EFFECTS OF PAPER WRAPPERS ON THE PHYSICAL AND CHEMICAL PROPERTIES OF FRESH HORTICULTURAL PRODUCTS

Thesis for the Degree of Ph. D.

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1927

THESIS

Farm Journal – Marketing

Tissue Paper wrappers

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Submitted to the Faculty of the Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of Doctor of Philosophy

by
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June 1927

Approved May 24, 1927
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THESIS

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INTRODUCTION

The demands of modern civilization for clean, unblemished, attractively wrapped foodstuffs, combined with the necessity of preserving the natural flavors of these food materials, have resulted in a large increase in the amounts and kinds of paper used to protect and preserve agricultural products. Though paper is used more extensively in the dairy and meat packing, than in the vegetable and fruit product industries, it is being used more and more for the protection of fresh horticultural products, in transit and in storage. Citrus fruits, apples, pears, peaches, mangoes, avocados, figs, tomatoes, flowers and plant seedlings intended for shipment are commonly wrapped with paper. It is frequently used to protect other extra fancy horticultural products such as celery, cauliflower, asparagus, melons, endive and rhubarb. Specially prepared papers are also used to blanch celery in the field, to protect cabbage plants from cabbage maggots, to mulch growing plants (especially pineapples), to protect and force plants in the field, to protect flowers from foreign pollen in pollination work, and even to protect and preserve fruits, such as grapes, from injury by insects, diseases, frosts and mechanical agencies. Paper packages are employed for the distribution of most horticultural and agricultural seeds and paper boxes and cartons are used extensively for the shipment of flowers, canned goods and other horticultural products. Even paper pots and paper bands are substituted for clay pots so commonly used by gardeners, florists and nurserymen.

Review of Literature

The utilization of paper in the horticultural and agricultural industries is closely related to the development of the paper industry. Although paper-making from rag fibers was a well-established art in China at the dawn of the Christian era, it was not until after the invention of the paper machine by Louis Robert, in France, in 1799 that paper was produced on such a scale as to warrant its extensive use for the preservation of agricultural products. By 1830 improved paper 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 (27). Prior to 1860 practically all paper was made from rag fibers, cotton and linen. This resulted in a scarcity of rags, and the discovery of the process of making pulp from wood finally relieved this situation and permitted a great growth of the paper industry.

Shortly after the introduction of the improved paper machines accounts of paper being used in the horticultural industries began to appear. In 1837 John Turnbull (28) used papers which he oiled, for protecting dahlias from frosts. 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". He gave directions for oiling the paper. In 1842 the use of paper for preserving seeds is mentioned (26) while in 1832 seed was kept in vials,

tin cases, and earthen jars, but probably not in paper packages (30).

Paper was apparently used for packing and displaying fruits as far back as 1847 as is illustrated from the following quotation regarding displays:- "We have known a thin sheet of tissue paper to occasion the loss of a medal (21). In 1856 brown paper was used to separate layers of pears in barrels (2) and paper was also placed 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 (14). After this period and in conjunction with the development of the fruit shipping industry, the use of paper in this branch of horticulture, became more common. The use of paper for protecting vegetables in transit came somewhat later and its use for cucumbers and tomatoes was not reported until 1899 (10).

As far back as 1848 W.Deans (16) in England, used papers impreguated 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 (25), paper collars were first used to protect cabbage plants from the attacks of root maggots, in 1887. Paper bags were used to protect growing grape clusters from disease and insect pests in 1882 (9).

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 (31).

Paper was used for blanching celery for exhibition purposes in 1881 (7), but it did not come into general use for blanching celery until about 1920 (12). The protection of the trunks of young fruit trees from rabbits by means of paper is recorded in 1916 (11). Although it doubtless had been used much earlier than that for this purpose.

Directions for making paper boxes were given as early as 1882 (8). This industry at the present time offers one of the largest outlets for paper manufactures.

Paper has recently been used extensively for mulching pineapples.

It is evident from the foregoing that paper has been utilized for many and various purposes in the horticultural industries. A still greater use of paper, for the preservation and protection of horticultural products, depends largely upon its physical and chemical effects upon these products. In all probabilities these influences which include effects on the succulence, flavor, color and on undesirable contaminations of foodstuffs vary greatly with the kinds of paper that are used. Very little is known concerning these effects of papers of different kinds on the quality of horticultural products. Sando (24) finds that tomatoes ripened off the vine without ventilation had a high acid content and a low soluble carbohydrate (sugars) content while well ventilated tomatoes contained comparatively more sugar and less acid

and possessed a flavor more nearly like that of fruits ripened on the vines. He concludes 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 modifies 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 (18) states that lack of oxygen inhibits the development of tomato color.

McKay, Fischer and Nelson (23) find 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 growth of diseases.

Apple scald, which is considered by Brooks and Cooley (13) 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 such paper uniformly among the fruits in the packages.

Some papers are, therefore, desirable for certain purposes and undesirable for others. One kind of paper may be suitable for mechanical protection but unfit for protection against the loss of the natural moisture from the wrapped products. Some papers are unfit for wrapping products shipped under certain conditions of temperature and humidity, but may be satisfactory for the protection of these same products if the shipping conditions are altered. Specially treated papers may be suitable for specific purposes as for instance oiled papers in the prevention of apple scald. Again papers may be used solely or primarily as a means of advertising, or for display purposes. The utilization of attractively printed or lithographed papers as wrappers for advertising purposes as well as for food preservation, is still in its infancy. "Sunkist," "Blue Goose" and other similar brand names, have a very definite meaning to the buying public, and are of course of great value to the producers of the products sold under these names. Without the use of printed paper labels and wrappers the value of these trade names would be greatly curtailed.

It is evident that a careful selection of the right types of paper is necessary in order to insure the desired results. The investigations herein described were undertaken to determine the value of papers of different kinds in the packing of a number of the more common fresh vegetables, flowers and nursery stock.

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, genuine vegetable parchment and a special water indestructable 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 largely 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 (27).

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 peptization. When the paper is plunged into water after the short acid treatment this process is stopped and a gelatinous hydrate is formed (27). Parchment papers may be made from most kinds of paper but only that made from the most refined and purefied 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 impreguated with paraffin, while self sealing waxed paper, is not only impreguated, but is coated on both sides with sufficient paraffin, so that it will make a practically moisture proof union when melted by the application of the proper degree of heat. Self sealed waxed papers are used for preserving the foodstuffs (especially cereals) in packages against moisture fluctuations. The packages are wrapped and sealed by machinery. 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 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.

Several weights of papers 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 to determine the effects, of papers used in different ways, upon the quality of the different vegetables and fruits. Light penetration and insulation tests 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 determining 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 were also made to determine if possible any correlation between the activity of the enzyme and the changes which were taking place.

The loss in weight data were secured by wrapping each lot in paper and placing the lots immediately in their respective storage chambers. Most products were kept under four environments: (1)In a Frigidaire refrigerator where the temperature was kept at about 32^{o}F. and the relative humidity at approximately 87. (2) In an ordinary ice cooled refrigerator where the temperature was about 50^{o}F. and relative humidity approximately 70. (3) In a nearly air tight chamber where the temperature was about 80^{o}F.(high) and relative humidity of approximately 81. The humidity in the chamber was kept up by fanning

current of air over exposed water surfaces by means of a small electric fan. (4) In the chemical laboratory where the temperature was 80°F. and the relative humidity about 32. Of course the humidity in this room fluctuated with weather conditions.

At the end of the designated period each lot was removed, weighed and the loss in weight calculated.

As soon as the weight was recorded a sample of each lot was taken and the sap extracted in an oil hydralic press. The sap was collected in a beaker, immediately centrifuged and filtered. The filtered sap was then tested for refractive index, freezing point depression and acidity. The centrifuge was run at 1900 revolutions per minute; the radical distance of centrifuge head being 16 centimeters. Total solids were determined, by direct readings, on an Abbe-Spencer refractometer at 20°C. A Hortvet type, cryoscope discribed in the Jour. of Ind. and Eng. Chem for March, 1921, was used for determining the freezing point depressions. The colorimetric method, of 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 40-100 gram

samples were preserved by covering with sufficient hot (75°C.) 95 per cent alcohol to insure a concentration of 75 per cent, and heated at 75°C. for one hour. Chemically pure calcium carbonate was added (.25 gr.) before the samples were heated. The samples were then extracted with 80 per cent alcohol and the filtrate made up to volume (500c.c.). The residue was dried at 60°C., ground to pass a 60-mesh sieve and $\frac{1}{5}$ aliquots weighted out for analysis. Dry weights were calculated from $\frac{1}{10}$ portions of the extract and $\frac{1}{5}$ aliquots of the residue. The $\frac{1}{5}$ alquots were extracted with (30-40°C.) water and combined with the alcohol extract in the case of the grapes to make sure that all the sugar was being 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 clearified, 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. Starch was inverted 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, clearified, deleaded after which sugar determinations were made. The residue from the taka-diastase digestion with 70 c.c. of water as washings and 4 c.c. of concentrated HCl were refluxed for 2.5 hours for acid hydrolyzable material. After neutralizeing, clearifying and deleading in the usual manner, the reducing power of an aliquot was determined. Total sugars were calculated as invert, starch as dextrose, and the acid hydrolyzable material was converted to dextrose with the factor .90. All sugar determinations were made after the Munson and Walker method.

Catalase was determined according to the method described in Mich. Agr. Exp. Sta. Tech. Bul. 78.

Photometric readings for the light penetration tests were made by means of solio paper in an ordinary photometer, such as described by Clements. (Research Methods in Ecology p. 49-51 University of Nebraska Publishing Co. 1905).

Other methods involving only limited cases will be described later.

EXPERIMENTAL

There are a number of ways in which papers may influence the quality of products. (1) They may modify the rate of moisture loss or in some instances (seeds for example) of moisture gain. (2) They may favor the development of diseases (or insects) or retard their spread depending upon the kinds of papers used and their surrounding environments. (3) They may by the exclusion or inclusion of products, by adsorption, or in some other manner change the taste or chemical composition of the inclosed products. (4) They may enhance or detract from the value of the pro-

duct simply by a modification of the appearance of the product (include cleanliness) or package in which it is displayed. Though it is impossible to keep these factors separate they will be discussed, in the pages which follow, in approximately the order in which they are listed above.

Loss in Weight

Many horticultural products are sold by weight and the loss of moisture, especially from leafy vegetables, quickly reduces their market value even though they are not sold on a weight basis. Other products such as most agricultural and horticultural seeds quickly lose their germination ability when exposed to humid environments when they take up moisture (stratified seeds excepted). The preservation of the natural moisture and approximate original weight of horticultural products is, therefore, of primary importance.

In all tests involving loss of weight data the products were wrapped so that they were in direct contact with the paper. Obviously the protection of produce against the loss of moisture may be best accomplished through the use of a paper coated or saturated with a substance not miscible in water, such as paraffin or oil. Such papers, however, also inhibit ventilation and are very likely to provide conditions favorable for decay.

Peas.- Peas are usually packed in hampers, bushel baskets and specially constructed crates. If in transit for

two days or more it is customary to place ice in the center of the peas 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 decomposed by water. In the refrigerator, or display case, in the home, or in the store, where dry peas are preferred, the problem may become one of preventing moisture loss. In the former case parchment or other water indestructable paper is preferred and in the latter case waxed papers may be found of value.

Table 1 gives the per cent loss in weight from peas wrapped with different papers under different environments. The peas (variety Telephone) were picked in the morning (Aug.4) and each lot of approximately 176 grams weighed and placed in its respective wrapper and environment before 5 P.M. of the same day. Care was used in picking and in selecting the samples to be sure to include only peas of like degree of maturity. This was relatively easy as this particular picking was the first from a very healthy lot of vines.

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 wrapped with waxed papers for seven days 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, under cold laboratory conditions, in preventing moisture loss it should be remembered that waxed papers would be totally unfit for lining packages used for peas because they are not strong enough to hold up under shipping conditions. Even the waxed Kraft papers of 70-90 pounds basis do not, as will be shown later, withstand much usage as well as 45-55 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.

It may be noted that the per cent loss of weight at 32°F. on the ninth day is less for all lots than on the seventh day. This occurs also with sweet corn and tomatoes as is shown in tables 2 and 3. No reason for this increase can be given. It is possible but not likely that this increased weight may be due to water condensation on the surface although an attempt was made to weigh all samples before the formation of this condensation.

Figure 1 shows the condition of three lots of peas held in the iced refrigerator for 12 days. In this case the self-sealing waxed paper gave the most satisfactory protection as the molds had not made sufficient headway to discolor the pods at this temperature.

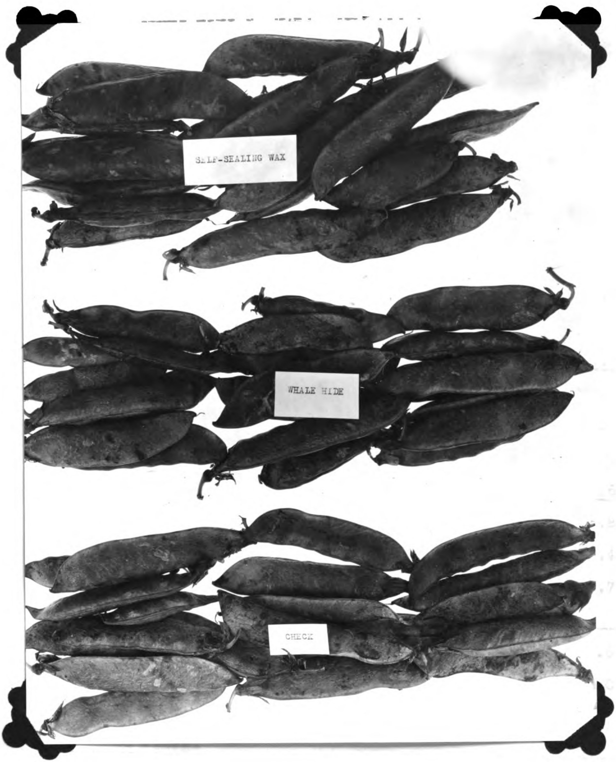

Fig.1.-Peas after 12 days of storage at 50°F.

This temperature limits mold development and the self-sealing waxed paper, therefore, proved most satisfactory.

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

Day of storage	Environment	Treatment				
		20# Wh.	25# P.	25# D.W.	25# 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 "	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 "	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 "	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 "					
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 "					

Wh.= whalehide paper. P = parchment paper. D.W.= dry waxed paper. S.S.W.= self sealing waxed paper.

These same legends will be used in the tables which follow.

Sweet Corn.-Kelly's hybrid sweet corn was gathered on September 17 and all lots wrapped and stored in their respective places the same day. Three ears were used in each test making the weight of each lot approximately 1000 grams. Figure 2 shows one lot wrapped with whalehide paper. The corn was stored under the same conditions and at the same places as the peas.

The loss in weight data are tabulated in Table 2. These data check fairly closely with those for peas and no additional comments are necessary regarding them. Figures 3 and 4 show the effects of temperature and humidity on corn, with and without the husks, after nine days of storage. The corn silks quickly decomposed whalehide paper as is shown in figure 2.

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. The vines at this time were about half defoliated with Septoria and great care was exercised in securing uniform solid fruits for all lots. Three tomatoes were included in each lot with a total weight per lot of from 360 to 480 grams. The losses in weight in per cent from the different lots are shown in table 3. Though the weight losses are not nearly as great as for sweet corn and peas, yet they are as great as 10 per cent in 12 days time. The papers have the same relative protective value as was the case with corn and peas.

Table 2.-Weight lost by corn stored under different conditions, in per cent.

Day of storage	Environment	Treatment 20 lbs.Wh.	25 lbs.S.S.W.	Ck.
3	32°F.	3.3	.4	.9
	50°F.	4.2	1.9	4.7
	80°F. low humidity	10.8	1.4	10.8
	80°F. high "	4.2	1.4	4.0
5	32°F.	2.4	.8	3.2
	50°F.	4.7	2.1	12.4
	80°F. low humidity	16.7	3.8	19.3
	80°F. high "	8.9	3.7	6.8
7	32°F.	2.7	1.5	1.3
	50°F.	7.8	2.0	11.1
	80°F. low humidity	22.7	4.8	22.8
	80°F. high "	10.5	4.2	12.1
9	32°F.	2.4	1.3	1.3
	50°F.	11.7	3.1	11.0
	80°F. low humidity	25.6	5.2	29.8
	80°F. high "	10.8	3.8	14.8
12	32°F.	3.5	1.2	2.6
	50°F.	13.6	2.9	13.5
	80°F. low humidity	29.9	7.0	41.4
	80°F. high "	12.9	4.5	17.8

Figure 2.-Corn wrapped for experimental tests. Note that the corn silks have decomposed the whalehide paper at both ends of the package.

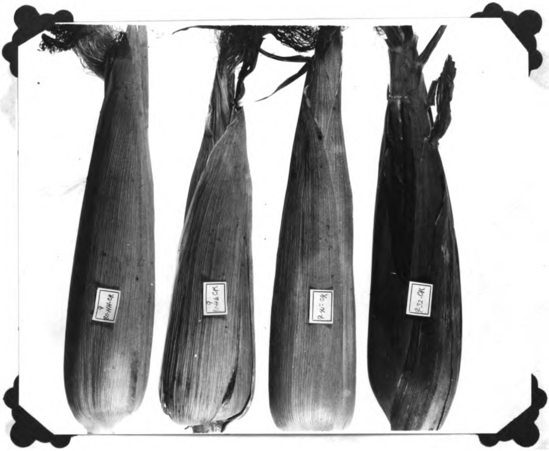

Figure 3.-Sweet corn after nine days of storage at different temperatures and humidities.

Fig.4.-Sweet corn after nine days of storage at different temperatures and humidities. Same as Figure 3 but with husks removed.

The small loss of moisture from tomatoes, as compared with peas and sweet corn, is surprising in view of the fact that tomato fruits are about 95 per cent water while the peas and sweet corn used in these experiments contained 78 and 62 per cent of water respectively at the start of the tests. The unwrapped tomatoes in the laboratory had lost only 8 per cent of their weight in 9 days while the similar lots of corn and peas had lost 29.8 and 77.7 per cent of their weight respectively. There is a relatively greater surface exposed to evaporation for a given weight of peas, as compared to the surface exposed for the same weight of corn or tomatoes, and this no doubt accounts for some of the difference in loss of weight between peas and tomatoes. There are however approximately equal surfaces of tomatoes and corn exposed for equal weights of these products. This factor cannot, therefore, be responsible for the greater loss of weight from corn. Some of this difference may be due to the escape of moisture from the point where the products were severed from the plant. The greatest difference in the moisture loss from corn and tomatoes is very likely due to the difference in the protective coverings. The tomato skin is according to Gardner and Kendrick (19) devoid of stomata. This, however, probably does not account for all of its protection against moisture loss. The skin of the fully ripened tomato is coated or impregnated with a waxy material which is not miscible with water and it is very likely that this waxy covering aids materially in preventing moisture

loss. In this connection, it may be of interest to note the applicability of the polar conception of molecules and groups, as developed by Langmuir (22) Harkins (20) and others, in predicting the possible uses of different kinds of paper for protecting different 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 (become soluble) and contaminate these foods. Waxed paper is used around bread largely because it is transparent and customers can thus see the bread without removing the wrapper. It also protects the bread against excessive

Figure 5.-Note the shriveled skins of the tomatoes held in the high temperature and low humidity (LH) room.

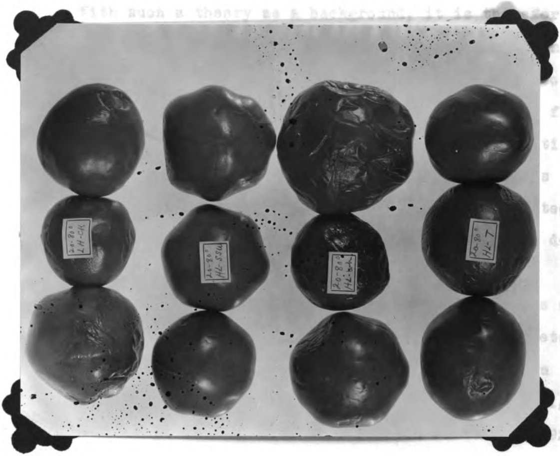

Figure 6.-Tomatoes stored 20 days at 80°F. Note the turgid condition of the lot protected by waxed paper (S.S.W.).

moisture loss. The practice of applying a considerable amount of butter, to the surface of bread, had to be discontinued as it was found that the contact of non polar grease and a non polar paper was not practicable.

With such a theory as a background, it is therefore not so hard to understand why the 95 per cent polar water in a tomato, is held in place by a very thin but non polar coating or skin. Figure 5 shows tomatoes which had been stored for 20 days under different temperature and humidity conditions. Figure 6 shows the effect of paper wrappers on tomatoes stored for 20 days. Though the waxed paper effectively prevented moisture loss it also interfered with the normal color development.

Grapes.-On October 13, 1926 a number of varieties of grapes were placed in 2-quart climax baskets, the baskets and grapes wrapped with different papers, and placed in common and cold storage. Table 4 shows the losses in weight from these lots. The "A" lots were removed January 3, 1927 while all other lots were removed from storage and weighed November 23, 1926. The losses in weight are small in all lots due to the cold humid storage conditions. The common storage was especially damp. The temperature in the cold storage rooms was approximately 32-34°F. while that in common storage ranged from 40-50°F. The papers used around grapes had the same relative protective value against moisture loss, as with peas, corn, and tomatoes.

Table 4.-Loss of weight from grapes stored under different conditions (in per cent).

Variety	Environment	Wt.at start grams	Wt.lost grams	Loss per cent
Lignan Blanc	Wh.cold storage	1010	55	5.4
" "	Ck. " "	915	75	8.2
Niagara	Wh.Common storage	1295	10	.8
"	S.S.W. " "	1340	7	.5
"	Ck. " "	1190	5	.4
"	Wh.Cold storage	1230	65	5.3
"	Wh.(a) " "	1180	100	8.5
"	S.S.W. " "	1260	30	2.4
"	S.S.W.(a)" "	1255	45	3.6
"	Ck. " "	1060	75	7.1
"	Ck.(a) " "	1142	132	11.6
Concord	Wh.Common storage	1045	15	1.4
"	S.S.W. " "	1025	5	.5
"	Ck. " "	1015	0	.0
"	Wh.Cold Storage	1040	65	6.3
"	Wh.(a)" "	1115	100	9.0
"	S.S.W." "	1000	20	2.0
"	S.S.W.(a) "	1035	30	2.9
"	Ck.Cold "	1010	78	7.7
"	Ck.(a) " "	1005	130	12.9
Wyoming	Wh. Cold Storage	1105	70	6.3
"	S.S.W. " "	1025	22	2.1
"	Ck. " "	1030	75	7.3

Table 4.-continued

Dimond	Wh. Cold storage	1125	55	4.9
"	S.S.W. " "	1120	28	2.5
"	Ck. " "	1030	65	6.3
Agawan	Wh. " "	995	50	5.0
"	S.S.W. " "	1000	15	1.5
"	Ck. " "	1045	80	7.7
Worden	Wh. " "	930	50	5.4
"	Wh.(a) " "	965	90	9.3
"	S.S.W. " "	835	12	1.4
"	S.S.W.(a)" "	1060	45	4.2
"	Ck. " "	1065	80	7.5
"	Ck.(a) " "	895	120	13.4
Salem	Wh. " "	1100	65	5.9
"	Wh.(a) " "	1085	100	9.2
"	S.S.W. " "	1090	15	1.4
"	S.S.W.(a)" "	1025	40	3.9
"	Ck. " "	1040	65	6.3
"	Ck.(a) " "	1305	165	12.6
Brighton	Wh. " "	1015	30	3.0
"	Wh.(a) " "	1245	95	7.6
"	S.S.W. " "	1155	25	2.2
"	S.S.W.(a)" "	1105	30	2.7
"	Ck. " "	1135	65	5.7
"	Ck.(a) " "	995	110	11.1
Empire State	Wh. " "	1290	60	4.7
"	Wh.(a) " "	1315	110	8.4

Table 4.- continued

Empire State	S.S.W.	Cold storage	1265	25	2.0
"	S.S.W.(a)	" "	1280	45	3.6
"	Ck.	" "	1285	70	5.4
"	Ck.(a)	" "	1110	120	10.8
Deleware	Wh.	" "	1050	50	4.8
"	Wh.(a)	" "	1265	130	10.3
"	S.S.W.	" "	1230	30	2.4
"	S.S.W.(a)	" "	860	45	5.2
"	Ck.	" "	1000	70	7.0
"	Ck.(a)	" "	835	95	11.4

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. The results of this test are given in table 5. There were 6 plants in each bunch and each of the bunches weighed about 2400 grams at the start. In this test the same lots were reweighed on the five different dates while separate lots were provided at the start for corn, peas, tomatoes and grapes, so that the lots could be used for chemical tests as soon as they were weighed. Figures 7 and 8 show the same 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 8 is a soft rot. On the fifth day this rot had become very serious in this (S.S.W.) lot. The figures show plainly that losses of moisture influence greatly the appearances of celery.

Table 5.-Loss in weight (in per cent) for celery stored in a laboratory where the temperature was 80^{0}F and relative humidity around 32 per cent.

Day of storage	Treatment Wh.	S.S.W.	Ck.	Notes
1	12.2	8.8	14.1	
2	19.4	12.9	25.0	
3	27.4	16.9	34.9	
4	34.3	21.9	42.8	Rot starting in S.S.W. See photo
5	40.8	27.5	50.5	None marketable on 5th day.

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 Mr.F.F. Dutton of Sanford, Florida included four crates of celery in a shipment to Thierwechter Brothers at Detroit. This shipment was loaded April 11 and the express shipment from Thierwechter arrived in Lansing 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 loss in weight data are presented in table 6 and a photograph of the four lots, taken on the date of their arrival in Lansing, is shown in figure 9. The figures do not indicate that washed celery wilts any faster than unwashed celery. There is, however, a definite relation of 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 as is frequently stated

Figure 7.-Celery stored 4 days in a high temperature, low humidity room. Left to right: S.S.W.-Wh.-and Check lots.

Figure 8.-Celery stored 4 days in a high temperature, low humidity room. Same as Fig.9 with papers removed. Left to right: S.S.W.-Wh.-and check lots. Note rot starting on S.S.W. lot.

Figure 9.-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 pre-cooled. 4. Washed, precooled and wrapped.

the decline must be due to other factors than wilting. Wet celery or even dry celery at high temperatures will rot as is shown in figure 8. At low temperatures neither wet nor 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 no doubt to storage at high temperatures which should never be allowed with any celery. Moreover as will be shown later celery shipped "ruff" frequently reaches the sales counter without being washed. This fact alone should caution celery growers against shipping "ruff" stock if they are looking for increased celery consumption .

In this connection the method of washing, wrapping, shipping and precooling has an important bearing on the keeping qualities of celery. Celery may be considered washed but not precooled if water above 40°F. is used. Celery so washed and then placed in poorly cooled cars is likely to rot. If top ice is used in addition to bunker ice this celery may carry all right if it had been cooled to nearly 40°F. in the so-called precooler. Water has a high thermal capacity and is, therefore, a much better precooling medium than air. The celery in Mr. Dutton's Plant at Sanford is precooled in a very effective manner. The washing and wrapping are done previous to precooling. Precooling is accomplished by passing the celery through ice cold water, for a period of 30 minutes, after which it is sprayed with ice cold water to remove adhering disease spores. It is then passed through a cold room directly into

Table 6.-Loss in weight from "ruff", "ruff" precooled, washed precooled, and washed, wrapped and precooled celery. Tests started after celery had been in transit 11 days.

Lots	Weight at start	Per cent loss of weight 16 hrs.	44 hrs.	96 hrs.	168hrs.
"Ruff" not washed	Crate 58.7 lbs.	2.6			
"Ruff" precooled not washed	Crate 63.1 lbs.	2.7			
Washed precooled	Crate 61.5 lbs.	2.1			
Washed wrapped precooled	Crate 57.1 lbs.	2.3			
"Ruff" not washed	4 stalks 1609 g.		27.5	43.4	64.6
"Ruff" precooled not washed	4 stalks 1770 g.		24.2	46.6	66.7
Washed precooled	4 stalks 2058 g.		19.6	35.6	53.1
Washed wrapped precooled	2 stalks 1065 g.		18.1	33.1	48.8

iced cars and as soon as the cars are loaded the celery is top iced (4000 pounds per car). The precooling water (cooled by brine coils from an ammonia system) is changed frequently in order to remove dirt and disease organisms.

It is often stated that washed celery stalks turn brown. A close inspection of lot 3 figure 9 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 10. The figures in table 6 show that this lot lost much less moisture than the other lots, moreover it brought a much better price when sold, which is after all the ultimate test of value.

Figure 10.-This celery was washed then wrapped and then precooled by passing through water at 32-34^{o}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 of stalk.

Nursery Stock.-Whalehide paper, with and without burlap, was used to wrap the ball of earth left around the roots of each plant in a shipment of 25 plants, including 9 species of Juniperus, and 39 plants including 13 species of Threja, from Painesville, Ohio to Grand Rapids, Michigan. The plants were wrapped as they were dug in the fields April 5. They were weighed, placed in large boxes and shipped by freight April 6. Upon their arrival in Grand Rapids, April 15, they were again weighed. The losses from all lots were slight and uniform. Under the conditions of this experiment the paper gave no additional protection against the relative low water loss (1-2 per cent probably largely through transpiration). It was noted, however, that the whalehide paper used alone (one thickness of 55 pound paper) provided protection almost equal to the burlap and that the paper in most cases remained untorn even though the plants and attached balls of earth in some cases weighed as much as 45 pounds.

Seed.- Many garden seeds deteriorate when stored under humid conditions, as in humid climates, unless protected 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 the chemical laboratory and in the moist atmosphere of the etherization chamber, while one set was sent to Mr.Russel Mason of the Stokes Seed Company at Sanford, Florida. The tomato seed for the tests was

furnished by the Indiana Canners Association, while all the other seeds were furnished by Stokes Seed Company. The tests were started March 17, and terminated April 22, with the exception of the Florida lot. The data for beans and tomatoes are presented in table 7.

Although it was necessary to discontinue the test earlier than desired, the data prove 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 protected by the waxed paper. After the start of this experiment it was found that 30 pound self sealing waxed paper should have been used instead of the 25 pound grade. Dr. Des Autels of the Kalamazoo Vegetable Parchment Company states that the 30 pound grade has much greater protection value against moisture transfers than the 25 pound grade.

The differences in germination percentages, come within the limits of experimental error, and do not therefore indicate any decrease in germination capacity for any lot. It is interesting, however, to note the rapidity, at which the lots that had taken up considerable moisture germinated. The unwrapped lot of beans, kept in the moist chamber, had yielded a 75 per cent germination after three days while the wrapped lot yielded only 48 per cent germination. Had the tests continued for a month or two longer it is possible that the seeds which took up the most moisture would have had their vitality impaired.

Table 7.-Gain or loss in weight and germination capacity of Indiana Baltimore tomato and Round Pod Kidney Wax bean seed stored under different conditions

Vege-table	Treatment	Weight seed (grams)			Germination(per cent)				
		March 11	April 22	Per cent gain	March 17	April 25-30 3 days	3-6 days	Total	Gain
Bean	Ck.-Dry room	40	39.19	-2.0	96	4	92	96	0
"	Ck.-Moist "	40	43.00	7.5	96	74	18	92	-4
"	S.S.W.Dry "	40	39.42	-1.5	96	14	86	100	4
"	S.S.W.Moist "	40	41.22	3.1	96	48	52	100	4
Tomato	Ck.-Dry room	134.20	132.68	-1.1	97	6	83	95	-2
"	Ck.-Moist "	136.87	142.65	4.2	97	40	55	97	0
"	S.S.W.-Dry "	137.37	136.50	- .6	97	10	82	98	1
"	S.S.W.-Moist "	142.40	145.05	1.9	97	19	74	93	-4

Plants.-Many hundreds of millions of plants (principally tomato and cabbage), are shipped from southern to northern sections each year. During cool weather these plants, especially cool season plants, are packed without either dirt or sphagnum moss around their roots, but later it is necessary to use well moistened moss. The conservation of moisture in this moss during warm weather becomes a very important consideration. The problem 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 8 are therefore due primarily to losses through the paper or bottom of the basket and are not augmented by plant transpiration losses. Such a test, although not a commercial test, nevertheless throws light on the direct effectiveness of the papers .

Table 8.-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 Wax(25 pound)	2000	7.0	24.8

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

Shipments of cabbage plants were received from the Carlisle Plant Company of Valdosta, Georgia. One shipment wrapped with waxed papers, although arriving in good condition, very plainly showed that such paper was not suitable to line crates or boxes with slatted bottoms, when the plant roots had a chance to puncture the paper. 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 11. Although the paper is torn in several places, the torn places are of no importance, and the protection against the escape of moss and moisture must be considered good. Forty-five pound whalehide, would no doubt be better than 35 pound whalehide, for this purpose.

Another shipment of cabbage plants from the same Company, showed that waxed paper, when placed against a solid foundation so that the roots of the plants would 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.

The main conclusion which may be drawn from the loss in weight tests are as follows:

1. Waxed papers provide much protection against the loss of moisture from fresh celery, peas, sweet corn, tomatoes, grapes, tomato and bean seed, and from moss

Figure 11.-Whalehide paper lining the bottom of plant shipping crate. Crate expressed from Carlisle Plant Compâny, Valdosta, Georgia. Note the paper protecting the moss around the roots is practically untorn.

around the roots of plant seedlings.

2. Waxed papers also protect seed from the absorption of undesirable moisture from humid air.

3. Parchment and whalehide papers, are capable of withstanding hard usage, when in or wet by water, without having their usefulness or appearance impaired. (See figures 10 and 11).

4. Parchment and whalehide papers provide considerable protection against moisture loss, but not nearly as much as waxed paper.

5. Waxed paper inhibits ventilation and encourages decay at high temperatures. (See figure 8).

6. Continued cold and rather moist environments, are apparently best for preserving the moisture content of celery, peas and sweet corn.

7. Washing, if properly done, does not cause a noticeable discoloration of the celery stalks. (See figure 9).

8. Washing and precooling, as well as icing methods, are important operations in celery marketing and must be considered along with kinds of wrappers.

9. Tomatoes lose moisture much slower than peas, sweet corn and celery.

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 yet the ultimate test, of that complex which constitutes quality, is

human taste amd even that differs considerably among different individuals. A few of the characteristics, of the different products, as determined by taste and sight, 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 an excellent quality throughout the test (12 days) as determined by taste. 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 nineth 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 oil hydrolic press under 5.5 tons pressure, and in its subsequent centrifying and filtration a number of differences were noted. All sap, from lots characterised 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 5 minutes as compared to 2-5 hours for sap from high quality peas. The amount of sap extracted at the pressure used had nothing to do with the color or 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 and doubtless could be used to detect quality differences. The 50°F. lots (i.e. between cold storage and high temperature conditions) showed intermediate properties until the nineth 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 approximated 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 became better as they ripened, but in no case did the fruits ripened off the vines taste as good as the vine-ripened fruits. Tomatoes ripened in the high humidity chamber and especially those wrapped with waxed papers developed a flat taste and the formation

of red color ceased after the seventh day.

Grapes.-Aside from the differences in the quality of different varieties of grapes, which are better depicted under the chemical data, the chief difference between lots was in the presence or absence of mold. In common storage, when the humidity was especially high, the self sealing wax paper provided protection against mold (apparently kept moisture out) while it favored the development of mold in the less humid cold storage room. The effect of this humidity difference is clearly shown in table 4. 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.

From the recorded observations listed above it is apparent that:

1. Peas and corn lose flavor upon standing in warm places. Storage at comparatively low temperatures is the best means of preserving the quality in these fresh (not canned or manufactured) products.

2. High quality in peas is associated with a green colored, colloidal, slowly filterable sap.

3. Tomatoes ripened in the high humidity chamber had a poor flavor and did not develop a normal red color.

4. Grapes did not lose flavor upon standing in a low humidity room but eventually wilted so that they were unmarketable as fresh grapes.

5. No differences in taste, due to the use of papers, could be detected except possibly that tomatoes wrapped

with waxed papers had a somewhat flatter taste than those in the other lots.

Total 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. Refractive indices and freezing point depressions are both measurements of dissolved molecular solids. The amount of these solids determines largely the concentration of tissue fluid. Since it is these solids, such as sugars, that 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 $-6^{\circ}C$. before the sap was extracted. The peas were wrapped in two thicknesses of cheesecloth and subjected to 5.5 tons pressure in an hydraulic press for 10 minutes; 70 gms. yielded about 23 c.c. of sap. In many instances the cheesecloth became lodged between the walls of the cylinder and the piston. This made it difficult to remove the piston, and

made the pressure actually exerted on the peas variable. 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 moisture loss, total solids and freezing point depressions are given in table 9. There is a distinct decrease in total solids and a lowering 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 high humidity lots contain somewhat more dissolved materials as recorded by these two indices (note exception on fifth day). This is rather hard to explain in view of the greater amount of water (for dilution) in the high humidity lots.

The differences between the 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 value for total solids

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and for the freezing point depressions were not raised.

It is interesting to note that high total solids and high cryscope readings correspond closely to high quality as indicated by taste.

Tomatoes.-The effects of paper, temperature and humidity on the moisture loss, total solids, freezing point depressions and pH values are given in table 10. Sixty gram samples, taken through the center of the three tomatoes in each lot as shown in figure 12, furnished 53-55 grams of pulp for subsequent tests.

The data show a slight increase in total 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 (24), but the evidence here presented does not support his conclusion that the use of wrappers increases the acidity. The pH values were compared with titrations of 5 c.c. of sap with $\frac{n}{20}$NaOH. The number of c.c. of $\frac{n}{20}$NaOH required to neutralize 5 c.c. of extraxt, from the 15 and 20 day lots, is shown with the corresponding pH values in table 11. The pH and titration values correspond very closely.

The only effect of the papers that is pronounced is the lower total solids and lower freezing point depression of the lots wrapped with self sealing waxed papers. This is no doubt due to the lessened moisture loss from these lots with a consequent dilution of the dissolved materials. These lots colored more poorly than the other lots. It was

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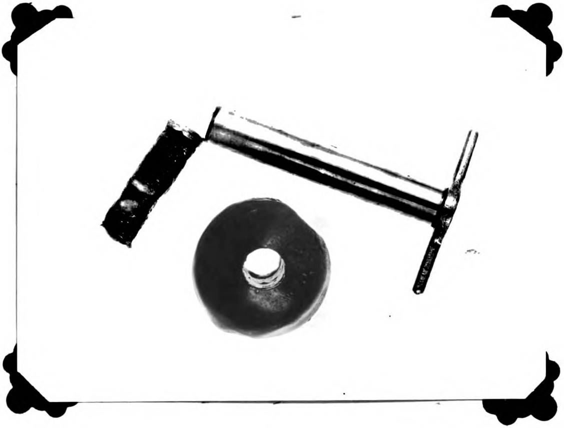

Figure 12.-Method of securing samples of tomatoes for analysis.

Table 11.-Comparison of pH values and titration tests on the 15 and 20 day tomato lots.

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

also thought that the tomatoes had less taste, and this may have been due to 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.

Though there were some detectable changes in the tomatoes as they ripened under the different conditions, off the vines, the most conspicuous changes apparently took place as the fruits acquired the red color on the vines. For instance, the Earliana tomatoes at the start of the experiment were just starting to color. At this time they had a total solid content as measured on the refractometer of 5.1, while vine ripened tomatoes had a total solid content of 6.9. Likewise the pH values of turning tomatoes were 4.1 or 4.2, while those of vine ripened tomatoes were around 4.5. Though the acidity of tomatoes ripened in the laboratory decreases to approximately the same point as that of vine ripened tomatoes, it is significant that the soluble solids in artificially ripened tomatoes do not approach closely those of vine ripened tomatoes. There is no doubt that the large difference in quality between green picked and ripe picked tomatoes is due to this soluble solid factor. Sando (24) found this same difference.

Grapes.-The effects of paper on losses of weight, total solids, freezing point depressions and pH values of

extracted grape sap are shown in table 12. These data show that grapes have a much higher soluble solid content than peas or tomatoes. It is noticeable that the Brighton, Deleware and Salem varieties contain more total sugar than the other varieties. It is remarkable that acidity (pH 2.8) is uniform for all lots in spite of the soluble solid content. It is also surprising to note that the acidity of grapes is much greater than that of tomatoes (pH 4.1-4.6). Titratable acidities were also determined, and they correspond with the pH values much the same as shown in table 11 under the discussion of tomatoes.

Effects of the different papers are not detectable. 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 9).

A study of the data on total solids, cryescope determinations and pH values, shows the following:

1. High temperatures cause the total solid content of peas to decrease as is shown by the refractometer and cryescope indices of the extracted saps.

2. Peas may be kept for 12 days at 32°F. and still retain a relatively high percentage of soluble solids.

3. The waxed papers, especially the self sealing waxed paper, by preventing moisture loss, caused the remaining

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soluble solids to remain diluted and thus show lower values. This indicates, of course, that the decrease of quality in peas is not due to moisture loss.

4. Tomato soluble solid content increases slightly as the fruits ripen off the vine. Thus tomatoes respond differently than peas in this respect.

5. Vine ripened tomatoes always have a higher quality and more soluble solids than fruits ripened after picking.

6. Wrapping did not increase the acid content of the Earliana tomatoes used in these tests.

7. Waxed papers and paraffin coatings, inhibited partially and totally respectively, the red color formation in tomatoes.

8. The greater dilution of the soluble solids, resulting from the retention of moisture by waxed papers, was evident in the tomato tests as well as in the pea tests.

Carbohydrate Analyses

Samples of peas, corn and grapes were preserved at periods when it was thought the greatest differences could be detected by chemical tests. Total sugars, starch and acid hydrolyzable materials were determined in all cases.

Peas.-The data for peas are given in table 13. All calculations are made on a dry weight basis. Peas which contained 18.6 per cent sugar (as invert), at the start, contained only 2.1-2.8 per cent at the end of seven days storage in 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. Here the sugar content has decreased to 2.1-2.8 per cent and the starch content 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.

The total solids as measured by the refractometer, and the freezing point depressions as measured by the cryoscope, correspond closely with the total sugar content as shown by the sugar analyses. Thus total solid readings from 10.5-11.6 correspond to 11.4-18.6 per cent sugars, and freezing point depressions of from 0.841 to 0.891 correspond to 11.4 to 18.6 per cent sugars. A total solids reading of 6.3 and a cryoscope reading of 0.329 correspond to a total sugar content of 2.1 per cent in the case of peas held, at 80°F., in self sealing waxed paper, at a low humidity, for 7 days. The apparent discrepancies in the 80°F. lots at low humidity for both the check and whalehide lots 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 depres-

Table 13.-Comparison of freezing point depression, total solids, total sugars, starch, acid hydrolyzable material and dry matter in peas stored under different conditions

Environment		Per cent composition				
		Total solids	Total sugars as invert	Starch as dextrose	Acid hydrolyzable material as dextrose	Dry matter
32°F.-Ck-3days	.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 " Wh.-7 days	.729	10.1	2.8	11.0	16.8	28.46
80°F.low " 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.-7days	.841	10.5	11.4	3.3	10.6	23.30

sion reading. Apparently the small amount of soluble solids (2.4 per cent), when condensed in the few cubic centimeters of extracted sap, were 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 cyroscope 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 per cent 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. At any rate it would be necessary to construct rather complete tables in order to convert the readings made by means of these instruments into sugar percentages. It is interesting to note that the refractometer readings for total solids are somewhat less than the chemical analyses show.

Corn.- The data in table 14 clearly show that the sugar content of sweet corn decreases in high temperatures, and that paper wrappers have little or no effect in preserving the sugar content. Although the data are meager, it seems that the sugar in corn is converted very quickly into starch, with little accumulation as intermediate acid hydrolyzable material. Furthermore, the starch content of

Table 14.-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 as dextrose (per cent)	Dry matter (per cent)
First day	10.3	44.5	4.1	31.71
32°F.-Ck. 7days	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 " S.S.W. 7 days	1.6	48.8	6.0	34.46

corn is much higher than in peas while the acid hydrolyzable material is less aboundant.

Grapes.- The carbohydrate analyses and corresponding indices for the cryoscope and refractometer for grapes are given in table 15. Grapes contained less than one half 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 different varieties. Wyoming and Agawan show consistently high qualities by all indices. In general the chemical analyses, cryoscope and refractometer readings correspond.

By contracting the analyses of peas, corn and grapes it seems that the quality of all three depends largely upon

Table 15.-Freezing point depression, total solids, total sugars, acid hydrolyzable material and dry matter in grapes stored under different conditions.

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

their sugar content, and so far as these products are concerned, 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 time 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 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 contentrated through desiccation.

Catalase

It is generally conceeded that the changes within tissue are at times at least accelerated by enzymes. In order to get some measure of catalase activity tests were run on different lots of peas. The procedure in making these determinations was the same as described in Mich.Agr.Exp. Sta. Tech. Bul. 78. The amount of oxygen given off in three minutes by the different lots,is recorded in table 16. Only a few of the data are shown in the table as no significant differences could be detected between the lots wrapped with different papers. The data do not warrant any conclusions.

Table 16.-Catalase Activity in peas stored under different conditions

Day	Environment	Per cent weight lost		Oxygen liberated in c.c.	
		S.S.W.	Ck.	S.S.W.	Ck.
3	32°F.	.9	3.8	3.54	3.58
	50°F.	3.2	10.6	2.40	3.30
	80°F. Low humidity	6.1	26.1	3.63	2.98
	80°F. High humidity	2.3	10.2	3.55	3.73
7	32°F.	1.7	7.5	3.63	3.90
	50°F.	5.6	25.6	3.25	3.90
	80°F. Low humidity	14.9	68.9	2.25	2.88
	80°F. High humidity	4.6	24.6	2.38	1.85
9	32°F.	1.5	6.2	3.80	3.50
	50°F.	11.5	34.4	3.25	2.65
	80°F. Low humidity	17.9	77.7	2.33	4.40
	80°F. High humidity				

The catalase activity of tomatoes was determined and 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 all seasons of the year. 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, supplied by Mr. Lukens of the Florex Gardens, North Wales, Pennsylvania, were used for conducting these tests. Such boxes are commonly used by this and other firms for express shipments, in the wholesale flower trade. 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. The data secured from these tests are presented in table 17. 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

Table 17.-Effects of different methods of insulation for the preservation of flowers in boxes. (Three pounds of ice and three pounds of flowers used in each box).

Conditions of tests	Outside temp. °F.	Hours after start of test 0	2	4	6	8	?	End of test
Newspaper & felt	19	54	30	30			(5) 28	Geranium leaves not frozen
" alone	19	50	30	28			(5) 27	" " frozen
Newspaper & felt	76	43	39	48	52	55		Some ice left
" & Wh. on outside	76	39	37	46	46	56		Some ice left
Newspaper	76	41	48	46	46	57		Some ice left
Whalehide	76	45	50	48	55	61		Some ice left
Newspaper & corrugated boxing	76	57	54	54	55	57	(12) 63	No ice left
Newspaper alone	76	55	50	48	52	61	(12) 66	No ice left
Newspaper & corrugated boxing & wrapper	76	48	45	45	45	50	(10) 48	10 grams of ice left
Newspaper & wrapper	76	46	46	45	46	50	(10) 55	1 grams of ice left
Padded box (paper and corrugated boxing)	76	45	46	48	50	54	(9) 55	Considerable ice left
Newspaper	76	48	48	50	52	57	(9) 59	Little ice left

Table 17-continued

Wh.,4 layers--felt in middle	76	50	50	54			(10) 63	
Newspaper alone	76	46	46	45			(10) 50	
Wh. 4 layers--cotton batting & wrapper	76	52	48	48	50	51	(12) 52	130 grams of ice left
Newspaper & wrapper	76	52	50	46	45	54	(12) 59	19 grams of ice left
Newspaper & 45# Wh. wrapper	76	59	50				(11) 57	
Newspaper & 90# Kraft wrapper	76	59	50				(11) 63	

value as equal weights of whalehide. Experienced florists claim this difference, if any, is due tomthe 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° 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 material 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 if such is available.

The color of the outside wrapper should be dark in the winter, to absorb heat from the sun, and light colored during the summer to reflect the heat. The importance of this precaution depends of course upon the length of time which such packages are likely to be exposed to the sun's rays.

Lettuce Tests.- In answer to a large number of questionnaires sent to grocerymen the statement was repeatedly made that celery 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 the Frigedaire refrigerator. Since this refrigerator is specially constructed, with no ice surface exposed to the storage chambers, it was necessary to regulate the humidity by means of water, sulphuric acid and water sulphuric acid mixtures. The low humidity was secured by

pure sulphuric acid which theoretically should provide a relative humidity of near zero. One lot was started at a low humidity and raised at the end of the second day to a high humidity by exposing a large surface of water in the chamber. The 50 per cent relative humidity lot was approximated with a 44 per cent sulphuric acid in water mixture. The humidity of the one lot was increased to see if the earlier results showing increased weights could be duplicated. The data for lettuce are shown in table 18.

The differences for tomatoes were similar to those for lettuce but less pronounced. No gain in weight was noticed during the tests although all weighings of the 100 gram samples were made to the second decimal place. The losses in weight from the low humidity chamber were considerable in the check and whalehide wrapped 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 large loss in weight of the lot held at a low humidity for two days and then increased to 100 per cent relative humidity is surprising.

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 Hardee and Gentile of Maimi, Florida, were carefully inspected. Two crates of tomatoes were expressed from Homestead, Florida

Table 18.-Loss in weight from leaf lettuce held in a Frigidaire refrigerator at 32°F. and varying humidities

Environment		Per cent loss in weight after 1 day	2 days	3 days	5 days	7 days	8days
Humidity low	Wh.	1.2	2.7	3.9	6.0	8.4	9.3
" "	S.S.W.	0.0	0.0	.2	.9	.9	2.1
" "	Ck.	3.1	7.3	9.9	12.6	15.7	17.0
" " Ck. (1st and 2nd days only)		1.9	3.8	6.1	9.0	12.6	12.8
Humidity high	(100%)Ck.	1.0	2.0	2.8	4.2	5.5	5.6
"	(50%)Ck.	2.0	4.3	6.2	9.4	12.6	13.9

on March 11. The tomatoes, in one crate, were wrapped with tissue paper and those in the other crate with 20 pound whalehide paper. They reached East Lansing on March 18. The tomatoes were packed in six basket crates. Records were taken on three dates as shown in table 19. On March 18 there were three rotten tomatoes, among 72 fruits wrapped with whalehide, and no rotton fruits wrapped in tissue. The order is, however, reversed on March 26, when eight tissue wrapped, and only one whalehide wrapped fruits were rotten. The data for the lower tier of three 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 this time, 450 tomatoes wrapped with tissue, and 450 wrapped with whalehide, were examined in five different crates from each treatment. Only one rotten tomato was found wrapped with tissue while nine whalehide wrapped fruits were rotten. One crate of each lot was sent to East Lansing and the data shown in table 20 were taken on april 9.

The tomatoes wrapped with whalehide are somewhat larger than the tissue wrapped fruits. A part of this difference in weight is due no doubt to the somewhat

Table 19.-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 "	(wilted)				4.9	7	1.7
Wh.No.3 "	(rotten)	3	.5	1	.2	12	2.9
Wh. Total		72	20.4		19.1	72	19.5
Tissue No.1tomatoes		72	19.8		11.1	47	11.8
Tissue No.2 "	(wilted)				5.2	15	3.4
Tissue No.3	(rotten)			8	1.6	10	2.1
Tissue Total		72	19.8		17.9	72	17.3

Table 20.-Number and weight of tomatoes, graded to indicate quality, from a shipment arriving in Detroit,April 2, from Homestead, Florida

	Wh.		Tissue	
Grade	No.	Wt.(lbs.)	No.	Wt.(lbs.)
No.1 tomatoes (solid)	26	5.6	9	2.0
No.2 " (soft and wilted)	86	19.7	115	23.9
No.3 " (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

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.(See table 3). The data in table 19 show 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.

It is very difficult to gauge the value of appearances. 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 13 shows the attractive manner in which his corrugated, three basket, tomato crates are packed.

Figure 13.-Alternate red ripe tomatoes wrapped with green whalehide paper make a very attractive package. Note that complementary colors are used.

The contrast between the green wrapper and the complimentary red color is very striking and appealing. Mr. Bloom also claims that the "cushiony" effect of the heavy 20 pound whalehide paper is a great aid in the protection of ripened tomatoes.

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. 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. Individually wrapped heads (whalehide) were not desired because the product could not be seen, although the commission merchants agree that such wrappers would likely be of value during cold weather to prevent freezing.

On October 20 a number of heads were cut and brought immediately to East Lansing and placed in cold storage. On December 2, when the tests were completed, the leaves from 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 even worse than from those wrapped with whalehide. In spite of the loss of leaves the heads were in excellent shape and tasted very good when cooked.

Lettuce.- The indestructibility of whalehide paper in water led the Kalamazoo Vegetable Parchment Company to make tests to determine its value for lining wet head lettuce crates. Figure 14 shows representative crates lined with a good grade of waxed kraft (left) and 55 pound whalehide (right) from a test shipment made from California to Philadelphia.

For additional tests of the value of this paper for lettuce shipments arrangements were made with Mr.E.T.Jack of Jack Brothers and McBurney Company, Brawley, California to use the paper for experimental shipments. The following letter gives the opinion of one of those engaged in the fresh vegetable trade as to the value of these different papers for this purpose.

Cedar Rapids, Iowa.
February 8, 1927.

PFE 19009

Jack Brothers & McBurney Company,
Brawley, California.

Gentlemen:

The above car of Golden Quality Head Lettuce arrived this morning, and the car was of usual Golden Quality standard, the heads being firm, green, and crates well packed. The buyers are entirely satisfied with this splendid car of Head Lettuce,

and we believe with this start, we will be able to hold the trade completely in line on Golden Quality stock.

We noticed the ten crates of Lettuce in the doorway, on which the new whalehide paper was used, balance of the car contained the regular pink paper used in your Golden Quality cars. We were very favorably impressed with the whalehide, and carefully examined the ten crates. The whalehide paper on arrival was in much better condition, and tougher than the old paper. There is only one objection to the whalehide, that is we wish you would have it in pink color with the Golden Quality label printed thereon. The Cedar Rapids buyers feel this is an individual mark, and since they have the trade started on pink paper with Golden Quality Brand, they seem to prefer this color. We thought perhaps the new whalehide could be secured in this color, and if so it would be entirely satisfactory to all our trade.

We believe this new paper will keep the Lettuce in much better condition, especially for reshipping into the country. It is not broken thereby retaining the even temperature inside the crate, prolonging the ice to a considerable extent. These are only a few of the advantages we see, and we hope the car we have loading will contain all whalehide if possible.

Yours very truly,

C.H.Robinson Company

By O.P.Moody, Manager.

Tests were also made with leaf lettuce. The following letter to the Ashtabula Growers Association summarizes the opinion of another dealer as to the value of this paper for

Figure 14.-Two crates of head lettuce shipped in a top iced car from California to Philadelphia. Crate on left lined with a good grade of waxed kraft and crate on right lined with 55 pound whalehide. Note untorn condition of crate lined with whalehide. (Courtesy of Kalamazoo Vegetable Parchment Company).

lining leaf lettuce baskets.

Ashtabula Growers Ass'n.,
Ashtabula, Ohio.

Gentlemen:

Noting your query, Re the new kind of paper you are trying out, will say that the trade seems to take it kindly. It being waterproof it does not become soaked, hence in transportation the paper does not tear so readily and the lettuce arrives in condition showing better appearance, than if some of the paper were torn and mussed. We think that it is an improvement over the old paper.

Very truly yours,

M.U.Mackey.

An excellent illustration of the use of parchment paper for the protection of leaf lettuce is shown in figure 15.

Light Penetration

A paper which is tough, not decomposed by water and transmits considerable light is desirable for protecting pistillate and staminate flowering parts in plant pollination work. It is also thought by some that the transmission of ultra violet light is especially desirable for this purpose.

In order to test the value of different papers for this purpose photometric readings, made on solio paper, were made in sunlight, (noon March 22) and eight inches from the

Figure 15.-White parchment paper makes a very attractive wrapper for leaf lettuce.

light of a 75 volt Burdiek ultra violet light machine used in the Michigan State College medical dispensary. The data are presented in table 21. 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 quite so readily as through the glass, Celoo-glass,etc. Glass cloth and waxed manila transmit comparatively little of either light while the whalehide papers exclude practically all light from both sources. The amount of ultra violet light passing through gauze is interesting in view of hospital practices.

No tests were made to determine the value of various materials for hot bed covers and plant protectors. The data in table 21 may, however, be used in predicting the possible use of these materials for these purposes.

Survey Among Commission Merchants and Grocerymen

In order to get the opinion of the trade, concerning the investigations and results secured from the foregoing tests, and to enlarge upon these findings, 225 questionnaires were sent to commission merchants and about 1600 to grocerymen. Ninety replies were received from commission merchants and 227 from grocerymen. The results are tabulated, so as to include the questions asked, in tables 22 and 23.

Table 22.- Opinions of 93 commision merchants regarding methods of handling celery

Method of Handling	
Prefer to handle:	
"Ruff" Celery	41
Washed "	14
Washed, precooled and wrapped celery	23
Realized profit from graded, washed and wrapped celery	25
Realized no " " " " " " celery	21
Precooled celery stands up better than "ruff" not precooled	55
Precooled " does not " " as good as " " precooled	9
Washed celery deteriorates faster than unwashed	10
Top ice should be used in addition to bunker ice	27
Top ice should not be used in addition to bunker ice	31
Precooled celery needs top icing	18
Precooled celery does not need top icing	40
Vegetable parchment wrappers help sale of celery	58
Vegetable parchment wrappers do not help the sale of celery	13

Table 23.- Opinions of 227 grocerymen regarding methods of handling celery

Which do you prefer to handle?		
(a) Washed and wrapped celery		142
(b) Washed but unwrapped celery		37
(c) "Ruff" celery		34
Is "ruff" celery frequently offered for sale without washing?	Yes	106
	No	95
Which keeps longest?		
(a) Washed and wrapped celery		67
(b) Washed but unwrapped celery		11
(c) "Ruff" celery		132
Do you think it pays to display celery in refrigerated glass cases?	Yes	113
	No	80
Which is the greater aid in disposing of vegetables and fruits? (a) Appearance and quality		211
(b) Low price		1
Are any vegetables injured by refrigerating them at 32°-34° F.?	Yes	119
	No	60
What vegetables do you think could be most	Celery	116
profitably protected and displayed	Asparagus	40
in Genuine Vegetable Parchment Paper?	Celery, cabbage	29
Cucumbers, endive, lettuce, tomatoes, rubarb		10-17

It is interesting to note that a greater proportion of commission merchants desire to handle "ruff" celery though the grocerymen as a rule prefer to handle washed and wrapped celery. Though grocerymen prefer the washed and wrapped celery they at the same time indicate that the "ruff" stock will keep the longest. This is in keeping with the statements already made, to the effect, that this is due to poor precooling methods and to poor storage facilities at destination points. In other words if the water (or moisture) applied during washing is accompanied with low temperatures the quality of the celery will be retained. If, however, water is applied and the temperatures allowed to rise the product will rot, while a similar condition with a deficiency of moisture would result in wilting, and wilted products have not apparently been rated as poor quality, or their detection has not been so apparent. Most grocerymen and commission merchants agree that precooling is a desirable practice, although a few object to it because of the moisture applied in most precooling practices.

It is surprising to note that the majority of grocerymen favor the displaying of celery in glass cases although some point out the wilting effect of certain types of refrigerators.

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

Most grocerymen think that temperature of from 32°

to 34°F. injure certain vegetables. Bananas among the fruits were frequently mentioned in this connection. Some thought certain vegetables became frozen at 32°F. The question is in this respect not clear and much of the evidence would no doubt have been qualified if this point had been more clear. Nevertheless there may be some justification for the statement frequently made, that the product must be disposed of immediately after being removed from the refrigerator. While there is plenty of evidence to the effect that vegetable tissues do not freeze at 32°F. (requires below 30°F. in most cases), yet there is no definite proof that such a low temperature (32°F.) does not alter the tissues to such an extent as to increase transpiration, permeability, etc.

While 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 paper to conceal defects. This, of course, should never be premitted. 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 by 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 unaminous 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 quarantee of quality. Green whalehide paper around red ripe tomatoes, as shown in figure 13, is an excellent example of color combinations being used to enhance the display value, and white parchment around celery (figure 10) and lettuce (figure 15) are good examples 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 instances 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 depends 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 rot when exposed to high temperatures. Such papers were, however, found of value in protecting produce against moisture loss in dry refrigerators where the temperatures were below 45^{o}F. Waxed papers were also of value in preventing 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 about the proper degree of ventilation and protection against disiccation for such products.

The chemical effects, resulting from the used paper wrappers, are negligable. Wrappers do not prevent the conversion of sugars into starch, in the case of 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 in that of oiled papers which are used to prevent apple scald.

Paper is an excellent insulating material. Newspaper is, however, fully as effective as the other papers included in these tests for this purpose, and the use of other papers for insulation would be justified only on the basis of more attractive appearances.

SUMMARY

1. Waxed papers are effective in reducing moisture loss or increase. They, however, 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 correct moisture content of seeds kept in humid regions.

2. Parchment and whalehide papers are highly resistant to disintergration 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 lining 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 solids by the refracto-

meter, 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 quality 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 seems to be more abrupt, since acid hydrolyzable ma 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 reipened off the vine never reached 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 as equal weights of whalehide. 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 Cel-o-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. Moist cool conditions are essential for the preservation and storage of fresh perishable leafy vegetables. Precooling and top icing are aids toward these ends but the excess moisture is bound to favor rotting if the temperature is permitted to rise much above 34°F. Grocerymen agree that appearance and quality are more important in the selling of fresh vegetables and fruits than cost.

ACKNOWLEDGEMENTS

This investigation was made possible through a fellowship fund provided by the Kalamazoo Vegetable Parchment Company of Kalamazoo, Michigan. Credit is also due to officials of this Company who cooperated in in a splendid manner throughout the year the tests were being made. Acknowledgements are due particularly to Mr.J.Kindelberger, Mr.E.C.Stoll and Dr.G.F.Des Autels.

Acknowledgements are also due Dr.J.W.Crist under whose direction the technical part of the work was undertaken and completed, to Professors V.R.Gardner and George Starr, and Mr.J.B.Edmonds for helpful criticisms during the course of the investigation and for reviewing the manuscript. Credit is also due Dr.O.S.Robinson for making hydrogen ion determinations.

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. Chmon. New series 14: 53.

6. ______

1881. Models of plants. Gard. Chron. New series 15:87.

7. ______

1881. Celery for exhibition. Gard. Chron. New series. 16:725.

8. ______

1882. How to make paper boxes.

Gard. Chron. New series:17: 835.

9. ______

1882. Protection against grape rot.

Rural New Yorker. 41:142.

10. ______

1899. Packing and grading tomatoes, cucumbers and grapes,

Gard. Chron. 3rd series. 26:293.

11. ______

1916. Protecting fruit trees from rabbits.

Gard. Chron. 59:311.

12. Beattie, W.R.

1922. Cèlery growing. Farmers' Bul. 1269.

13. Brooks, Charles, and Cooley, J.S.

1925. Oiled paper and other oiled material in the control of scald on barrel apples. Jour. Agr. Research 29:129-135.

14. Coleman, W.

1879. Packing peaches for market.

Gard. Chron. New series. 13:718-719.

15. Crist.J.W.

1927. Effects of certain nutrient conditions on activity of oxidase and catalase. Mich. State Tech. Bul. 78.

16. Deans, W.

1848. Fumigation. Gard.Chron. Apr.8:238.

17. Delany, Mary.

1897. Paper Mosaics. Gard. Chron. Third series 22:36.

18. 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.

19. Gardner, N.W., and Kendrick, J.B.

1923. Bacterial spot of tomato and pepper. Phyto. 13.No.7:307-315.

20. 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.

21. J.S.

1847. Grapes. Gard.Chron.Sept.4:592.

22. Langmuir, Irving.

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

23. McKay, A.W., Fischer, G.L., and Nelson, A.E.

1921. The handling and transportation of cantaloupes. Farmers' Bul. 1145.

24. Sando, C.E.

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

25. Slingerland, M.V.

1894. The cabbage root maggot. Cornell Bul. 78.

26. Strickland, H.E.

1842. Seed experiments. Gard. Chron. July 9:454.

27. Tucker, E.C. and others.

1924. The manufacture of pulp and paper. Vol.4 sec.1: 1-3 and Sec. 6:34-37. McGraw Hill Book Co.

28. Turnbull, John.

1837. Description of an oiled paper cap for protecting dahlias when in flower. London's Gard. Mag. 13:211-212.

29. University of Hawaii.

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

30. Willich, Charles, M.

1832. Preservation of seed. Loudon's Gard. Mag. 8:358.

31.

1880. Packing flowers. Gard.Chron. New series 14:812.

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