been completed, the reducing power of an aliquot was determined. Total sugars were calculated as invert, starch as dextrose, and the acid hydrolyzable material was converted from dextrose with the factor 0.90. All sugar determinations were made after the Munson and Walker method.

Catalase was determined according to the method described in Mich. Sta. Coll. Exp. Sta. Tech. Bul. 78 (14).

Photometric readings for the light penetration tests were made by means of solio paper in an ordinary photometer such as described by Clements (12).

Other methods involving a limited number of cases will be described later.

Loss in Weight Experiments

Many horticultural products are sold by weight and the loss of moisture, especially from leafy vegetables, quickly reduces their market value. Even those that are not sold on a weight basis lose value as their moisture evaporates. On the other hand, many kinds of seeds quickly lose their viability if exposed to humid environments. The use of wrappers that will retain the natural moisture content or will exclude moisture, as the case may be, therefore, may be well worth while from this standpoint.

Peas.—Peas are usually packed in hampers, bushel baskets, or crates. If they are to be in transit for two or more days, it is customary to place ice in the center of the container to prevent heating, as the cold air from the bunkers is not sufficient. The melting ice not only keeps the peas cold but also keeps them moist. Obviously any paper which is used to line the containers must not be decomposable by water.

Table 1 gives the loss of weight in percentage from peas wrapped with various papers and placed in different environments. The peas (variety-Telephone) were picked in the morning and each lot placed in its respective wrapper and environment before 5:00 p. m. of the same day.

The data indicate the value of low temperature, high humidity, and waxed paper for the preservation of the moisture content of fresh peas. At high temperatures, however, peas kept for seven days in waxed paper became moldy. The growth of mold was greatest in the high humidity chamber. On the ninth day, all the peas in the high temperature, high humidity chamber were so moldy as to be unfit for tests, while those held at a high temperature and low humidity were badly dried. Although waxed papers proved superior to parchment and "whalehide" papers in preventing moisture loss, they are not strong enough to hold up under shipping conditions. Even the waxed kraft papers of 70 to 90 pounds basis do not withstand this usage as well as 45 to 55 pound "whalehide".

There was practically no difference between the moisture-retaining value of parchment and "whalehide" and the slight difference can be attributed to the difference in weight of the papers used.

Table 1.—Weight lost by peas stored under different storage conditions, in per cent

Days in Storage	Environment	Loss				
		20 lbs. Wh.	25 lbs. P.	25lbs. D.W.	25lb.S.S.W.	Ck.
3	32° F.	3.8	2.6	2.0	.9	3.8
	50° F.	9.2	....	....	3.2	10.6
	80° F. Low humidity	23.9	21.3	13.1	6.1	26.1
	80° F. High humidity	9.1	8.7	5.7	2.3	10.2
5	32° F.	3.2	3.1	3.7	1.3	6.0
	50° F.	15.4	....	....	4.2	21.4
	80° F. Low humidity	46.7	41.6	27.3	10.5	53.4
	80° F. High humidity	14.5	12.0	6.2	4.0	20.2
7	32° F.	6.4	4.7	4.5	1.7	7.5
	50° F.	25.7	....	....	5.6	25.6
	80° F. Low humidity	60.3	55.0	39.4	14.9	68.9
	80° F. High humidity	18.2	18.8	10.8	4.6	24.6
9	32° F.	4.1	3.9	3.0	1.5	6.2
	50° F.	32.0	....	....	11.5	34.4
	80° F. Low humidity	70.3	66.9	44.4	17.9	77.7
	80° F. High humidity	....	....	....	....	....
12	32° F.	5.7	4.1	3.3	1.8	5.6
	50° F.	40.3	....	....	10.2	51.0
	80° F. Low humidity	....	....	....	....	....
	80° F. High humidity	....	....	....	....	....

Wh. = "whalehide" paper. P. = parchment paper. D. W. = dry waxed paper.. S. S. W.= self-sealing waxed paper. Ck. = check.
These same symbols are used in the tables which follow.

Sweet Corn.—The losses in weight from Kelly's hybrid sweet corn were less than half as much as from peas. The effects of paper wrappers and varying temperatures and relative humidities on moisture losses were analogous to their effects on peas.

Tomatoes.—On September 8, Earliana tomatoes, which were just starting to turn, were harvested, wrapped, and placed in storage under the same conditions as provided for peas and sweet corn. Though the weight losses were much smaller than for sweet corn and peas, the papers showed the same relative protective value.

The difference in the moisture loss from corn and tomatoes is probably due largely to the difference in the protective coverings. The tomato skin is devoid of stomata and the fully ripened fruit is impregnated with a waxy material which is not miscible with water.

In this connection, it may be of interest to note the applicability of the polar conception of molecules and groups, as developed by Langmuir (19), Harkins (17), and others, in predicting the possible uses of different kinds of paper for protecting various commodities.

According to this theory, molecules or groups which contain OH, COOH, CO, CN, or $CONH_2$ groups are characterized by stray fields of force and great activity while compounds (non-polar) lacking these groups, are relatively inactive. Double and triple bonds act like the polar groups mentioned but to a less degree. Water and the lower alcohols are, according to this theory, highly polar while benzene, ether, paraffin, and similar compounds are highly non-polar. Compounds of similar polarity are miscible and compounds differing in their polarity become less and less miscible depending upon the difference in their degree of polarity. The non-polar waxy skin of the tomato thus provides an excellent protection against the escape or evaporation of polar water or moisture. Waxed papers are used around cereals and other agricultural products to protect them against changes in moisture content. Hydrated, more polar cellulose such as is found on parchment papers, must be used around non-polar products such as butter and fat meats, otherwise the paper (waxed) would disintegrate and contaminate these foods.

Grapes.—The papers used around a number of varieties of grapes had the same relative protective value against moisture loss as they had with peas, corn, and tomatoes.

Celery.—In the first test with celery, started September 9, three bunches were exposed to the laboratory conditions where the temperature was high and the humidity low. Figures 1 and 2 show the same lots

Figure 1.—Celery stored 4 days in a high temperature, low humidity room. Left to right: S.S.W.-Wh.-and check lots.

of celery, wrapped and with the wrappers removed, four days after the start of the experiment. The dark spot below the label on the bunch to the left of Figure 2 is a soft rot. On the fifth day this rot had become very serious in this (S.S.W.) lot.

The statement is frequently made that washed celery will not hold up as long as "ruff" celery. In order to secure data on this question, four crates of celery were included in a shipment from Sanford, Florida, to Detroit, Michigan. This shipment was loaded April 11, and the express shipment from Detroit arrived in Lansing, Michigan, April 21. The celery in the car was top iced. Ice was also placed in the bunkers of the car as is the usual practice. The data indicate that washed does not wilt any faster than unwashed celery. There is, however, a definite relation between the size of stalks to the weight lost, the larger stalks losing moisture less rapidly than the smaller stalks. If washed celery does not hold up as long as "ruff" celery the decline must be due to other factors than wilting. Wet or even dry celery will rot at high temperatures, as is shown in Figure 2. At low temperatures neither wet nor

Figure 2.—Celery stored 4 days in a high temperature, low humidity room. Same as Figure 1 with papers removed. Left to right: S.S.W.-Wh.-and check lots. Note rot starting on S.S.W. lot.

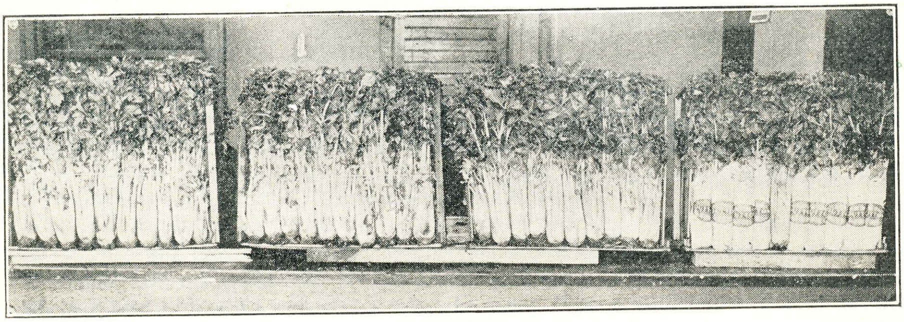

Figure 3.—Celery cut from same field packed and shipped on same date by Mr. F. F. Dutton, Sanford, Florida. Photo 11 days after celery was cut. Left to right: 1. Rough field pack. 2. Field pack precooled. 3. Washed and precooled. 4. Washed, precooled and wrapped.

dry celery will rot or wilt excessively in reasonable lengths of time. Much of the loss of washed celery and consequent prejudice against it, is due to storage at high temperatures.

It is often stated that washed celery stalks turn brown. A close inspection of lot 3, Figure 3, does not show any such discoloration. In fact, lots 3 (washed) and 4 (washed and wrapped) have a much better appearance than the "ruff" stock in lots 1 and 2. A "close-up" of lot 4 is shown in Figure 4. The lot wrapped with parchment paper lost much less moisture than the other lots; moreover, it brought a much better price.

Figure 4.—This celery was washed then wrapped and then precooled by passing through water at 32-34° F. for 30 minutes. The photograph, taken 11 days later, does not show any torn paper. Stalk in center unwrapped to show healthy white color.

Lettuce Tests.—In answer to a large number of questionnaires sent to grocerymen, the statement was repeatedly made that lettuce wilts in refrigerated, glass show-cases. When ice is frozen in refrigerators the ice formation is bound to reduce the relative humidity of the air. In order to test the weight losses under such conditions and to determine the value of papers in preventing such losses, experiments were conducted with lettuce and tomatoes in a refrigerator in which humidity was regulated by means of water, sulphuric acid, and water-sulphuric acid mixture.

The losses in weight in the low humidity chamber were considerable in the check and whalehide lots. The self sealing waxed paper provided excellent protection, the loss being less than the check loss in the 100 per cent relative humidity chamber. The differences for tomatoes were similar to those for lettuce but less pronounced.

Nursery Stock.—Whalehide paper, with and without burlap, was used to wrap the ball of earth around the roots of each plant in a shipment of 25 plants including 9 species of Juniperus, and 39 plants including 13 species of Thuya, from Painseville, Ohio to Grand Rapids, Michigan. The plants were wrapped as they were dug in the field April 5, boxed, and shipped by freight April 6. They arrived in Grand Rapids April 15. The losses from all lots were slight and uniform. Under the conditions of this experiment the paper gave no additional protection against water loss. However, "whalehide" paper used alone (one thickness of 55-pound paper) provided protection almost equal to the burlap and in most cases remained untorn, even though the plants and attached ball of earth in some cases weighed as much as 45 pounds.

Seed.—Many garden seeds deteriorate when stored under humid conditions, and for that reason need protection from atmospheric moisture. In order to test the value of self sealing waxed paper for this purpose, lots of parsnip, celery, spinach, bean, and tomato seeds were weighed and stored, with and without the protection of waxed paper, in the dry atmosphere of a laboratory room and in a moist chamber; and one set was sent to Mr. Russell Mason of the Stokes Seed Company at Sanford, Florida. The tests were started March 17 and terminated April 22 with the exception of the Florida lot.

The data showed that the waxed paper provides considerable protection against absorption and loss of moisture. The unwrapped seed in the moist chamber took up twice as much moisture during the brief interval of the test as that which was protected by the waxed paper. The differences in germination after the storage tests came within the limits of experimental error.

Plants.—Many carloads of plants, principally tomato and cabbage, are shipped from southern to northern sections each year. During cool weather they are packed without either dirt or sphagnum moss around their roots, but, later, it is necessary to use well moistened moss. The retention of moisture in this moss during warm weather is important and is complicated by the necessity of leaving the tops of the plants exposed to the air for ventilation.

In order to determine the value of waxed and "whalehide" papers in preserving the moisture in moss, definite weights of wet moss were placed in bushel baskets lined with papers. The moss was covered from above with 30-pound waxed paper. The losses shown in Table 2 are, therefore, due primarily to losses through the paper or bottom of the basket and are not augmented by plant transpiration losses.

Table 2.—Loss in weight from sphagnum moss in bushel baskets lined with papers

Lots	Weight of wet moss (grams)	Per cent loss in weight after	
		4 days	18 days
Check	2000	30.0	76.5
Whalehide (35-pound)	2000	24.5	65.3
Self-sealing waxed (25-pound)	2000	7.0	24.8

The data clearly indicate the greater value of waxed paper in retaining the moisture.

Experimental shipments of cabbage plants from Valdosta, Georgia, plainly showed that waxed paper was not suitable for lining crates or boxes with slat bottoms. Another shipment with the bottom of the boxes lined with "whalehide" showed that this paper was much better suited for this type of work. One of the crates lined with "whalehide" is shown in Figure 5. Waxed paper, when placed against a solid foundation so that the roots of the plants could not puncture it, retained much more moisture in moss than the "whalehide" paper. This was true in spite of the fact that the waxed paper was badly decomposed at the end of the trip.

Total Soluble Solids, Freezing Point Depression, and Acidity

In order to have some definite standards by which quality might be measured, the refractive indices, freezing point depressions, and pH values of the extracted saps were secured. Both refractive indices and freezing point depressions are measurements of dissolved molecular

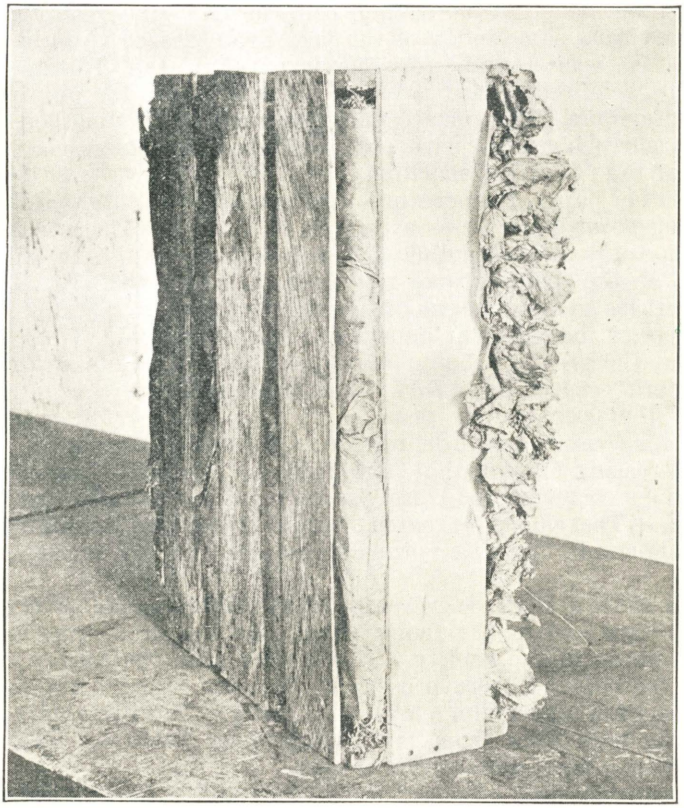

Figure 5.—"Whalehide" paper lining the bottom of plant shipping crate. Crate expressed from Carlisle Plant Company, Valdosta, Georgia. Note the paper protecting the moss around the roots is practically untorn.

solids. The amount of these solids determines largely the concentration of tissue fluid. Since these solids, such as sugars, are responsible, in a large measure at least, for flavor, these two indices are frequently a very reliable measure of quality. This is especially true of sweet products such as grapes, sweet corn, peas, and muskmelons. For other products such as head and leaf lettuce, celery, and cabbage, the crispness of the product associated with water content is the dominating factor so far as quality is concerned. In such cases high refractive indices and large freezing point depressions would likely be correlated with low rather than high quality.

Peas.—The shelled peas were frozen over night at -6° C. before the sap was extracted. The peas were wrapped in two thicknesses of cheese cloth and subjected to 5.5 tons pressure in a hydraulic press for 10 minutes. At this pressure, 70 grams of fresh peas yielded about 23 c.c. of sap. In many instances the cheese cloth became lodged between the walls of the cylinder and the piston. This caused a variation in the pressure actually exerted on the peas. Following a similar trouble with corn, the cloth was abandoned. With all products except peas sufficient pressure was used to pulp the products immediately.

This method, aside from saving considerable time, has the added value of providing some index of the pressure required to pulp different products. It was found, for instance, that the Italian tomato, Re Umberto, required almost twice as much pressure for pulping as the American Earliana. The tomato pulp produced by this method is, moreover, apparently identical with that produced in commercial factories by means of the "Cyclone" machine.

The effects of paper, temperature, and humidity on total soluble solids and freezing point depressions are given in Table 3. There is a distinct decrease in total soluble solids and a lessening of the freezing point depression as the temperatures rise from 32° F. to 80° F. This indicates a decrease in the amount of dissolved material.

The effects of the different papers are not so marked. It is, however, evident that the greater amount of water retained in lots wrapped with waxed papers (especially S.S.W), has prevented the concentration of the sap of the poor quality peas, so that the values for total soluble solids and for freezing point depressions were noticeably small.

It is interesting to note that high total soluble solids and high cryoscope readings corresponded closely to high quality as indicated by taste.

Tomatoes.—The effects of paper, temperature, and humidity on the total soluble solids, freezing point depressions and pH values are given in Table 4.

The data show a slight increase in total soluble solids as the storage periods advance and as the fruits ripen. At the same time there is a gradual decrease in the acidity. This agrees with the results of Sando (21), but the evidence here presented does not support his conclusion that the use of wrappers increases the acidity. The pH values are presented along with data from the titrations in Table 5. The pH and titration values correspond very closely.

The only pronounced effect of the papers is the production of lower total soluble solids and a decrease of the freezing point depressions of the lots wrapped with self sealing waxed papers. This is no doubt due to the greater dilution of the dissolved materials. These lots colored more poorly than the other lots. The tomatoes seemed to have less taste, possibly because of the greater dilution of the dissolved solids. A few tomatoes were coated with paraffin which was effective in completely inhibiting the formation of red color, although the fruits remained firm. Paraffin used around the stem end did, however, delay the attack of storage rots which commonly start at this point.

Table 3.—Effect of paper, temperature, and humidity on the total soluble solids and freezing point depressions of extracted pea sap

Day of storage	Environment	20 lbs. Wh.		25 lbs. P.		25 lbs. D. W.		25 lbs. S. S. W.		Ck.	
		Total soluble solids per cent	Freezing point depression	Total soluble solids per cent	Freezing point depression	Total soluble solids per cent	Freezing point depression	Total soluble solids per cent	Freezing point depression	Total soluble solids per cent	Freezing point depression
3	32° F.	11.3	.917	11.2	.855	11.1	.882	11.8	.882	11.6	.882
	50° F.	9.8	.729	....	....	....	....	9.7	.728	9.2	.723
	80° F. Low humidity	7.3	.586	7.2	.568	7.1	.539	6.7	.502	7.7	.586
	80° F. High humidity	7.8	.603	7.6	.622	8.0	.623	7.2	.567	7.8	....
5	32° F.	10.4	.828	11.7	.866	10.2	.767	10.7	.835	10.9	.801
	50° F.	7.8	.639	....	....	....	....	7.6	.615	8.8	....
	80° F. Low humidity	7.6	.514	7.1	.507	6.8	.421	5.9	.408	7.8	.536
	80° F. High humidity	6.3	.569	6.8	....	6.7	.449	6.9	.436	6.0	.414
7	32° F.	10.5	.842	11.2	.874	12.0	.952	11.2	.897	11.7	.949
	50° F.	8.1	.658	....	....	....	....	6.9	.568	7.1	.600
	80° F. Low humidity	10.1	.729	8.6	.594	6.8	.446	6.3	.396	11.5	....
	80° F. High humidity	6.9	.478	6.9	.512	6.9	.507	6.8	.582	6.9	.479
9	32° F.	10.1	.848	10.5	.773	9.3	.727	10.0	.735	10.7	.847
	50° F.	7.2	.574	....	....	....	....	5.9	.509	6.7	.498
	80° F. Low humidity	10.0	....	11.0	....	8.8	....	7.2	....	....	....
	80° F. High humidity	....	....	....	....	....	....	....	....	....	....
12	32° F.	10.2	.755	9.8	.721	10.0	.759	9.9	.795	11.2	.875
	50° F.	7.1	.604	....	....	....	....	5.8	.437	7.8	.600
	80° F. Low humidity	....	....	....	....	....	....	....	....	....	....
	80° F. High humidity	....	....	....	....	....	....	....	....	....	....

Table 4.—Effect of paper, temperature and humidity on the total soluble solids, freezing point depressions, and pH values of extracted tomato sap

Day of storage	Environment	Treatment: 13 lbs. Tissue			20 lbs. Wh.			25 lbs. S. S. W.			Ck.		
		Total soluble solids per cent	Freezing point depression	pH.	Total soluble solids per cent	Freezing point depression	pH.	Total soluble solids per cent	Freezing point depression	pH.	Total soluble solids per cent	Freezing point depression	pH.
3	32° F.	5.6	.554	4.1	5.6	.534	4.2	5.1	.492	4.2	5.1	.486	4.2
	50° F.	4.9	.480	4.1	5.0	.473	4.1	5.0	.453	4.1	4.9	.450	4.1
	80° F. Low humidity	5.0	.450	4.2	5.6	.552	4.3	5.2	.547	4.3	4.7	.502	4.2
	80° F. High humidity	4.6	.411	4.3	4.9	.494	4.3	5.1	.450	4.3	5.3	.497	4.2
5	32° F.	5.6	.609	4.1	5.0	.542	4.1	5.0	.520	4.1	4.9	.500	4.2
	50° F.	5.1	.458	4.3	5.0	.434	4.3	5.0	.447	4.3	5.0	.491	4.2
	80° F. Low humidity	5.2	.487	4.3	5.2	.462	4.3	4.9	.386	4.3	5.1	.405	4.3
	80° F. High humidity	4.9	.399	4.3	5.5	.523	4.3	5.5	.576	4.2	4.9	.474	4.3
7	32° F.	5.6	.566	4.2	5.0	.468	4.2	5.0	.454	4.2	4.9	.482	4.3
	50° F.	4.9	.450	4.3	5.6	.576	4.3	5.0	.460	4.3	4.9	.462	4.3
	80° F Low humidity	5.5	.559	4.3	5.0	.458	4.3	4.4	.408	4.4	4.7	.383	4.4
	80° F. High humidity	4.6	.396	4.4	4.9	.430	4.4	5.0	.494	4.3	5.3	.532	4.4
9	32° F.	5.5	.476	4.3	5.5	.539	4.2	4.9	.430	4.2	4.7	.403	4.2
	50° F.	5.0	.449	4.3	5.0	.462	4.3	4.9	.425	4.4	5.2	.502	4.3
	80° F. Low humidity	5.1	.470	4.4	5.1	.481	4.4	4.9	.437	4.4	4.9	.426	4.3
	80° F High humidity	4.2	.358	4.4	4.9	.412	4.3	4.3	.378	4.2	5.2	.510	4.3
12	32° F.	5.2	.470	4.3	5.2	.522	4.2	5.2	.481	4.2	5.2	.487	4.2
	50° F.	5.1	.471	4.3	5.3	.499	4.3	5.1	.490	4.3	5.3	.492	4.3
	80° F Low humidity	5.2	.465	4.4	5.1	.457	4.3	4.9	.422	4.4	4.9	.411	4.4
	80° F. High humidity	4.1	.328	4.5	5.0	.456	4.4	4.9	.456	4.4	4.8	.446	4.4
15	32° F.	5.5	.586	4.0	5.1	.471	4.2	5.4	.536	4.3	5.2	.479	4.2
	50° F.	5.0	.493	4.3	5.2	.471	4.3	5.5	.532	4.3	5.1	.472	4.3
	80° F. Low humidity	5.5	.568	4.3	5.5	.475	4.5	4.6	.433	4.5	5.1	.431	4.5
	80° F. High humidity	4.9	.431	4.4	4.8	.412	4.5	5.0	.492	4.4	....	....	....
20	32° F.	5.0	.481	4.2	5.1	.477	4.2	5.2	.445	4.3	5.0	.504	4.2
	50° F.	5.8	.587	4.2	5.5	.550	4.2	4.9	.485	4.4	5.3	.531	4.3
	80° F. Low humidity	5.5	.524	4.3	5.3	.517	4.5	4.9	.416	4.4	4.7	.418	4.5
	80° F. High humidity	4.5	.366	4.6	4.4	.325	4.6	4.9	.425	4.5	5.1	.480	4.4

Table 5.—Comparison of pH values and titration tests on the 15 and 20 day tomato lots

Day	Environment	Treatment							
		Tissue 13 lbs.		Wh. 20 lbs.		S.S.W. 25lbs.		Ck.	
		pH	c. c. $\frac{N}{20}$ NaOH	pH	c. c. $\frac{N}{20}$ NaOH	pH	c. c. $\frac{N}{20}$ NaOH	pH	c. c. $\frac{N}{20}$ NaOH
15	32° F.	4.0	3.25	4.2	2.36	4.3	1.86	4.2	2.05
20	32° F.	4.2	2.52	4.2	2.42	4.3	1.70	4.2	2.27
	Average	4.1	2.89	4.2	2.39	4.3	1.78	4.2	2.16
15		4.3	1.90	4.3	1.50	4.3	2.84	4.3	2.18
20	45° F.	4.2	3.05	4.2	2.69	4.4	1.44	4.3	2.43
	Average	4.25	2.48	4.25	2.10	4.35	2.14	4.3	2.31
15		4.3	2.05	4.5	1.73	4.5	.85	4.5	1.33
20	80° F. Low humidity	4.3	2.15	4.5	1.59	4.4	1.22	4.5	.95
	Average	4.3	2.10	4.5	1.66	4.45	1.04	4.5	1.14
15		4.4	1.40	4.5	1.23	4.4	2.25	......	......
20	80° F. High humidity	4.6	.84	4.6	.75	4.5	1.50	4.4	1.67
	Average	4.5	1.12	4.55	.99	4.45	1.88	4.4	1.67

Grapes.—The effects of paper on total soluble solids, freezing point depressions and pH values of extracted grape sap are shown in Table 6. These data show that grapes have a much higher soluble solid content than peas or tomatoes.

Differences in the effects of the various papers are negligible. This is not surprising in view of the small moisture losses in the cold storage and cool, moist, common storage. Moreover, soluble sugars in grapes are largely unaltered, even after dehydration, so that no reduction in the soluble solid content would be expected from exposure to high temperatures (80° F.) and dry atmospheres, as is the case with peas (Table 3).

Carbohydrate Analyses

Samples of peas, corn, and grapes were preserved for determinations of total sugars, starch, and acid hydrolyzable materials at periods when it was thought the greatest differences could be detected.

Peas.—The data for peas are given in Table 7. Peas which contained 18.6 per cent sugar (as invert), at the start contained only 2.1 to 2.8 per cent at the end of seven days storage at high temperatures, while those held at 32° F. still possessed most of their original sugar (60-80 per cent). Apparently the sugar was first converted into acid hydrolyzable material, as is shown by the cold storage lots where only a partial sugar loss is shown, and later to starch, as is shown by the large amount in the high temperature lots, where the starch content has increased 400 per cent, though the acid hydrolyzable material is but little greater than in the cold storage lots. The dry matter content, of course, varies with the storage conditions.

Table 6.—Effects of paper on total soluble solids, freezing point depressions and pH values of extracted grape sap

Variety	Kind of storage	Treatment								
		20 lbs. Wh.			25 lbs. S. S. W.			Ck.		
		Total soluble solids per cent	F. p. depression	pH	Total soluble solids per cent	F. p. depression	pH	Total soluble solids per cent	F. p. depression	pH
Niagara	Common	13.8	1.624	2.8	14.0	....	2.8	14.0	1.637	2.8
Niagara	Cold	14.3	1.706	2.8	14.0	1.613	2.8	14.3	1.647	2.8
Niagara	Cold (a)	14.2	1.636	3.09*	14.3	....	3.09*	14.7	....	3.09*
Concord	Common	15.4	1.954	2.8	15.4	1.914	2.8	15.0	1.822	2.8
Concord	Cold	14.7	1.754	2.8	15.1	1.856	2.8	14.7	1.659	2.8
Concord	Cold (a)	13.7	1.605	3.0*	13.2	1.618	2.96*	14.8	1.847	3.09*
Lignan Blanc	Cold	15.3	1.875	3.0	....	....	....	16.0	1.990	3.2
Wyoming	Cold	16.8	2.050	2.8	17.1	2.105	2.8	17.3	....	2.8
Diamond	Cold	15.0	1.761	2.8	15.0	1.821	2.8	14.4	1.707	2.8
Agawan	Cold	17.5	2.108	2.8	....	....	....	....	....	....
Worden	Cold	16.1	2.028	2.8	15.9	1.996	2.8	15.9	1.960	2.8
Worden	Cold (a)	14.4	1.828	3.09*	12.6	1.665	3.12*	14.1	1.768	3.00*
Salem	Cold	18.9	2.399	2.8	....	....	....	....	....	....
Salem	Cold (a)	16.5	1.916	3.00*	16.0	1.950	3.00*	....	....	....
Brighton	Cold	18.2	2.348	2.8	....	....	....	....	....	....
Brighton	Cold (a)	18.0	2.230	3.09*	....	....	....	....	....	....
Empire State	Cold	14.8	1.711	2.8	14.7	1.722	2.8	14.1	1.731	2.8
Empire State	Cold (a)	15.6	1.840	2.85*	....	....	....	....	....	....
Delaware	Cold	18.3	2.297	2.8	18.0	2.229	2.8	18.8	2.464	2.8
Delaware	Cold (a)	19.2	2 479	3.19*	....	....	....	....	....	....

*Determined by calomel electrode. (a) Tested January 3, all others November 23.

Table 7.—Comparison of freezing point depression, total soluble solids, total sugars, starch, acid hydrolyzable material and dry matter in peas stored under different conditions *

Environment	F. p. depression	Per cent composition				
		Total soluble solids	Total sugars as invert	Starch as dextrose	Acid hydrolyzable material	Dry matter
32° F. Ck. 3 days	.882	11.6	18.6	2.7	4.6	20.81
80° F. Low humidity Ck. 7 days	....	11.5	2.4	10.6	17.8	30.79
80° F. Low humidity Wh. 7 days	.729	10.1	2.8	11.0	16.8	28.46
80° F. Low humidity S. S. W. 7 days	.329	6.3	2.1	11.7	16.7	22.50
32° F. Ck. 7 days	.951	11.7	13.4	6.1	13.8	21.91
32° F. S. S. W. 7 days	.891	11.2	15.8	3.4	10.9	21.70
32° F. Wh. 7 days	.841	10.5	11.4	3.3	10.6	23.30

*Carbohydrate analyses based on dry weight.

The total soluble solids, as measured by the refractometer, and the freezing point depressions, as measured by the cryoscope, correspond closely with the total sugar content. The apparent discrepancies in the 80° F. lots at low humidity for both the check and "whalehide", can be explained on the basis of the amount of extracted sap. In the case of the check it was possible to extract only a few cubic centimeters compared with a normal of 23 cubic centimeters. This amount was not sufficient to secure a freezing point depression reading. Apparently the small amount of soluble solids (2.4 per cent), when condensed in the few cubic centimeters of extracted sap, was sufficient to give a refractive index which signified a much higher sugar content. The same is true of the lot wrapped in "whalehide" and held at 80° F. It is evident, therefore, that while both the refractometer and cryoscope may be used in determining approximately the sugar content of peas, the data secured therefrom must be carefully correlated with the proportion of extracted sap. This, of course, depends upon the percentage of dry matter contained in the pea samples. If the moisture content varies but little from the normal for green peas, the refractometer and cryoscope readings would be fairly reliable, but if the peas are badly desiccated the readings might be of little value.

Corn.—The data in Table 8 show that the sugar content of sweet corn decreases at high temperatures and that paper wrappers have little

Table 8.—Total sugars, starch, acid hydrolyzable material and dry matter in sweet corn stored under different conditions *

Environment	Total sugars as invert (per cent)	Starch as dextrose (per cent)	Acid hydrolyzable material (per cent)	Dry matter (per cent)
First day	10.3	44.5	4.1	31.71
32° F. Ck. 7 days	7.1	49.1	4.4	36.13
80° F. Low humidity, Ck. 7 days	1.2	51.1	6.9	42.73
80° F. Low humidity, S. S. W. 7 days	1.6	48.8	6.0	34.46

*Carbohydrate analyses based on dry weight.

effect in preserving the sugar content. It seems that the sugar in corn is converted very quickly into starch, with little intermediate accumulation of acid hydrolyzable material.

Grapes.—The carbohydrate analyses and corresponding indices for the cryoscope and refractometer for grapes are given in Table 9. Grapes contained less than one-half of one per cent of starch, even though the seeds were included in the analyses. The acid hydrolyzable material is also low. The sugar content as invert is very high. There is no appreciable difference in the sugar content of Concord grapes wrapped with the various papers or stored under different conditions. The most conspicuous differences are between the several varieties.

Contrast of the analyses of peas, corn and grapes seems to indicate that the quality of all three depends largely upon their sugar content and that this quality decreases most rapidly in those products that normally contain the most starch. Thus corn (check lots) lost 31 per cent, peas 28 per cent, and grapes none of their sugar content in seven days at 32° F. The sugar content of grapes will in fact increase relatively with the loss of moisture.

It is evident that high temperatures are associated with a rapid transformation of sugars to starch in corn and of sugars to acid hydrolyzable materials and then to starch, in peas. Papers which protect against moisture losses have little effect on this process. Refractive indices and cryoscope readings correspond closely to the sugar content, as shown by chemical analyses, except in cases when the small amount of sugar remaining has become concentrated through desiccation.

Table 9.—Freezing point depression, total soluble solids, total sugars, acid hydrolyzable material and dry matter in grapes stored under different conditions *

Variety	Environment	F. p. depression	Total soluble solids	Total sugars invert (per cent)	Total acid hydrolyzable material (per cent)	Dry matter (per cent)
Concord...	Wn. Common storage....	1.954	15.4	53.3	2.3	18.99
Concord...	S. S. W. Cold storage.....	1.856	15.1	53.2	2.3	19.17
Concord...	Ck. Cold storage..........	1.659	14.7	48.3	....	19.65
Concord...	Wh. Cold storage.........	1.754	14.7	56.3	....	18.19
Diamond..	Wh. Cold storage.........	1.761	15.0	55.9	....	18.01
Agawan...	Wh. Cold storage.........	2.108	17.5	58.7	....	20.66
Wyoming..	Wh. Cold storage.........	2.050	16.8	66.4	4.4	21.25
Niagara...	Wh. Cold storage.........	1.706	14.3	59.7	....	16.29

*Carbohydrate analyses based on dry weight.

Quality as Determined by Taste

Although chemical analyses and also refractive indices and freezing point depressions are very useful in detecting minute differences in certain properties, the ultimate test of that complex which constitutes quality is human taste and even that differs considerably among different individuals. A few of the characteristics of the different products, as determined by taste, will, therefore, be recorded in order that they may supplement the chemical data.

Peas.—Peas wrapped with different papers and kept in cold storage retained their quality throughout the test (12 days). In fact, a lot kept in cold storage 40 days still had an excellent flavor when cooked. On the fifth day the peas kept at 50° F. still had a good flavor but declined to fair and poor on the seventh and ninth days. Peas kept at 80° F. at both high and low humidities declined rapidly in quality and were worthless three days after the start of the experiment. Under humid conditions and high temperatures mold started in five days.

In extracting sap for chemical tests, with the hydraulic press, under 5.5 tons pressure, and in its subsequent centrifuging and filtration a number of differences was noted. All sap from lots characterized from taste tests as having high quality had a bright green color, filtered very slowly and the solid residue did not separate by centrifuging at 1900 revolutions per minute. Poor quality lots yielded sap that filtered in five minutes as compared to 2-5 hours for sap from high quality peas. The amount of sap extracted at the pressure used did not alter the color or the ease of filtration. The peas kept under high humidity, high temperature conditions yielded much sap which filtered quickly, lacked the green color and separated with a great amount of sediment at the bottom of the tube, when centrifuged. These differences were very distinct and conspicuous. The 50° F. lots (i. e. between cold storage and high temeperature conditions) showed intermediate properties until the ninth day, when the quality had become poor. These observations would indicate that the green colored, obviously colloidal state of the extracted sap is associated with high quality.

Sweet Corn.—Decline in quality of sweet corn, as measured by taste, closely paralleled that of peas held in similar environments. It was impossible to extract the corn sap with a cheesecloth around the cut corn in the press, due apparently to the accumulation of a colloidal mat in the cheesecloth and around the edge of the plunger, thus preventing the escape of sap.

Tomatoes.—The sap extracted from different lots of tomatoes, in contrast to that from peas, showed no consistent differences in color, rate of filtration or sedimentation following centrifuging, during the course of the tests. The flavor of the tomatoes improved as they ripened, but in no case did the fruits ripened off the vine taste as good as the vine-ripened fruits. Tomatoes ripened in the high humidity chamber and especially those wrapped with waxed paper developed a flat taste. The red color of fruits wrapped with waxed papers failed to develop normally.

Grapes.—Aside from the differences in the quality of different varieties of grapes, the chief difference between lots was in the presence or absence of mold. In common storage, where the humidity was especially high, the self sealing waxed paper provided protection against mold (apparently kept moisture out) while it favored the development of mold in the less humid cold storage room. The grapes in common storage were decidedly inferior in quality to those held in cold storage. Grapes apparently became sweeter while they lost moisture upon standing in the laboratory.

Catalase

It is generally conceded that the changes within tissue are, at times at least, accelerated by enzymes. In order to obtain some measure of catalase activity, tests were run on different lots of peas. No significant differences could be detected between the lots wrapped with different papers. The catalase activity of tomatoes was found to be almost zero.

Insulation Tests

The problem of preventing the transfer of heat from one part of a package or container to another is of great importance in the handling of many horticultural products. It is of particular interest to florists because of the great value of the products which they must ship during periods of temperature extremes and wide temperature fluctuations. To determine the effectiveness of prevailing practices in providing insulation, a number of tests were conducted with flowers. Two wooden boxes, 12 by 8 by 36 inches, such as are common in the wholesale flower trade, were used for conducting these tests. The boxes were lined with various combinations of newspaper, whalehide, cotton, felt padding and corrugated boxing. The outside was also wrapped with kraft or "whalehide" papers or left unwrapped according to the nature of the tests. The first two tests were run outdoors at 19° F. while the others were conducted in a laboratory where the temperature was 76° F. In all cases three pounds of ice and an equal weight of flowers were placed inside the boxes. The outstanding differences which may be noted are:

1. Newspaper has fully as good or better insulation value than equal weights of "whalehide". Experienced florists claim this difference, if any, is due to the slight dead air spaces created on newspaper through the use of type. At any rate preliminary tests, with paper around ice, demonstrated that crumpled papers had greater insulation value than the same weight of uncrumpled papers.
2. Felt pads or cotton batting on the inside of the boxes provided considerable additional protection.
3. One thickness of "whalehide" or kraft paper on the outside provided protection equal to the felt pad on the inside. This is likely due to the creation of a dead air space, between the boards and outside air, and also to the exclusion of convection air currents from the inside of the box.
4. One thickness of 45-pound "whalehide", as an outside wrapper, provided protection almost equal, or equal to 90-pound kraft used similarly. Since previous tests proved that kraft will not stand up when wet and "whalehide" will, it is evident that "whalehide" would be more satisfactory as an outside wrapper.
5. Corrugated boxing provided considerable insulation value but not sufficient to make its use on the inside of wooden boxes practicable.

While no direct tests were made to determine the amount of ice melted by warm packages it is evident that the boxes and packing material should be cooled to as near 32° F. to 34° F. as is consistent with packing practices, in order that the ice will not be used up in cooling packing materials. The total weight of box and paper packing in these boxes was about 5000 grams. If we assume the specific heat of the packing to be approximately one-half that of water (wood = .42) it is easy to see that fully one-half of the three pounds of ice would be melted in reducing the temperature of the packing material from 75° F. to 45° F. This, of course, does not mean that the boxes and paper should be kept in the refrigerator but rather in a cool room.

Shipping Tests

Tomatoes.—The celery shipping tests have already been described under the discussion of loss in weight of celery. In order to verify laboratory tests relative to tomato shipments a number of shipments from Florida, were carefully inspected. The tomatoes, in one crate expressed from Homestead, Florida, were wrapped with tissue paper and those in the other crate with 20-pound "whalehide" paper. The tomatoes were packed in six-basket crates. Records were taken on three dates as shown in Table 10. On March 18 there were three decayed tomatoes among 72 fruits wrapped with "whalehide", and no decayed fruits wrapped in tissue. The order is, however, reversed on March 26, when eight tissued wrapped, and only one of the "whalehide" fruits was decayed. The data for the lower tier of these baskets show no significant differences. The tomatoes wrapped with "whalehide" were, however, larger and the excess size and corresponding bulge and crowding and bruising of fruits may have been responsible for some of the rot among the "whalehide" wrapped fruits.

Another shipment of 12 crates of tomatoes wrapped with "whalehide" was included in a car unloaded in Detroit, April 2. At that time, 450 tomatoes wrapped with tissue and 450 wrapped with "whalehide" were examined in five different crates from each treatment. Only one decayed tomato was found wrapped with tissue while nine "whalehide" wrapped fruits were decayed. One crate of each lot was sent to East Lansing and the data shown in Table 11 were taken on April 9.

Table 10.—Number and weight of tomatoes, graded to indicate quality, from a shipment made March 11 from Homestead, Florida

Grade	Upper tier				Lower Tier	
	March 18		March 26		April 2	
	No.	Wt. (lbs.)	No.	Wt. (lbs.)	No.	Wt. (lbs.)
Wh. No. 1 Tomatoes	69	19.9	....	14.0	53	14.9
Wh. No. 2 Tomatoes (wilted)	....	....	....	4.9	7	1.7
Wh. No. 3 Tomatoes (rotten)	3	.5	1	.2	12	2.9
Wh. Total	72	20.4	....	19.1	72	19.5
Tissue No. 1 Tomatoes	72	19.8	....	11.1	47	11.8
Tissue No. 2 Tomatoes (wilted)	....	....	....	5.2	15	3.4
Tissue No. 3 Tomatoes (rotten)	....	....	8	1.6	10	2.1
Tissue Total	72	19.8	....	17.9	72	17.3

The tomatoes wrapped with "whalehide" were somewhat larger than the tissue wrapped fruits. A part of this difference in weight is due to the somewhat greater protective value of the "whalehide" paper, as the previous data showed that moisture loss from tissue-wrapped fruits was somewhat greater than from "whalehide" wrapped fruits. The data in

Table 11 shows that the tomatoes wrapped with "whalehide" remain marketable longer than those wrapped with tissue (5.6 pounds for Wh. compared to 2.0 pounds for tissue) but that more fruits wrapped with "whalehide" rotted. Both results likely follow from a difference in ventilation.

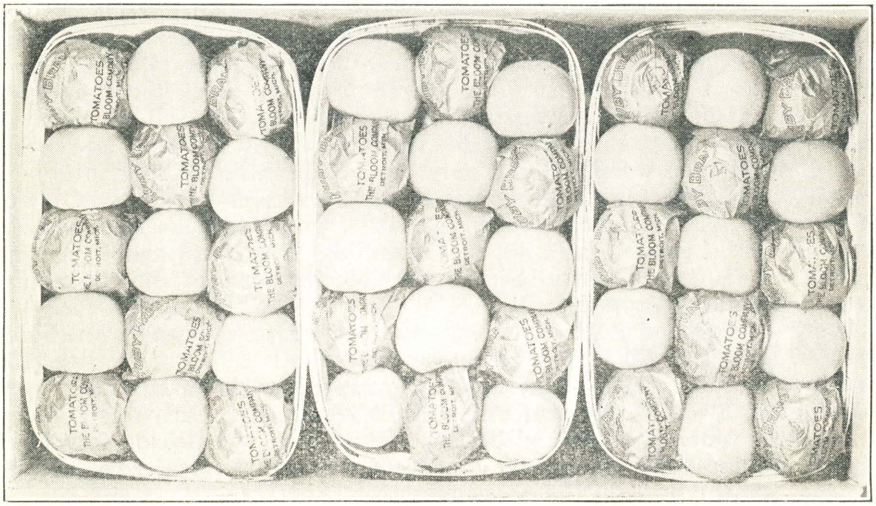

Figure 6.—Alternate red ripe tomatoes wrapped with green "whalehide" paper make a very attractive package. Note that complementary colors are used.

It is very difficult to measure the value of appearance. Mr. Frank Bloom, a commission merchant in Detroit, has, however, through the use of attractive papers, packages, and fancy quality, built up a very nice trade in repacked tomatoes. Figure 6 shows the attractive manner in which his corrugated, three-basket, tomato crates are packed. The contrast between the green wrapper and the complementary red color is very striking and appealing. Mr. Bloom also states that the "cushioning" effect of the heavy 20-pound "whalehide" paper is a great aid in the protection of ripened tomatoes.

Table 11.—Number and weight of tomatoes, graded to indicate quality from a shipment arriving in Detroit, April 2, from Homestead, Florida

Grade	20 lbs. Wh.		13 lbs. Tissue	
	No.	Wt. (lbs.)	No.	Wt. (lbs.)
No. 1 Tomatoes (solid)	26	5.6	9	2.0
No. 2 Tomatoes (soft and wilted)	86	19.7	115	23.9
No. 3 Tomatoes (rotten)	45	8.8	36	6.6
Green	7	1.3	6	1.1
Turning	11	2.1	9	1.8
Total	175	37.5	175	35.4

Cauliflower.—Cauliflower shipping tests were conducted in cooperation with Walter and Orlando Harry at South Haven, Michigan. Heads capped with 25-pound self sealing waxed paper brought 25 to 50 cents per dozen more on the Chicago market than heads not so capped. Individually wrapper heads (whalehide) were not desired because the product could not be seen. "Whalehide" liners for the top of the crate stood up better than the kraft paper used by most of the growers. Closely trimmed heads became dislocated in the box and did not, therefore, arrive in good condition.

On October 20 a number of heads were cut and placed in cold storage. On December 2, when the tests were completed, the leaves in all lots had dropped. During this period the refrigerating machinery was inactive for three days and this may account for some of the poor results. Paraffin placed on the cut stem ends dropped off due to the wilting of the stem and was, therefore, of no value. Sphagnum moss wrapped around the roots and saturated with water had completely dried out and apparently had given no protection. The leaves from heads wrapped with waxed paper dropped as badly or perhaps worse than from those wrapped with "whalehide". In spite of the loss of leaves the heads were in excellent condition and tasted very good when cooked.

Lettuce.—The "whalehide" and parchment papers are, as has been shown by the celery shipping tests, very resistant to tearing when wet. Tests carried on in cooperation with E. T. Jack of Jack Bros. and McBurney Co., Brawley, California, and with the Ashtabula Growers Association of Ashtabula, Ohio, demonstrated the value of "whalehide" for lining containers in which both head and leaf lettuce were being shipped. The untorn paper is much more attractive than torn paper and several commission merchants think that it retards the melting of the ice on the inside of the package and thus maintains an even low temperature inside the lettuce crate. The Grand Rapids Growers' Association uses white parchment paper to line its lettuce packages. This paper undoubtedly is a very material aid in increasing the attractiveness of the package.

Light Penetration

In order to test the value of different papers for protecting pistillate and staminate flowers in plant pollination work photometric readings made on solio paper were made in sunlight (noon March 22) and eight inches from the light of a 75-volt Burdiek ultra-violet light machine used in the Michigan State College medical dispensary. The intensity of transmitted light was measured by the degree of darkening of the solio paper. Both sunlight and ultra-violet light, according to this measure, pass readily through "Cel-o-glass", glass (sunlight only tested), "Vitrex", waxed papers, and "Flex-o-glass". Both pass through parchment paper readily but not so readily as through the glass, "Cel-o-glass", and the other materials. Glass cloth and waxed manilla transmit comparatively little of either light while the "whalehide" papers exclude practically all light from both sources.

No tests were made to determine the value of various materials for hot-bed covers and plant protectors. The data presented may, however, be used in predicting the possible use of these materials for these purposes.

Survey Among Commission Merchants and Grocerymen

In order to obtain the opinion of the trade concerning the investigation and results secured from the foregoing tests, and to enlarge upon these findings, 225 questionnaires were sent to commission merchants and about 1,600 to grocerymen. Ninety replies were received from commission merchants and 227 from grocerymen.

With only one exception grocerymen agree that appearance and quality are more essential for the sale of fruits and vegetables than cheap prices. Two or three considered both to be of equal value.

Though most commission merchants and grocerymen favor the use of parchment paper for wrapping certain vegetables, it is well to emphasize some of their objections. Some state that there is a tendency to use such papers to conceal defects. Others favor the paper for protective purposes but not for display, as the paper conceals the attractiveness of the products. This objection is, of course, partly justifiable.

Discussion

Though this study has dealt primarily with the effect of paper on the retention of quality of fresh horticultural products, during the period of storage and shipment, observations incident to the investigation indicate clearly that its influence on the appearance or attractiveness of these products, as they reach the market, is of far greater importance. Retailers are almost unanimous in their opinion that appearance along with good quality, is more important than low price in making sales. The use of attractive packages and wrappers not only draws attention to the products, but suggests that the grower has taken considerable pride in producing and packing them and, in a way, they are a kind of guarantee of quality. Green "whalehide" paper around red ripe tomatoes, as shown in Figure 6, is an excellent example of color combinations being used to enhance the display value and white parchment around celery (Figure 4) is a good example of the use of paper for display purposes.

Quality may be preserved by providing mechanical protection against bruising, by preventing the loss of moisture, by preventing the spread of diseases and in some measure by delaying detrimental internal changes of a chemical nature. Sometimes one, sometimes another, of these functions is most important.

Of greatest importance from the standpoint of quality change in many vegetables is moisture loss, for quality depends largely on crispness and crispness on moisture content. This holds true for most leafy vegetables, such as lettuce, celery, cabbage and spinach. Other vegetables and fruits that are sold by weight have their value decreased by moisture loss, even though their flavor may not be noticeably changed. Parchment and "whalehide" papers are suitable for reducing the amount of water loss from many products shipped in the dry state. Waxed papers should be used with caution in wrapping horticultural products, especially if the products are likely to decay when exposed to high temperatures. These papers were, however, found valuable in protecting produce against moisture loss in dry refrigerators where the temperatures were below 45° F. Waxed papers also tended to prevent the absorption of moisture by seeds from humid atmospheres.

Products which are shipped in contact with water or ice, if wrapped, require a paper such as parchment or "whalehide", which will stand up under such conditions. These papers not only remain untorn when wet but provide the proper degree of ventilation and protection against desiccation for such products.

The chemical effects, resulting from the use of paper wrappers, are negligible. Wrappers do not prevent the conversion of sugars into starch, in corn and peas, and they do not influence the quality of grapes to any marked degree. An exception to the effect of paper on chemical changes is that of oiled papers which are used to prevent apple scald.

Summary

1. Waxed papers are effective in reducing moisture loss or increase. However, they limit ventilation and encourage rotting of perishable products at high temperatures. Their greatest value seems to be for the prevention of wilting of produce held in refrigerators, and for the maintaining of the desired moisture content of seeds kept in humid regions.

2. Parchment and "whalehide" papers are highly resistant to disintegration in water and in moist conditions and are, therefore, suitable for wrapping products which should be or are shipped in contact with ice. The tests here reported demonstrate their value for lining leaf and head lettuce crates, for wrapping celery and for covering the bottom of plant shipping crates. The use of these papers could no doubt be profitably extended to the shipment of peas and to leafy cool season vegetables, such as kale, parsley, cress and spinach.

"Whalehide" papers, used as wrappers for ripe tomatoes, apparently have considerable cushioning value which aids in protecting the product against mechanical injuries. Both "whalehide" and parchment papers, unlike waxed papers, permit the passage of sufficient air to provide ventilation for most perishable products and at the same time they protect them against excessive losses of moisture.

3. The measurement of total soluble solids by the refractometer, as well as the freezing point depressions by the cryoscope, afford quick measures of quality and check, with minor exceptions, fairly closely with chemical analyses.

4. Total sugars in sweet corn and peas, but not grapes, were quickly reduced in quantity upon exposure to high temperatures. Papers had no effect upon this change except to prevent moisture loss and thus cause a greater relative reduction, due to dilution, of the sugar solution. Low temperatures (32° F.) greatly delayed this loss of quality resulting from the loss of sugar.

5. The sugar in peas was apparently first changed to acid hydrolyzable material and then to starch. The change in corn seemed to be more abrupt, since acid hydrolyzable material, as an intermediate product, was not detected.

6. Tomatoes ripened in the high humidity chamber colored poorly and had a poor flavor. No increase in acidity either as pH or titratable acidity could be detected in tomatoes as a result of wrappers or humidity. The acidity decreased as the ripening (off the vines) processes advanced. Paraffin-coated tomatoes did not develop any red color. Tomato fruits ripened off the vine never attained the same quality as vine-ripened fruits.

7. Newspaper on the inside of flower boxes provides fully as good or better insulation against heat or cold than equal weights of "whalehide" paper. Felt pads and cotton batting on the inside of the boxes provided considerable insulation. A paper wrapper on the outside of the box was equal in insulation value to a felt pad on the inside. A 45-pound "whalehide" wrapper provided insulation equal to 90-pound kraft.

8. Both sunlight and ultra-violet light pass freely through Celo-glass, glass (sunlight only tested), Vitrex, Flex-o-glass and waxed papers. Parchment paper also transmitted considerable sunlight and ultra-violet light but "whalehide" excludes, almost entirely, both of these forms of light.

9. The answers from the questionnaires to grocerymen and commission merchants tend to substantiate the results secured in the foregoing tests so far as shipping practices are concerned. Grocerymen agree that appearance and quality are more important in the selling of fresh vegetables and fruits than cost.

Literature Cited

1. Anonymous
1845. Paper for drying plants for the herbarium. Gard. Chron. Apr. 5; 223.
2. ————
1856. Hints on keeping and ripening fruits. Hovey's Gard. Mag. 22; 445.
3. ————
1859. Packing fruit. Rural New Yorker 10; 287
4. ————
1879. Australian oranges. Gard. Chron. New Series 13; 465.
5. ————
1880. Tebb's traveling flower-pot. Gard. Chron. New Series 14:53.
6. ————
1881. Celery for exhibition. Gard. Chron. New Series 16:725.
7. ————
1882. Protection against grape rot. Rural New Yorker 41:142.
8. ————
1899. Packing and grading tomatoes, cucumbers and grapes. Gard. Chron. 3rd Series 26:293.
9. ————
1916. Protecting fruit trees from rabbits. Gard. Chron. 59:311.
10. Beattie, W. R.
1922. Celery growing. Farmers' Bul. 1269.
11. Brookes, Charles, and Cooley, J. S.
1925. Oiled paper and other oiled materials in the control of scald on barrel apples. Jour. Agr. Research 29:129-135.
12. Clements, F. E.
Research methods in Ecology. 1905, p. 49.
13. Coleman, W.
1879. Packing peaches for market. Gard. Chron. New Series 13:718-719.

14. Crist, J. W.
1927. Effects of certain nutrient conditions on activity of oxidase and catalase. Mich. State College Exp. Sta. Tech. Bul. 78.

15. Deans, W.
1848. Fumigation. Gard. Chron. Apr. 8:238.

16. Duggar, B. M.
1913. Lycopersicum, the red pigment of the tomato, and the effect of conditions upon its development. Wash. Univ. Studies. Vol. 1, Part 1. No. 1:22-45.

17. Harkins, W. D., Davis, C. H., and Clark, G. L.
1917. The orientation of molecules in the surfaces of liquids, the energy relations at surfaces, solubility, adsorption, emulsification, molecular association and the effects of acids and bases on interfacial tension. Jour. Amer. Chem. Soc. 39:541.

18. J. S.
1847. Grapes. Gard. Chron. Sept. 4:592.

19. Langmuir, Irving
1919. The arrangement of electrons in atoms and molecules. Jour. Amer. Chem. Soc. 41:868.

20. McKay, A. W., Fischer, G. L., and Nelson, A. E.
1921. The handling and transportation of cantaloupes. U. S. D. A. Farmers' Bul. 1145.

21. Sando, C. E.
1920. The process of ripening in the tomato, considered from the commercial standpoint. U. S. Dept. of Agr. Bul. 859.

22. Slingerland, M. V.
1894. The cabbage root maggot. Cornell Univ. Agr. Exp. Sta. Bul. 78.

23. Strickland, H. E.
1842. Seed experiments. Gard. Chron. July, 9:454.

24. Tucker, E. C., and others
1924. The manufacture of pulp and paper. Vol. 4, sec. 1:1-3 and sec. 6:43-37. New York.

25. Turnbull, John
1837. Description of an oiled cap for protecting dahlias when in flower. Loudon's Gard. Mag. 13:211-212.

26. University of Hawaii
1923. Second annual short course in pineapple production. 36-39, 74-75, 143-144.

27. Willich, Charles M.
1832. Preservation of seed. Loudon's Gard. Mag. 8:358.

28. W(orlidge), J.
1683. Art of gardening. London, p. 264.

29. ———
1880. Packing flowers. Gard. Chron. New Series 14:812.