EFFECT OF TEMPERATURES, OVERWRAP MATERIALS AND CHEMICAL COATINGS ON QUALITY OF ELBERTA PEACHES

INTRODUCTION

It is known that fresh fruits contain a great amount of minerals and vitamins which are essential to the growth and health of the human body. It is also known that great quantities of fruits are lost on their way from the producer to the consumer. It is, therefore, necessary to keep fruits in the fresh condition as long as possible while in the marketing process, not only to effect a financial saving to all concerned but also to maintain public health at a high level.

One of the recent techniques employed to preserve the fresh condition of fruits has been that of prepackaging, which refers to the practice of fruit packaging in some sort of a container in the size and shape suitable for consumer use without further repacking.

It is not generally known that consumers prefer prepackaged to bulk produce but preliminary studies in Ohio indicated that consumers do prefer prepackaged to produce packaged in bulk. In other studies it has been found that prepackaging and refrigeration together produce much better results than either alone with regard to the marketable life of produce.

A great amount of information on the condition of fruit, while in storage and in transit exists but there is very little in regard to the best ma[illegible]se in prepackaging fruits or more specifically in the prepackaging of peaches as a means of reducing spoilage and prolonging

their fresh storage life.

Problem

What recommendations could be made relative to the storage temperature, packaging and coating materials and methods in prepackaging Elberta peaches to lengthen their fresh storage life?

Problem analysis.--Before answering the major question, it is necessary to answer the following:

1. What effect do various factors have on the loss of weight of the fruit?
2. What effect do various factors have on the changes in physiological and pathological conditions of the fruit?
3. What effect do various factors have on changes in the chemical composition of the fruit?

Delimitations.--This experiment has been limited to the packaging of tree-ripened Elberta peaches from the 1947 harvest grown in the Colorado Western Slope in Mesa County . The experiment deals with the use of different wrapping and coating materials and storage temperatures.

Definition of terms

Coating materials are those substances applied to the individual fruit to envelop it completely, such as waxes, etc.

Packaging materials consist of a paperboard tray or boat and a transparent film used as an overwrap.

MATERIALS AND METHODS

This experiment was carried out in conjunction with an experimental prepackaging plant operated by the Farmers Union Cooperative Association, Palisade Colorado. The purpose of the study was primarily to

yield information that would be of value to anyone desiring to engage in the prepackaging of peaches in a commercial scale.

Plan of work

The fruit was brought in by various growers scattered throughout the region under consideration to the prepackaging plant where the experimental tree-ripened fruit was selected from the commercial prepackaging line. A random sample of the fruit was taken and from it a number of maturity indexes were determined. These indexes included, pressure test (using a tester with a 5/16 inch diameter tip), color (using color charts arranged from green to deep orange on a wheel), weight, size (diameter) and per cent total soluble solids of the fruit as determined by an Abbe refractometer.

The experimental fruit was given the same treatment as the fruit in the commercial prepackaging line in that it was brushed, hand-sorted for bruises, scratches, size and stage of maturity. They were then packaged by a Package Machinery Corporation prepackaging machine. Those films lending themselves to packaging by the machine were packaged and heat sealed by the machine's heat sealing unit. The cellulose acetate-wrapped units were hand wrapped since this film is not heat-sealing.

The total number of units was broken up into three storage temperature lots, namely, 36° F., 45° F., and room temperature (70°-80° F.). The lot in each temperature storage was divided into five observation lots with each of the ten treatments represented by three replications.

The ten treatments used were as follows:

1. Nontreated
2. Cellulose acetate-wrapped
3. LST (perforated) cellophane-wrapped
4. LSAT cellophane-wrapped
5. MSAT cellophane-wrapped

6. LST (perforated) cellophane with propylene glycol.
7. LST (perforated) cellophane with primafresh wax and experimental preservative K5807
8. LST (perforated) cellophane with primafresh wax
9. Pliofilm
10. LST cellophane-wrapped

Scoring methods

Appearance, color, per cent decay and/or molds, shriveling condition, firmness (determined by use of a pressure tester equipped with a 5/16 inch tip, and by feel), taste (determined by three or more persons) and marketability (determined after taking all the above factors into consideration) were used as quality factors in scoring each of the treatments and temperatures. The scoring was done on a scorecard basis. The criterion used in evaluating the different treatments was that of the use of a scale ranging from the absolutely unmarketable fruit represented by zero per cent and the perfect fruit represented by 100 per cent. With the passage of time the fruit in storage in the different types of packages and different storage temperatures, naturally, deteriorated in quality but at different rates and to different levels down the graded scale.

All observations with regard to quality factors except taste were made by the same individual to reduce personal error.

Statistical methods used

The analysis of variance was used to determine the presence or absence of significant differences between groups. After significant differences between groups were shown to be present, a series of t tests were made to determine what groups were significantly different when compared with each other and all other groups in the experiment.

The analysis of covariance was used to analyze the simultaneous variation of two correlated factors, namely, appearance and taste used in determining the quality of the fruit.

RESULTS

Results of treatments

The cellulose acetate-wrapped, LSAT cellophane-wrapped and the nontreated lot were the top-ranking three treatments in that order as determined by their score means. The differences in means of these three treatments were not significant. The LST (perforated) cellophane-wrapped, LST cellophane-wrapped, MSAT cellophane-wrapped and pliofilm-wrapped treatments were intermediate in mean score rank between the top-ranking three above and the bottom-ranking three, namely, the LST (perforated) cellophane-wrapped, chemically treated lots.

Results of temperatures

The 36° F., storage temperature proved to be significantly higher or better than the 45° F., and room temperatures, when using the method of fruit scoring already explained. The 45° F., storage temperature proved to be better than the room temperatures not quite at the one per cent level of significance but significantly better at the five per cent level.

Results of pressure tests

Analysis of variance showed no significant differences to exist between treatments in the 36° F., storage. It showed, however, significant differences to exist between periods. There were no significant differences (decreases) in pressure test between the first and second periods and between the second and third periods in the case of the nontreated and cellulose

acetate-wrapped treatments. Those treatments that showed a significant decrease in pressure test between the first and second and second and third observations were the LST cellophane-wrapped and MSAT cellophane-wrapped. The pliofilm-wrapped treatment showed a significant decrease between the second and third observations. From the above it is seen that the nontreated and cellulose acetate-wrapped fruit remained firmer than that which was wrapped with the more moisture retaining films. This was possibly due to the accumulation of end products of respiration and moisture which are conducive to physiological breakdown of the cell structure of the fruit causing it to become softer.

Analysis of appearance and taste

The treatment differences for taste are not significant within a storage temperature. All the correlation coefficients of taste on appearance were highly significant indicating that taste is highly correlated with appearance.

Analysis of four treatments differing in moisture retentive qualities

To simplify the discussion the various films used have been roughly divided into four parts on the basis of their moisture retentive qualities. The following four treatments are representative and will be used:

1. Nontreated
2. Cellulose acetate-wrapped- the least moisture retentive film used
3. LSAT cellophanewrapped- allowed moisture to escape gradually from the enclosed container,
4. Pliofilm-wrapped- one of the most moisture retentive of the films used

In the 36° F., storage the four treatments just mentioned allowed

the fruit to remain in a marketable condition for 17 days.

In the 45° F., storage the nontreated and the cellulose acetate-wrapped treatments allowed the fruit to remain marketable for 13 days, the LSAT cellophane-wrapped for 10 days and the pliofilm-wrapped treatment kept the fruit in a marketable condition for four days. At room temperatures the nontreated and cellulose acetate-wrapped fruits remained marketable for seven days while the LSAT cellophane was marketable after 4 days in storage but was rendered unmarketable between that time and after seven days in storage.

From the above it is seen that at the lower temperatures the effect of the films used on quality of the fruit is almost zero. Physiological activities at low temperatures are depressed. At the higher temperatures the rate of respiration is increased and the various wrappers exert their influence. In the 45° F., storage the LSAT cellophane which allows for a gradual loss of moisture prevented shriveling and preserved the quality of the fruit. After some length of time (10 days in this experiment), however, the moisture transpired and possibly the accumulation of end products of respiration exceeded the amount allowed to escape, which is the film's limiting factor after a certain length of time. The accumulation of moisture and end products of respiration in the package favors mold growth and physiological breakdown of the fruit. Pliofilm, of course, provided a perfect seal and by so doing accelerated spoilage of the fruit.

A casual inspection of the results of the experiment might lead one to believe that the cellulose acetate film is the film to use in preference to any other including the LSAT cellophane . However, there are some limitations to its use. Some of these are that the film causes an excessive amount of shriveling, it tends to crack at the sharp folds especially when

it is handled as it would in a commercial operation, and it is not heat-sealing, a sealing process commonly used in present-day prepackaging machines. After the merits and limitations of the cellulose acetate film and LSAT cellophane film are fully considered, it is concluded that the LSAT cellophane is preferable to the cellulose acetate film in a commercial peach prepackaging operation.

SUMMARY

1. The different treatments used in this experiment did not affect the taste of the fruit at any one temperature. Appearance and taste were very highly correlated in the fruit used in this experiment.

2. At 36° F., the quality of the fruit is preserved and there tends to be little variation in the quality of the fruit in the different treatments because the physiological activity of the fruit is reduced, rendering the influence of the films less effective.

3. Tree-ripened peaches not wrapped and not chemically treated remained in a marketable condition for 17 days at 36° F., 13 days at 45° F., and seven days at 70°-85° F.

4. In the case of peaches, the more moisture retentive overwrap films were the least effective in preserving peaches in a marketable condition.

5. Prepackaged peaches can be maintained in a marketable condition up to 17 days with any of the films used at a storage temperature of 36° F.; 13 days at 45° F. when cellulose acetate-wrapped or unwrapped; and seven days at room temperature (70°-80° F.) when cellulose acetate-wrapped or unwrapped.

6. The results obtained in this experiment indicate that the use of primafresh wax alone, and with chemical preservative K5807, and the use of propylene glycol alone as preservatives of quality accelerated rather than retarded the amount of physiological breakdown and spoilage.

7. Of the films tested the 450 LSAT cellophane film proved to be the more desireable in the commercial prepackaging of peaches, when appearance, taste, firmness, marketability and other quality factors used in this experiment along with the characteristics of the films themselves are given due consideration.

This study showed that the chemicals used, although, commonly applied successfully as preservatives on other fruits do not prevent mold growth and subsequent spoilage in the case of peaches. This does not mean that the peach fruit cannot be successfully treated but rather that other chemicals should be tried. It may be that treatments not involving the dipping of the fruit in applying the chemical are more satisfactory.

T H E S I S

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EFFECT OF TEMPERATURES, OVERWRAP MATERIALS, AND CHEMICAL COATINGS ON PREPACKAGED ELBERTA PEACHES

Submitted by

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In partial fulfillment of the requirements

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COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Manuel R. Ornelas

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BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF Science

MAJORING IN Horticulture

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Permission to publish this thesis or any part of it must be obtained from the Dean of the Graduate School.

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Chapter I

INTRODUCTION

Fresh fruits contain a great quantity of minerals, vitamins, and other substances essential to the growth and health of the human body. It is, therefore, necessary to keep fruits while in the marketing process in the fresh condition as long as possible to enable the ultimate consumer to buy a sound product.

It is not generally known that consumers prefer prepackaged to bulk produce but in preliminary studies by Hauck (6), 1946, it was found that 416 of 482 patrons, or 86.3 per cent, in Columbus, Ohio, preferred prepackaged produce.

The great amount of produce discarded as waste from the point of production to the consuming centers is the one great problem confronting not only the growers, middlemen and retailers but the consuming public as well, in that eventually everybody pays one way or another for the wastes incurred.

Statistics compiled by Kling (11), 1943, showed that 26 per cent of the deciduous fruits are disposed as waste in the marketing process. His estimates indicated that wastage of fruits and vegetables after leaving the farms amounted to about 20 per cent. He pointed out that if these estimates are correct they indicate that more food is wasted than was consumed annually by our armed forces

and lend-lease shipments combined, during World War II.

A study made by Hauck (6), 1946, concerning the losses and damage occasioned by the necessary trimming, sorting and reconditioning in the retail stores revealed that of each 100 pounds (not including containers) received in the store, 36.1 pounds of bunched beets, 32.3 pounds of cauliflower, 20.4 pounds of head lettuce, and 14.8 pounds of broccoli had to be disposed as garbage.

In another study Hauck (8), 1946, comparing the wastes incurred at the retail store by prepackaged and bulk produce which included carrots, cauliflower, celery, sweet corn, lettuce and tomatoes, found that the total wastes incurred by the bulk produce amounted to 17.3 per cent by weight while that of prepackaged produce amounted to only 1.8 per cent. Non-prepackaged peaches incurred a wastage of 3.2 per cent by weight at the retail store and all this waste was due to molds and decay.

In a marketing experiment with sweet corn, Hauck (7), 1946, found that husked prepackaged sweet corn in 300 MSAT cellophane bags, five or six ears per bag, or the same number in individaul paperboard trays overwrapped with the same kind of cellophane, remained in a perfectly saleable condition after delivery to the grocery store. The corn usually remained saleable long enough to enable the retailer to dispose of it without reducing the price. He said that in moving prepackaged corn from the warehouse to the retail store a big saving was effected, since 49.2 per cent of the total weight was eliminated in husks, trimmings and unsaleable corn. Many favorable comments about the product were received from patrons and no corn was returned

to the retail stores as unsatisfactory.

A mass of information on the condition of fruit, while in storage and in transit, exists but there is very little information in regard to the best materials and methods to use in prepackaging fruits or more specifically in the prepackaging of peaches as a means of reducing spoilage and prolonging their fresh storage life.

The problem

What recommendations could be made relative to the storage temperature, packaging and coating materials and methods in prepackaging Elberta peaches to lengthen their fresh storage life?

Problem analysis.-- Before being able to answer the question, it is necessary to know the changes effected in the fruit as regards the:

1. Weight
2. Physiological and pathological condition, and
3. Chemical composition of the fruit, at the beginning, while in progress, and at the termination of the experiment.

Delimitations. -- Wastage of fruit, after harvesting, is due to physiological and pathological activities. These are diminished by chemical treatment, refrigeration and the use of wrapping and coating materials. This experiment deals with the use of wrapping and coating materials and refrigeration. Furthermore, it has been confined to the packaging of the Elberta variety of peaches from the 1947 harvest grown in the Colorado Western Slope in Mesa county and in the vicinity of Palisade, Colorado.

Definition of terms

Prepackaging, as used here, means the packaging of peaches in some sort of a container in the size and shape suitable for consumer use without any further packaging.

The Western Slope of Colorado refers to that region west of the divide and comprising the important peach producing counties of Mesa, Delta, Montrose and Garfield.

Coating materials are those substances applied to the individual fruit to envelop it completely, such as waxes, etc.

Packaging materials consist of a paperboard tray or boat and a transparent film used as an overwrap.

Chapter II

REVIEW OF LITERATURE

Studies on maturity.— In a paper on peach maturity studies Morris (14), 1932, concluded that neither color nor pressure test alone is adequate as a maturity standard, but that a combination of the two seemed to be the best method of arriving at a standard gauge to use in harvest work. He did not give definite color and pressure test standards, however, as indicating the proper stage of ripeness for distant shipment, nor did he attempt to define the limits of color and pressure within which suitable quality and condition may be obtained. His findings indicated that normally colored fruit with a pressure test range of 12 to 20 pounds on the unpeeled cheeks and a light yellow to a deep yellow ground color on the darker side of the fruit gives the highest quality. He stated that neither the form of fruit nor ease of separation of the fruit from the trees can be used as maturity indexes. His tester was equipped with a 5/16 inch tip.

Coe (4), 1933, concluded that while there was considerable variation in pressure tests and ground color under different conditions these indexes of maturity appeared to be more useful and accurate than any others tested. He did not find any consistent correlation between freedom of pit and color of fruit of the same picking. A significant negative correlation between ground color and

pressure tests was evident with both Elberta and Early Elberta peaches. Furthermore, he found that sugar content increased markedly with delay in harvesting. This increase was mostly sucrose. In 1932 this increase in total sugars ranged from 16 to 25 per cent in five days. With a delay in harvest there was an increase in size and yield, until soft rot ripe.

Blake (2), 1936, found that sucrose, the sugar responsible for the sweetness of peaches, constitutes from 60 to 70 per cent of the sugar content during their flesh ripening period. Fruits containing less than five per cent sucrose in his studies possessed poor edible quality. The sucrose content of peaches increased mainly during the latter part of maturity, for the most part by translocation of sucrose and reducing sugars from other parts of the tree. He found, however, that sucrose cannot be taken as an index of sweetness of peaches because from his results it was evident that even though the relative concentration of reducing sugars was low it had a marked influence upon the edible quality of the fruit. The concentration of total sugars, he said, appeared to be a more reliable index of quality and sweetness of peaches than does the concentration of sucrose.

In another phase of the same studies, he suggested some pressure test standards by the use of a pressure tester having a plunger equipped with a 5/16 inch tip. He classified the stages of maturity into five groups for marketing purposes as follows: 1. Soft ripe- These were those fruits giving a pressure test of less than six pounds. This classification included those fruits that attained

the maximum edible quality having ripened on the tree. 2. Firm ripe- These were the fruits that gave a pressure test of 8.0 to 11.0 pounds. These were those desirable for immediate sale as they became soft within 24 hours at ordinary summer temperatures. 3. Hard ripe- These included those peaches that gave a pressure test of 12 to 14 pounds. This group included those that could be held safely one day at room temperatures and were still firm enough to be sold the next day. 4. Nearby shipping- These included those that gave a pressure test of 15 to 17 pounds. This maturity was the one suited for shipments of several miles. 5. Long distance shipping- In this group were fruits suited for shipping 800 to 1,000 miles or more from southern and eastern districts.

Haller (5), 1941, suggested that for testing peaches (1) a 5/16 inch pressure tester with a penetration of 5/16 inch be used, (2) two tests be made on each peach; one on each pared cheek and (3) that a random sample of 20 to 30 fruits be taken for the pressure tests.

Studies on storage.-- In experiments with wrapped and unwrapped cantaloupes McKay (13), 1921, found that wrappers interfered 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, favored the spread of disease. The wrapped melons were slightly firmer than the unwrapped ones, because the wrappers retarded to some extent the evaporation of moisture. The difference, however, was so slight that it did not compensate for the increase in decay and mold which the wrapping caused.

As a result of storage studies of Elberta peaches at room temperatures, Blake (2), 1936, found that ripe peaches decreased in sugar content during storage and that the rate at which sucrose was lost per day of storage increased with the degree of the ripeness of the fruits when stored. He attributed this loss to rapid respiration at room temperatures. He stated that peaches have very little capacity for ripening after they have been picked from the tree and that because of a deficiency of reserve carbohydrates they do not increase materially in concentration of sucrose or total sugars, although they soften and develop more yellow color. For this reason, he said, peaches behave very differently compared to apples which have large amounts of reserve carbohydrates stored in them to ripen off the tree. Furthermore, peaches picked before maturing and stored do not develop good edible quality as compared with tree ripened peaches. He also found that the acid content increased more in fruits that were not mature while it decreased in the mature fruits after having placed them in storage. His conclusions regarding the sugar and acid limits for good edible quality were that peaches having an acid concentration above 15 (10 cc of juice requiring more than 15 cc of N/10 alkali for neutralization) together with a total sugar concentration of less than seven per cent are distinctly sour and distasteful.

Morris (14), 1932, using Elberta peaches giving a pressure test of from 10 to 18 pounds pressure by using a pressure tester equipped with a 5/16 inch diameter plunger tip and having a ground color of deep yellow to light orange around a crimson cheek kept a good quality for 16 days at a storage temperature of from 32 degrees

to 35 degrees Fahrenheit. After having been in this storage for 37 days their color was slightly faded or dull and the quality was not good.

Blake (2), 1936, found that the loss in weight of Elberta peaches kept at room temperature was fairly uniform throughout the storage period. The rate at which stored peaches lost weight was not affected materially by their stage of maturity or by the growth status in regard to the C/N ratio of the respective trees.

Refrigeration is essential in preserving the fresh life of most fruits and vegetables. In determining the fresh storage life of various fruits and vegetables in bulk and in prepackaged form and in refrigerated and non-refrigerated storage, Hauck (6), 1946, concluded that packaging alone, through protection afforded against physical damage and dehydration were about the same as with refrigeration alone in terms of lengthened shelf life and substantially better than with refrigeration alone in terms of maintaining saleable weight. He stated, that packaging and refrigeration together produced results much better than either alone.

Previous work on prepackaging.-- Experimenting with "whalehide" paper, parchment paper, dry waxed paper and self-sealing waxed paper, Brown (3), 1928, found that from the standpoint of quality change in lettuce, celery, cabbage and spinach, for quality depends largely on crispness and crispness on moisture content the chemical effects resulting from the use of paper wrappers were negligible. Wrappers did not prevent the conversion of sugars into starch in corn and peas, and they did not influence the quality of grapes to any marked extent.

An exception to the effect of paper on chemical changes is that of oiled papers which are used to prevent apple scald. Waxed papers, he also stated, are effective in reducing moisture loss or increase, however, they limit ventilation and encourage rotting of perishable products at high temperatures. Their greatest value, he said, seemed to be for the prevention of wilting of produce held in refrigerators. He also found that both "whalehide" and parchment papers, unlike waxed papers, permitted the passage of sufficient air to provide ventilation for most perishable products while at the same time they protected them against excessive losses of moisture. His data indicated that the measurement of soluble solids by the refractometer, as well as the freezing point depressions by the cryoscope, afford quick measures of quality and check, with minor exceptions, fairly closely with chemical analysis.

Stahl (16), 1936, in studies dealing with the effect of various wrappers and temperatures on citrus fruits concluded that of 22 different wrappers used the best in preserving weight, appearance, taste, preventing occurrence of decay and pitting and in prolonging the length of time the fruit can be held in storage in marketable conditions were the moistureproof cellophane and aluminum foils; the semi-moisture proof cellophane and waxed paper being next best. The amount of decay varied directly with temperature, length of storage period, and moisture retentiveness of the wrapper. At temperatures below 42 degrees Fahrenheit, however, decay in all wraps was negligible.

In another prepackaging investigation with cucumbers and

the use of different kinds of cellophane and waxed paper, Whitacre (18), 1939, found that the best methods of packaging to preserve weight, turgidity, texture, flavor, and palatability for the longest time were the storing of the product at 40 degrees Fahrenheit and the treating of the cucumbers by (1) wrapping them individually in moisture proof cellophane, or (2) packing them unwrapped in large light-weight wood or corrugated paper containers lined with moisture-proof cellophane, or (3) placing the unwrapped fruit in a refrigerator humidifier. For eight to ten days these methods kept the produce as good as fresh and up to two weeks they were quite acceptable.

Working with pliofilm as a wrapper for fruits, Stahl (17), 1942, found that under refrigeration and conditions approximating those of the retail store pliofilm was effective in reducing the weight loss of citrus fruits without limiting the escape of respiratory gases evolved from the fruit. In the same experiments with pliofilm-wrapped Jewel peaches of hard-ripe and soft-ripe maturities, he found that of the three temperatures, namely, 37 degrees, 42 degrees and 54 degrees Fahrenheit, the best one for storing peaches was 42 degrees Fahrenheit. Fruit held in storage at 37 degrees Fahrenheit showed physiological breakdown or darkening of the flesh after 10 days in storage. Pliofilm retarded ripening and softening at all temperatures, and the life of the fruit was more than doubled by the pliofilm wrappers. He stated that the initial freshness, color, texture and taste of the wrapped peaches were well preserved by the pliofilm wrappers during the entire storage period of four and five weeks.

Using pliofilm as a wrapper for peaches, Judkins (10), 1946, concluded that the material was effective in reducing moisture losses but that in so doing, a saturated atmosphere was created surrounding the fruit enabling rots on the fruit to develop. A very distasteful, fermented, alcoholic flavor developed in the air-tight wrappers which rendered the fruit inedible in about two days in peaches stored at 70 degrees Fahrenheit. Once these off-flavors developed they were not decreased or lost if the fruit was unwrapped and held in storage at either 40 degrees or 70 degrees Fahrenheit. He attributed these off-flavors to the accumulation of end-products of respiration in the sealed packages and not to absorption of flavor or odor from the pliofilm itself. The respiration rate of stored peach fruit, he stated, is at least 50 and possibly 100 per cent higher than for oranges, and about 50 per cent higher than for apples. This higher respiration rate may be an important factor in explaining the poor response of peaches to storage in pliofilm packages.

The above results indicate that the probable solution of the existing problem in prolonging the fresh, marketable condition of prepackaged peaches may be the employing of films that allow a free exchange of gases between the inner and outer atmospheres of the packages.

Chapter III

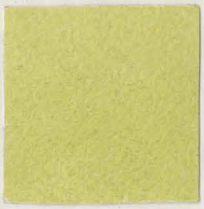
MATERIALS AND METHODS

This experiment was carried out in conjunction with an experimental prepackaging plant set up by the Farmers Union cooperative Association, Palisade, Colorado. This study was primarily designed to yield some information that would be of practical value to any one desiring to go into the business in a commercial scale.

The fruit used was obtained from the Farmers Union cooperative Association which in turn collected the fruit from the various growers which were scattered throughout the region under consideration. The fruit was selected at random from the packing shed at Palisade, Colorado. Fruit in the tree ripe stage of maturity was used. A pressure test index was determined by the use of a Ballauf U. S. D. A. spring type pressure tester equipped with a 5/16 inch diameter plunger tip and graduated to measure the resistance offered by the fruit ranging from zero to thirty pounds. The color of this fruit was determined by the use of a color chart consisting of seven colors representing the stages of maturity that the ground color of the fruit goes through in the process of maturing. The chart was prepared by using the color nomenclature as given by Maerz and Paul (12), 1930. The colors used were those that appear on page 20. The ground color of each of the fruits was matched with

1. Green

7. Mirabelle



2. Greenish yellow

6. Corn yellow

3. Sulfur yellow

5. Amber yellow

4. 10 K 1

Figure 1.--Color charts used in the determination of color of the fruit used. Color nomenclature from Maerz and Paul, (12), 1930.

these colors and the number of the chart most closely resembling the fruit was assigned it.

Size was determined by the use of vernier calipers and designated in inches and tenths of an inch. Weights were measured on a triple beam balance accurate to within two tenths of a gram. The total soluble solids were determined by means of an Abbe water cooled refractometer and the reading corrected for temperature. The percentage of sucrose on the basis of total soluble solids was obtained from the international table of refractive indices (1), 1945. These various maturity indices of a sample of the fruit used are given in Table 1.

A given lot of peaches in the tree-ripe stage of maturity was taken from the fruit coming in from the field and packaged in the same manner as the other peaches being processed in the commercial prepackaging line. In this way it was assured that the experimental fruit received the same treatment as that given to the fruit being handled commercially up to this point, at least, in the marketing channel. A random sample of fruits to be prepackaged in the experiment was taken to determine the maturity of the lot by means of the various indexes already mentioned.

The fruits were brushed in the first operation then hand sorted for size, scratches, bruises and stage of maturity. They were then placed on the trays which kept moving over a belt toward a Package Machinery Corporation prepackaging machine which overwrapped the trays and fruit with the film, sealing the film over the tray by the use of heat, in the case of those films that lent themselves

Table 1.--INDEXES OF MATURITY OF A RANDOM SAMPLE OF FORTY SIX ELBERTA PEACHES USED IN THE PREPACKAGING EXPERIMENT IN THE WESTERN SLOPE OF COLORADO-1947.

INDEX	MEAN	STANDARD DEVIATION	STANDARD ERROR
Pressure test[1]	8.37	± 8.46	±1.25
Size (inches)[2]	2.64	± .21	± .03
Color[3]	6.20	± 1.27	± .19
Weight (grams)	183.09	±41.30	±6.09
Total soluble solids (percent)[4]	10.98	± 2.17	± .32

[1]Average of four tests on the unpeeled fruit, one on either side of suture and on cheeks.

[2]Taken on the narrow width of the fruits by the use of a vernier caliper.

[3]Determined by comparing each fruit with each of the seven color charts and assigning the fruit the number of the chart most closely resembling the ground color of the fruit.

[4]Determined by the use of an Abbe water cooled refractometer. Figures represent the average of two determinations; one on the ripe and one on the green side of the fruit.

to heat sealing. The cellulose acetate film which is a non heat-sealing film was sealed by the use of scotch tape. The control treatment consisted of the fruits in the trays without any overwrap films over them. These trays were merely reinforced by using scotch tape over the top of the tray.

Each of the package units contained four fruits. All the packages were separated into three groups each of which was placed in one of the three storage temperatures. Ten side ventilated master containers holding 15 consumer packages in two layers within the master container were used. The three storage temperatures used were 36 degrees Fahrenheit, 45 degrees Fahrenheit and room temperature (70 to 80 degrees Fahrenheit), while the corresponding average relative humidities were 70 per cent 85 per cent and 37 per cent. These were commercial storages and of necessity there was a slight fluctuation in temperatures and humidity. No attempt was made to control either the temperature or relative humidity. Three repetitions or samples of each treatment were used. The packages were randomized within the master containers and the master containers were placed one over the other five high in two stacks to simulate actual storage conditions. The containers were changed within the stacks after each observation or storage period so that no container stayed in the same location in the stack throughout the experiment.

The 15 packages in each treatment and each temperature were divided into five observation lots of three packages each. This allowed for taking observations at five different times throughout the experiment. This was necessary since observations of taste,

pressure tests and refractive indices necessitated destroying the fruit making up an observation lot.

The ten experimental treatments involved the use of various kinds of transparent films as overwraps alone and with some commercial preservatives. The following are the experimental treatments used.

I Nontreated

II 100 CA 48 cellulose acetate

III 300 LST cellophane (perforated with a hole in the center top of the package in the shape of a triangle $\frac{1}{4}$ inch on the side)

IV 450 H LSAT cellophane

V 300 H MSAT 86 cellophane

VI 300 H LST cellophane (perforated)with propylene glycol in an equal volume of water

VII 300 H LST cellophane (perforated) with experimental preservative K5807 in wax solution as used in treatment 8. Two ounces of the preservative were added to three gallons of the wax solution

VIII 300 H LST (perforated) with primafresh wax (two parts of water to one part of wax by volume)

IX Pliofilm grade p6 gauge 75

X 300 H LST cellophane

Number one above was the control treatment and served as the basis of comparison. All the films used are more or less transparent but with varying degrees of moisture retention qualities. Information as to the various characteristics of the films was obtained from the manufacturers. To simplify presentation, the treatments are roughly divided into four parts on the basis of the mois-

ture retentive qualities as follows:

1. The nontreated lot which did not involve the use of any film.

2. The cellulose acetate film which is noted for its absolute lack of moisture retentive qualities and, therefore, allows loss of moisture as rapidly as though there were no wrapper over it. Cellulose acetate is also noted for its stability in dimensions, its insensitivity to softening by water and for its ability to remain unusually brilliant and clear. It, however, is not heat sealing like the other films used in this experiment. Cellulose acetate is said to be used in the prepackaging of fresh fruits and vegetables where a rapid turnover offsets the drying out tendency. Cellulose acetate film has a tendency to crack at the edges when folded.

3. The 450 LSAT cellophane which is semi-moisture retentive and permits a controlled loss of moisture and which is, thus claimed to lessen the tendency to molding of the fruit. The loss of moisture, it is claimed, is not great enough to produce objectionable shriveling. This is a heat-sealing film. It has been found to do well in the packaging of spinach.

4. This includes the other films used which are supposed to be highly moisture retentive and heat-sealing. These are the 300 H LST cellophane, 300 H MSAT 86 cellophane and pliofilm p6 guage 75. It is claimed that LST cellophane has been found to perform quite well in the packaging of relatively dry items, such as tomatoes.

Some commercial chemical preservatives were used in connection with the 300 H LST perforated film. The three chemicals used were propylene glycol, primafresh wax, and an experimental chemical preservative with the designation K5807 in combination with the primafresh wax. Some information about each of the chemical preservatives obtained from the manufacturers is as follows:

Propylene glycol-While propylene glycol is odorless and relatively non-toxic, it is not tasteless. It must be used with discretion. Although, propylene glycol has a relatively high boiling point a film applied to the fruit will evaporate in about 24 hours. It is necessary, therefore, that the packaging material

retard the rate of dissipation. It is recommended that the propylene glycol be applied at room temperatures or lower. It is usual to apply the chemical at 100 per cent concentration. The manufacturers claimed that propylene glycol can not be used very well on small fruits because when used on these it will affect the taste. The fruit or vegetable on which it is used should have a sufficiently tough skin to prevent the propylene glycol from drawing moisture out of the center. This chemical is supposed to preserve fresh fruits and vegetables by inhibiting mold growth. When using it as a preservative for fruits and vegetables it is recommended that it be applied at room temperatures or lower.

Primafresh wax- This wax, as other waxes used in the preservating of fresh fruits and vegetables, is designed to retard shrinking and, at the same time, improve the appearance of fruits and vegetables. The latter quality, however, applies especially to fruits and vegetables which possess a tough, smooth and naturally waxy, shiny skin such as tomatoes and apples.

Experimental preservative K5807- This is a non-phenolic, organic chemical which is harmless when taken internally in the amounts that would be encountered on the surface of fruits or vegetable as a three to five per cent water dip. This chemical is supposed to preserve fresh fruits and vegetables by inhibiting mold growth. A wetting agent is necessary to use along with it when used to treat fruits and vegetables that have a waxy coating which prevents an even film of solution from remaining on the fruit. K5807 can be dispersed in a wax emulsion and can be applied to the fruit

in this form.

The 300 H LST cellophane was perforated with a triangular hole about one-fourth inch on the side because the manufacturers of the film recommended that the packages of peaches be ventilated to prevent anaerobic fermentation and the consequent off-odors and off-flavors. The recommendation was to punch a hole one-fourth inch in diameter through the film as a means of preventing anaerobic respiration.

It is known that peaches in storage develop different kinds of mold growth and rots. It was hoped that the various chemical preservatives would inhibit the development of these undesirable organisms.

Statistical methods used

The analysis of variance was employed to determine whether or not there existed significant differences between groups of factors used in the experiment. After the presence of significant differences between the groups was determined, a series of independent group comparisons were made to determine the presence or absence of significant differences between one and every group by the use of the t test. A formula given by Snedecor (15), 1946, that deals with the comparison of groups with different numbers of observations was used.

The analysis of covariance was used to analyze the simultaneous variation of two correlated factors used in determining the quality of the fruit, namely, appearance and taste.

Methods used in scoring

The merits of the various treatments in the preservation of the fruit quality were evaluated by the use of certain factors which add up to a 100 per cent condition representing the utmost in quality of the fruit.

The factors, with their respective breakdowns, were taken into consideration in evaluating the different treatments with the corresponding weights assigned to each on a 100 per cent basis, as follows:

	Factor		Weight
1.	Appearance		15
	Excellent	15	
	very attractive	10	
	attractive	5	
	fair	2	
	unattractive	0	
2.	Color		10
	normal	10	
	fair	5	
	off-color	0	
3.	Per cent decay and / or molds		20
	sound	20	
	25 per cent	15	
	50 per cent	10	
	75 per cent	5	
	100 per cent	0	
4.	Shriveling condition		10
	None	10	
	slight	5	
	moderate	2	
	severe	0	
5.	Firmness (pressure tester)		5
	four pounds per square inch and over	5	
	three to four pounds per square inch	4	
	one to three pounds		

	per square inch	3
	zero pounds per square inch	0
6.	Firmness (determined by feeling) ----------	5
	Firm	5
	fairly firm	4
	soft	3
	very soft	0
7.	Taste (as determined by three or more persons)--	20
	Excellent	20
	good	15
	fair	10
	poor	5
	undesirable	0
8.	Marketability (after taking all above into consideration) ----------	15
	Marketable	15
	doubtful	7
	unmarketable	0

The weights assigned to each factor varied from zero to the number representing the total grade or weights having been assigned to that factor as they appear above.

The criterion used in evaluating the different treatments was that of the use of a scale ranging from the absolutely unmarketable fruit represented by zero per cent and the perfect fruit represented by 100 per cent. With the passage of time the fruit in storage in the different types of packages and different storage temperatures, naturally, deteriorated in quality but at different rates and to different levels down the graded scale.

All observations with regard to the quality factors were made by the same individual to reduce personal error.

Chapter IV

EXPERIMENTAL RESULTS

Results of treatments

The values of t as shown in Table 2 have been used as the basis of comparison of the mean quality scores of treatments.

From the table it can be seen that treatment number II, the cellulose acetate-wrapped treatment received a higher score than the LSAT cellophane-wrapped treatment and the control treatment and a significantly higher (at the one per cent level) score than all the other treatments used in the experiment except the LST (perforated) treatment which was exceeded significantly at the five per cent level.

The LSAT cellophane -wrapped treatment which proved to be next in score rating to the cellulose acetate treatment, received a higher score than the LST (perforated) cellophane-wrapped, the LST cellophane-wrapped, the MSAT cellophane-wrapped and the control treatment, and a very significantly higher (at the one per cent level) score than the chemically treated lots (VI, VII and VIII) and a significantly higher (at the five per cent level) than the pliofilm-wrapped treatment.

The control treatment which was third in score rating received a higher score than the pliofilm-wrapped, MSAT cellophane-wrapped and LST cellophane-wrapped treatments and a significantly

TABLE 2 .-- t VALUES SHOWING THE COMPARISONS OF THE MEANS OF THE QUALITY SCORES OF TEN PREPACKAGING TREATMENTS.

TREATMENT	VI	VIII	VII	IX	V	X	III	I	IV	II
MEAN	22.487	22.910	26.311	44.689	52.318	54.355	55.356	58.333	60.755	66.222
STANDARD DEVIATION	25.490	27.242	24.044	30.959	31.108	33.637	25.433	21.852	20.600	18.673
RANK	10	9	8	7	6	5	4	3	2	1

t VALUES

VI	OBSERVED t		—	.053	.532	2.704	3.675	3.711	4.625	5.520	7.601	7.650
	REQUIRED t	.05	—	2.014	2.008	2.008	2.008	2.008	2.008	2.008	2.008	2.004
		.01	—	2.690	2.678	2.678	2.678	2.678	2.678	2.678	2.678	2.669
VIII	OBSERVED t		—	—	.474	2.707	4.360	3.998	4.615	5.440	5.976	7.379
	REQUIRED t	.05	—	—	2.008	2.008	1.997	2.000	2.004	2.004	2.004	2.000
		.01	—	—	2.678	2.678	2.654	2.660	2.669	2.669	2.669	2.669
VII	OBSERVED t		—	—	—	2.483	3.934	3.636	4.505	5.412	5.802	7.488
	REQUIRED t	.05	—	—	—	2.004	2.000	2.008	2.000	2.000	2.000	2.000
		.01	—	—	—	2.669	2.660	2.678	2.660	2.660	2.660	2.660
IX	OBSERVED t		—	—	—	—	.974	1.183	1.500	1.978	2.445	3.220
	REQUIRED t	.05	—	—	—	—	2.000	2.000	2.000	2.008	2.000	1.997
		.01	—	—	—	—	2.660	2.660	2.660	2.678	2.660	2.654
V	OBSERVED t		—	—	—	—	—	.255	.420	.908	1.295	2.306
	REQUIRED t	.05	—	—	—	—	—	1.997	1.997	1.997	2.004	1.994
		.01	—	—	—	—	—	2.654	2.654	2.654	2.669	2.648
X	OBSERVED t		—	—	—	—	—	—	.136	.569	.932	1.841
	REQUIRED t	.05	—	—	—	—	—	—	2.004	1.997	1.997	1.997
		.01	—	—	—	—	—	—	2.669	2.654	2.654	2.654
III	OBSERVED t		—	—	—	—	—	—	—	.510	.948	2.050
	REQUIRED t	.05	—	—	—	—	—	—	—	1.997	1.997	1.994
		.01	—	—	—	—	—	—	—	2.654	2.654	2.648
I	OBSERVED t		—	—	—	—	—	—	—	—	.046	1.631
	REQUIRED t	.05	—	—	—	—	—	—	—	—	1.997	1.994
		.01	—	—	—	—	—	—	—	—	2.654	2.648
IV	OBSERVED t		—	—	—	—	—	—	—	—	—	1.168
	REQUIRED t	.05	—	—	—	—	—	—	—	—	—	1.994
		.01	—	—	—	—	—	—	—	—	—	2.648
II	OBSERVED t		—	—	—	—	—	—	—	—	—	—
	REQUIRED t	.05	—	—	—	—	—	—	—	—	—	—
		.01	—	—	—	—	—	—	—	—	—	—

Note: The key to the above treatments is that given on page 30

higher (at the one per cent level) score than the chemically treated lots.

The LST (perforated) cellophane-wrapped treatment which was fourth in score rating received a higher score than the pliofilm-wrapped, the MSAT cellophane-wrapped and the LST cellophane-wrapped treatments and a significantly higher (at the one per cent level) rating than the chemically treated lots (VI, VII and VIII).

The LST cellophane-wrapped treatment which was fifth in score rating received a higher score than the pliofilm-wrapped treatment and the MSAT cellophane-wrapped treatment and a very significantly higher (at the five per cent level) rating than the chemically treated lots (VI, VII and VII).

The MSAT cellophane-wrapped treatment which was sixth in score rating received a higher score than the pliofilm-wrapped treatment and a very significantly higher (at the one per cent level) score rating than the chemically treated lots.

Finally, the pliofilm-wrapped treatment received a very significantly higher (at the one per cent level) score rating than the three chemcially treated lots except one which it exceeded significantly at the five per cent level.

Results of temperatures

The means of the fruit quality scores as affected by the three temperatures used are compared by t values on Table 3. From the table it can be seen that the 36° F. storage temperature was very significantly better (at the one per cent level) than the 45° F. and the room temperature storage. The 45° F. storage temperature

Table 3.--t VALUES SHOWING COMPARISONS OF THE MEANS OF THE QUALITY SCORES OF THREE STORAGE TEMPERATURES USED IN THE PEACH PREPACKAGING EXPERIMENT.

TEMPERATURE		Room Temperature 70° - 85°F.	45°F.	36°F.
MEAN		19.21	44.75	75.17
STANDARD DEVIATION		26.35	27.13	30.28
RANK		3	2	1
		t VALUES		
Room temperature 70° - 85°F.	Observed t	-----	2.042	4.374
	Required t .05	-----	1.976	1.972
	.01	-----	2.609	2.601
45°F.	Observed t		-----	3.020
	Required t .05		-----	1.974
	.01		-----	2.605
36°F.	Observed t			-----
	Required t .05			-----
	.01			-----

Fruit that spoiled completely and whose score was zero was not included in the calculation of the above t values.

proved to be better than the room temperature not quite at the one per cent level of significance but significantly better than room temperature at the five per cent level.

Results of pressure tests

The mean pressure tests of the fruit in the different treatments, different temperatures and different periods in the 36° F. storage are given on Table 4. The analysis of variance showed significant differences between treatments not to exist but indicated the existence of significant differences between periods. From Table 4 it can be seen that there were no significant differences between the first and second and between the second and third observations in the case of the nontreated lot and cellulose acetate-wrapped treatments. However, there was a significant decrease (at the one per cent level) in the case of the nontreated lot from the first to the third observation.

In the case of some treatments there was a higher pressure test observed in the second observation than in the first. These differences were not significant, however. The same was true of certain treatments between the second and third observations.

Those treatments that showed a significant decrease in pressure tests (at the five per cent level or better) between the first and second observation periods were, the LST cellophane-wrapped, the LST cellophane-wrapped with primafresh wax, the MSAT cellophane-wrapped and the LST cellophane-wrapped with propylene glycol. Those treatments that showed a significant decrease (at the five per cent level or better) between the second and third observations

Table 4.—MEANS OF PRESSURE TESTS IN POUNDS PER SQUARE INCH OF PRE-PACKAGED ELBERTA PEACHES AT 36° F. STORAGE.

TREAT-MENT	FIRST OBSERVATION AFTER 4 DAYS	SECOND OBSERVATION AFTER 10 DAYS	THIRD OBSERVATION AFTER 13 DAYS
I	5.0	4.0	2.8
II	3.5	4.3	3.6
III	8.6	7.2	3.9
IV	5.5	6.2	3.9
V	5.2	4.9	2.6
VI	5.2	2.6	3.7
VII	5.9	4.3	3.0
VIII	5.9	2.3	3.7
IX	5.9	4.8	3.3
X	7.2	4.2	4.0

Significant differences between treatments do not exist as shown by the analysis of variance.

The least significant difference between temperature required: at 1% level= 1.9 at 5% = 1.5

Key to Treatments

I Nontreated
II Cellulose acetate 48
III 300 H LST (perforated) cellophane
IV 450 H LSAT cellophane
V 300 H MSAT 86 cellophane
VI 300 H LST (perforated) cellophane with propylene glycol
VII 300 H LST (perforated) cellophane with Primafresh wax and experimental preservative K5807
VIII 300 H LST (perforated) cellophane with Primafresh wax
IX Pliofilm grade p6 Gauge 75
X 300 H LST cellophane

were, the LST (perforated) cellophane-wrapped, LSAT cellophane-wrapped, MSAT cellophane-wrapped and the pliofilm-wrapped treatments.

Analysis of appearance and taste

The analysis of variance of taste independent of appearance, Table 5, shows both between treatment differences and between temperature within treatment differences highly significant at the one per cent level. Likewise, the analysis of variance of appearance shows the treatment differences and between temperature within treatment differences highly significant at the one per cent level.

A covariance study, Table 6, of taste on appearance shows that treatment differences are not significant for taste. When the variability due to appearance is removed the between treatment differences in taste are definitely not significant, and the between temperature within treatment differences are much decreased, but still highly significant at the one per cent level.

The correlation coefficients are all highly significant indicating that taste is highly correlated with appearance.

Analysis of data by use of quality factors on a percentage basis

The scores of the various factors used in evaluating quality of prepackaged Elberta peaches under the various conditions were converted from a scorecard as explained on page , to a percentage basis to facilitate direct comparisons between any two of them on an equal basis and to render them easier to interpret. All the scores of the various factors of quality expressed in percentages along with a key to marketability of the fruit under the various conditions are given in Tables 7, 8 and 9.

Table 5.--ANALYSIS OF VARIANCE OF THE EFFECT OF VARIOUS PREPACKAGING MATERIALS ON THE APPEARANCE AND TASTE OF ELBERTA PEACHES FROM THE WESTERN SLOPE OF COLORADO-1947.

VARIABILITY DUE TO	D/F	APPEARANCE				TASTE	
		M.S.	OBSERVED F	REQUIRED F .05	REQUIRED F .01	M.S.	OBSERVED F
Totals	329	----------	----	----	----	----------	-----
Between treatments	9	37,792.699	30.16**	1.91	2.48	14,772.938	12.28**
Within treatments	320	1,252.869	----	----	----	1,202.655	
Between temperatures Within treatments	20	4,618.766	4.49**	1.61	1.95	4,462.215	4.53**
Within temperatures Within treatments	300	1,028.476	-----	----	----	985.351	-----

** Significant at the one per cent level

Table 6.--ANALYSIS OF COVARIANCE AND ERRORS OF ESTIMATE OF THE EFFECT OF VARIOUS TREATMENTS ON THE CORRELATION OF APPEARANCE AND TASTE.

VARIANCE DUE TO	D/F	SQUARES AND PRODUCTS			r	ERRORS OF ESTIMATE		
		x^2	xy	y^2		D/F	S.S.	M.S.
Totals	329	741,052.36	430,343.18	517,804.92	0.695**	328	267,896.14	---------
Between treatments	9	340,134.29	205,390.15	132,956.44	0.966**	(9)	9,266.95	1,029.661
Within treatments	320	400,918.07	224,953.03	348.849.48	0.573**	319	258,629.52	810.751
Between temperatures Within treatments $_w$	20	92,375.32	69,871.35	89,244.31	0.769**	(20)	40,972.47	2,048.623
Within temperatures Within treatments $_w$	300	308,542.75	155,081.68	295,605.17	0.514**	229	217,657.05	727.950
Correction terms		1,096.731.82	969,731.82	857,820.08	----	---	----------	---------

F - between treatments (adjusted values) equals $\frac{1029.661}{810.751}$ equals 1.27 (not significant)

F - between temperatures within treatments (adjusted values) equals $\frac{2048.6235}{727.95}$ equals 2.81**

TABLE 7 .--QUALITY OF PREPACKAGED ELBERTA PEACHES STORED AT 36° F., EXPRESSED AS PERCENTAGES. PALISADE, COLORADO AUGUST-SEPTEMBER-1947.

TREATMENT	FIRST OBSERVATION AFTER 4 DAYS										SECOND OBSERVATION AFTER 7 DAYS									
	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN
I	86	100	100	100	100	100	25	100	M	88	100	100	100	100	80	100	100	100	M	97
II	100	100	100	100	100	100	100	100	M	100	100	100	100	100	80	100	75	100	M	94
III	86	100	100	100	100	100	75	100	M	95	100	100	100	100	80	100	100	100	M	97
IV	100	100	100	100	100	100	65	100	M	95	100	100	100	100	80	100	100	100	M	97
V	100	100	100	100	100	100	79	100	M	96	100	100	100	100	100	100	75	80	M	94
VI	13	60	100	100	100	100	90	80	M	80	40	33	80	100	60	100	25	0	U	55
VII	0	0	100	100	100	100	90	80	M	71	13	0	100	100	80	100	25	0	U	52
VIII	40	60	100	100	100	100	80	100	M	85	0	33	60	100	40	100	25	0	U	45
IX	100	100	100	100	100	100	100	100	M	100	100	100	100	100	100	100	40	33	U	84
X	100	100	100	100	100	100	100	100	M	100	100	100	100	100	100	100	75	100	M	97

TREATMENT	THIRD OBSERVATION AFTER 10 DAYS										FOURTH OBSERVATION AFTER 17 DAYS									
	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN
I	100	100	100	50	80	60	100	100	M	86	100	100	100	20	40	60	100	100	M	77
II	100	100	100	50	100	80	100	100	M	91	100	100	100	50	100	80	100	100	M	91
III	100	100	100	100	80	100	100	100	M	97	100	100	85	100	100	100	90	33	U	88
IV	100	100	100	100	100	100	100	100	M	100	100	100	100	100	100	100	85	100	M	98
V	66	100	90	100	80	100	90	66	M	86	100	100	90	100	60	100	40	33	U	78
VI	20	0	90	100	80	100	90	47	U	66	0	0	90	100	40	100	0	0	U	29
VII	20	0	100	100	80	100	60	47	U	63	53	100	75	40	80	100	25	0	U	58
VIII	0	80	60	100	100	100	35	0	U	59	0	100	65	100	60	100	40	0	U	58
IX	100	100	100	100	100	100	80	100	M	97	87	100	90	100	60	100	60	100	M	87
X	100	100	100	100	80	100	100	100	M	97	100	100	100	100	100	100	100	100	M	100

TREATMENT	FIFTH OBSERVATION AFTER 29 DAYS										MEAN (ALL OBSERVATIONS)	STANDARD DEVIATION
	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN		
I	100	100	100	0	0	60	25	0	U	48	79.6	33.2
II	100	100	100	20	0	60	60	33	U	58	87.2	25.0
III	100	100	90	100	0	80	50	0	U	65	88.7	10.6
IV	100	100	100	100	0	80	50	0	U	66	91.5	23.7
V	53	100	90	100	0	80	40	0	U	58	82.8	27.1
VI	0	0	0	0	0	0	0	0	U	0	48.4	43.1
VII	53	65	35	0	0	0	0	0	U	17	52.5	41.6
VIII	0	100	30	0	0	0	0	0	U	16	52.7	42.1
IX	66	100	75	100	20	80	25	0	U	58	85.4	26.6
X	87	100	90	100	0	80	25	0	U	60	90.9	24.8

EACH OF THE ABOVE PERCENTAGES IS AN AVERAGE OF THREE REPLICATIONS.

KEY TO TREATMENTS

I. NONTREATED
II. 100 CELLULOSE ACETATE 48
III. 300 H LST CELLOPHANE (PERFORATED)
IV. 450H LSAT CELLOPHANE
V. 300H MSAT 86 CELLOPHANE
VI. 300H LST CELLOPHANE (PERFORATED) WITH PROPYLENE GLYCOL
VII. 300H LST CELLOPHANE (PERFORATED) WITH EXPERIMENTAL PRESERVATIVE K5807.
VIII. 300H LST CELLOPHANE (PERFORATED) WITH PRIMAFRESH WAX.
IX. PLIOFILM GRADE P6 GAUGE 75.
X. 300H LST CELLOPHANE

KEY TO MARKETABILITY

M- MARKETABLE
U - UNMARKETABLE

TABLE 8.--QUALITY OF PREPACKAGED ELBERTA PEACHES STORED AT 45°F., EXPRESSED AS PERCENTAGES. PALISADE, COLORADO., AUGUST-SEPTEMBER-1947.

TREATMENT	FIRST OBSERVATION AFTER 4 DAYS										SECOND OBSERVATION AFTER 10 DAYS									
	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN
I	100	100	100	100	100	100	100	100	M	100	100	100	92	20	20	60	100	42	M	73
II	100	100	100	100	92	100	100	100	M	99	100	100	100	50	30	80	58	100	M	77
III	100	100	100	100	100	100	100	100	M	100	55	100	83	100	46	100	83	33	U	75
IV	100	86	100	100	92	100	92	100	M	96	100	100	100	100	20	100	100	100	M	90
V	100	100	100	100	100	100	100	100	M	100	100	100	100	100	40	100	92	100	M	92
VI	66	33	100	100	87	100	18	36	U	68	0	0	25	100	0	0	25	0	U	19
VII	27	100	92	100	80	100	25	62	M	73	0	0	0	100	0	0	25	0	U	16
VIII	55	100	92	100	86	100	58	100	M	86	0	0	8	100	0	0	25	0	U	17
IX	89	100	92	100	100	100	83	62	M	91	43	100	92	100	72	100	17	0	U	66
X	100	100	100	100	100	100	100	100	M	100	66	66	67	100	0	100	67	66	M	67

TREATMENT	THIRD OBSERVATION AFTER 13 DAYS										FOURTH OBSERVATION AFTER 17 DAYS									
	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN
I	89	100	100	30	0	60	100	67	M	67	22	66	50	13	0	40	75	0	U	33
II	100	100	100	50	0	80	75	100	M	76	67	100	92	20	0	60	33	0	U	47
III	33	100	83	100	0	100	42	33	U	61	10	100	83	100	0	100	25	0	U	52
IV	67	100	92	100	0	100	17	67	M	68	0	100	67	100	0	100	25	0	U	49
V	33	100	58	100	0	100	33	33	U	57	0	33	17	33	0	32	8	0	U	15
VI	0	0	0	0	0	0	0	0	U	0	0	0	0	0	0	0	0	0	U	0
VII	0	0	0	0	0	0	0	0	U	0	0	0	0	0	0	0	0	0	U	0
VIII	0	0	0	0	0	0	0	0	U	0	0	0	0	0	0	0	0	0	U	0
IX	33	100	67	100	0	100	8	33	U	55	0	33	17	33	0	32	8	0	U	15
X	55	100	75	100	0	100	42	33	U	63	0	66	25	66	0	66	17	0	U	30

TREATMENT	FIFTH OBSERVATION AFTER 29 DAYS										MEAN (ALL OBSERVATIONS)	STANDARD DEVIATION
	APPEARANCE	COLOR	DECAY	SHRIVELING CONDITION	PRESSURE TEST	FIRMNESS (FEEL)	TASTE	MARKETABILITY SCORE	MARKETABILITY KEY	MEAN		
I	0	0	0	0	0	0	0	0	U	0	54.6	43.3
II	100	67	67	13	0	60	25	0	U	42	67.0	36.8
III	0	0	0	0	0	0	0	0	U	0	57.7	43.9
IV	0	0	0	0	0	0	0	0	U	0	60.6	45.4
V	0	0	0	0	0	0	0	0	U	0	52.8	44.9
VI	0	0	0	0	0	0	0	0	U	0	17.2	37.8
VII	0	0	0	0	0	0	0	0	U	0	17.8	35.1
VIII	0	0	0	0	0	0	0	0	U	0	20.6	37.9
IX	0	0	0	0	0	0	0	0	U	0	45.3	42.6
X	0	0	0	0	0	0	0	0	U	0	51.9	42.2

EACH OF THE ABOVE PERCENTAGES IS AN AVERAGE OF THREE REPLICATIONS.

KEY TO TREATMENTS

I. NONTREATED.
II. 100 CELLULOSE ACETATE 48.
III. 300H LST CELLOPHANE (PERFORATED).
IV. 450H LSAT CELLOPHANE.
V. 300H MSAT 86 CELLOPHANE.
VI. 300H LST CELLOPHANE (PERFORATED) WITH PROPYLENE GLYCOL.
VII. 300H LST CELLOPHANE (PERFORATED) WITH EXPERIMENTAL PRESERVATIVE K5807.
VIII. 300H LST CELLOPHANE (PERFORATED) WITH PRIMAFRESH WAX.
IX. PLIOFILM GRADE P6 GAUGE 75.
X. 300H LST CELLOPHANE.

KEY TO MARKETABILITY

M- MARKETABLE
U- UNMARKETABLE

Table 9.--QUALITY OF PREPACKAGED ELBERTA PEACHES AT ROOM TEMPERATURE (70°- 85° F.) EXPRESSED AS PERCENTAGES.

FIRST OBSERVATION - AFTER 4 DAYS

Treatment	Appearance	Color	Decay	Shriveling Condition	Pressure Test	Firmness (Feel)	Taste	Marketability Score	Marketability Key	Average
I	100	100	100	100	46	80	75	100	M	88
II	100	100	100	100	46	80	80	100	M	86
III	65	100	30	100	60	86	42	66	M	69
IV	100	100	100	100	80	86	58	100	M	91
V	100	100	90	100	92	100	33	100	M	88
VI	0	25	16	100	0	86	0	0	U	28
VII	0	25	33	100	0	100	16	66	M	42
VIII	0	0	0	100	0	86	8	0	U	24
IX	30	65	42	100	28	100	0	0	U	45
X	100	100	100	100	80	100	42	64	M	86

Each of the above percentages is the average of three replications

Key to Treatments

I Non treated
II 100 Cellulose Acetate
III 300 H LST Cellophane (perforated)
IV 450 H LSAT Cellophane
V 300 H MSAT 86 Cellophane
VI 300 LST Cellophane (perforated) with propylene Glycol
VII 300 LST Cellophane (perforated) with experimental preservative K5807
VIII 300 LST Cellophane (perforated) with Primafresh wax
IX Pliofilm grade p6 Gauge 75
X 300 H LST Cellophane

Key to Marketability

M - Marketable
U - Unmarketable

Table 9.—QUALITY OF PREPACKAGED ELBERTA PEACHES AT ROOM TEMPERATURE (70° - 85° F.) EXPRESSED AS PERCENTAGES.—Continued

SECOND OBSERVATION - AFTER 7 DAYS

Treatment	Appearance	Color	Decay	Shriveling Condition	Pressure Test	Firmness (Feel)	Taste	Marketability		Average
								Score	Key	
I	100	100	92	40	0	60	75	100	M	83
II	100	100	100	100	0	80	75	100	M	82
III	0	100	42	66	0	100	0	0	U	39
IV	66	100	92	100	0	100	33	33	U	66
V	0	100	33	100	0	86	8	0	U	43
VI	0	0	0	0	0	0	0	0	U	0
VII	0	33	8	66	0	100	0	0	U	26
VIII	0	0	0	0	0	0	0	0	U	0
IX	0	0	0	0	0	0	0	0	U	0
X	33	33	33	33	32	32	0	0	U	25

Each of the above percentages is the average of three replications

Key to Treatments

I Nontreated
II 100 Cellulose Acetate
III 300 H LST Cellophane (perforated)
IV 450 H LSAT Cellophane
V 300 H MSAT 86 Cellophane
VI 300 LST Cellophane (perforated) with propylene Glycol
VII 300 LST Cellophane (perforated) with experimental preservative K5807
VIII 300 LST Cellophane (perforated) with Primafresh wax
IX Pliofilm grade p6 Gauge 75
X 300 H LST Cellophane

Key to Marketability

M - Marketable
U - Unmarketable

Table 9.--QUALITY OF PREPACKAGED ELBERTA PEACHES AT ROOM TEMPERATURE (70°- 85° F.) EXPRESSED AS PERCENTAGES.--Continued

TREATMENT	MEAN (ALL OBSERVATIONS)	STANDARD DEVIATION
I	31.70	43.33
II	34.02	45.47
III	21.42	35.81
IV	31.20	43.33
V	26.05	42.08
VI	5.67	20.87
VII	13.67	29.67
VIII	4.85	20.58
IX	9.12	24.98
X	22.05	35.52

Each of the above percentages is the average of three replications

Key to Treatments

I Nontreated
II 100 Cellulose Acetate
III 300 H LST Cellophane (perforated)
IV 450 H LSAT Cellophane
V 300 H MSAT 86 Cellophane
VI 300 LST Cellophane (perforated) with propylene Glycol
VII 300 LST Cellophane (perforated) with experimental preservative K5807
VIII 300 LST Cellophane (perforated) with Primafresh wax
IX Pliofilm grade p6 Gauge 75
X 300 H LST Cellophane

Key to Marketability

M - Marketable
U - Unmarketable

In converting the score of a factor from that appearing on a scorecard basis to the one desired on a percentage basis, the following formula was used:

$$\frac{\text{rating of fruit sample for any one factor}}{\text{Scorecard weight of the factor}} \times 100 = \text{score (in per cent)}$$

Analysis of four treatments differing in moisture retentive qualities

On the basis of moisture retentive qualities of the wrapping materials used, the treatments are roughly divided into four parts as was explained in page 25. The data were taken on a scorecard basis and plotted on graphs. The total score of a treatment, representing the average of three replications, was calculated at each observation. This information along with the marketability of the fruit for the various conditions of the experiment is given in Figures 2, 3, 4 and 5.

Observed characteristics of the films used

To give an idea of the behavior of the various films used as overwraps in the prepackaging of peaches, the third observation lot examined on September 12 from the 45° F., storage was observed for condition of the tray and the visibility of the overwrap film used over it. This information is summarized in Table 10.

Changes in weight of prepackaged peaches

The weight data of the prepackaged fruit were unreliable due to the fact that a mechanical disorder was discovered in the scales used, when the experiment was already in progress and too late to correct. The weight data have been omitted entirely since valid conclusions could not be drawn from them.

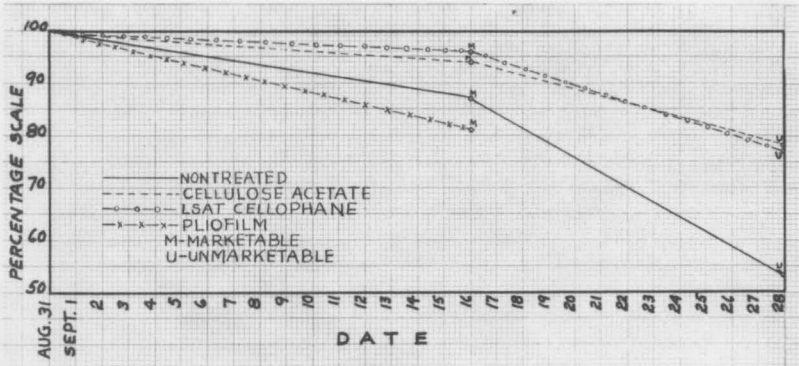


FIGURE 2.--ANALYSIS OF OBSERVATIONS OF PREPACKAGED PEACHES IN 36°F. STORAGE.

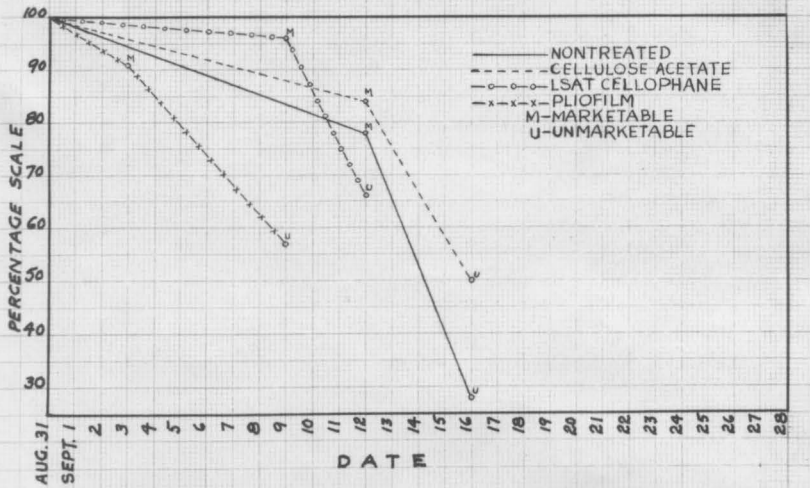


FIGURE 3.--ANALYSIS OF OBSERVATIONS OF PREPACKAGED PEACHES IN 45°F. STORAGE.

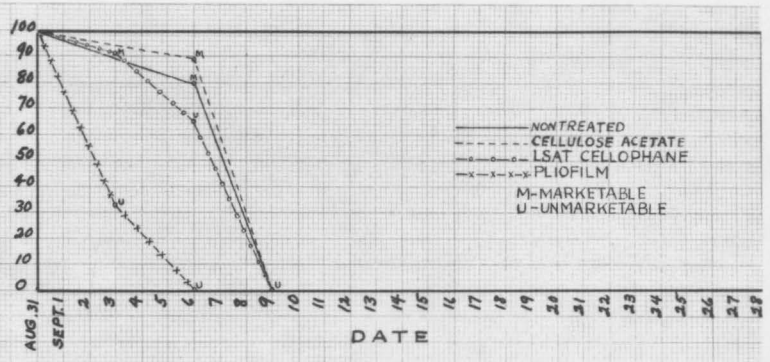


FIGURE 4.--ANALYSIS OF OBSERVATIONS OF PREPACKAGED PEACHES AT ROOM TEMPERATURES (70°-85°F.).

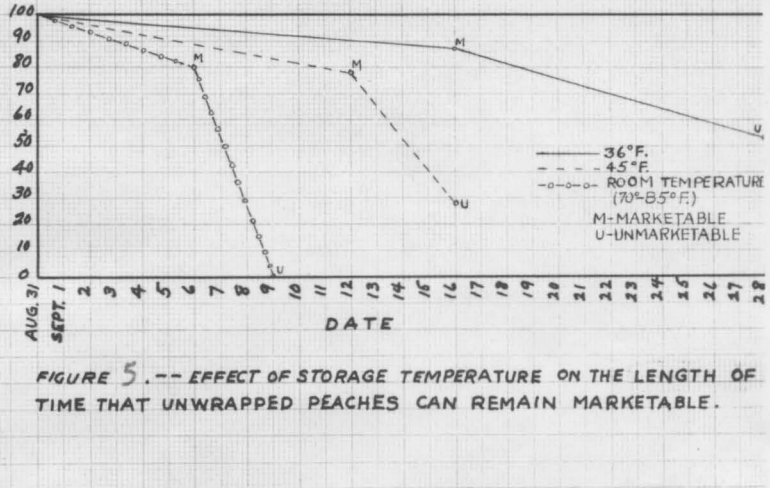


FIGURE 5.--EFFECT OF STORAGE TEMPERATURE ON THE LENGTH OF TIME THAT UNWRAPPED PEACHES CAN REMAIN MARKETABLE.

NOTE: THE GRAPHS ON THIS PAGE WERE PREPARED FROM DATA AS GATHERED ON A SCORECARD BASIS AS IS EXPLAINED ON PAGE 44

Table 10.--SOME COMMENTS ON PACKAGES AND FILMS ON THE THIRD OBSERVATION IN THE 45° F. STORAGE OF PREPACKAGED ELBERTA PEACHES.

TREATMENT	PACKAGE	FILM (VISIBILITY, ETC.)
I	Very strong and upright No change throughout experiment	No film
II	Very strong and upright No change throughout experiment	Perfectly clear and visible. No water drops adhering to film at any time. Cracks at folds.
III	Soft and limp, does not hold shape	Cloudy with water droplets adhering to film but visible.
IV	Not as strong as I and II but is upright and holds shape well	Cloudy but visible
V	Soft, does not hold shape well	Cloudy but visible
VI	Very soft and limp, does not hold shape	Cloudy but visible
VII	Very soft and limp, does not hold shape	Cloudy but visible
VIII	Very soft and limp, does not hold shape	Cloudy but visible
IX	Very soft and limp, does not hold shape	Cloudy but visible
X	Very soft and limp, does not hold shape	Cloudy but visible

Per cent total soluble solids in prepackaged peaches

The per cent total soluble solids in the fruit was determined by the use of an Abbe refractometer. The data have been tabulated for the various treatments and periods in the 36° F. storage temperature, in order from the highest to the lowest per cent total soluble solids in the different treatments. These data are given in Table 11.

Table 11.--TREATMENTS ARRANGED IN ORDER FROM HIGHEST TO LOWEST PER CENT TOTAL SOLUBLE SOLIDS IN THE FRUIT AT 36° F. STORAGE.

AFTER 4 DAYS			AFTER 10 DAYS			AFTER 13 DAYS			AFTER 29 DAYS		
Rank	Treat-ment	% T.S.S.	Rank	Treat-ment	% T.S.S.	Rank	Treat-ment	% T.S.S.	Rank	Treat-ment	% T.S.S.
1	V	14.3	1	I	12.4	1	I	12.8	1	I	13.5
2	I	13.7	2	II	11.6	2	II	12.4	2	III	12.6
3	VI	12.0	2	IX	11.6	3	V	12.2	3	II	12.0
4	IX	11.8	3	IV	11.1	4	IX	11.8	3	IV	11.2
5	II	11.6	4	VII	10.9	5	VI	11.3	4	X	11.1
6	III	11.2	5	V	10.8	6	VII	10.9	4	V	11.1
7	VII	10.7	6	VI	10.5	7	III	10.8	5	IX	10.9
8	IV	10.6	7	III	10.4	8	IV	10.7	-	--	----
9	VIII	10.2	7	VIII	10.4	9	VII	10.4	-	--	----
10	X	9.8	8	X	10.3	10	X	10.3	-	--	----

Treatments VI, VII and VIII on the last observation were spoiled and could not be analyzed

Key to Treatments

I	Nontreated
II	100 Cellulose Acetate
III	300 H LST Cellophane (perforated)
IV	450 H LSAT Cellophane
V	300 H MSAT 86 Cellophane
VI	300 LST Cellophane (perforated) with propylene Glycol
VII	300 LST Cellophane (perforated) with experimental preservative K5807
VIII	300 LST Cellophane (perforated) with Primafresh wax
IX	Pliofilm grade p6 Gauge 75
X	300 H LST Cellophane

Chapter V

DISCUSSION

The differences in mean scores made by the top four treatments were not significantly different in comparing fruit quality. They ranked as follows based on actual scoring of fruit quality:

1. Cellulose acetate-wrapped (Treatment II)
2. LSAT cellophane-wrapped (Treatment IV)
3. Nontreated (Treatment I)
4. LST (perforated) cellophane-wrapped (Treatment III)

If one were to base any conclusions on the ranking of the above four treatments, treatment II would be better than treatment IV, I and III and treatment IV would be inferior to treatment II and better than treatments I and III. Actually, there are other factors entering into the problem of selecting the treatment that performed the most satisfactorily in this experiment. In the first place the differences in the ability of the above four treatments to preserve quality in peaches were not significant. Furthermore, appearance, although an important factor is not the all important consideration in determining market quality. The appearance of the cellulose acetate-wrapped unit (treatment II) remained high for long periods of time and were apparently marketable at the end if only appearance were taken into consideration. However, when the taste

test was given to the cellulose acetate-wrapped fruit, it was found that it definitely was not acceptable for marketing. In addition the cellulose-acetate wrapped fruit showed a considerable amount of shriveling throughout the experiment as was proven by observation and shown in Tables 7, 8 and 9. The percentages of total soluble solids for the treatments used are given in Table 11. These data serve as an indirect means of pointing out moisture losses in the fruit in the various treatments and during periods of observation. As the moisture is given off by the fruit and dissipated into the atmosphere the juice in the fruit gradually becomes more concentrated with soluble solids. Some wrappers used allowed more moisture to escape than others. Those materials that allowed the most moisture to escape from the fruit showed the highest percentage total soluble solids readings. The longer the fruit remained in storage, the greater was the total soluble solids readings.

On the first observation of the experiment the number II treatment (cellulose-acetate) which supposedly allows a free transfer of gases and moisture between the inside and outside atmosphere of the package was intermediate in the percentage total soluble solids of the fruit. At the same time the nontreated lot was second in percentage total soluble solids of the fruit. As time passed the unwrapped treatment moved to the top rank and remained there throughout the length of the experiment. The cellulose-acetate treated lot moved up and remained next to the unwrapped lot. The fruit wrapped in LSAT cellophane remained in an intermediate position throughout with regard to the percentage total soluble solids. These observa-

tions tend to confirm the manufacturer's rating of LSAT cellophane as a semi-moisture retentive film. The highly moisture retentive films used in this experiment were those that kept the fruit with the least percentage total soluble solids as was expected. All observations proved that the cellulose acetate-wrapped fruit lost an excessive amount of moisture rendering the film undesirable for use in the prepackaging of peaches, in spite of the excellent appearance it gave as a prepackaged unit. Furthermore, the cellulose acetate film was observed to crack and break at the sharp folds and does not lend itself to heat sealing which is the commonly used method of sealing in prepackaging machines.

Since appearance and taste are two very important considerations in the marketing of any fruit, the data for these two quality factors were analyzed by an analysis of variance to find out how the various treatments differed in their effect on these two quality factors. The analysis showed that there were very significant differences existing between treatments with regard to appearance and taste. When a covariance study was made on these two correlated factors and the values adjusted it was found that the differences in taste due to treatments are not significant at any one temperature. A highly significant correlation of taste with appearance was found to exist under all conditions of the experiment. It can be safely said on the basis of data collected in this experiment that the different wrapped materials or treatments used in this experiment did not affect the taste of the fruit enclosed and that there exists a high correlation of taste with appearance.

The results of the various observations made after these had been converted into numerical evaluation of the various treatments on a scorecard basis are presented in the form of graphs, Figures 2, 3, 4 and 5.

From Figure 2, the 450 LSAT cellophane turned out to be the best one in the 36° F., storage, with cellulose acetate next, the nontreated lot and pliofilm at the bottom on the graded scale. At this temperature, all the four treatments kept the fruit in a marketable condition for sixteen days after having been packaged. All other treatments not shown in the graph were unmarketable at this time. The lines indicating the nontreated lot, cellulose acetate and LSAT treatments were extended to September 28. This was done merely to bring out the fact that the fruit in these treatments possessed an excellent appearance and would have been marketable had it not been for their undesirable taste which rendered them unmarketable at that time. The severe and moderate shriveling that the nontreated lot and cellulose acetate underwent may have accounted for the downward movement of the lines on the scale.

The last observation was deliberately delayed until September 28 to find out if these fruits could last that long in a marketable condition.

In Figure 3, it is seen that the LSAT cellophane treatment enabled the fruit at 45° F., to be kept in a perfectly marketable condition for nine days. Some decay developed which was given a heavy discount in grading. This also brought the appearance of the fruit down. This is also another important factor to consider

in determining whether or not a fruit is marketable. The behavior of the fruit in this overwrap material is in keeping with the manufacturer's rating and its intermediate moisture retentive qualities which after awhile cause moisture to accumulate inside the package and provide conditions favorable to mold growth. The taste of the fruit came down along with the other factors of mold growth and appearance, rendering the fruit unmarketable on September 12. The difference between the nontreated lot and cellulose acetate-wrapped treatments on September 12 was only slight and this was due to a little more shriveling in the nontreated lot. It is significant to note that the cellulose acetate-wrapped fruit was still holding well in appearance on September 28, although the taste was very undesirable, having a flat and even bitter flavor. The fruit overwrapped with pliofilm was marketable when observed on September 3, but was rendered unmarketable sometime between that date and September 9. The reason for this was a dropping of the taste factor possibly due to an excessive amount of carbon dioxide or to an insufficient amount of oxygen which interfered with normal respiration.

The marketable life of peaches in the various wrappers at room temperature is clearly seen on Figure 4. At this temperature it is seen that cellulose acetate-wrapped fruits remained the longest time in a marketable condition with the nontreated lots next down the scale.

The LSAT cellophane-wrapped fruit remained marketable only for three days, while the untreated and cellulose acetate-wrapped fruits remained in a marketable condition for six days. Here again

it is seen that the less moisture retentive a film is the longer it will keep peaches in a marketable condition. The high moisture retentive pliofilm did not keep the fruit (at room temperature) in a marketable condition even up to the first observation on September 3. All the fruits showed a physiological breakdown and mold growths causing them to be discarded on September 9 when the last observation was made. The intermediate moisture retentive LSAT film preserved the fruit in a marketable appearance for three days while the non-moisture retentive cellulose acetate enabled the fruit to remain in a marketable condition for six days, although at this date the fruit in the cellulose acetate was beginning to lose its firmness through the excessive loss of moisture.

In Figure 5 is seen the influence that the different temperatures of storage had on the time that unwrapped peaches remained in a marketable condition. There is no doubt but that the 36° F., temperature storage was the best one in which to store peaches. From this graph it is seen that at room temperature the unwrapped peaches remained in a marketable condition for only seven days while a similar lot of fruits in a storage temperature of 36° F., kept for 17 days or nearly three times as long as those at room temperature.

The films used in this experiment varied not only in their moisture retentive characteristics but also in visibility, strength and manner of sealing when using them as overwraps over prepackaged produce. Of prime consideration as far as this study is concerned are the moisture retentive quality, visibility and gaseous exchange characteristics of the films.

The cellulose acetate is a film that allows moisture to leave the package as it is liberated from the fruit and for this reason a high amount of shrinkage takes place. On the other hand this rapid moisture loss permits perfect visibility through the film and has the added advantage of less accumulation of moisture in the fruit and tray. Moisture accumulation promotes mold growth and causes the package to become water soaked and lose its shape. The film, however, has a disadvantage in that it is brittle and tends to crack and break at the sharp folds. Furthermore it is not heat-sealing, which is the more commonly used method of sealing in present-day wrapping machines. All other films are heat-sealing and seemed to be strong enough to stand the handling given the units in a commercial operation.

The LSAT cellophane film is semi-moisture retentive and more or less allows for a gradual loss of moisture, thereby preventing peaches from becoming shriveled and at the same time preserving the quality of peaches as observed in this experiment. After some length of time, however, the moisture given off by the fruit exceeds the amount allowed to escape through the film. This favors mold growth and subsequent lowering of quality which is the film's limiting factor after a certain length of time. The film, however, is heat-sealing and keeps its transparency fairly well. After the merits and disadvantages of both the 450 LSAT cellophane and 100 CA cellulose acetate films are given due consideration, it is concluded that LSAT film is more desirable to use than cellulose acetate in a commercial operation when large volumes of prepackaged peaches are

to be handled.

The high moisture retentive films such as pliofilm, of course, do not have a place in the prepackaging of peaches as was shown in this experiment.

The characteristic rate at which physiological activity proceeds in a given kind of produce item is the important factor that determines how long that kind of product can remain in good marketable condition; the slower the physiologic action the longer the product will remain marketable and vice versa. Different fruits will vary in the rate at which physiological activities proceeds. Temperature is an important factor in influencing that rate, other factors remaining constant. A high temperature speeds up physiological activity while a low temperature depresses it.

From Figure 2, it is seen that on September 16 at 36° F. there was a small variation in the quality of the fruit in the various treatments. There was a spread of 15 points on the graded scale ranging from the lowest score of 81 per cent for pliofilm, to the highest or 97 per cent for LSAT cellophane.

From Figure 3, it can be seen that at 45° F. the spread in quality scores was greater on September 9 than at 36° F. on September 16. Here the spread is 39 points on the graded scale between the lowest score of 57 per cent made by pliofilm and the highest or 96 per cent, the score of the LSAT cellophane treatment.

The data on Figure 4 indicate that a still greater spread occurs even earlier. In fact, the spread was from 89 to 0 on the sixth day after treatment. The highest score of 89 per cent was

made by the cellulose acetate treatment and the lowest or 0 per cent made by pliofilm.

From this discussion it is evident that as the temperature rises there is more of a spread or difference in the scores or quality among the various treatments and that this wide difference takes place earlier at the higher temperatures. The question then is, why is there such a small difference in the quality of the fruit in the various treatments of 36° F. after 17 days while there is such a wide variation in the quality of the fruit in a much shorter time at room temperature and 45° F.?

This can be explained on the basis that at the lowest temperature of 36° F., physiological activity, the important factor that determines the length of marketable life of the fruit, is almost at a standstill. At this temperature mold growth is inhibited. The wrapper films act only as regulators of the amount of moisture that is allowed to escape from the package and in the transfer of gases between the inside and outside atmospheres.

The moisture inside the package is released from the fruit by transpiration and respiration activities at a rate depending on the temperature. At 36° F., then physiological action is almost at a standstill; very little moisture is transpired by the fruit and the effectiveness of the different kinds of wrappers in the preservation of fruit quality is almost zero. The small differences observed in the quality of the fruit in the different treatments at 36° F. therefore, are due to individual variations of the fruits and may be due to chance. The wrapper films, therefore, may exert

very little influence in the preservation of the fruit quality at the lower temperatures.

At the higher temperatures, however, the physiological activities are accelerated, causing more moisture to be given off by the fruit. This allows the various films to exert their individual differences. The point then is that the temperature is the important factor in the retention of fruit quality at 36° F., while at higher temperatures the various films exert their influence.

Cellulose acetate allowed all the moisture to escape while pliofilm retained the greater part of it in the package. In the case of peaches it has been observed that the higher the moisture retentive capacity a film has the more conducive it is to spoiling of the fruit and vice versa. This accounts for the big difference in quality of the fruit at an early date between the cellulose acetate and the pliofilm treatments in the room temperature lot.

Chapter VI

SUMMARY

1. Tree-ripened Elberta peaches were prepackaged using cellulose acetate, LST cellophane, LST (perforated) cellophane, LSAT cellophane, MSAT cellophane, pliofilm and LST (perforated) cellophane with chemically treated fruit. The chemicals used were propylene glycol, primafresh wax and experimental preservative K5807. Storage temperatures of 36° F.,45° F. and room temperatures (70° F.-85° F.) were used. Appearance, color, decay, shriveling condition, pressure test, firmness as determined by feel and taste as determined by three or more persons were the factors used in determining quality. The fruit was divided into five observation lots each of which was inspected at a different time when the fruit was declared marketable or unmarketable, after considering all the above quality factors.

2. The different treatments used in this experiment did not affect the taste of the fruit at any one temperature. Appearance and taste were very highly correlated in the fruit used in this experiment.

3. At 36° F. the quality of the fruit is preserved and there tends to be little variation in the quality of the fruit in the different treatments because the physiological activity of the fruit is re-

duced, rendering the influence of the films less effective.

4. Tree-ripened peaches not wrapped and not chemically treated remained in a marketable condition for 16 days at 36° F., 12 days at 45° F. and six days at 70°-80° F.

5. In the case of peaches, the more moisture retentive overwrap films were the least effective in preserving market life of the fruit.

6. Prepackaged peaches can be maintained in a marketable condition up to 16 days with any of the films used at a storage temperature of 36° F.; 12 days at 45° F., when cellulose acetate-wrapped or unwrapped; and six days at room temperature (70°-80° F.), when cellulose acetate-wrapped or unwrapped.

7. The results obtained in this experiment indicated that the use of primafresh wax alone, and with chemical preservative K5807, and the use of propylene glycol alone as preservatives of quality accelerated rather than retarded the amount of physiological breakdown and spoilage.

8. Of the films tested the 450 LSAT cellophane film proved to be the more desirable in the commercial prepackaging of peaches, when appearance, taste, firmness, marketability and other quality factors used in this experiment along with the characteristics of the films themselves are given due consideration.

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