PROCESSING EFFECTS ON STANLEY AND BLUEFREE PLUM NECTAR, PLUM JUICE AND CANNED PLUMS

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ABSTRACT

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By

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Stanley and Bluefree varieties of Michigan-grown plums were examined. Five harvest dates of the Stanley and three of the Bluefree plums were harvested and subjected to various ripening treatments prior to canning. The canned plums were examined after six months of storage. The Stanley variety plums possessed deeper color, higher soluble solids content and lower acidity than the Bluefree plums. No one particular ripening treatment proved to be superior than the others, although an extended ripening resulted in weight and flavor losses.

Plum nectar was prepared by pulping heated, halved, de-stoned plums. The puree was mixed with an equal volume of sugar sirup, adjusted to equilibrate at 17$\pm$.5°B, heated and bottled.

Plum juice was extracted from the processed puree. After a 24-hour pectinol treatment, the juice was filtered, clarified and bottled.

Homogenization of the nectar, using high pressures (2000 + 1000 psig) prevented pulp sedimentation.

Color changes in nectar and juice were examined periodically to study the effect of storage. A brown precipitate developed during storage and tended to mask the anthocyanin pigments. Samples stored in the dark resulted in the least color degradation. Temperature of storage, homogenization and pasteurization had little effect on the color stability.

The addition of certain additives aided in the stability of the pigments. SO_2 prevented anthocyanin losses at concentrations of 25 to 100 ppm in plum nectar. In juice samples, none of the additives completely inhibited color changes. However, color changes were controlled somewhat in the samples containing SO_2 and sodium hexametaphosphate.

Optimum color extraction was observed at pulping temperatures above 180°F. The rate of enzymatic browning was not retarded at temperatures below 180°F, and with temperatures over 200°F the percentage of total solids greatly increased due to evaporation.

Evaluation of sugar and acid levels showed that 21% soluble solids was the preferred concentration in nectar and juice; 0.35% acid was preferred in the nectar samples, while 0.45% was the preferred acid level for juice.

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INTRODUCTION

The Stanley and Bluefree plum varieties have gained in importance in the Michigan plum industry. Since 1959, when only one-third of the state's production was of these varieties, their control of the state's production has increased to over 90% (Antle and Grieg, 1969). In 1970, approximately 97% of the 10,000 harvested tons were processed (88% canned, 9% frozen) and 3% was sold fresh (Agricultural Statistics, U.S.D.A., 1971). In 1971 the production increased 80% to approximately 18,000 tons, with most of the product being utilized by the canning industry.

The maturity of the plums and ripening conditions after harvest are the major factors in producing a good sound product. During the past few years, investigations have dealt with these factors and the effects of storage on the pre-canned product. Ernest, Birth and Sidwell (1958) developed a technique for measuring the internal color, thus predicting the plums maturity so that a properly matured product could be harvested.

Sorber (1942) recommended post-harvest storage conditions of 31-32°F and a relative humidity of

80-85%. Any decrease in the relative humidity may cause shriveling of the skins while any increases might cause a splitting of the skins (Hulme, 1970). According to Gerhardt and English (1946) this low-temperature storage should follow a holding period at higher temperatures to avoid flesh discolorations and a mealiness of the pulp.

These storage conditions, unless modified or controlled, produce flavor and weight losses over time (Couey, 1961, Handbook No. 66, U.S.D.A., 1968). Shutak and Christopher (1948) showed that these losses could be controlled with the addition of less than 40% CO_2 and that a somewhat tart taste could be added to the flavor. CO_2 increased storage life and aided in the prevention of plum rot.

The increase in plum production has also resulted in the search for new plum products. A plum juice product is made by pulping the product and adjusting the sugar levels to enhance the juice's natural flavor (Paul, 1944). This juice product is, however, basically a puree containing the juice and fruit pulp. Before pulping the whole plums and exposing the anthocyanin pigments to the air, causing oxidation, a heating treatment should be completed to inactivate any enzymatic reaction. Pederson, Beattie and Stotz (1947) reported that both enzymes and O_2 produced off-flavors in addition

to the browning reactions. Cruess, Rivera and Gibson (1950) showed that unheated juice from prunes quickly browned in the presence of air.

The heat treatment should be high enough to inactivate the enzymes but not too high as to produce any off flavors. Kilbuck (1948) found that any temperature over 185°F produced a burnt flavor. Ponting (1960) suggested a temperature of 180°F as the critical point for enzyme inactivation, and that over 194°F the flavor and texture qualities of plums decreased.

In another study, Beavens and Beattie (1942) reported that, in pulpy juice, the pulp should be removed to produce the clear, sparkling red juice because this pulp tended to mask the red color. Walker and Patterson (1954) and Walker et al. (1950) made use of a filtering procedure to remove the pulpy material. The plums were heated, extracting the color, and pulped to produce a puree. This puree was treated with pectic enzymes to break down the pulp structures; then the mixture was filtered, with filter aids, to produce a clear sparkling juice.

Another field of study being investigated is that of a plum pie. Various combinations, such as a plum-apple, apple as well as a whole plum pie, have been processed and market studies involving consumer acceptance have been carried out. Antle and Grieg (1969) reported,

> While apple pie was ranked highest by the largest number of consumers a significant number ranked plum pie or plum-apple pies as their first preference. The results of the taste panel test and a subsequent questionnaire indicated that over two-thirds of the consumers thought that the "overall appeal," "color," and "taste" of both the plum pie and plum-apple pie was "good."

A major area of concern involves the color stability of a plum juice or nectar after processing. During this period, certain chemical reactions take place which cause a browning effect or a brown precipitation in the product.

Anthocyanin pigments produce the natural red color in the plum product. Naturally occurring in the epidermal layers of the fruit, they tend to be more stable than other pigments once they are formed. This stability is due to the pigment not being fat soluble and being located in the cytoplasm of these layers (Goodwin, 1965, Hulme, 1970). However, when the cells are broken open by processing, the pigments are exposed to the air and to possible oxidation. These oxidation or enzymatic reactions produce a browning effect and/or a brown precipitation. Many ideas have been proposed as to the origin of these color changes. Pederson, Beattie and Stotz (1947), Meschter (1953) and Lukton (1956) have found that it was basically an oxidation reaction of phenolic type compounds resulting in a brown precipitate. Others, such as Nebesky, Esselen,

McConnell and Fellers (1949) believed that because of these reactions the anthocyanin pigment could possibly have been destroyed or that a new pigment could have been formed.

A substantial amount of work has dealt with observing the effects of processing and storage on the products color retention. Tressler and Pederson (1936) and Joslyn (1942) proposed that both the time and temperature of processing and the amount of O_2 the product is exposed to affects the amount of color loss. They also concluded that pH, sugar levels and light play minor roles in color degradation. After processing the product can still be affected by the amount of O_2 with which it comes into contact. Daravingas and Cain (1965) recommend a nitrogen packing to completely inhibit any color changes.

Other studies discuss the role of chemical color inhibitors either in the product or added in its processing. The idea of ascorbic acid browning inhibition has proven puzzling. Chung-Yen Peng (1962) suggested that ascorbic acid serves as a H+ donor and, as with other antioxidants, inhibits browning. Beattie, Pederson, Wheeler (1943) and Pederson, Beattie, Stotz (1947) found that as the color changes in anthocyanins began to occur, the amount of ascorbic acid tends to decrease and that simply adding additional ascorbic acid did not inhibit

these color losses. Malic acid has also been used during the processing steps to control enzymatic browning and, if necessary, is removed after processing by ionic exchange columns (Ponting, 1960).

Two other inhibitors gaining widespread use for color stabilization are SO_2 and polyvinyl pyrrolidone. Goodman and Markakis (1965) experimented with the use of SO_2 on a pure anthocyanin sample and suggested that the color inhibition might be due to a binding of the SO_2 to any carbonyl compounds which are present. They stated that, in a juice, possible higher concentrations of SO_2 would be required for color stability. Bolin and Porter (1967) found that concentrations of approximately 100 ppm of SO_2 could retard color deterioration for up to two weeks in a prune juice product. Similar investigations dealing with SO_2 found the same browning inhibition qualities (Pederson, Beattie, Stotz, 1947, and Ponting, 1960).

Polyclar, the polyvinyl pyrrolidone food grade, is a relatively new product being used extensively in the wine and beer industries (Caputi and Peterson, 1965). It is added to the product, mixed in and allowed to stand for a period of time. Then, it is usually removed by some type of filtration. It is believed that the compound absorbs the naturally present polyphenols which are thought to oxidize to darker pigments. Some of the

other possible advantages in using this product are that storage stability, color clarity and flavor may be enhanced (Clemens and Martinelli, 1958, Prescott and Lane, 1964).

Possibly the best procedures to follow in preventing browning are the techniques proposed by Markakis, Livingston and Fellers (1957). First, they suggest working with a product of high pigment and low ascorbic acid content and then the use of as low a processing temperature as possible. Next the removal of O_2 from the product is required. The fourth suggestion is a lowering of the pH with citric acid and, last, avoid any contamination with metallic ions. Cruess (1958) also suggested this last step for he found that in unprotected cans, the product's color darkened.

This study was undertaken not only to examine maturity levels and color changes but also to examine the effects of various processing procedures, storage conditions and color loss inhibitors on nectar and juice made from the Stanley and Bluefree varieties of plums.

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MATERIALS AND METHODS

Raw Material

Stanley and Bluefree varieties of plums (Prunus domestica) were examined in this study. Two harvest years, 1970 and 1971, were used. The 1970 harvest was obtained from the southwestern area of Michigan and consisted only of the Stanley variety. These plums were washed, halved, de-stoned, packed 20+5 into 30-pound tins and frozen. The 1971 harvest was received from the Palmer Orchard in Leslie, Michigan and consisted of both the Stanley and Bluefree varieties. These samples were returned to the Food Science building and divided into two lots. One lot was washed, halved, de-stoned, individually quick-frozen and packed in polyethylene lined boxes. Approximately 15% additional sugar was spread over these samples before sealing. The second lot was used in the canning study.

Canning Study

The 1971 harvest of plums was divided into two lots, one frozen and the other used for a maturity and

ripening study.* The two varieties, Stanley and Bluefree, were harvested at various stages of maturity. The Stanley variety was harvested on five separate dates at seven-day intervals. The Bluefree variety harvest was identical except only three dates were used. After the plums were picked, washed and cooled in cold running H_2O, they were divided into four separate lots. Lot one was canned immediately; lot two was stored at 70°F for one week and then canned; lot three was stored at 32°F for one week then at 70°F for one week and then canned; the last lot, number four, was stored at 32°F for two weeks, then at 70°F for one week and canned. 285 ± 15g. of fruit were packed in a 303 can covered with 200°F 40°B sugar sirup, exhausted to a center temperature of 160°F (1 minute) sealed and processed for 15 minutes at 210°F. Canned fruit was divided into two lots. One lot was stored at 36-38°F, and the second lot was stored at room temperature (70-75°F). After a storage period of six months, each variety, harvest date, ripening treatment and storage condition were examined by taste panels for color, flavor and texture.

Representative lots of each ripening treatment were also halved, de-stoned and frozen.

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*This study was undertaken in cooperation with the Horticulture Department at Michigan State University.

Nectar Processing

The halved frozen plums were partially thawed and placed into steam jacketed stainless steel kettles and heated with constant stirring until the temperature of the plums reached 180° ± 10°F. After being held at this temperature 1-2 minutes, the fruit was pulped twice, using the .023-inch screens on the Langsenkamp laboratory pulper. A representative sample was taken and the soluble solids content determined, using a Bausch and Lomb refractometer. The soluble solids were adjusted to 17.5±.5% using an equal weight of sugar sirup. The acid level was then adjusted to 0.4%, using citric acid. The nectar was then heated to 180-185°F, filled into sterilized jugs, inverted for 2-5 minutes, cooled and stored at 36-38°F.

Juice Processing

Plum juice was made from the pulped plums. The pulp was cooled to 100°F, 2g /1 liter Spark L* was added and well mixed into the pulp and held overnight at room temperature. Cellulose pulp was added to warm H_2O (100 grams of cellulose/2.0 gallons H_2O), thoroughly broken up and the excess H_2O squeezed out with the aid of a sieve. The cellulose pulp then was mixed in with the enzyme-treated plum pulp and squeezed through a

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*Pectinol, name from Marschall Division of Miles Laboratories, 1127 Myrtle Ave., Elkhart, Indiana, 46514.

nylon press cloth into a stainless steel bucket. Since the juice was still cloudy, it was mixed with Hi-flo super cel and filtered using a Buchner funnel, no. 5 Whatman filter paper and a suction flask. Adjustments for sugar and acid levels were made again whenever required. The juice was then heated to 180-185°F and filled into sterilized bottles, inverted 2-5 minutes and stored at 36-38°F.

Homogenization

Nectar from the Stanley variety, 1970 harvest, was separated into three batches. The first batch was heated to 140°F, the second to 160°F, and the third to 180°F. Each batch was then divided into five lots, with each lot being homogenized at a different pressure, using a two-stage Manton-Gaulin homogenizer. The varying pressures were:

lot 1	no pressure, control sample;
lot 2	500 psig first stage;
lot 3	1000 psig first stage
lot 4	1000 psig first stage and 1000 psig second stage;
lot 5	2000 psig first stage and 1000 psig second stage.

All of the samples were placed into sterile bottles of approximately 350 ml capacity. Pasteurization was accomplished in a water bath at 140-145°F for 30 minutes. The bottles were then cooled and stored at room temperature (75-80°F) in the dark. The samples

were examined periodically for sedimentation until no further settling was observed.

A second homogenization experiment was conducted. The same procedure used above was followed, eliminating the 180°F batch and the 500 psig treated lot. The samples were placed into sterilized sealable test tubes to a volume of 60 mls. These samples were stored at room temperature in both the light and dark and in a cold room (36-38°F) in the dark. The amount of sedimentation was determined as above until no further settling was observed.

Pasteurization

Twenty-pound samples of both the Stanley and Bluefree varieties, 1971 harvest, were made into nectar using the nectar-processing procedure. After adjusting the sugar and acid levels each variety was divided into two batches with one being heated to 140°F and the other to 160°F. Each batch was homogenized at these respective temperatures at 3000 psig (2000 psig first stage + 1000 psig second stage). After homogenization, the batches were divided into two lots per batch for pasteurizations. One lot from each batch was pasteurized at 145±3°F for 30 minutes (low temperature long hold) and the other lot was pasteurized at 170-180°F for 15 seconds (high temperature short hold). The samples were transferred

into sterilized bottles, cooled and stored at 36-38°F. Anthocyanin pigment changes were recorded periodically for 20 weeks.

Analytical Color Measurements

1970 Stanley Harvest

Nectar.--The plums were heated to 180°±10°F, pulped and adjusted to 17.5% with a sugar sirup and to 0.4% acid using citric acid. The nectar was then divided and stored at room temperature in the light and dark and at cold room temperatures. These samples were examined periodically for up to 29 weeks for color changes. Ten grams of nectar was mixed with 30 grams of 0.5% oxalic acid. This mixture was allowed to stand one hour and then was filtered. (It was found that a one-hour period achieved the maximum effect of the acid, Appendix Table 37). A 4 ml aliquot of this filtered nectar-acid mixture was then diluted to 20 ml with Na Citrate-HCL buffer, pH 3.5 and allowed to stand for 30 minutes for maximum color development. A Spectronic 70 (Bausch and Lomb) was set to 100% transmittance with a H_2O blank, and absorbance was read, using a wavelength of 512 nm (this was found to be the optimum wavelength, Appendix Table 35).

Juice.--Juice was made up according to the processing procedure. The juice was divided into three

lots and each lot was stored under a different condition, room temperature, in light and dark and cold room. These samples were then examined periodically for up to 32 weeks for color changes. A representative sample was taken and filtered. A 2 ml aliquot of this filtered juice was then diluted to 20 ml with Na-citrate-HCL buffer, pH 3.5.

The color was allowed to develop for 30 minutes before an absorbance reading on the Spectronic 70 was taken. A H_2O blank was used to set the instrument to 100% transmittance and the 512 nm wavelength was used.

1971 Harvest

Nectar.--The pasteurization samples were examined periodically for a period of 20 weeks. A 10 gm sample was mixed with 30 gm of 0.5% oxalic acid, allowed to stand 1 hour and filtered. A 2 ml aliquot was taken and diluted to 10 ml with two Na citrate-HCl buffers, one at a pH of 2.0 and the other at a pH of 5.0.

They were held for 30 minutes, and the absorbance was read on a H_2O blank adjusted Spectronic 70 unit. The absorbance of anthocyanin pigment was recorded as the difference between absorbance at pH 2.0 and pH 5.0.

Juice.--Juice samples of both Stanley and Bluefree 1971 harvest were used. A sample from each harvest date was prepared and stored under room temperature and cold room conditions. At specified intervals for a

period of 20 weeks, a representative quantity was taken from each sample, and the amount of color was measured. The juice was filtered and an aliquot of 1 ml was mixed with 9 ml of buffer. Samples were mixed with both pH buffers, and the amount of anthocyanin present was recorded.

Color Extraction

Juice.--Representative frozen samples from four harvest dates of the Stanley variety and two harvest dates of the Bluefree variety were thawed, pulped and juiced. Two heating periods were used, namely 170°F for 1 minute and 180°F for 2 minutes. The juice was prepared as previously described and the color was determined at pH 2.0 and pH 5.0.

Nectar.--Eighteen one-pound samples of mature 1971 harvested Bluefree plums were thawed and heated to six different temperatures before pulping. These temperatures were 160°, 170°, 180°, 190°, 200° and 210°F. Three samples were used with each temperature, and they were held at these temperatures for three different time periods; 1, 2 and 3 minutes. The color differences between the heating treatments were measured using the two pH buffer method.

Color Stability

1971 Stanley variety plums were thawed, heated, pulped, adjusted and cooled. The nectar was then divided into three lots and each lot was treated with a different chemical additive. Sodium hexametaphosphate (Na_{16} P_{14} O_{43})* was added at concentrations of .1%, .2%, .5% and 1% by weight. Lot two received .1%, .2%, .5% and 1% of ascorbic acid. The third lot was mixed with SO_2 in the form of $NaHSO_3$ at 10ppm, 25ppm, 50ppm and 100ppm concentrations. The samples were then stored at room temperature for 50 days. Color changes were measured to determine the effects of these additives on the color.

This same procedure was followed using the juice. A fourth additive, P.V.P.**, was used here at concentrations of .1%, .2%, .5% and 1%. Control samples of both nectar and juice were made up and color losses were recorded.

Sensory Evaluation

Paired Preference.--In the canning study, samples in cold room and normal room temperature storage were paired and the panelists were asked to indicate their preference of the two. This procedure was done comparing

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*Monsanto Co., 800 N. Lindbergh Blvd., St. Louis, Missouri.

**Polyvinyl Pyrrolidone, G.A.F. Corp., 140 W 51st St., New York, N.Y., 10020.

the harvest dates of each variety. The paired preference technique was also used comparing the effects of time in processing upon flavor quality in nectar. This procedure involved samples processed at 200°F. The times examined were 3 minutes versus 1 minute.

Hedonic Scale.--The second procedure involved the use of a hedonic scale which measured the panel's evaluation of each sample for color, flavor and texture in the canned samples. The samples were first presented by harvest dates, then the three ripening techniques were evaluated with another harvest date, no ripening effect, sample. Both of these tests were made to determine the optimum harvest date, ripening technique, and storage condition for both the Stanley and Bluefree plums.

Ranking.--Nectar and juice samples were presented to the panelists, who were asked to rank them in order of preference of flavor, placing the most preferred sample first and the least preferred one last. Using this technique, sugar and acid were varied in both the nectar and juice to find the most preferred levels. In the nectar and juice, the acid levels were adjusted to 0.35, 0.45, 0.55 and 0.65%, with citric acid and the sugar levels were adjusted to 15, 17, 19 and 21% soluble solids. The results of these panels were examined statistically.

The ranking procedure was also used in a flavor dilution experiment. With both nectar and juice, dilutions of 1:1, 1:1 1/2 and 1:2 volume of fruit to sugar sirup were made up and the panelists asked to rank them in order of preference. The nectar samples contained 18.5±.5% sugar and 0.35% acid. The juice samples contained 20.5±.5% sugar and 0.45% acid. Samples of different temperature treatments were ranked for preference on flavor. The temperatures were 160, 180, 200 and 210°F. The time variable was kept constant at 2 minutes.

Numerical Rating Scale.--Representative samples of nectar and juice were presented to the panel. The samples differed only in the amount of time they were stored. Samples were taken from cold room storage (36-38°F) and allowed to warm up to 40°F. The panelists were asked to compare the flavor of each with a reference sample of newly made product. In the nectar procedure, the samples stored for 2, 4, 8 and 12 months were used. The juice samples were stored 4 1/2, 9 and 12 months.

RESULTS AND DISCUSSION

Canning of Stanley and Bluefree Varieties

The canned Stanley and Bluefree plums were examined after a six-month storage for vacuum, gross weight, drained weight, sirup weight, cut out soluble solids, pH, acid, sugar/acid ratios and color (Tables 1 and 2). Initial soluble solids were recorded prior to canning.

Vacuum

Vacuum readings varied from .8 to 9.9 inches Hg averaging 4.5 inches Hg. No consistency was obtained in the measurements taken on the Stanley variety. The Bluefree unripened samples gave lower readings than any of the ripened plums.

Gross Weight

In the Stanley variety, no differences were noted, but by observation it can be seen that these values decreased slightly in the more mature plums as the ripening time increased. Differences were noted in the

TABLE 1. Objective Measurements on 1971 Canned Stanley Plums.

Harvest Date	Ripening Treatment	Vacuum	Gross Wt.	Drained Wt.	Sirup Wt.	Initial S.S.	Cut Out S.S.	pH	Acid g/100g Frt.	S/A Ratio	Color
		Inches Hg	g	g	g	%	%**				Absorbance
1. 8/23/71	A. None	2.8	591.6	298.8	217.8	13.4	28.6cd	3.5	.51	57.0	.075
	B. 1 wk 70°F	7.5	596.1	305.3	215.8	12.9	27.0bc	3.6	.57	47.2	.115
	C. 1 wk 32°F + 1 wk 70°F	3.8	601.7	301.8	224.9	22.0	26.5b	3.5[a]	.60[b]	44.2[a]	.174
	D. 2 wks 32°F + 1 wk 70°F	2.8	606.6	302.8	228.8	15.3	30.1e	3.6	.57	53.2	.446
2. 8/30/71	A. None	4.0	603.7	286.0	242.7	16.0	29.1de	3.5	.60	48.8	.157
	B. 1 wk 70°F	7.5	602.5	297.5	230.0	25.6	30.2e	3.6	.61	49.2	.359
	C. 1 wk 32°F + 1 wk 70°F	4.5	609.4	305.0	221.4	20.5	30.2e	3.6[a]	.55[b]	55.2[a]	.587
	D. 2 wks 32°F + 1 wk 70°F	4.5	607.3	301.0	231.3	20.7	29.3de	3.6	.52	56.6	.442
3. 9/6/71	A. None	2.5	604.0	275.0	254.0	17.6	29.8de	3.7	.46	64.7	.426
	B. 1 wk 70°F	6.0	606.0	257.5	273.5	17.0	29.5de	3.7	.39	76.4	.626
	C. 1 wk 32°F + 1 wk 70°F	4.8	600.0	272.8	253.2	20.0	29.0d	3.8[b]	.41[a]	71.0[b]	.567
	D. 2 wks 32°F + 1 wk 70°F	5.5	596.3	281.5	239.8	19.0	27.7f	3.9	.35	79.3	.671
4. 9/15/71	A. None	5.0	609.9	271.0	263.9	16.5	33.2ef	3.7	.42	79.0	.301
	B. 1 wk 70°F*	---	-----	-----	-----	----	------	---	---	----	----
	C. 1 wk 32°F + 1 wk 70°F	5.0	597.6	258.0	264.6	20.8	26.2b	3.8[b]	.36[a]	72.8[b]	.386
	D. 2 wks 32°F + 1 wk 70°F	4.5	586.0	269.0	242.0	20.2	21.0a	3.9	.32	65.6	.566
5. 9/21/71	A. None	2.0	607.6	271.5	261.1	17.3	29.3de	3.8	.40	74.2	.365
	B. 1 wk 70°F	4.5	603.4	287.5	240.9	18.3	28.4cd	3.8	.43	66.7	.771
	C. 1 wk 32°F + 1 wk 70°F	4.0	600.8	293.0	232.8	19.8	28.0cd	3.9[b]	.40[a]	69.6[b]	.985
	D. 2 wks 32°F + 1 wk 70°F	4.5	601.9	296.0	230.9	19.8	28.4cd	3.9	.40	71.8	1.127
			N.S.	N.S.	N.S.	N.S.					

*Lost sample

**Like letters indicate no significant differences

TABLE 2. Objective Measurements on 1971 Canned Bluefree Plums.

Harvest Date	Ripening Treatment	Vacuum	Gross Wt.	Drained Wt.	Sirup Wt.	Initial S.S.	Cut Out S.S.	pH	Acid $\frac{g}{100g}$ Frt.	S/A Ratio	Color
		Inches Hg	g	g	g	%	%**				Absorbance
1. 9/6/71	A. None	1.3	603.9	287.0	241.9	13.9	29.5f	3.3	.70	42.4	.199
	B. 1 wk 70°F	4.0	603.6	254.5	274.1	15.9	28.5e	3.4	.59	48.1	.491
	C. 1 wk 32°F + 1 wk 70°F	5.0	581.4	258.5	247.9	17.2	27.3d	3.4	.59	46.2	.579
	D. 2 wks 32°F + 1 wk 70°F	8.0	587.5	288.0	224.5	16.3	24.3a	3.4	.55	44.3	.688
2. 9/15/71	A. None	2.5	596.3	289.0	232.3	14.0	25.8c	3.3	.69	37.4	.180
	B. 1 wk 70°F	5.5	598.0	267.5	255.5	15.4	26.3c	3.3	.69	38.4	.326
	C. 1 wk 32°F + 1 wk 70°F	6.3	589.6	289.8	224.8	17.8	25.2b	3.4	.70	36.0	.521
	D. 2 wks 32°F + 1 wk 70°F	3.5	599.2	277.3	246.9	17.3	26.4c	3.4	.59	44.6	.469
3. 9/21/71	A. None	.8	600.4	278.3	247.1	14.5	26.1c	3.3	.66	39.6	.221
	B. 1 wk 70°F	9.9	589.4	272.0	242.4	16.5	28.5e	3.4	.65	43.7	.525
	C. 1 wk 32°F + 1 wk 70°F	2.8	598.4	287.5	235.9	17.3	25.9c	3.3	.69	37.8	.601
	D. 2 wks 32°F + 1 wk 70°F	4.5	600.4	274.0	251.4	17.5	28.7e	3.3	.67	43.1	.566
			N.S.	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

**Like letters indicate no significant differences

Bluefree variety between the unripened and ripened plums. Overall, the unripened sample weights were higher than the ripened plums.

Drained Weight

Higher drained weights were obtained for the Stanley than for the Bluefree variety. In the Stanley samples the ripened plums generally gave higher drained weights than the unripened plums. This may be due to some water loss during the ripening period. The Bluefree variety plums did not show this effect. No relationship could be established between ripening treatment, maturity and the drained weight of the varieties studied.

Sirup Weight

The drained sirup from the drained weight measurements was also weighed. No differences were found between the unripened and ripened samples. In the Stanley variety a slight increase in weight was observed with a marked difference between the first harvest and the other four harvest dates. The Bluefree variety weights showed no noticeable differences (Table 2).

Soluble Solids

The initial soluble solids of the Stanley plums varied from 12.9 to 25.6 while those of the Bluefree

varied from 13.9 to 17.8. The unripened plum measurements were significantly lower than the ripened samples in both varieties. Higher readings were obtained in the samples ripened using the two shorter ripening periods; 1 week at 70°F and 1 week at 32°F + 1 week at 70°F (Tables 1 and 2).

The cut out soluble solids content of the canned Stanley plums varied from 21.0 to 33.2. The Bluefree plums readings varied from 24.3 to 29.5. In both varieties no relationship was found between the harvest dates, ripening treatment and soluble solids content. The Stanley variety showed a slight increase in soluble solids content as the maturity of the plums increased (Table 1).

pH and Total Acidity

The Stanley variety pH readings increased as the product matured from approximately 3.5 to 3.9. The Bluefree readings stayed relatively constant between 3.3 to 3.4.

The Bluefree variety gave higher acid readings and lower pH readings than the Stanley variety.

Total acidity for Stanley plums decreased from .55 to .4 g/100g fruit as maturity advanced.

The total acidity measurements of the Bluefree variety plums varied slightly but no differences were

noted as the plums matured. The values varied from .61 to .67 g/100g fruit.

Within each harvest date no differences were found between the unripened and ripened samples for either variety.

Sugar/Acid Ratio

The sugar/acid ratio values obtained for the Stanley variety were significantly higher than those for the Bluefree variety. No differences were observed between the unripened and ripened samples of each harvest in the Stanley plums. An increase in these values was noted, however, as the product matured, initially calculated as 44.2 and increasing up to 79.3.

The Bluefree samples showed differences between the unripened and ripened plums with the unripened plum readings being lower than those from the ripened samples. The S/A ratio from this variety fluctuated between 36 and 48.1 with harvest maturities.

Color

Both varieties showed similar results. As the plums matured, the amount of color increased. In addition, within each harvest date, the use of any ripening treatment increased the amount of pigment present.

Differences were observed between the unripened and ripened samples from both varieties. The Stanley variety absorbance values increased from .075 to 1.127 while those for the Bluefree increased from .199 to .688. From the 9/6/71 harvest on, the readings for the Stanley variety were slightly higher than those from the Bluefree variety.

Sensory Evaluation of Canned Plums

After the objective measurements were completed, the plums were quartered, de-stoned and subjected to sensory evaluation. The first test conducted was that of a paired preference examination, Table 3 (Roessler, Baker, Amerine, 1956). Sample A was stored at room temperature, and sample B was subjected to cold room storage. No significant preference for either storage, in either variety was found.

The second sensory evaluation procedure used was Hedonic scaling (Peryam and Pilgrim, 1959) involving color, flavor and texture.

In Tables 4 and 5, the means of the panelists judgings are summarized for harvest date vs. each ripening treatment within that harvest date. In Tables 6 and 7, the mean data for date vs. date are given. In this evaluation, the ripening treatments were examined with the same ripening treatment from another harvest.

TABLE 3. Paired Preference Analysis of Storage Conditions After Processing on Canned Stanley and Bluefree Variety Plums (Sample A = Room temperature Storage, B = Cold Storage).

Variety	Harvest Date	Preference (freq.)	
		A	B
Stanley	8/23/71	33	31
Stanley	8/30/71	27	37
Stanley	9/6/71	31	25
Stanley	9/15/71	21	27
Stanley	9/21/71	29	19
Bluefree	9/6/71	20	28
Bluefree	9/15/71	27	21
Bluefree	9/21/71	26	22
Overall harvest Dates			
Stanley		141	139
Bluefree		73	71

TABLE 4. Hedonic Scaling for Color, Flavor and Texture on Stanley Plums, Date vs. Ripening Treatment.

Harvest Date	Ripening Treatment	Panel Means**		
		Color	Flavor	Texture
1. 8/23/71	A. None	3.7a	4.9a	8.0g
	B. 1 wk 70°F	5.8c	6.1bc	5.7d
	C. 1 wk 32°F and 1 wk 70°F	5.8c	6.2bc	6.4e
	D. 2 wks 32°F and 1 wk 70°F	7.8g	6.2bc	4.2bc
2. 8/30/71	A. None	5.5b	6.5c	6.6ef
	B. 1 wk 70°F	7.1fg	7.3d	5.7d
	C. 1 wk 32°F and 1 wk 70°F	7.2fg	5.8b	4.8c
	D. 2 wks 32°F and 1 wk 70°F	6.2d	6.2bc	4.6c
3. 9/6/71	A. None	6.6e	6.5c	6.7ef
	B. 1 wk 70°F	6.7e	5.4b	4.2bc
	C. 1 wk 32°F and 1 wk 70°F	5.9cd	6.0bc	4.9c
	D. 2 wks 32°F and 1 wk 70°F	6.6e	5.1a	4.1b
4. 9/15/71	A. None	6.7e	6.0bc	4.1b
	B. 1 wk 70°F*	---	---	---
	C. 1 wk 32°F and 1 wk 70°F	7.0eg	5.9bc	2.6a
	D. 2 wks 32°F and 1 wk 70°F	6.6e	5.8b	3.1a
5. 9/21/71	A. None	5.8c	6.0bc	7.0fg
	B. 1 wk 70°F	7.5g	6.7c	3.9b
	C. 1 wk 32°F and 1 wk 70°F	7.3fg	6.3bc	3.6ab
	D. 2 wks 32°F and 1 wk 70°F	7.7g	6.4c	3.3a

*Lost sample

**Like letters indicate no significant differences within each column

TABLE 5. Hedonic Scaling for Color, Flavor and Texture on Bluefree Plums, Date vs. Ripening Treatment.

Harvest Date	Ripening Treatment	Panel Means*		
		Color	Flavor	Texture
1. 9/6/71	A. None	4.2a	5.7b	5.3c
	B. 1 wk 70°F	6.7e	6.8a	3.6a
	C. 1 wk 32°F and 1 wk 70°F	6.5e	6.7a	3.6a
	D. 2 wks 32°F and 1 wk 70°F	6.9f	6.1ab	4.3b
2. 9/15/71	A. None	4.8b	5.6b	3.9a
	B. 1 wk 70°F	5.4c	6.2a	3.8a
	C. 1 wk 32°F and 1 wk 70°F	6.7e	6.7a	3.9a
	D. 2 wks 32°F and 1 wk 70°F	6.1d	6.0ab	4.2ab
3. 9/21/71	A. None	4.7b	6.0ab	5.1c
	B. 1 wk 70°F	6.6e	6.2a	4.5b
	C. 1 wk 32°F and 1 wk 70°F	7.0f	5.5b	4.4b
	D. 2 wks 32°F and 1 wk 70°F	7.0f	6.2a	4.5b

*Like letters indicate no significant differences within each column

TABLE 6. Hedonic Scaling for Color, Flavor and Texture on Stanley Plums, Date vs. Date.

Harvest Date	Ripening Treatment	Panel Means**		
		Color	Flavor	Texture
1. 8/23/71	A. None	4.2a	6.0ab	5.8cd
	B. 1 wk 70°F	6.2cde	6.0ab	4.8c
	C. 1 wk 32°F and 1 wk 70°F	4.6ab	5.5a	4.8c
	D. 2 wks 32°F and 1 wk 70°F	6.7de	7.0b	4.7c
2. 8/30/71	A. None	5.8cde	6.3ab	4.9c
	B. 1 wk 70°F	7.0e	6.1ab	4.7c
	C. 1 wk 32°F and 1 wk 70°F	6.8de	6.4ab	4.8c
	D. 2 wks 32°F and 1 wk 70°F	6.6de	6.5ab	5.0cd
3. 9/6/71	A. None	6.2cde	6.3ab	6.0c
	B. 1 wk 70°F	6.6de	5.9ab	4.7c
	C. 1 wk 32°F and 1 wk 70°F	5.8cde	6.3ab	4.7c
	D. 2 wks 32°F and 1 wk 70°F	6.4cde	5.3a	4.0bc
4. 9/15/71	A. None	6.2cde	6.2ab	6.1c
	B. 1 wk 70°F*	------	-----	-----
	C. 1 wk 32°F and 1 wk 70°F	6.3cde	5.7a	2.7ab
	D. 2 wks 32°F and 1 wk 70°F	5.5c	4.8a	3.3ab
5. 9/21/71	A. None	6.8de	6.3ab	6.2d
	B. 1 wk 70°F	5.4b	5.8ab	4.7c
	C. 1 wk 32°F and 1 wk 70°F	6.7de	6.2ab	3.1ab
	D. 2 wks 32°F and 1 wk 70°F	6.2cde	6.2ab	2.6ab

*Lost sample

**Like letters indicate no significant differences within each column

TABLE 7. Hedonic Scaling for Color, Flavor and Texture on Bluefree Plums, Date vs. Date.

Harvest Date	Ripening Treatment	Panel Means*		
		Color	Flavor	Texture
1. 9/6/71	A. None	5.3abc	6.0a	5.0c
	B. 1 wk 70°F	5.3abc	6.4a	3.4ab
	C. 1 wk 32°F and 1 wk 70°F	6.2bc	6.4a	3.9ab
	D. 2 wks 32°F and 1 wk 70°F	6.9cd	6.6a	5.7c
2. 9/15/71	A. None	4.3ab	5.8a	4.8c
	B. 1 wk 70°F	6.6cd	6.3a	4.0ab
	C. 1 wk 32°F and 1 wk 70°F	6.0bc	6.0a	3.4ab
	D. 2 wks 32°F and 1 wk 70°F	6.0bc	6.1a	4.0ab
3. 9/21/71	A. None	4.7ab	6.1a	4.8c
	B. 1 wk 70°F	6.0bc	5.8a	3.3a
	C. 1 wk 32°F and 1 wk 70°F	7.5d	6.2a	4.6bc
	D. 2 wks 32°F and 1 wk 70°F	6.3bc	6.4a	3.1a

*Like letters indicate no significant differences within each column

These four tables of data were analyzed by analysis of variance and Duncan's multiple range test at p = .05 (Mendenhall, 1968; Sokol and Rohlf, 1969).

Color

In the Stanley variety, maximum color ratings were obtained for the third and fourth harvests (Table 4). With the Bluefree variety the color ratings increased between the first and second harvest but there was no further increase in the third harvest. Color ratings increased for all ripening methods and in general the highest ratings were obtained for the longest ripening time. No significant differences were found between color ratings when ripening methods of each harvest date were compared (Tables 6 and 7).

The color ratings are in general agreement with the absorbance color measurements.

Flavor

The flavor ratings were similar for all treatments indicating that neither harvest maturity nor ripening methods had any marked effect. These results also indicated that a relatively wide range in sugar/acid ratios had little effect on the flavor of the canned plums.

Texture

The texture ratings decreased with increased fruit maturity and with increased ripening time after harvest.

The scale rating of 5 indicates neither a soft nor tough texture. A range of $4\pm.2$ to $6\pm.2$ indicates the most desirable texture. Ratings below or above this range indicate either a soft or firm texture. In the Stanley variety unacceptable firm texture readings were recorded in the harvests of 8/23/71, 8/30/71, 9/6/71 and 9/21/71 in the unripened samples. Undesirably soft texture ratings were found in the longer ripening treatment samples of the last two harvests.

In the Bluefree variety no samples were found to be too firm. The shorter ripening periods produced too soft ratings in the first two harvests.

Homogenization of Stanley Plum Nectar

Homogenization pressure effects the amount of sedimentation more than storage or temperature of processing (Tables 8-11, Figures 1-4). Without homogenization sedimentation occurred throughout the storage period for all three extraction temperatures and the total amounts of sediment were similar at the end of 56 days. Initial sedimentation was significantly higher in the 180°F extraction (Table 8).

Significant linear relationships were established in all samples (Figures 1-4).

Increasing the homogenization pressure from 500 to 3000 psig decreased the amount of sedimentation with little or no sedimentation at 3000 psig. Higher amounts

TABLE 8. Pulp Sedimentation of Nectar Samples Heated to 140°, 160° and 180°F.

	0 (3 hrs)	Time (days)					
		2	4	7	14	28	56
140°F	3.0	35.0	60.5	73.5	82.5	103.5	108.5
160°F	4.0	39.0	65.0	81.0	85.0	99.5	112.5
180°F	18.5	63.5	89.5	105.0	110.0	114.0	120.0

Solid lines denote no significant sedimentation from initial time.

TABLE 9. Pulp Sedimentation of Nectar Samples Heated to 140°F and Homogenized at 500-3000 psig.

	0 (3 hrs)	Time (days)						
		2	4	7	14	28	56	
		mls						**
500 psig	0.0	1.0	1.8	2.0	3.0	3.0	3.3	ab
1000 psig	0.0	2.5	5.3	6.5	7.0	7.8	8.5	b
2000 psig	0.0	0.0	0.0	0.5	0.5	0.5	0.8	a
3000 psig	0.0	0.0	0.0	0.0	0.0	0.3	0.3	a

** Like letters indicate no significant differences between pressures

Solid lines indicate no significant sedimentation from initial time

TABLE 10. Pulp Sedimentation of Nectar Samples Heated to 160°F and Homogenized at 500-3000 psig.

	0 (3 hrs)	Time (days) 2	4	7	14	28	56	**
				mls				
500 psig	0.0	0.8	1.5	3.0	4.3	4.8	4.8	ab
1000 psig	0.0	3.0	4.0	5.8	6.5	7.0	7.0	b
2000 psig	0.0	0.0	0.0	0.3	0.3	0.8	1.0	a
3000 psig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	a

**Like letters indicate no significant differences between pressures

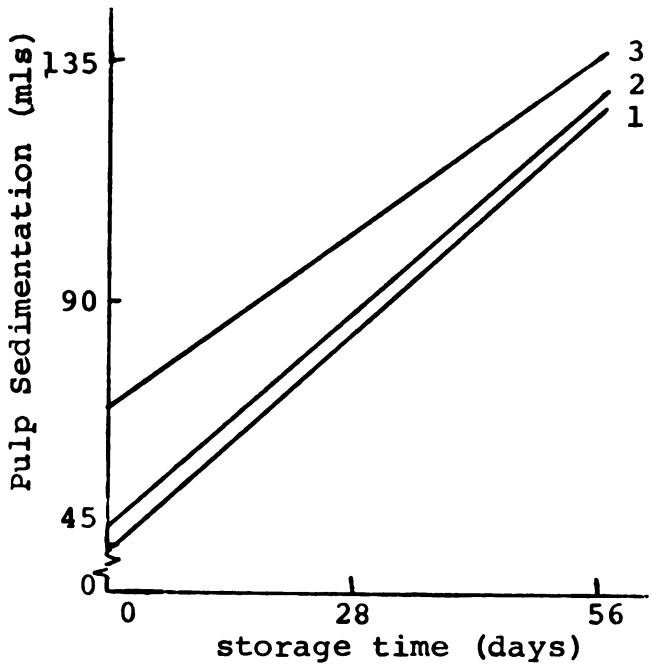
Solid lines indicate no significant sedimentation from initial time

TABLE 11. Pulp Sedimentation of Nectar Samples Heated to 180°F and Homogenized at 500-3000 psig.

	0 (3 hrs)	Time (days) 2	4	7	14	28	56	**
				mls				
500 psig	0.0	8.3	12.5	13.8	13.8	14.8	14.8	a
1000 psig	0.0	4.3	6.8	7.8	8.0	8.3	8.5	ab
2000 psig	0.0	2.0	5.5	6.8	7.5	8.0	7.8	ab
3000 psig	0.0	0.0	0.0	0.3	0.5	1.0	1.0	b

**Like letters indicate no significant differences between pressures

Solid lines indicate no significant sedimentation from initial time

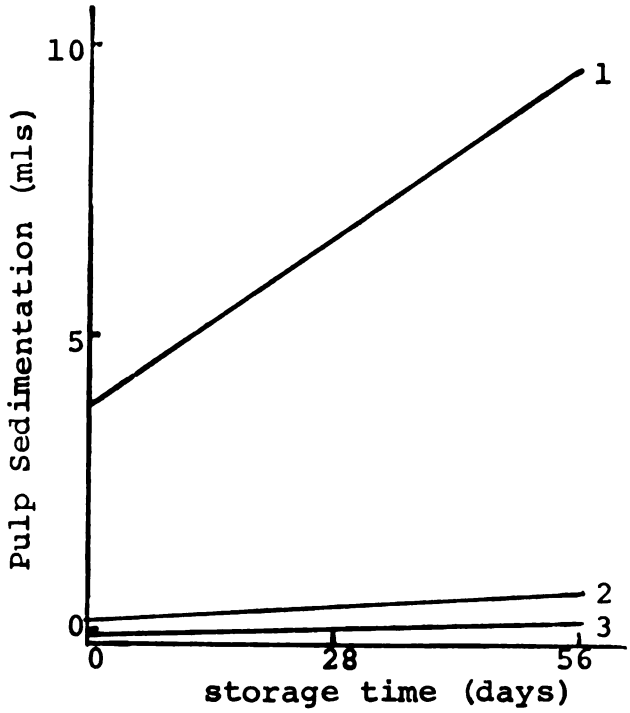


1 = 140°F r = .736*
y = 1.47x+43.17

2 = 160°F r = .726*
y = 1.43x+46.71

3 = 180°F r = .643*
y = 1.17x+70.12

Figure 1. Effects of 0 psig Upon Pulp Sedimentation Homogenized at 140°F, 160°F and 180°F, Stored in Light at Room Temperature.



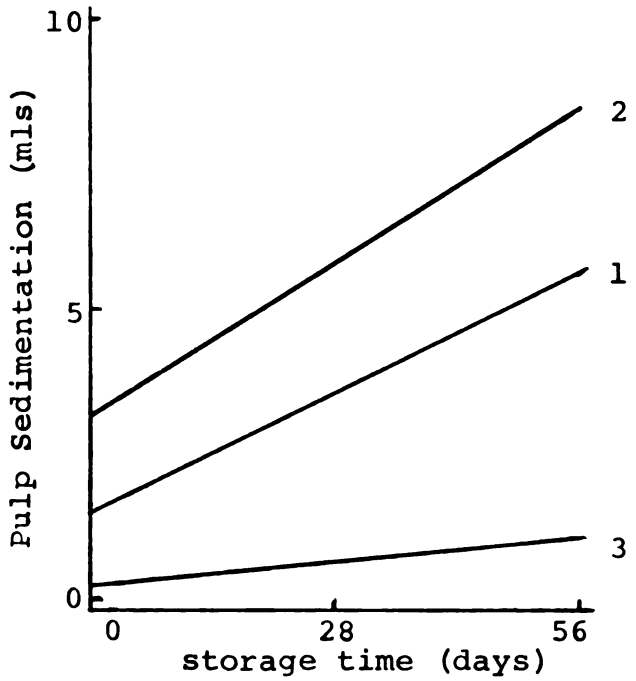
1 = 1000 psig r = .401*
y = .11x+3.61

2 = 2000 psig r = .440*
y = .01x+.12

3 = 3000 psig r = .390*
y = .005x+-.014

Figure 2. Effects of Pressures, 500-3000 psig, Upon Pulp Sedimentation Homogenized at 140°F, Stored in Light at Room Temperature.

*Significant at 5% level

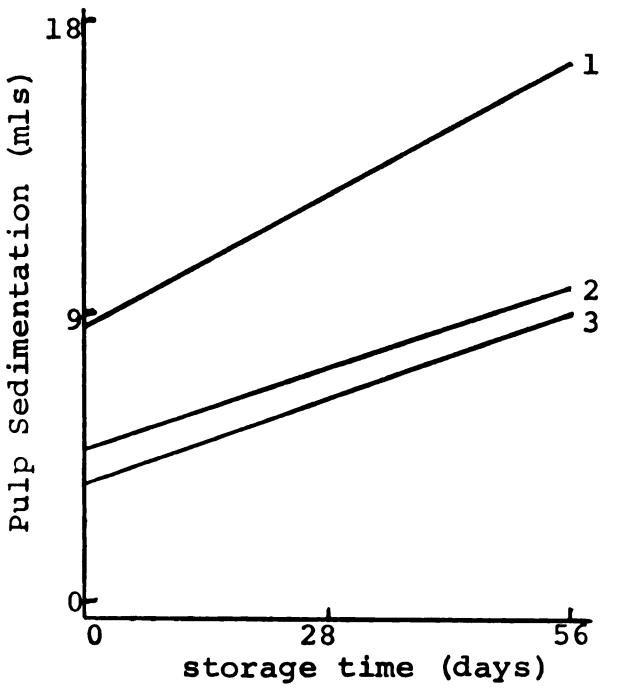


1 = 500 psig r = .531*
y = .077x+1.50

2 = 1000 psig r = .587*
y = .088x+3.35

3 = 2000 psig r = .544*
y = .019x+.017

Figure 3. Effects of Pressures, 500-3000 psig, Upon Pulp Sedimentation Homogenized at 160°F, Stored in Light at Room Temperature.



1 = 500 psig r = .458*
y = .15x+8.74

2 = 1000 psig r = .537*
y = .09x+4.78

3 = 2000 psig r = .586*
y = .01x+3.78

Figure 4. Effects of Pressures, 500-3000 psig, Upon Pulp Sedimentation Homogenized at 180°F, Stored in Light at Room Temperature.

*Significant at 5% level

of sedimentation occurred in the 180°F heated nectar. There was no marked differences between 140°F and 160°F heated nectar. Most of the settling occurred during the first 7 days of storage (Tables 9-11).

Homogenized plum nectar stored at 70°F in the light and dark and at 36-38°F in the dark showed no differences in sedimentation except that the 140°F, 2000 psig, 70°F dark storage sample had less sediment than the 36-38°F stored sample (Tables 12-18). As in the previous study, increased homogenization pressure decreased the amount of sedimentation and in the 160°F 3000 psig sample no sedimentation was observed. Most of the settling occurred during the first 14 days of storage.

TABLE 12. Pulp Sedimentation of Nectar, Samples Heated to 140°F Homogenized at 0 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)	Time (days)				
		14	28	56	84	112
			mls			
70°F light	0.8	15.0	17.8	18.3	18.3	18.3
70°F dark	1.4	17.4	18.2	18.8	18.8	18.8
36°-38°F	1.3	16.3	17.5	18.3	18.3	18.3

TABLE 13. Pulp Sedimentation of Nectar, Samples Heated to 140°F Homogenized at 1000 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)	Time (days)				
		14	28 mls	56	84	112
70°F light	0.0	3.7	4.3	4.4	4.7	5.0
70°F dark	0.0	4.6	4.7	4.9	5.1	5.1
36°-38°F	0.0	4.6	4.7	5.1	5.2	5.2

TABLE 14. Pulp Sedimentation of Nectar, Samples Heated to 140°F Homogenized at 2000 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)		Time (days)					
			14	28 mls	56	84	112	*
70°F light	0.0	a	0.55	1.8	1.95	2.2	2.2	ab
70°F dark	0.0	a	0.7	0.75	1.2	1.25	1.25	b
36°-38°F	0.0	b	2.41	2.6	2.8	2.8	2.8	a

*Like letters indicate no significant differences between storages

Solid lines indicate no significant sedimentation from initial time

TABLE 15. Pulp Sedimentation of Nectar, Samples Heated to 140°F Homogenized at 3000 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)	Time (days)						
		14	28 mls	56	*	84	112	*
70°F light	0.0	0.4	0.5	0.6	a	0.7	0.7	a
70°F dark	0.0	0.4	0.4	0.4	b	0.4	0.4	b
36°-38°F	0.0	0.4	0.4	0.4	b	0.4	0.4	b

*Like letters indicate no significant differences between storages

TABLE 16. Pulp Sedimentation of Nectar, Samples Heated to 160°F Homogenized at 0 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)		Time (days)				
			14	28 mls	56	84	112
70°F light	0.6	a*	15.5	18.3	18.8	18.8	18.8
70°F dark	1.2	b	16.7	18.2	18.8	18.8	18.8
36°-38°F	0.7	a	16.7	18.3	18.8	18.8	18.8

*Like letters indicate no significant differences between storages

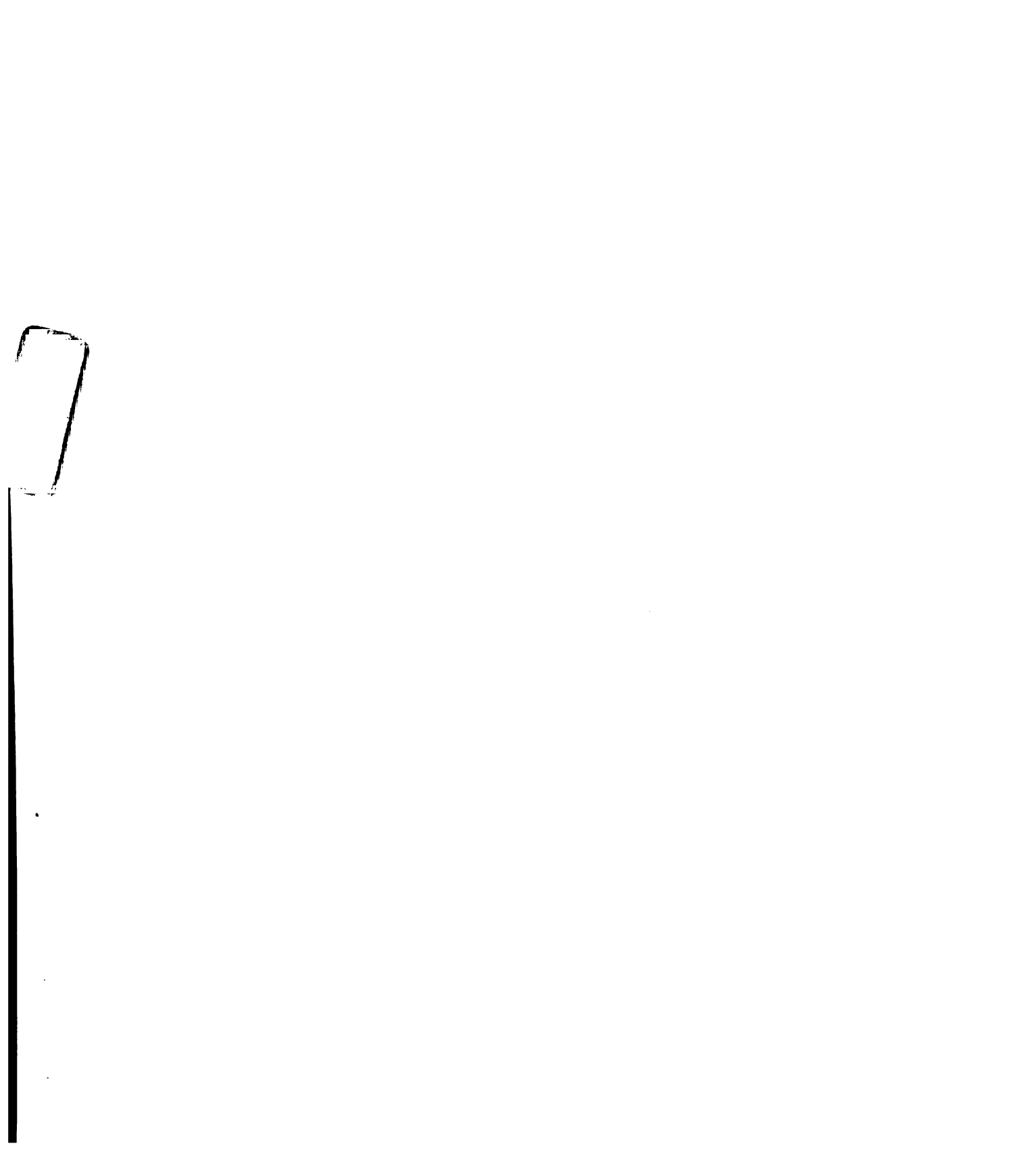


TABLE 17. Pulp Sedimentation of Nectar, Samples Heated to 160°F Homogenized at 1000 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)	Time (days)					
		14	28	56	84	112	*
			mls				
70°F light	0.0	2.1	2.3	2.4	2.85	2.85	a
70°F dark	0.0	3.25	3.6	3.9	3.9	3.9	b
36°-38°F	0.0	2.55	2.75	2.8	2.85	2.85	a

*Like letters indicate no significant differences between storages

TABLE 18. Pulp Sedimentation of Nectar, Samples Heated to 160°F Homogenized at 2000 psig, Stored in Light and Dark at Room Temperature and in Cold Storage.

	0 (3 hrs)	Time (days)					
		14	28	56	84	112	*
			mls				
70°F light	0.0	2.5	3.1	3.25	3.25	3.25	a
70° dark	0.0	2.1	1.95	2.05	2.05	2.05	b
36°-38°F	0.0	2.16	2.65	2.7	2.7	2.7	ab

*Like letters indicate no significant differences between storages

Color Measurements on 1970 Stanley Plum Nectar and Juice

In the nectar samples no linear relationship was observed between storage time and color changes. In the juice samples correlations were found in all treatments (Figure 5).

Nectar

Absorbance readings decreased slightly during the first 108 days of storage and then increased. Visual observations indicated that the increase was associated with the development of a brown coloration that tended to mask the anthocyanin pigment (Table 19). This is in agreement with results reported by Beavens and Beattie (1949). Slightly less brown coloration occurred in the samples stored at 70°F in the dark than those stored in the light at 70°F or in cold storage at 36-38°F.

Juice

The absorbance readings obtained on the juice showed the same trend as that of the nectar. However, juice stored at 36-38°F showed slightly less brown coloration than the other stored samples during the storage period (Table 20 and Figure 5).

Color Measurements on 1971 Stanley and Bluefree Plum Nectar

Anthocyanin content was not significantly affected by either the homogenization or pasteurization

1 = rm. temp. dark $r = .651^{*}$
$y = .0002x+.163$

2 = rm. temp. light $r = .726^{*}$
$y = .0003x+.155$

3 = cold storage $r = .473^{*}$
$y = .0001x+.175$

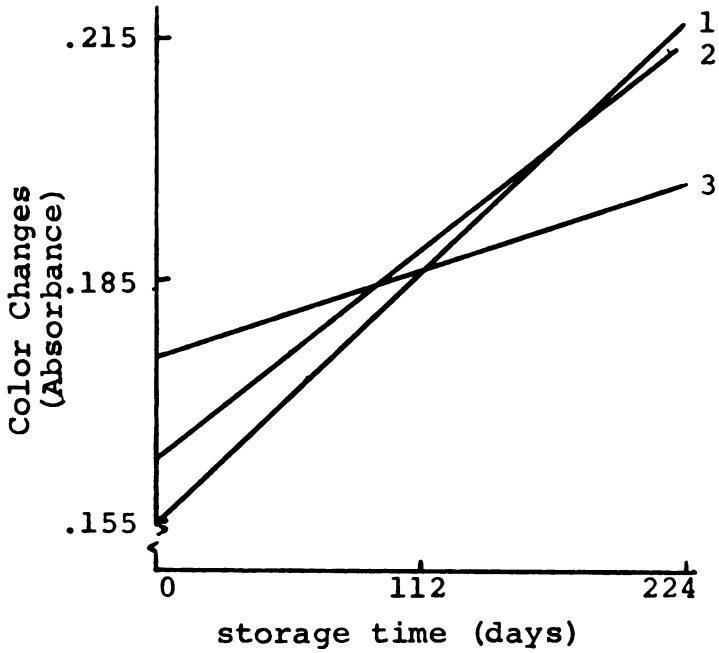


Figure 5. Juice. Color Changes in 1970 Harvested Stanley Plums, Stored in Cold Storage and at Room Temperature in Light and Dark vs. Time.

*Significant at 5% level

TABLE 19. Absorbance Values at 512nm of Stanley Plum Nectar Stored Under Three Different Storage Conditions.

	Time (days)									
	0	14	28	56	84	108	132	158	182	203
70°F light	.172	.149	.133	.176	.135	.129	.143	.161	.176	.185
70°F dark	.172	.149	.139	.180	.135	.131	.139	.155	.165	.174
36°-38°F	.172	.157	.151	.180	.168	.163	.163	.170	.178	.185

TABLE 20. Absorbance Values at 512nm of Stanley Plum Juice Stored Under Three Different Storage Conditions.

	Time (days)									
	0	14	28	56	84	112	140	168	196	224
70°F light	.185	.151	.201	.145	.147	.153	.163	.176	.196	.210
70°F dark	.195	.200	.185	.155	.208	.153	.155	.157	.167	.181
36°-38°F	.192	.203	.220	.220	.185	.157	.220	.174	.170	.167

procedures. Loss of color occurred during storage. The loss was not significant for Stanley nectar after 140 days of storage but was significant for the Bluefree nectar with maximum loss occurring after 84 days of storage (Tables 21-22).

TABLE 21. Differential Absorbance Values of Pasteurized and Homogenized Stanley Plum Nectar.

	Time (days)					
	0	28	56	84	112	140
Low T long hold	.353	.342	.341	.330	.322	.314
High T + short hold	.362	.346	.320	.316	.302	.297

Solid lines indicate no significant changes in absorbance

TABLE 22. Differential Absorbance Values of Pasteurized and Homogenized Bluefree Plum Nectar.

	Time (days)					
	0	28	56	84	112	140
Low T long hold	.182	.161	.151	.147	.105	.092
High T + short hold	.187	.166	.147	.131	.092	.074

Solid lines indicate no significant changes in absorbance

Color Measurements on 1971 Stanley and Bluefree Plum Juice

Color extraction from the plums processed at 170°F was much less than that obtained from the plums processed at 180°F (Table 23). During the 140-day storage period the anthocyanin color loss in the 170°F

TABLE 23. Effect of Time on Color Retention in 1971 Plum Juice; Absorbance Readings of Stanley and Bluefree Varieties.

Harvest Date	Variety	°F Processing Temp.	Storage	Time (days)					
				0	28	56	84	112	140
8/23/71	Stanley	170°	RM	.035	.026	.031	.025	.008	.000
8/23/71	Stanley	170°	CS	.036	.027	.027	.019	.003	.000
8/30/71	Stanley	170°	RM	.121	.058	.041	.020	.012	.011
8/30/71	Stanley	170°	CS	.118	.115	.067	.017	.011	.011
9/06/71	Stanley	170°	RM	.048	.027	.017	.013	.003	.000
9/06/71	Stanley	170°	CS	.047	.034	.019	.006	.003	.000
9/21/71	Stanley	170°	RM	.128	.083	.046	.038	.025	.015
9/21/71	Stanley	170°	CS	.136	.112	.102	.083	.078	.074
9/15/71	Bluefree	170°	RM	.036	.016	.013	.004	.000	.000
9/15/71	Bluefree	170°	CS	.037	.034	.019	.003	.000	.000
9/21/71	Bluefree	170°	RM	.056	.037	.027	.024	.023	.014
9/21/71	Bluefree	170°	CS	.051	.046	.040	.018	.011	.000
8/23/71	Stanley	180°	RM	.674	.486	.297	.257	.253	.246
8/23/71	Stanley	180°	CS	.676	.624	.631	.546	.530	.509
8/30/71	Stanley	180°	RM	.564	.396	.245	.212	.211	.209
8/30/71	Stanley	180°	CS	.567	.564	.551	.397	.394	.351
9/06/71	Stanley	180°	RM	.829	.666	.434	.296	.263	.245
9/06/71	Stanley	180°	CS	.830	.797	.767	.708	.683	.643
9/21/71	Stanley	180°	RM	.729	.540	.397	.329	.279	.218
9/21/71	Stanley	180°	CS	.740	.641	.584	.515	.493	.497
9/15/71	Bluefree	180°	RM	.762	.605	.527	.434	.410	.372
9/15/71	Bluefree	180°	CS	.778	.722	.734	.719	.692	.651
9/21/71	Bluefree	180°	RM	.903	.720	.556	.428	.303	.285
9/21/71	Bluefree	180°	CS	.904	.901	.860	.842	.819	.760

RM = room temperature - 70°F; CS = cold storage - 36-38°F

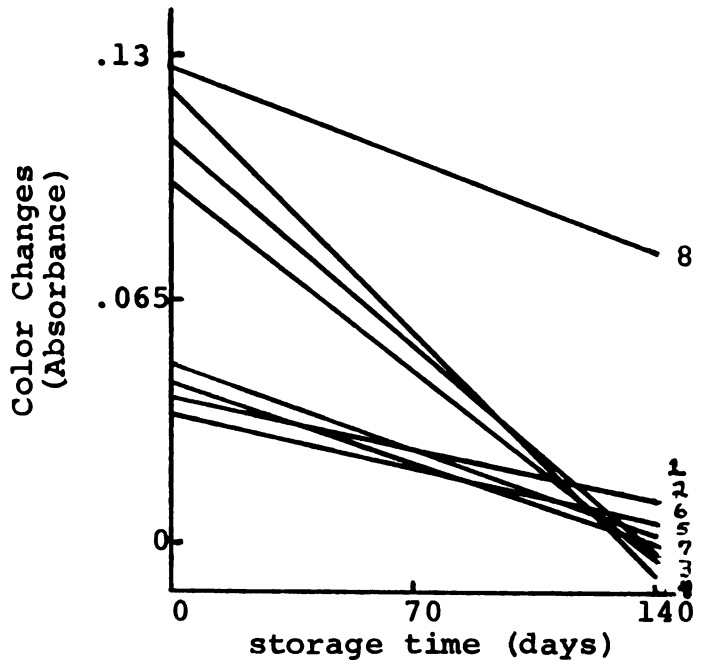
processed juice was from 50 to 100% whereas in the 180°F processed juice the loss ranged from 20 to 70% (Table 23, Figures 6-9). This is in agreement with the results of Kilbuck (1948) and Ponting (1960) who indicated the critical temperature for enzyme inactivation to be 180°F.

Color losses occurred at a more rapid rate and were greater in the samples stored at 70°F than in those stored at 36-38°F.

In all of the samples there was a linear relationship between storage time and the amount of color loss.

Effect of Temperature and Time On Color Extraction of 1971 Bluefree Plum Nectar

The results of the extraction procedure are given in Table 24. A high degree of correlation was obtained between the amount of color extracted and the temperature of processing, r = .965 (Figure 10). At temperatures below 180°F increased holding time resulted in better color extraction whereas above 180°F the results were variable, indicating that holding for more than 1 minute may not be necessary. Temperatures above 180°F tended to concentrate the pigment and produced higher absorbance readings.



1 = 8/23rm r =-.850*
y = -.0002x+.038

2 = 8/23cs r =-.961*
y = -.0003x+.037

3 = 8/30rm r =-.897*
y = -.0007x+.094

4 = 8/30cs r =-.938*
y = -.0009x+.121

5 = 9/6 rm r =-.944*
y = -.0003x+.041

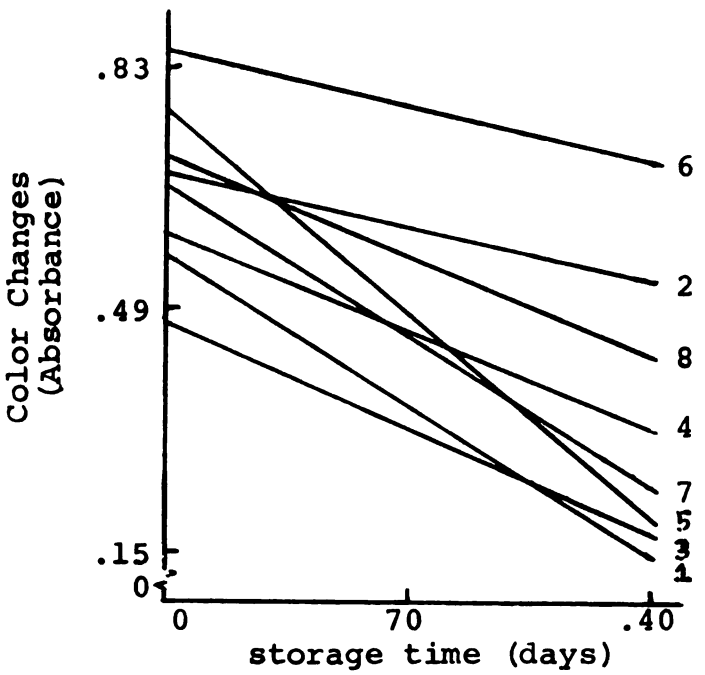
6 = 9/6cs r =-.955*
y = -.0003x+.043

7 = 9/21rm r =-.938*
y = -.0008x+.110

8 = 9/21cs r =-.961*
y = -.0004x+.128

rm - 70°F storage
cs - 26-38°F storage

Figure 6. Juice. Effect of Storage and Time on the Anthocyanin Content in Stanley Plum Juice Processed at 170°F.



1 = 8/23rm r =-.879*
y = -.003x+.574

2 = 8/23cs r =-.962*
y = -.001x+.672

3 = 8/30rm r =-.869*
y = -.002x+.475

4 = 8/30cs r =-.931*
y = -.002x+.596

5 = 9/6rm r =-.945*
y = -.004x+.76

6 = 9/6cs r =-.990*
y = -.001x+.833

7 = 9/21rm r =-.961*
y = -.003x+.659

8 = 9/21cs r =-.945*
y = -.002x+.703

rm - 70°F storage
cs - 36-38°F storage

Figure 7. Juice. Effect of Storage and Time on the Anthocyanin Content in Stanley Plum Juice Processed at 180°F.

*Significant at 5% level

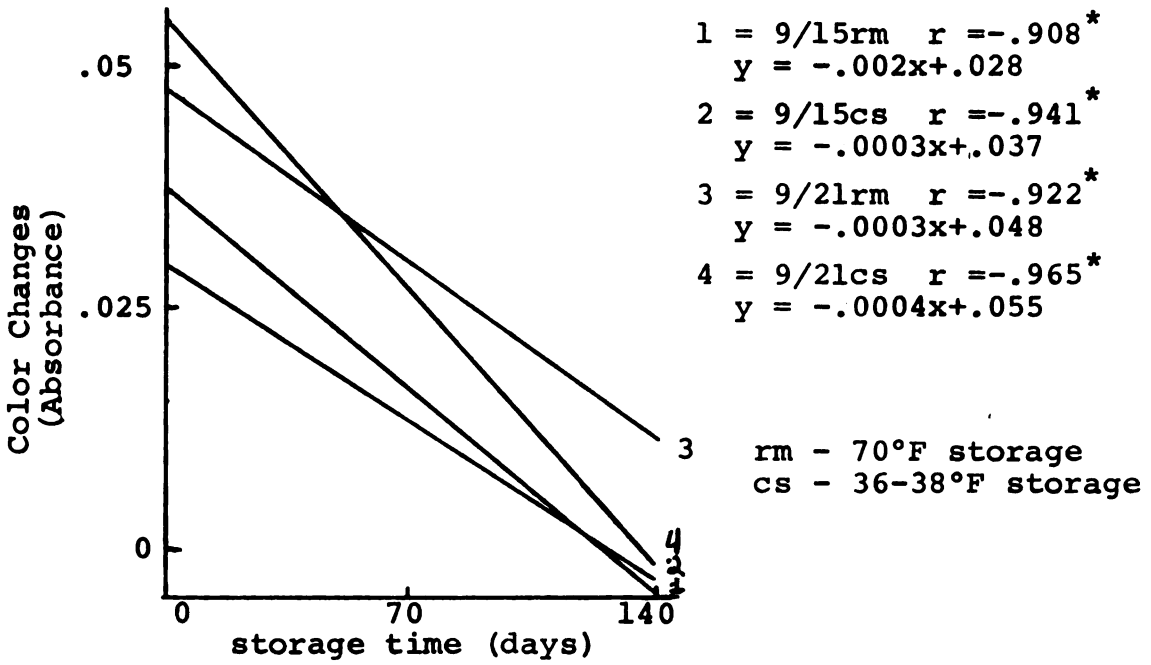


Figure 8. Juice. Effect of Storage and Time on the Anthocyanin Content in Bluefree Plum Juice Processed at 170°F.

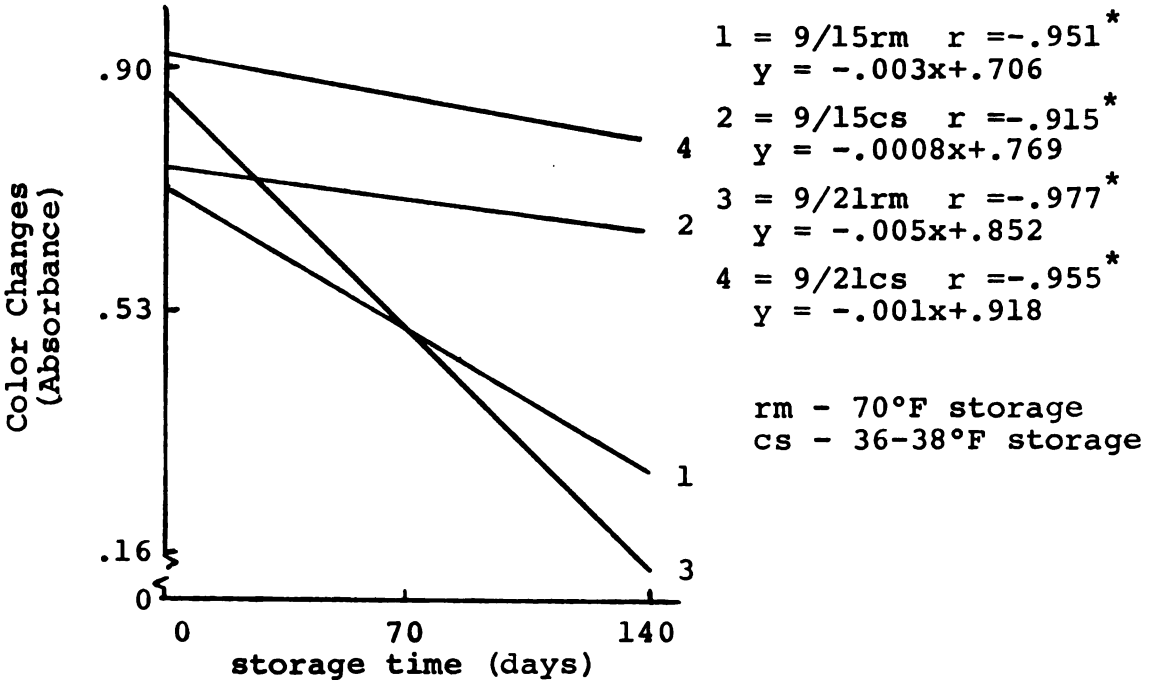


Figure 9. Juice. Effect of Storage and Time on the Anthocyanin Content in Bluefree Plum Juice Processed at 180°F.

*Significant at 5% level

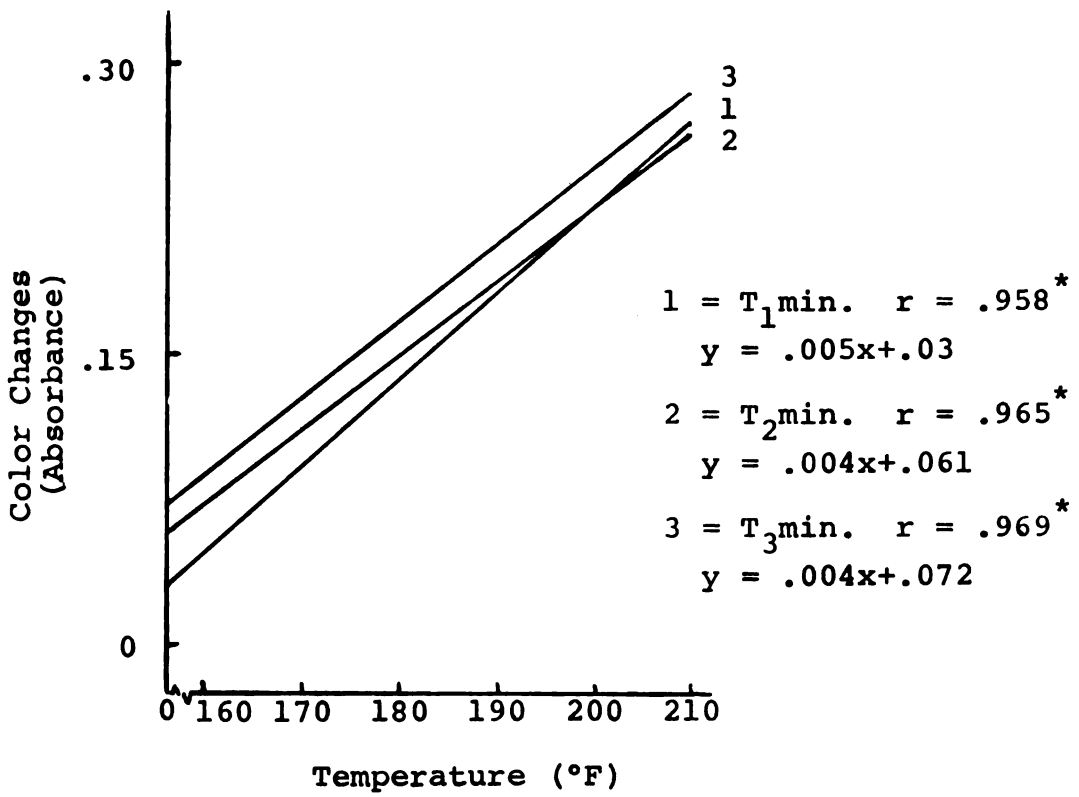


Figure 10. Nectar. Effects of the Holding Period Before Pulping Upon Color Extraction at Various Temperatures.

*Significant at 5% level

TABLE 24. Processing Temperature Effects on Color Extraction Bluefree Plum Nectar.

Holding Period (minutes)	Temperature (°F) of Processing					
	160°F	170°F	180°F	190°F	200°F	210°F
	Absorbance Readings					
1	.023	.066	.164	.173	.183	.283
2	.046	.132	.137	.177	.218	.269
3	.068	.134	.138	.186	.268	.273

Effect of Chemical Additives on Color Stabilization in Stanley Plum Nectar and Juice

Nectar

The results are given in Table 25. Ascorbic acid was the least effective additive in preventing color destruction and the amount of destruction increased with increasing concentrations (.1-1.0%) (Figure 12). SO_2 prevented color destruction the best and complete retention was obtained at levels of 25 to 100 ppm (Figure 11). Color destruction in the presence of (Na_{16} P_{14} O_{43}) was similar to that obtained in the control sample (Figure 13).

The color changes were significantly related to storage time except in the nectar samples containing 25 ppm concentrations of SO_2.

TABLE 25. Chemical Additives; Effects of Storage Time on Color Retention in 1971 Stanley Plum Nectar and Juice.

Additive	Concentration	Time Days				
		0	2	12	25	50
		Absorbance Readings				
		Nectar				
	control	.296	.278	.255	.218	.222
SO_2	10 ppm	.296	.285	.267	.260	.248
	25 ppm	.296	.285	.270	.285	.291
	50 ppm	.296	.275	.281	.291	.327
	100 ppm	.296	.269	.287	.286	.312
Ascorbic acid	.1%	.296	.289	.248	.246	.126
	.2%	.296	.277	.232	.207	.065
	.5%	.296	.285	.195	.156	.045
	1.0%	.296	.293	.178	.163	.043
Sodium Hexameta Phosphate	.1%	.296	.298	.273	.271	.212
	.2%	.296	.303	.306	.288	.257
	.5%	.296	.295	.281	.261	.213
	1.0%	.296	.312	.303	.267	.195
		Juice				
	control	.778	.691	.594	.492	.410
SO_2	10 ppm	.777	.769	.661	.545	.500
	25 ppm	.774	.767	.676	.541	.478
	50 ppm	.778	.743	.658	.649	.511
	100 ppm	.774	.648	.612	.527	.513
Ascorbic acid	.1%	.778	.717	.598	.372	.273
	.2%	.774	.554	.492	.365	.215
	.5%	.778	.485	.403	.208	.191
	1.0%	.773	.440	.270	.125	.082
Sodium Hexameta Phosphate	.1%	.778	.769	.662	.558	.497
	.2%	.778	.750	.684	.548	.481
	.5%	.778	.739	.665	.614	.522
	1.0%	.778	.645	.581	.500	.511
P.V.P.	.1%	.776	.726	.620	.404	.312
	.2%	.771	.563	.505	.388	.262
	.5%	.774	.593	.410	.246	.212
	1.0%	.778	.417	.269	.169	.111

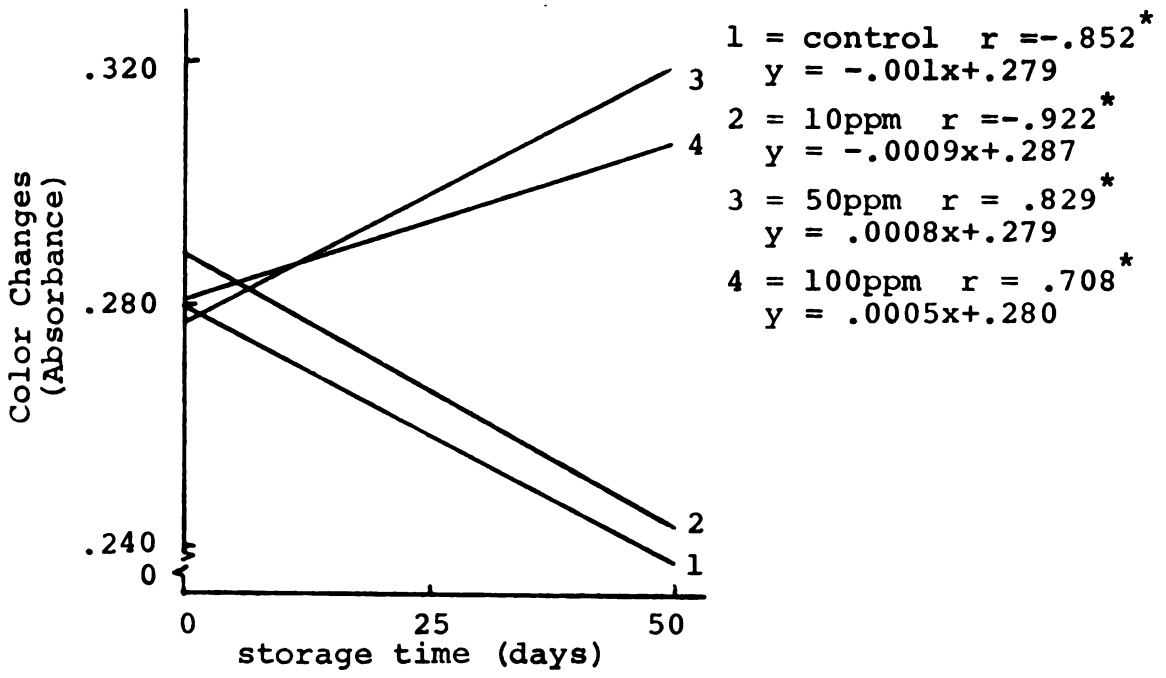


Figure 11. Effects of Varying Concentrations of SO_2 on the Anthocyanin Content in Nectar.

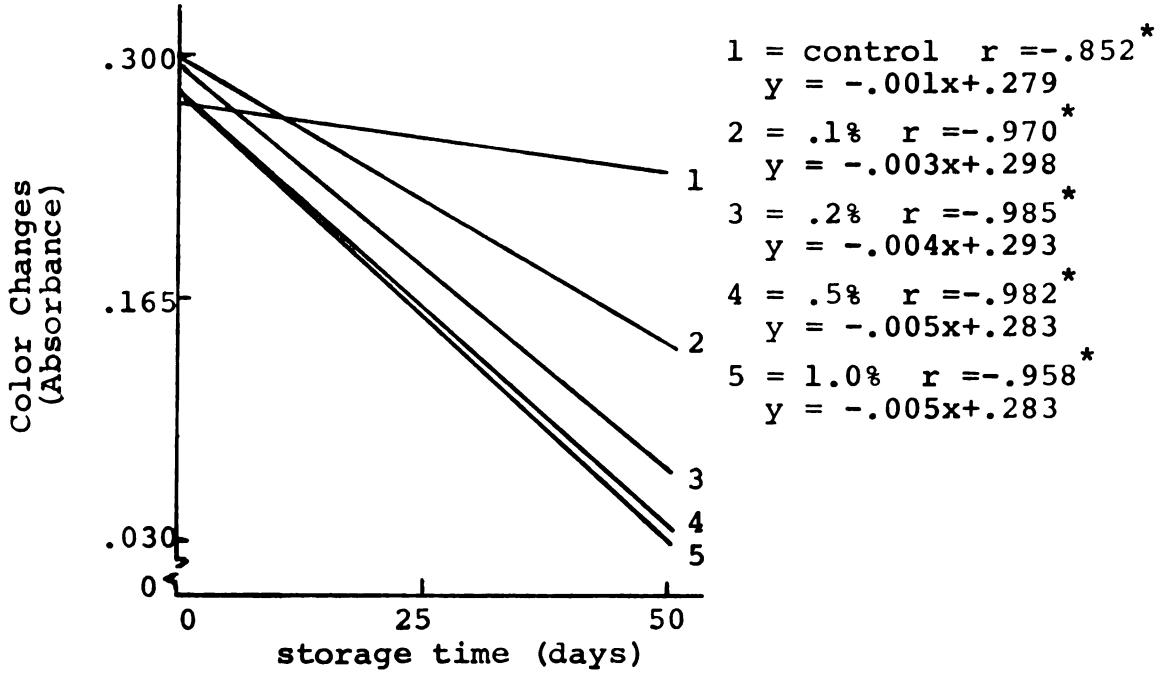


Figure 12. Effects of Varying Concentrations of Ascorbic Acid on the Anthocyanin Content in Nectar.

*Significant at 5% level

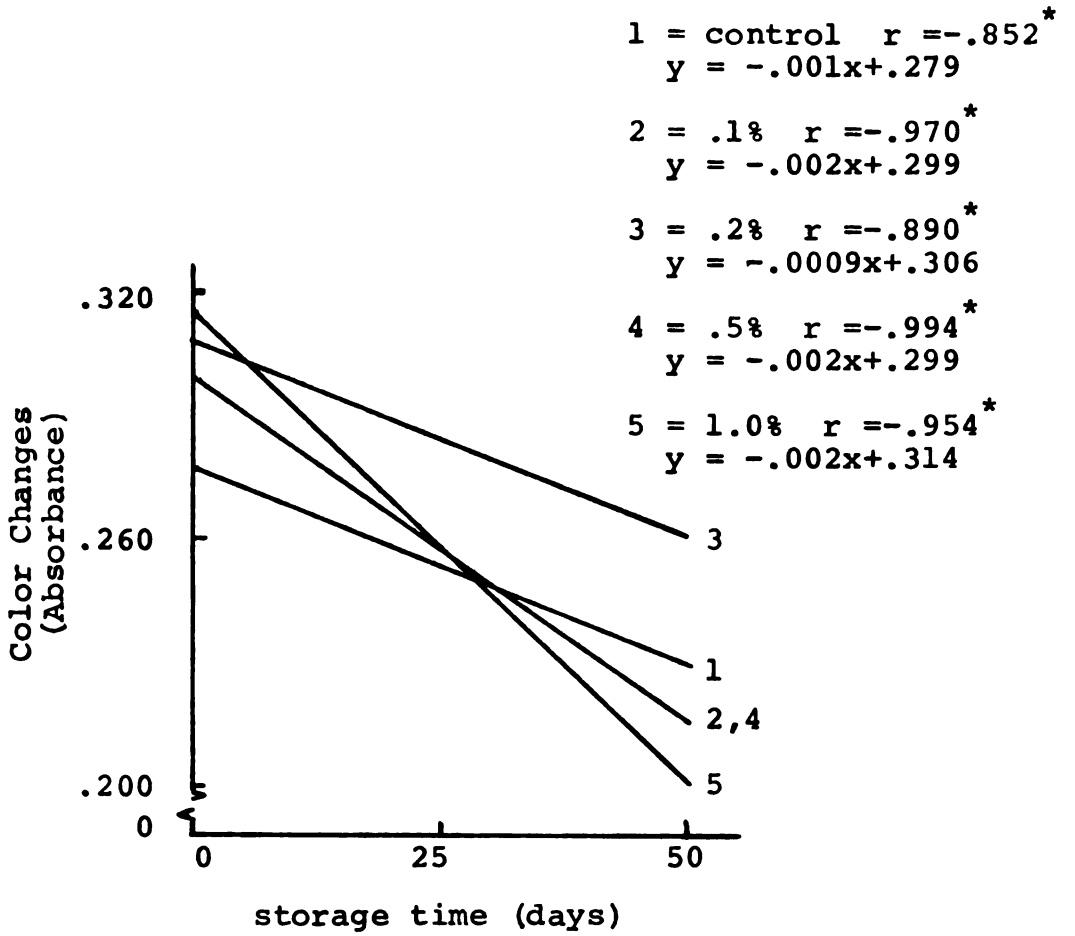


Figure 13. Effects of Varying Concentrations of $Na_{16}P_{14}O_{43}$ on the Anthocyanin Content in Nectar.

*Significant at 5% level

Juice

None of the chemical additives completely prevented color destruction. As in the nectar, ascorbic acid was the least effective additive in preventing color loss and the amount of loss increased with increasing concentrations (Table 25, Figure 15). Both SO_2 and (Na_{16} P_{14} O_{43}) were effective in reducing color loss (Figures 14 and 16). There were no marked differences in the effect of the various concentrations.

P.V.P. was more effective in preventing color destruction than ascorbic acid. However, as with ascorbic acid, increasing concentrations increased the amount of color loss (Figure 17).

In the juice samples containing high concentrations of (Na_{16} P_{14} O_{43}) no linear relationship was observed between color change and storage time.

Sensory Evaluation of Stanley Nectar and Juice

Sugar-Acid Levels

Nectar.--Acid levels used were 0.35, 0.45, 0.55 and 0.65% and the sugar levels were 15, 17, 19 and 21%. Chi square values were calculated using the rank sums procedure (Kramer, 1960). The results showed a 1% preference for 0.35% acidity at the 17% sugar level.

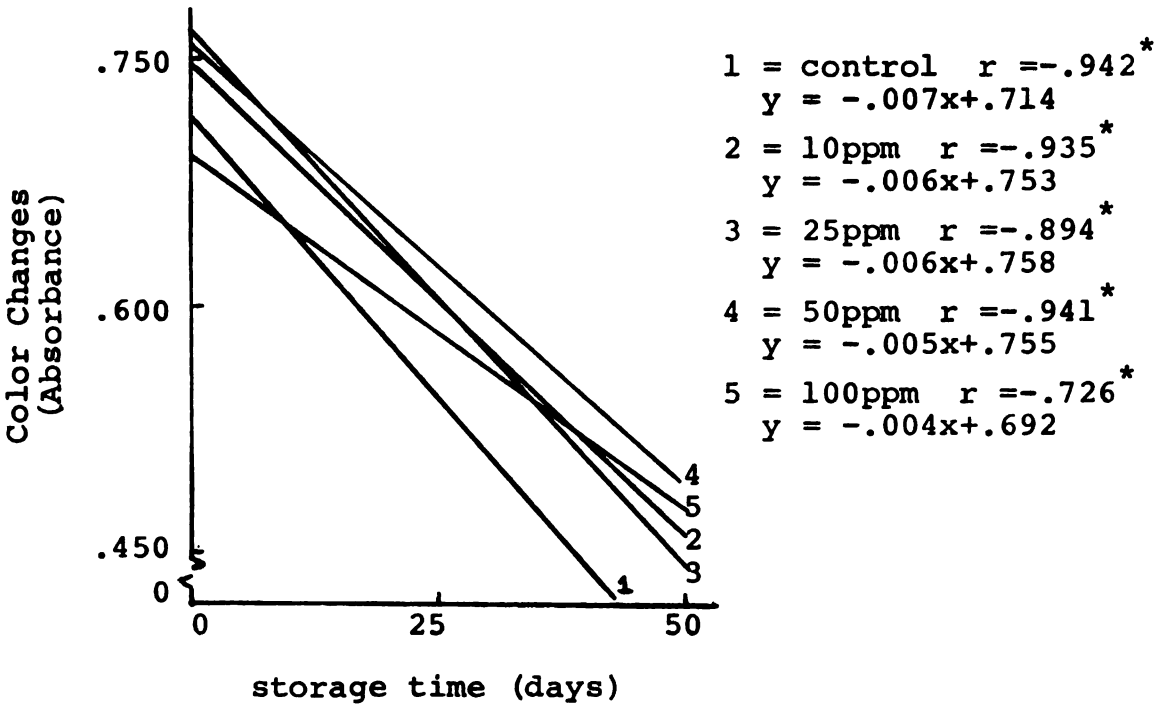


Figure 14. Effects of Varying Concentration of SO_2 on the Anthocyanin Content in Juice.

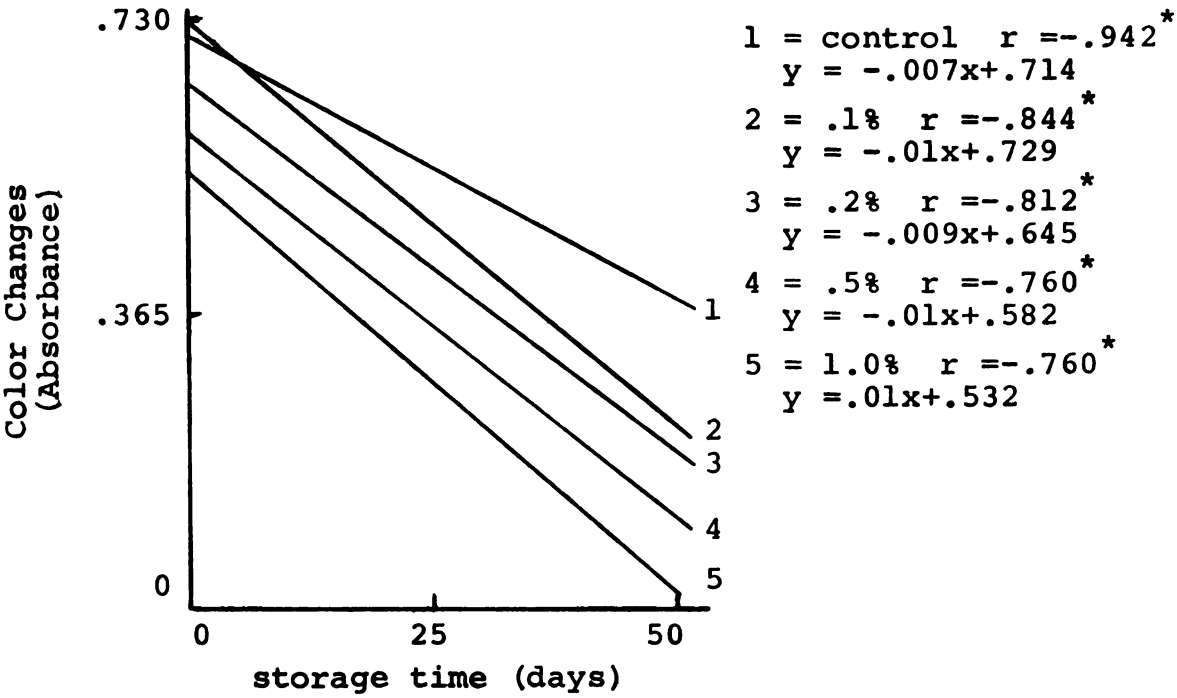


Figure 15. Effects of Varying Concentration of Ascorbic Acid on the Anthocyanin Content in Juice.

*Significant at 5% level

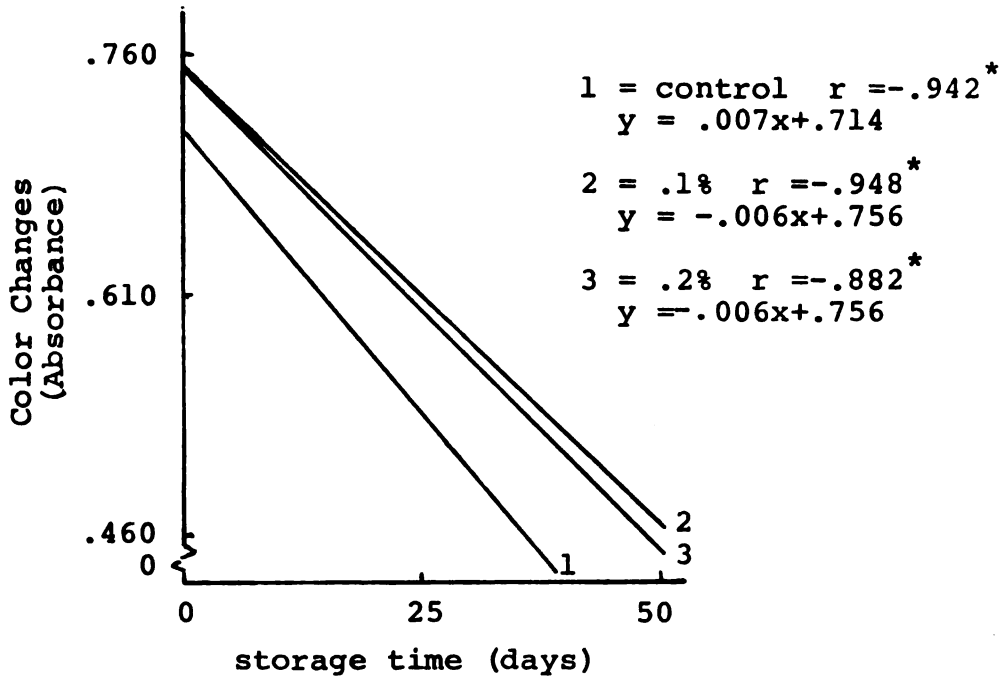


Figure 16. Effects of Varying Concentrations of $Na_{16}P_{14}O_{43}$ on the Anthocyanin Content in Juice.

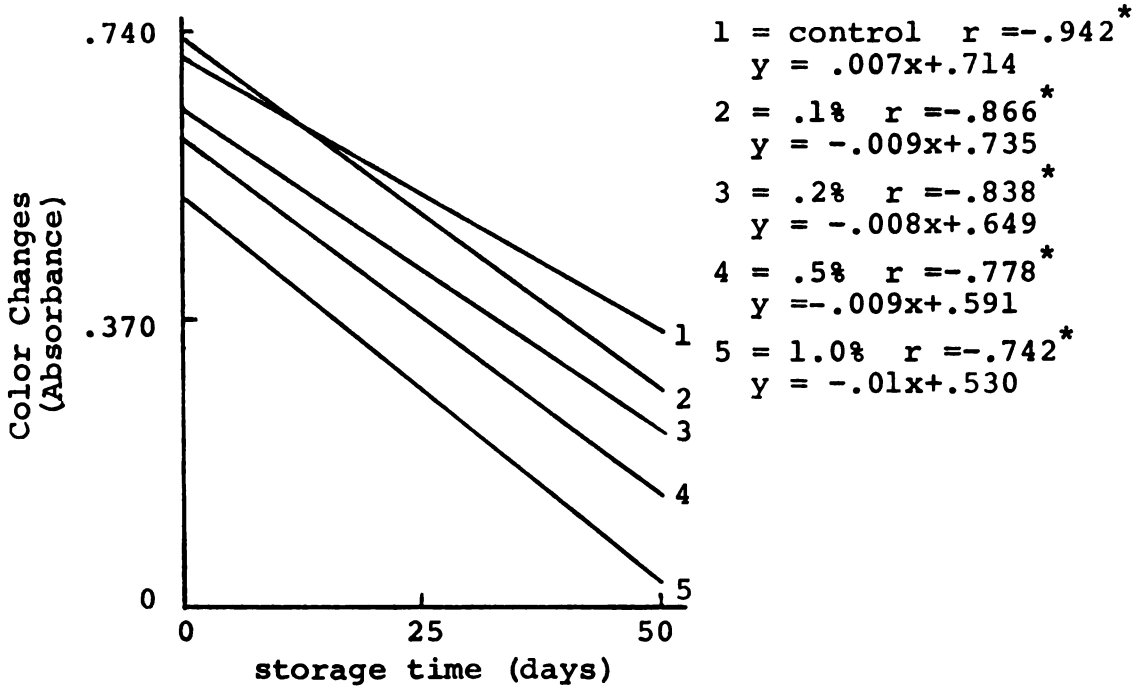


Figure 17. Effects of Varying Concentrations of P.V.P. on the Anthocyanin Content in Juice.

*Significant at 5% level

0.65% acidity was least preferred and there was no significant difference between the 0.45 and 0.55% acid levels (Table 26).

Significant differences were obtained between all sugar levels, at 0.35% acid, with 21% being most preferred (Table 27).

Juice.--Sugar and acid levels were the same as those used for the nectar. Chi square values were calculated using the rank sums procedure. With the sugar constant at 17%, the 0.45% acid level was preferred over the other samples at 1% significance. 0.35 and 0.65% were the least preferred acid levels. A 1% preference was noted for the 0.55% level over the 0.35 and 0.65% acid samples (Table 28).

Table 29 shows that with acid constant at 0.45% similar results as in the nectar evaluation were shown in the juice. The 21% sugar level was the most preferred sample. No difference was found between the 17% and 19% sugar levels and the least preferred sample contained 15% sugar.

TABLE 26. Sensory Preference for Acid Levels in Plum Nectar (Sugar level = 17±.5%, 80 panelists).

Acid %	Rank Sums				5%	1%
	1st	2nd	3rd	4th		
0.35	37	11	16	16	a *	a
0.45	14	30	22	14	b	b
0.55	19	18	29	24	b	b
0.65	10	21	13	36	c	c

*Like letters indicate no significant differences between treatments

TABLE 27. Sensory Preference for Sugar Levels in Plum Nectar (Acid level = 0.35%, 60 panelists).

Sugar %	Rank Sums				5%	1%
	1st	2nd	3rd	4th		
15	10	6	7	37	a *	a
17	13	16	26	5	b	b
19	13	28	12	7	c	c
21	24	10	15	11	d	d

*Like letters indicate no significant differences between treatments

TABLE 28. Sensory Preference for Acid Levels in Plum Juice (Sugar level = 17±.5%, 80 panelists).

Acid %	Rank Sums				5%	1%
	1st	2nd	3rd	4th		
0.35	13	18	17	32	a*	a
0.45	30	21	18	11	b	b
0.55	16	24	33	7	c	c
0.65	21	18	11	30	a	a

*Like letters indicate no significant differences between treatments

TABLE 29. Sensory Preference for Sugar Levels in Plum Juice (Acid level = 0.45%, 80 panelists).

Sugar %	Rank Sums				5%	1%
	1st	2nd	3rd	4th		
15	2	7	8	63	a*	a
17	23	25	30	2	b	b
19	25	26	26	3	b	b
21	30	22	16	12	c	c

*Like letters indicate no significant differences between treatments

Sensory Evaluations of Stanley Plum Nectar and Juice at Various Dilutions

Dilutions

Nectar.--Plum nectar was diluted with sugar solutions at 1:1, 1:1.5 and 1:2 ratios. Sugar and acid were kept constant at 18.5% and 0.35% respectively.

Nectar diluted 1:2 was ranked significantly higher than the other dilutions at the 5% level. At 1% preference the 1:1 dilution was the least preferred sample and no difference was found between the 1:1.5 and 1.2 dilutions (Table 30).

Juice.--Juice was diluted as in the nectar. Sugar and acid levels were kept constant at $20\pm.5$% and 0.45%. Significant differences were obtained between all dilutions with the 1:2 dilution being the most preferred and the 1:1 dilution being the least preferred (Table 31).

Sensory Evaluation of Plum Nectar Processed at Various Temperatures

Plum nectar was made using four different prepulping temperatures. Sugar and acid levels were kept constant at $18\pm.5$% and 0.35%. A 1% preference was shown for the 200°F process temperature. The 160°F processed sample was least preferred and the 180°F treatment was preferred over the 210°F process (Table 32).

TABLE 30. Sensory Preference for Dilutions of Plum Nectar (Sugar level = 18.5%, acid level = 0.35%, 80 panelists).

Dilution	Rank Sums			5%	1%
	1st	2nd	3rd		
1:1	16	29	35	a*	a
1:1.5	25	28	27	a	ab
1:2	39	23	18	b	b

*Like letters indicate no significant differences between treatments

TABLE 31. Sensory Preference for Dilutions of Plum Juice (Sugar level = 20±.5%, acid level = 0.45%, 80 panelists).

Dilution	Rank Sums			5%	1%
	1st	2nd	3rd		
1:1	18	14	48	a*	a
1:1.5	20	42	18	b	b
1:2	42	24	14	c	c

*Like letters indicate no significant differences between treatments

TABLE 32. Sensory Preference for Plum Nectar Processed at Different Temperature (Sugar level = 18±.5%, acid level = 0.35%, 24 panelists).

Treatment	Rank Sums				5%	1%
	1st	2nd	3rd	4th		
160°F 3 min	2	7	2	13	a*	a
180°F 3 min	7	5	11	1	b	b
200°F 3 min	13	6	2	3	c	c
210°F 3 min	2	6	9	7	d	d

*Like letters indicate no significant differences between treatments

Effect of Storage on Nectar and Juice Flavor

Nectar.--Table 33 summarizes the results of the numerical rating scale of four samples of nectar. A reference sample, termed control, was referred to when each sample was tasted. The degree of difference was measured, and a column for acceptance or non-acceptance was checked. Analysis of these differences was completed using the Tukey range one factor procedure (Tukey, 1953).

No significant differences were found at either the 5% or 1% levels between the samples. The two shorter period, stored samples were rejected at the 1% level while the longer stored samples were accepted.

Juice.--No differences were found between the shortest and longest stored samples, 4.5 months and one year. The 9-month storage was found to be significantly

TABLE 33. Effect of Storage Time on Nectar Flavor (Sugar level = 18±.5%, acid = 0.45%).

Sample	Storage Mo. at 36-38°F	Differences Total	Ranges Total	Difference 5%	Difference 1%	Acceptance %	
A	12	62	3	a*	a	92	accept
B	8	62	3	a	a	80	accept
C	4	51	3	a	a	50	reject
D	2	57	4	a	a	40	reject

*Like letters indicate no significant differences between treatments

poorer in flavor than the 1-year stored sample. All three samples possessed acceptable flavor ratings at the 1% level (Table 34).

Effect of Processing Time on Flavor in Nectar

A flavor preference panel was set up using nectar, which was processed at the same temperature but which was held at this temperature before processing for two different time periods. One sample was held for 1 minute while the second was held for 3 minutes before processing. The 3-minute sample was preferred in 27 out of 56 cases indicating no significant differences between the holding periods before processing.

TABLE 34. Effect of Storage Time on Juice Flavor (Sugar level = 18±.5%, acid level = 0.5%).

Sample	Storage Mo. at 36-38°F	Differences Total	Ranges Total	Difference 5%	Difference 1%	Acceptance %	
A	12	69	3	ab*	ab	75	accept
B	9	58	4	a	a	70	accept
C	4.5	77	2	b	b	70	accept

*Like letters indicate no significant differences between treatments

SUMMARY AND CONCLUSION

The Stanley variety plum proved to be superior to the Bluefree plum for canning. The Stanley had higher soluble solids, more color and higher drained weight readings than the Bluefree plums. The shorter harvest period of the Bluefree variety produced little variation in the acid and soluble solids readings and it is felt that these harvests were of a uniform mature plum. All the ripening techniques enhanced the color and soluble solids of the plums. No one ripening procedure proved to be superior to the others, except that an extended ripening occasionally resulted in weight and flavor losses.

High homogenization pressure resulted in a lower amount of pulp sedimentation. At 3000 psig, little or no sedimentation occurred. Increased temperature of homogenization slightly increased the amount of sedimentation.

Light and temperature of storage had little effect on pulp sedimentation.

During storage the anthocyanin content of plum juice and nectar decreased and a formation of a brown

precipitate was observed. The amount of light which the product was exposed to influenced the degree of color change while storage temperature had little effect on the color stability. The type of pasteurization, either high temperature short hold, or low temperature long hold, did not effect either the color extraction or pigment stability of processed nectar.

Pre-pulping processing temperatures of 180°F and above were shown to give optimum color extraction and enzyme inactivation. Temperatures below 180°F produced samples in which browning proceeded at a rapid rate. The longer the holding period at these temperatures, up to 3 minutes, gave higher absorbance readings immediately after processing. No off or burnt flavors were detected in these higher temperature processed nectars, but some nectar concentration was observed during processing.

In plum nectar SO_2 inhibited color changes more effectively than the other additives examined. Twenty-five ppm concentrations of SO_2 prevented any changes during the 50-day study. Higher SO_2 concentrations tended to bleach the red color during the first few days of storage. Ascorbic acid and sodium hexametaphosphate additives did not retard color losses.

In plum juice, SO_2 and sodium hexametaphosphate inhibited color losses the best. The rate of color loss increased with each increase in concentration with

ascorbic acid and P.V.P. The amount of pigment present decreased with time in all treatments.

Taste panel evaluation showed that a lower acid level was preferred, in the nectar, 0.35%, than in the juice samples, 0.45%. In both the juice and nectar samples, levels of 21% soluble solids was the most preferred sugar level. A 1:2 dilution, product to sugar sirup, in both the juice and nectar was significantly preferred for flavor over 1:1 and 1:1.5 samples.

An analysis of samples, stored for different periods of time under ideal conditions, showed no significant losses in flavor due to storage time.

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REFERENCES

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APPENDIX

APPENDIX

Wavelength for anthocyanin measurement was found using various wavelengths for samples from both the Stanley and Bluefree varieties.

TABLE 35. Color Absorbance at Different Wavelengths.

	Sample	Nanometers										
		400	450	475	500	510	512	515	520	525	530	550
Stanley	1	.20	.19	.34	.42	.48	.49	.48	.48	.47	.46	.33
	2	.18	.11	.22	.30	.33	.33	.33	.33	.33	.32	.22
	3	.19	.12	.35	.48	.54	.54	.53	.53	.51	.51	.35
	4	.20	.14	.25	.31	.32	.33	.32	.32	.31	.30	.22
Bluefree	1	.16	.10	.30	.40	.44	.44	.44	.44	.44	.43	.29
	2	.14	.12	.38	.52	.57	.57	.57	.57	.57	.55	.28

TABLE 36. Effect of Time on Buffers, After Oxalic Acid Treatment.

Time (minutes)	0	5	15	30	60	90	120	180	240	300
Absorbance readings	.252	.272	.272	.272	.281	.281	.281	.281	.281	.281

TABLE 37. Effect of Time on Oxalic Acid--Color Development with Oxalic Acid Before Filtering.

Time (minutes)	0	15	30	60	120	180	240	300
Absorbance readings	.174	.180	.183	.227	.228	.242	.233	.247

TABLE 38. Sedimentation, Regression Analysis on 1970 Stanley Plum Nectar vs. Time.

Treatment				M.S.			
Temperature	Pressure	S_e	S_b	Regression	Error	F	p
140°F	0 psig	27.19	.39	10494.22	739.11	14.20	<.003
140°F	500 psig	3.75	.04	19.60	14.10	1.39	<.249
140°F	1000 psig	4.88	.05	118.35	23.77	4.98	<.034
140°F	2000 psig	5.00	.01	1.57	.25	6.23	<.019
140°F	3000 psig	.25	.002	.28	.06	4.65	<.040
160°F	0 psig	27.32	.39	9956.59	746.24	13.34	<.003
160°F	500 psig	2.36	.024	56.89	5.57	10.21	<.004
160°F	1000 psig	2.35	.587	75.54	5.53	13.67	<.001
160°F	2000 psig	.57	.006	3.58	.33	10.91	<.003
160°F	3000 psig	---	---	.00	.00	---	---
180°F	0 psig	27.95	.40	6618.01	781.27	8.47	<.013
180°F	500 psig	5.58	.057	215.4	31.13	6.92	<.014
180°F	1000 psig	2.74	.028	79.09	7.52	10.51	<.003
180°F	2000 psig	2.66	.027	96.29	7.08	13.60	<.001
180°F	3000 psig	.05	.011	3.98	1.10	3.61	<.069

Treatment		d.f.		M.S.		F	p	sed. Correlation Pressure	F	p	sed. Correlation Heat	F	p	sed. Correlation Time	F	p
temp.	PSIG	Regression	Error	Regression	Error											
160-180°F	0-3000 PSIG	3	371	2368.3	499.6	47.4	<.0005	r=-.498	127.1	<.0005	r=.092	4.34	<.036	r=.145	10.6	<.001

TABLE 39. Chemical Additives; Regression Analysis on Plum Juice and Nectar, All Concentrations vs. Time.

Treatment			d.f.		M.S.		F	p	Color Correl. Conc.	F	p	Color Correl. Time	F	p
Nectar or Juice	Additive	Conc.	Regression	Error	Regression	Error								
Nectar	SO_2	10-100ppm	2	37	.000	.000	2.9	<.07	r= .337	4.9	<.034	r= .412	.9	<.361
Nectar	$Na_{16}P_{14}O_{43}$	.1-1%	2	37	.134	.001	188.9	<.0005	r=-.177	13.1	<.001	r=-.938	364.8	<.0005
Nectar	A.A	.1-1%	2	37	.018	.000	72.8	<.0005	r=-.040	.3	<.592	r=-.892	.45.3	<.0005
Juice	SO_2	10-100ppm	2	37	.193	.003	61.8	<.0005	r=-.117	2.2	<.146	r=-.869	121.3	<.0005
Juice	$Na_{16}P_{14}O_{43}$	.1-1%	2	37	.786	.022	36.2	<.0005	r=-.313	10.8	<.002	r=-.751	61.7	<.0005
Juice	A.A.	.1-1%	2	37	.112	.011	10.0	<.0005	r=-.109	.7	<.415	r=-.582	19.3	<.0005
Juice	P.V.P.	.1-1%	2	37	.710	.019	37.9	<.0005	r=-.344	13.4	<.001	r=-.744	62.5	<.0005

TABLE 40. Color Extraction; Regression Analysis on Plum Nectar, Processed at Different Temperatures and Time.

Treatment		S_e	S_b	M.S.		F	p
Temperature	Time			Regression	Error		
160-210°	1 min.	.027	.0005	.079	.001	112.0	<.0005
160-210°	2 min.	.02	.0003	.057	.000	136.5	<.0005
160-210°	3 min.	.02	.0003	.062	.000	155.2	<.0005

TABLE 41. Color Changes; Regression Analysis on Color Changes in 1970 Stanley Plum Nectar and Juice Stored Under Different Conditions.

Treatment		S_e	S_b	M.S.		F	p
Nectar/Juice				Regression	Error		
Nectar	rm. temp.-dk.	.02	.0006	.000	.000	.3	<.582
Nectar	rm. temp.-lt.	.02	.0006	.001	.000	3.2	<.087
Nectar	cold temp.-dk.	.015	.0004	.001	.000	4.1	<.052
Juice	rm. temp.-dk.	.021	.0005	.010	.000	25.0	<.0005
Juice	rm. temp.-lt.	.021	.0005	.017	.000	37.9	<.0005
Juice	cold temp.-dk.	.017	.0005	.003	.000	9.8	<.004

TABLE 42. Color Changes; Regression Analysis on 1971 Stanley and Bluefree Plum Juice vs. Time.

Treatment				S_e	S_b	M.S.		F	p
Variety	Process	Harvest	Storage			Regression	Error		
Stanley	170°F	8/23/71	rm.	.008	.00001	.002	.000	25.99	<.0005
Stanley	170°F	8/23/71	c.s.	.004	.00002	.002	.000	119.79	<.0005
Stanley	170°F	8/30/71	rm.	.019	.0001	.014	.000	41.02	<.0005
Stanley	170°F	8/30/71	c.s.	.018	.0001	.023	.000	72.68	<.0005
Stanley	170°F	9/6/71	rm.	.006	.00004	.003	.000	81.19	<.0005
Stanley	170°F	9/6/71	c.s.	.006	.00003	.003	.000	104.69	<.0005
Stanley	170°F	9/21/71	rm.	.015	.00009	.016	.000	72.81	<.0005
Stanley	170°F	9/21/71	c.s.	.007	.00004	.005	.000	120.75	<.0005
Bluefree	170°F	9/15/71	rm.	.006	.00004	.002	.000	47.17	<.0005
Bluefree	170°F	9/15/71	c.s.	.006	.00003	.003	.000	77.60	<.0005
Bluefree	170°F	9/21/71	rm.	.005	.00004	.002	.000	56.52	<.0005
Bluefree	170°F	9/21/71	c.s.			.003	.000	120.35	<.0005
Stanley	180°F	8/23/71	rm.	.083	.0005	.237	.007	34.13	<.0005
Stanley	180°F	8/23/71	c.s.	.018	.0001	.041	.000	122.89	<.0005
Stanley	180°F	8/30/71	rm.	.072	.0004	.160	.005	30.75	<.0005
Stanley	180°F	8/30/71	c.s.	.037	.0002	.091	.001	64.69	<.0005
Stanley	180°F	9/6/71	rm.	.079	.005	.521	.006	82.99	<.0005
Stanley	180°F	9/6/71	c.s.	.01	.00006	.051	.000	472.68	<.0005
Stanley	180°F	9/21/71	rm.	.053	.0003	.332	.000	119.34	<.0005
Stanley	180°F	9/21/71	c.s.	.032	.0002	.088	.001	84.24	<.0005
Bluefree	180°F	9/15/71	rm.	.046	.0003	.197	.002	94.14	<.0005
Bluefree	180°F	9/15/71	c.s.	.017	.0001	.016	.000	51.63	<.0005
Bluefree	180°F	9/21/71	rm.	.052	.0003	.571	.003	208.84	<.0005
Bluefree	180°F	9/21/71	c.s.	.016	.0001	.028	.000	104.34	<.0005

TABLE 43. Chemical Additives; Regression Analysis on Plum Nectar and Juice vs. Time.

Treatment		Concentration	S_e	S_b	M.S.		F	p
Nectar or Juice	Additive				Regression	Error		
Nectar	-	control	.018	.0003	.007	.000	21.2	<.002
Nectar	SO_2	10 ppm	.007	.0001	.003	.000	45.5	<.0005
Nectar	SO_2	25 ppm	.01	.0002	.000	.000	.1	<.814
Nectar	SO_2	50 ppm	.011	.0002	.002	.000	17.5	<.003
Nectar	SO_2	100 ppm	.011	.0002	.001	.000	8.1	<.022
Nectar	A.A.	.1%	.017	.0003	.035	.000	126.5	<.0005
Nectar	A.A.	.2%	.016	.0003	.065	.000	261.1	<.0005
Nectar	A.A.	.5%	.02	.0003	.082	.000	213.0	<.0005
Nectar	A.A.	1.0%	.03	.0005	.083	.001	89.9	<.0005
Nectar	$Na_{16}\ P_{14}\ O_{43}$	.1%	.008	.0001	.009	.000	129.2	<.0005
Nectar	$Na_{16}\ P_{14}\ O_{43}$	.2%	.009	.0002	.003	.000	30.6	<.001
Nectar	$Na_{16}\ P_{14}\ O_{43}$	.5%	.004	.00007	.009	.000	635.7	<.0005
Nectar	$Na_{16}\ P_{14}\ O_{43}$	1.0%	.014	.0002	.017	.000	80.6	<.0005
Juice		control	.05	.0009	.156	.002	63.3	<.0005
Juice	SO_2	10 ppm	.045	.0008	.111	.002	55.4	<.0005
Juice	SO_2	25 ppm	.064	.001	.132	.004	32.0	<.0005
Juice	SO_2	50 ppm	.036	.0006	.082	.001	61.6	<.0005
Juice	SO_2	100 ppm	.072	.001	.063	.005	12.1	<.008
Juice	A.A.	.1%	.133	.002	.349	.018	19.7	<.002
Juice	A.A.	.2%	.125	.002	.282	.018	15.5	<.004
Juice	A.A.	.5%	.168	.003	.308	.028	10.9	<.011
Juice	A.A.	1.0%	.183	.003	.407	.034	12.1	<.008
Juice	$Na_{16}\ P_{14}\ O_{43}$	.1%	.04	.0007	.114	.002	70.8	<.0005
Juice	$Na_{16}\ P_{14}\ O_{43}$	.2%	.067	.001	.124	.004	27.9	<.001
Juice	$Na_{16}\ P_{14}\ O_{43}$	.5%	.16	.003	.016	.026	.6	<.448
Juice	$Na_{16}\ P_{14}\ O_{43}$	1.0%	.115	.002	.013	.013	1.0	<.356
Juice	P.V.P.	.1%	.111	.002	.3	.012	24.1	<.001
Juice	P.V.P.	.2%	.114	.002	.244	.013	18.8	<.002
Juice	P.V.P.	.5%	.151	.003	.281	.023	12.3	<.008
Juice	P.V.P.	1.0%	.189	.003	.351	.036	9.8	<.014