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Approximately 200 raw prunes were harvested from each of five Italian prune trees near Corvallis every three days for nine consecutive harvest dates. Forty individual fruit from each tree were drawn at random and subjected to a series of fresh fruit quality tests.

For each quality factor which was measured, the experiments were set up as nine by five factorial analysis of variance studies with the numbers of observations in a replication depending upon the factor being studied.

The correlation of each objective and subjective test with canned fruit flavor was then calculated. The regression line, standard error of estimate, and 90 per cent confidence limits were calculated for each test which had a correlation of 0.80 or better with canned fruit flavor.

Several objective tests used on raw prunes such as soluble solids-acid ratio, pressure test, per cent soluble solids, titratable acidity and color of raw prune flesh measured by the Hunter Color-Color Difference Meter in the order named are significantly correlated with the flavor of the canned Italian prune. Analysis of variance and L.S.D. was used to determine that the first two of these tests show good three-day precision as a guide to harvest maturity. The others appear suitable for longer time intervals.

Certain objective tests such as pH values and fresh fruit weight are of little value to predict canned fruit flavor and show poor three-day precision as a guide to harvest maturity.

The subjective grading of raw prunes by outer skin appearance does not seem to be a precise way to predict canned fruit quality. The three-day precision as a guide to harvest maturity is poor.

Respiration of the fresh fruit shows a definite climacteric and the climacteric appeared at approximately the same time the fruit harvested exhibited optimum canned fruit flavor and color.

The remaining lot of fruit after the fresh fruit samples were removed was placed in 32° F. cold storage and held for processing the next day. Fruit from each tree each harvest date were processed in twelve No. 2 fruit enameled cans for use in canned fruit analysis studies.

Several canned prune quality factors such as per cent transmittance of the canned juice, canned fruit skin color as measured by the Hunter Color-Color Difference Meter and titratable acidity of the canned prune pulp can be used to predict or specify the canned fruit flavor.

Other objective tests used on canned prunes such as pH values, cut-out soluble solids and cut-out soluble solids-acid ratio are not highly correlated with canned fruit flavor.

Subjective tests used on canned prunes were color and flavor of the fruit. These factors were judged by a statistically selected panel of judges. The correlation between color and flavor of the canned fruit was the highest of the study ($r = +.9458$). The subjective color measurement seems to be very precise in predicting canned fruit flavor.

Every subjective and objective test carried out on the raw and canned prunes were correlated with canned fruit flavor because this factor was felt to be of singular importance in canned prune quality. Regression equations are given.

RELATION OF FRESH FRUIT QUALITY FACTORS TO THE CANNING QUALITY OF THE ITALIAN PRUNE

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RELATION OF FRESH FRUIT QUALITY FACTORS TO THE CANNING QUALITY OF THE ITALIAN PRUNE

INTRODUCTION

Oregon is the second largest prune-producing state in the United States and yields a little over half of the total crop produced in the Pacific Northwest. The Italian prune (Prunus domesticus L.), the single important variety grown in Oregon, ranked third in farm receipts for all Oregon tree fruit and nut crops in the 1939-1948 decade (65, pp.204-208). Prune acreage, however, is highest for all fruit crops grown in the state. In cash receipts it followed pears and apples, respectively, but now appears to be giving way to an increasing cherry industry.

About 90 per cent of Oregon's prune crop is grown west of the Cascades and 10 per cent east of the Cascades with most of the fruit cultivated in the eastern area being shipped into the fresh fruit market. The Willamette Valley is the largest single producing area, accounting for about 75 per cent of the total crop grown in the state (6, p.19).

During the 1939-48 decade, the yearly farm income from prunes produced in Oregon averaged about 3½ million dollars. About 30 per cent of the fresh Italian prune crop goes into canning, approximately 36 per cent into the drying of prunes, and 25 per cent into the fresh market (65, p.207). As can be seen, the canning of fresh prunes includes almost one-third of the total prune crop and constitutes a large annual income for the Oregon farmer.

Preliminary unpublished data indicate that the total prune acreage declined by one-fourth from 1948-1951, in both western and eastern Oregon (39, p.1). Decrease in acreage can probably be attributed to a simple matter of economics; prunes for the cannery and drier brought, on the average, only $41.40 per ton, while sour cherries brought $141.00 per ton, pears $100.80 per ton, and apples $69.20 per ton. Prunes for the fresh market brought $85.00 per ton (65, pp.156-220). It can be seen that the average income per ton for prunes going into canneries and driers is very much lower than for the three other main fruit crops grown in Oregon.

According to a survey of retail stores in this area and from consultation with canners in the Salem area, Italian prunes are considered to be fair movers from the retail shelf. The number 2½ can usually retails for 19-25 cents while pears, peaches and apricots generally retail for over 30 cents. The value per unit for prunes from processors must, therefore, be less than other fruit commodities. These figures indicate there is a rather urgent need for experimental work, as the first step, to add value or attractiveness to prune products from the state of Oregon. Already a very complete study has been carried out on the drying of prunes in Oregon by Wiegand (68, pp.1-35); however, there has been little work done on the canning quality of the fresh Italian prune.

It is the prupose of this work to make an extensive study of the fresh fruit quality factors which affect the subsequent canning quality of the Italian prune, and also to study those canned quality factors which are most useful in judging the final quality grade of the canned product. This knowledge should enable the cannery field man to more accurately predict from the fresh prunes what the future canning quality of a crop might be, and also greatly aid graders in quickly, efficiently, and objectively determining the final quality grade of their canned product. These problems have never been worked out to the complete satisfaction of the producers and packers of fresh Italian prunes in Oregon.

The canned purple prune-plum which has been marketed nationally is in reality a "fresh" canned Italian prune which has been packed in syrup. The word "fresh" is used here to distinguish these from the canned prunes made from rehydrated dried prunes canned in syrup. This purple prune-plum is not the same as the ordinary plum or the French prune which is grown extensively in California. The Italian prune is generally considered to be more acid.

The quality tests which have been applied herein to the raw prunes are as follows: color of flesh (measured by the Hunter Color-Color Difference Meter), pH, titratable acidity (expressed as malic acid), pressure test, per cent soluble solids, per cent soluble solids-acid ratio, weight, visual grading, and respiration of the fruit during the maturation period.

The quality tests which have been conducted on the canned samples are as follows: color of the outer skin (measured by the Hunter Color-Color Difference Meter), pH, per cent cut-out soluble solids, titratable acidity (expressed as malic acid), color of the juice (measured by the Lumetron Colorimeter), per cent cut-out soluble solids-acid ratio, and both color and flavor judged by a statistically selected panel of judges.

REVIEW OF LITERATURE

FRESH FRUIT STUDY. For years the producers of tree fruit crops have had to rely on so-called "rule of thumb" methods to determine whether a particular fruit was in suitable condition to harvest for the fresh market or cannery. Hartman (34, pp.1-24) stated that growers producing Italian prunes usually use color, texture of flesh, adhesion of the flesh to the pit, and size of the fruit to determine if an Italian prune orchard is ready for harvest. In conversations with prune growers in the Dallas, Oregon area, it was concluded that color of the flesh of the fruit was the most important factor considered in harvesting prunes for the cannery. If the prune flesh, upon halving the fruit, was a golden yellow color it was considered ready for harvest.

In apple harvesting, according to Smock and Neubert (59, p.161), apples to be sold for the fresh fruit market very shortly after harvest should be allowed to become almost "eating ripe". If they are to go into storage, they should be picked before they become "eating ripe", and if they are to be used for cooking purposes, they must be picked while they still have proper cooking quality.

According to Cravens and Mauch (15, pp.387-406), the harvesting of peaches seems to be a hit or miss operation and there seems to be no reliable method as a guide of picking.

It appears from earlier work of Hartman (34, pp.1-24), Smock and Neubert (59, p.161), Cravens and Mauch (15, pp.387-406) and others that the methods used to determine best harvest periods by farmers and field men of canneries have left much room for improvement to assure better quality and uniformity of fruit products.

Weight and Volume Increases. In an attempt to get away from the so-called subjectivity of these "rule of thumb" methods, some workers have attempted to correlate weight and volume increases with quality and harvest date of the fruit. Hartman (34, pp.1-24) showed in the Oaco prune orchard near Monroe, Oregon an increase in weight of 24.1 per cent and an increase in volume of 22 per cent during the final phases of the maturation period. The greatest increase took place early in the picking. He noticed that a slower increase in weight and volume later in the season was due to the fact that the fruit started to dry on the trees.

The per cent increase in weight of prunes was also checked by Gerhardt, English and Smith (25, pp.247-252) in 1943 and they found the greatest per cent increase of fruit weight was early in the season. A weight increase of 8.3 per cent over the weight found on the first harvest date was registered at the time the fruits showed 10.2 with the pressure tester, 1.22 total acidity, 15.2 per cent soluble solids, and 12.4 solids-acid ratio.

Later work by Gerhardt and English (24, pp.205-209) pointed out that per cent increase in weight throughout the picking season in three different orchards showed no consistent results; in the Freewater, Oregon orchard the second, in Cashmere, Washington the last, and at Stemilt Hill, Washington the second harvest date showed the greatest per cent increase in weight. Fisher (21, pp.183-186) stated that the fruit he studied increased in weight about one per cent per day.

In his work with the fig fruit, Crane (14, pp.93-98) studied the growth of the Mission fig, as measured by diameter, moisture and sugar content, and fresh and dry weights by weekly intervals throughout the summer of 1948. Three periods of growth were noted: 1st period - 5-6 weeks in duration, was accompanied by a rapid rate of increase in diameter and to a lesser extent in moisture content, and in fresh and dry weights; 2nd period - 3-4 weeks. The rate of increase in diameter, moisture, and fresh and dry weights was very much reduced; 3rd period - 3-4 weeks. This period was characterized by an accelerated rate of increase in diameter, fresh and dry weights, moisture and sugar content.

Davis (16, pp.146-152), working with peaches, took samples of 50 fruits at about weekly intervals from a few weeks prior to pit hardening until maturity, then weighed each; the diameters, sutures, and length were determined.

He said that the scatter of the points about the calculated line of best fit showed that 50 fruit is a sufficient number to represent the population from which they are taken. When compared to the weight, the cross diameter has the greatest seasonal change of the three diameters, the suture next, and the length the least. Either the suture or the cross diameter would seem to be suitable for calculating the seasonal relation between them and the weight of the fruit.

An increase of about 10 per cent in total weight for each three days that peaches remained on the tree was determined by Neubert, Veldhuis and Clore (50, pp.231,292-297). It appeared that the gain was not concentrated in any one period of growth but throughout the entire growing cycle. It was an advantage to the grower to leave the fruit on the tree as long as possible.

Haller and Magness (29, pp.1-23) stated that apples will increase in size as long as they stay on the tree, while Hartman and Bullis (35, p.34), working with sweet cherries, found that there would be a loss in tonnage if harvested too early in the maturing season or too late after the fruit have begun to dry on the tree.

Weight and volume increases for the most part have been used to determine the fruit yields for canning. The weight and volume increase data of Gerhardt and English (24, pp. 205-209) and Vincent, Verner and Blodgett (67, pp.1-19) could possibly be used to determine stage of fruit maturity. They did not, however, use these values to predict fresh fruit or canning quality.

Color Changes in Fruit. In his study of the Italian prune, Fisher (21, pp.183-186) checked the parallel of flesh and skin color to various other quality or maturity indices. Hartman (34, pp.1-24) also has described the flesh color of the fruit as changing from yellowish to golden yellow, and skin color from green to blue to deep blue during the final ripening period of the Italian prune.

Gerhardt and English (24, pp.205-209) showed that color of the flesh together with soluble solids-acid ratio are the two most dependable indices of maturity for the Italian prune, which is especially true when comparisons are made between orchards. Prunes with a flesh color of light green to light amber and a soluble solids-acid ratio of less than about 13 failed to attain satisfactory dessert quality. For best results in harvesting Italian prunes, a flesh color varying from medium to darm amber was used. When the flesh color was more intense (light apricot), as in the last pickings from the Freewater and Wenatchee orchards, the fruit was usually too ripe for distant shipment. They also studied the changes in skin color but felt that flesh color of the fresh fruit was a much better criterion of maturity.

Wiegand (68, pp.1-35), in his work on factors for consideration in standardization of Oregon dried prunes, stated the skin should have a deep purple color and the flesh should be dark reddish golden color for the best drying results.

Lott (44, pp.131-143) studied the changes in reflectance of flesh and skin of maturing Transparent and Duchess apples. This study showed an increase in reflectance from Transparent flesh and skin and from Duchess flesh between wave lengths 580 and 700 m.μ. as maturation progressed. In the Duchess skin, a decrease in reflectance between wave lengths 400 and 600 m.μ. and an increase in reflectance between wave lengths 640 and 700 m.μ. was shown as the fruit matured. The differences were great enough between samples to indicate the possibility of establishing maturity standards on the basis of color.

Smock and Neubert (59, p.162) asserted that ground color changes, which refer to the underlying green or yellow color, have been used to determine the maturity of apples. As apples ripen on the tree, the dark green undercolor changes to a slight tint of yellowish green and then to full yellow. The United States Department of Agriculture has prepared a color chart to aid in describing the ground color as to its shade of green or yellow. It was found that a great deal of experience was needed to determine the various shades of ground color which were exhibited by the various apple varieties. The ground color changes are probably best used with the McIntosh. Other color changes studied in apples are the development of red color and seed color changes inside the apples.

Hartman and Bullis (35, p.24) found a definite correlation between color and maturity in the dark varieties of sweet cherries. Light-colored varieties such as Napoleon, Wood and Waterhouse differed considerably from the dark sorts in their color development. The "ground" or "under-color" in these varieties changes from green to pale yellow during the ripening process. During the ripening season the juices of these light varieties show practically no color changes.

A review of the literature shows that color changes in many of the important deciduous fruits can be used as a method to predict the future quality of that fruit product. In the case of prunes, Hartman (34, pp.1-24), Fisher (21, pp.183-186), Gerhardt and English (24, pp.205-209), and Vincent, Verner and Blodgett (67, pp.1-19) have shown that skin color changes and flesh color changes are rather pronounced throughout the final part of the maturation period. Most workers seemed to believe that the changes in flesh color might be the most indicative of the quality of the product. This is borne out by the fact that many growers in Oregon schedule their harvesting by fruit flesh color.

Changes in pH. Gerhardt and English (24, pp.205-209) presented the pH data from three different prune orchards and found in two weeks at Freewater, Oregon the pH changed from 3.19 to 3.44; at Cashmere, Washington in 20 days from pH 3.25 to pH 3.53; and at Stemilt Hill, Washington in two weeks the pH changed from 3.35 to 3.42.

Caldwell (9, pp.1-54) gives a very good review of hydrogen-ion concentration changes in relation to growth and ripening in apples. He also worked with citrus, blackberries, cherries and strawberries. The young fruits immediately after setting have a hydrogen-ion concentration very close to that of the vegetative parts. Then the acidity rises very rapidly to that of the high values of a developing fruit. The change was from less than tenfold in strawberries to more than eightyfold in citrus. It is interesting to see that a large change of hydrogen-ion concentration markedly increases the imbibitional capacity of the photoplasmic colloids and also the pectins. Caldwell (9, pp.1-54) said the acidity of these fruits reaches its peak and levels off and remains constant for a while. Then with decrease in metabolic activity the hydrogen-ion concentration in the tissues decreases, the hydration decreases and continues to picking maturity. He felt that data from this work fitted fairly well many fruits and their growing curves.

In work with the Florida tangerines, Harding and Sunday (32, pp.1-59) have shown the pH gradually increased during the ripening period but made no mention of using pH as a method of checking the maturity of this fruit.

During the fourteen pickings in the growing season of Napoleon cherries grown near Corvallis, Oregon, Hartman and Bullis (35, p.17) found the pH ranged from 3.68 at the early part of the season to 3.96 the last picking of the season. They felt that as a general trend the cherries become less acid as they matured but there was no mention of using this change to judge the best time to harvest.

It can be seen that in most deciduous fruits the pH changes are rather slight and it is difficult to use the pH changes as a guide to changes in maturity. Only with citrus may it be possible to use changes in pH to check the stage of maturity through which the fruit may be passing.

<u>Titratable Acid Test.</u> In prune maturity studies Vincent, Verner and Blodgett (67, pp.1-19) found that the per cent of acid in the juice of prunes parallels rather closely the maturity changes of the fruit. They felt because of the turbidity and dark color of the juice it was difficult to determine the end point. In 1927 they found the acid test was without promise as a practical measure of prune maturity. In their data, however, per cent acid

expressed as malic declined during the picking season from a high of 1.31 on August 31 to a low of .60 October 6. The trend appeared to be steady and fairly uniform. In 1928 their data on per cent acid was very inconclusive, showing very little change in acidity throughout the season.

Tucker and Verner (64, pp.1-20) in a complete review of four years' work on Italian prunes used the data on acidity from the above paper and added to it data obtained during 1929 and 1930. The per cent acidity in 1929 decreased from a high of 1.21 on September 6 to a low of .80 on October 6. In 1930 per cent acidity decreased from 1.37 August 19 to .56 September 25. In both years the changes were rather regular and uniform. There was no mention, however, of the usability of the changes in acidity as a method to check maturity.

Gerhardt and English (24, pp.205-209) found in the three orchards they studied relatively high values for the total acids expressed as per cent malic acid. They determined the end point by electrometric titration. In the Freewater, Oregon orchard the total acidity decreased from 1.36 to .92 in two weeks; at Cashmere, Washington from 1.43 to 1.04 in a 20-day period; and at Stemilt Hill, Washington it declined from 1.36 to 1.16 in two weeks.

In a non-irrigated orchard at Monroe, Oregon, Hartman (34, pp.1-24) found a rather steady decline in per cent malic acid of the raw juice during ten harvest periods. The reduction was from 1.74 to .822. This was a much wider range than found by Gerhardt and English (24, pp.205-209). The change in acidity of prunes in the Love orchard studied by Hartman (34, pp.1-24) were from 1.44 to 1.07 per cent as malic acid. His conclusions were as follows: the acid content in the Italian prune undergoes a gradual and consistent reduction not only while attached to the tree but also while in storage.

Lott (44, pp.131-143), in his study of apples, found a steady decrease in per cent acid as the fruit reached maturity.

In work with sweet cherries, Hartman and Bullis (35, p.17) calculated the total acidity as per cent malic acid. In 1926 the first harvest date showed a .89 per cent, toward the middle of the picking period, .62 per cent and then at the end of the picking period, .71 per cent. In 1927 the first harvest date showed .75 per cent, toward the middle .62 per cent and the last harvest date .72 per cent. This appears to be rather a unique situation in sweet cherries.

From the literature covered concerning the per cent acidity changes in the Italian prunes it appears that in most cases there is a gradual and steady decrease in acidity as the fruit continues to mature.

Per Cent Soluble Solids Test. In work with the sugar content of the Italian prunes, Tucker (63, pp.578-582) found the sugar content to be more variable than firmness. The fruits which softened early in some orchards were high in sugar while those in other orchards were low in sugars. He found that fruit from orchards which were high in sugar tended to stay high while fruit from orchards low in sugar tended to stay low. The correlation of $+.16 \pm .06$ between firmness and sugar content showed contrary to expectations, that the soft prunes did not contain a higher percentage of sugar than did the firm prunes. Forty prunes tested showed a correlation of $+.844 \pm .022$ between flavor and sugar content. The data listed by Tucker (63, pp.578-582) showed that sugar content varies from year to year as well as between orchards at any one stage of firmness. It was concluded from his work on sugar content, that in some seasons and in some orchards, fruits never reach at any maturity the high quality and high sugar content that it does in other orchards.

In his study of prunes Fisher (21, pp.183-186) found by parallel chemical analyses that about 95 per cent of the soluble solids indicated by the refractometer are sugars. Using a Zeiss refractometer he found a steady rise in per cent soluble solids during a three-week period, from 14.3 on August 23 to 19.4 September 13. In the years 1936-37 and 1938 he found very different firmness readings for fruit having about the same refractive index. He felt that since the pressure test of prunes of a given sugar content may vary so widely from year to year, and in view of the fact that sugar content has been found very often correlated with quality, the refractive index is the more satisfactory index of harvest maturity. In his work it appeared that a soluble solids reading of 17 per cent constituted a dividing line between reasonably good and poor quality prunes. Fruits that tested over 19 per cent sugar usually did not hold up long in storage.

Hartman (34, pp.1-24) in his work on prunes found in the Oaco orchard an increase in sugars and other soluble solids from 12.6 to 18.9 per cent. He felt, however, that the sugar test was not reliable because most significant increases occurred late in the season. Error in this method also made it difficult to determine differences.

In unpublished data Hansen (31, p.1) found per cent soluble solids in a three-week period increased from 14.1 to 20.0 and then decreased slightly in the last harvest date to 19.0.

Gerhardt, English and Smith (25, pp.247-252) got best quality results in picking fruits with a per cent soluble solids reading between 14 and 16. They used a portion of the ground pulp of 25 fruit in a Zeiss pocket-model refractometer. This percentage of soluble solids seemed to be lower than those recommended by Fisher (21, pp.183-186).

In a later paper Gerhardt and English (24, p.205-209) stated per cent soluble solids can be of value in evaluating changes in maturity of the fruit from a single orchard but cannot be a dependable index of maturity when made between different orchards.

Vincent, Verner and Blodgett (67, pp.1-19) found the hydrometer reading or "sugar test" of the fruit juice subject to variation from so many sources as to be unreliable for maturity determinations. There was generally a significant increase in the hydrometer readings as the fruit matured but the increase was not uniform and was occasionally broken by a sudden and often considerable decrease at a time when there was no apparent reason for the change. In a later work Tucker and Verner (64, pp.1-20) bore out the fact that there was great seasonal variation in sugar content of prunes from various orchards. One year a fruit of "fair" flavor may have a relatively high sugar reading and in another year a fruit having a "fair" flavor would have a low per cent sugar. In 1927 "fair" flavored fruits had a per cent sugar content of 16.4. It was difficult to make any definite conclusions from their work as to the value of per cent sugar. They recommended, however, to start harvest at 16 per cent sugar and 12 pounds firmness.

<u>Soluble Solids-Acid Ratio Test.</u> In unpublished data Hansen (31, p.1) at Oregon State College found a range in

soluble solids-acid ratio of Italian prunes from 13.7 early in the season to 23.4 the last harvest date. He harvested only during a period of three weeks.

Gerhardt, English and Smith (25, pp.247-252) stated the ratio of soluble solids to acids appeared to offer the most practical guide to prune maturity. Fruits picked with soluble solids-acid ratio of 14.5 were best for fresh fruit shipment. In their harvesting of three weeks the soluble solids-acid ratio ranged from 10.5 for the first harvest date to 17.2 at the last harvest date. In Gerhardt, English and Smith's (25, pp.247-252) reference to the unpublished work of Chastain and Nydrin they stated that the latter authors got best results when the fruit destined for the fresh fruit market were harvested with a soluble solids-acid ratio from 12 to 15.

Gerhardt and English (24, pp.205-209) in a later paper found that fruit with a soluble solids-acid ratio of less than 13 failed to attain satisfactory dessert quality. The acceptable maturity range for Italian prunes required a soluble solids-acid ratio from 13 to 15. If the fruit had a soluble solids-acid ratio over 15 the fruit was usually too ripe for distant shipment. In their work with three orchards the soluble solids-acid ratio ranged from 10.8 for early harvest dates to 21.6 in the last harvest date at Stemilt Hill, Washington.

Lott (44, pp.131-143), in his study of apples, found the soluble solids-acid ratio increased continuously and was especially pronounced as full maturity was reached. In the tangerine Harding and Sunday (32, pp.1-59) found as the fruit ripened the soluble solids-acid ratio usually increased.

Sites and Reitz (58, pp.73-81) studied the Valencia orange and discussed the effect of position of the fruit on the soluble solids-titratable acid ratio. The ratio increased from the inside of the tree toward the periphery and from the bottom toward the top of the tree. The ratio of the juice was found to vary greatly between individual fruits on the same tree and this variation was shown to be related to position of the fruit on the tree.

Pressure Test. Hartman (34, pp.1-24) in early work with the Italian prune recorded the resistance in pounds of the prune to a rounded plunger 3/8" in diameter. He felt that only average specimens should be used and that for best results 20 - 30 fruits were needed to get a fair average of the orchard. In the Oaco orchard he found a reduction in pressure test readings of 13.6 pounds between August 10 and September 12; in the Love orchard a decrease in pressure of 7.7 pounds between July 31 and August 19 and in the college orchard a reduction of 7.5 pounds between August 12 and August 30. He found that it was best to harvest fruit for the fresh fruit market when the pressure test reading was between 12 and 15 pounds. He concluded the pressure test was the only guide of maturity which seemed applicable to the Italian prune at that time.

Fisher (21, pp.183-186), in his study of prunes during a three-year period, using the Ballauf 5/16" plunger on 10 prunes, found a steady and continual reduction of pressure in the fruit. In three weeks the pressure test dropped from 13.1 to 7.2. During three years experimentation he determined the per cent sugar of the fruit and its respective firmness from the pressure test. For fruits having the same sugar content the pressure test varied for the three years from 5.3 to 12.3. Fisher (21, pp.183-186) concluded that the pressure test was not a good method of checking maturity because of these great differences in firmness readings.

Gerhardt, English and Smith (25, pp.247-252) used the 5/16" plunger Magness-Taylor pressure tester and punctured two sides of 15 unpeeled fruit. They felt that this test did not indicate differences in maturity to the extent of being a dependable index. In three weeks the pressure test ranged from 10.9 to 7.0 at the Cashmere, Washington orchard. Gerhardt and English (24, pp.205-209) used the pressure test but found great variation in the maturity of Italian prunes from different orchards and grown under different cultural practices was great enough to preclude the use of firmness as a reliable index of maturity.

Tucker (63, pp.578-582) in earlier work found the sugar content of the Italian prune to be more variable than firmness. Acidity changes were found to parallel firmness very closely. The data showed that at a recommended picking firmness, the fruit varied in sugar content and likewise in flavor.

Vincent, Verner and Blodgett (67, pp.1-19) measured pressure resistance of the prune fruit by a modified Murneek pressure tester with a 5/16" plunger. Pressures were taken on twenty representative prunes punctured on both sides and without removing the skin. For best results for fruit going into the fresh fruit market, they advised picking the fruit between 11.5 and 8.5 pounds. Fruit picked at pressures above 12 pounds seldom attained the fine quality desired. Fruit picked at pressures below 8.5 showed danger of deterioration in storage. They felt pressure determinations should be made separately for each orchard except in cases of adjacent orchards under similar conditions of soil and culture. In 1927 the pressure range was from 12.6 to 6.4 while in 1928 the pressure range was from 9.6 to 5.7.

Tucker and Verner (64, pp.1-20) found a steady and uniform reduction in pressure throughout a season but found variations between orchards and between seasons. They felt the measurement of pressure was the best measure of maturity at hand then, but much care was necessary in its use.

Checking the firmness of fruit has been used elsewhere. Bouyonocos and Marshall (5, pp.211-213) developed a pressure tester which was usable on small and soft fruits. They found that compression measurements of 20 cherries from each lot were adequate for revealing differences in firmness. They expressed the measurements in per cent compression.

Haller (28, pp.1-22) in his review of fruit pressure testers discussed the various types in use, the Magness and Taylor, Blake's type for peaches, Hartman's Oregon type tester, the No. 16 brass wire, and the Idaho pressure tester.

As fruits mature and ripen there is a decrease in firmness. The principal objective of the pressure tester is to measure the maturity and ripeness of the fruits. Other factors such as temperature of the fruit, and turgidity and moisture content of the fruit, soil fertilization, soil moisture, thinning and rootstocks may also influence the readings and mask the relation of pressure test determination to maturity and ripeness. In pears the pressure test has been found of primary importance for establishing picking maturity standards. Haller (28, pp.1-22) felt that with peaches, plums, and Italian prunes the pressure test may be used to establish the color standards for pickings.

Haller, Lutz and Mallison (30, pp.1-21) found the pressure tester was a valuable supplementary method to determine more accurately the stage of ripeness of apples.

Lee and Oberle (43, pp.244-246) used the tenderometer to determine firmness in apples, peaches and pears. Pears and peaches showed the greatest changes; apples showed smaller differences because the fruit stayed in prime condition longer.

The fruit was peeled and cored or pitted and cut into one-quarter to three-eights inch cubes. Eight to ten fruit of each kind were used as a sample. A good dessert range for pears was 125-140. In peaches 60-70 represented the best stage for shipping, and for eating 17-25 was best. The pressure tester and the tenderometer were compared using apples. A coefficient of correlation of $+0.9600$ ± 0.0151 was obtained.

Verner (66, pp.57-62), in his work with stone fruits, found the Idaho tester apparently has no advantage over the plunger type for use on prunes. The Idaho tester was best when used on soft fruits rather than on fruits where tough skins would make a difference in readings.

Smock and Neubert (59, p.165), after reviewing the uses of pressure testers on apples, stated the primary usefulness of the pressure test is to tell the differences in firmness between two or more lots of the same variety on a given date or to determine the general degree of ripeness.

Robinson and Holgate (53, p.7) working with plums in New York used a 7/16" plunger Ballauf pressure tester. The two cheeks of each plum were pared and the average of the two readings recorded. They found plums which had a pressure below 10 pounds with the 7/16" plunger would ripen satisfactorily.

It may be seen from a review of literature there is much work pro and con as to the value of pressure testers on deciduous fruits.

<u>Respiration Tests</u>. In their text book, Smock and Neubert (59, pp.138-159) discuss respiration of apples and it was pointed out that many apple varieties respire at different rates with changes in the age of the fruit. Some attempts have been made to correlate the time of respiratory rise with the proper time of picking. In England, work has shown that some varieties should be picked just before the climacteric rise begins while work in Canada dealing with McIntosh indicate the fruit should be picked after its climacteric rise. In work in New York, however, it was recommended that McIntosh be picked before the climacteric rise begins because after the climacteric is reached, almost all the fruit drops from the trees. In New York they felt the climacteric was the most valuable single index.

It seemed to be of very little value in determining maturity of Rhode Island Greening or Northern Spy. It probably can be concluded in apples if the variety shows a sharp and marked rise in respiration or a distinct climacteric peak, respiration measurements might have real value in determining when to pick for experimental purposes.

There has been criticism of the method of measurement of respiration by the techniques using controlled temperature rooms (59, pp.138-159). Some workers have felt that respiration of attached fruit on the tree is not exactly parallel to fruit in the controlled temperature rooms. Smock and Neubert (59, p.142), however, reported work which measured the respiration rate of apples on the tree and found it to be essentially the same as that found 24 hours after harvest. A similar finding was made by Clendenning (13, pp.197-203) in work with tomatoes.

Roux (56, pp.317-327) studied the respiration rise and fall in peaches and plums. The respiration of fruit picked at intervals of growth was determined. It was shown that after picking, in both plums and peaches the very young fruit have an early and pronounced climacteric. Fruits of intermediate age have a very much delayed climacteric and exhibit the maximum longevity in storage. The ripest fruit were in the climacteric rise at the time of harvest.

Harvey and Rygg (36, pp.723-746), working with citrus, were trying to develop a simple indicator of the vitality of citrus fruit in relation to its keeping quality in storage and transportation. They undertook to utilize the respiratory process of citrus fruit under simple but specific conditions. In general, the method adopted consisted of filling with fruit a container capable of being made perfectly airtight and afterward recording the pressure changes as respiration of the fruit altered from approximately normal to the anaerobic type. This special respiratory test has been made upon apples, pears, grapes and tomatoes and other fruits and their responses suggest that this method might be of more use to them than to citrus as a simple and rapid test of maturity or vitality.

The work of correlating the types of pressure curves obtained from practice with its likely subsequent behavior on the market is very great. The practical value of the method can be determined only through its trial and use by many workers upon different varieties of fruit and in different localities.

CANNED FRUIT QUALITY STUDY.

Sensory Methods. The two most important senses involved in testing the quality of food are taste and color. Other senses will not be covered in this review. The problems which confront a person endeavoring to test a food's flavor and color subjectively are essentially the same and in this review, both factors will be considered together.

Of primary importance in the initiation of any taste or color evaluation work is the selection of a panel. Most generally experienced tasters have been shown to obtain better results than inexperienced tasters according to Helm and Trolle (37, pp.181-194). Dove (18, pp.187-190) has shown that a judge may be sensitive to one flavor but not equally sensitive to another. Hicks (38, pp.1-5) has shown that a panel does not necessarily have to be large but its members should be experienced in the tests being made.

Availability of judges is important in conducting a good panel. If possible, try to always have the same group present from day to day in the tests (10, pp.319-327). Knowles and Johnson (41, pp.207-216) felt that age was probably not necessarily associated with poor tasting ability. The flavor differences between sexes were not large enough to be considered important. Panel judges should be persons of good health and appetite and they should have a high sensitivity of taste and olfactory sense (38, pp.1-5).

Judges have been tested for reliability by at least eight different methods: ability to recognize duplicates, ability to arrange samples in correct order of concentration of sweetness, sourness, bitterness and saltiness, analysis of score on duplicate samples, deviation from panel average, deviation between duplicate samples, use of standard reference samples of predetermined score, use of questionnaire to discover eccentricities of taste, testing by period of training, and the control-chart method (47, pp.214-222).

The majority of panels were made up from 4 to 12 members.

Various Types of Tests Used. Ranking is probably one of the simplest methods of judging a food. In ranking the judges are asked to rank samples in decreasing or increasing order of some characteristic. Ranking tests have been made on all types of food products.

The paired test is used when two samples are submitted to judges according to Boggs and Hanson (3, pp.219-285). The paired samples are judged by comparison with each other. The judges are usually asked, "Which sample has the best flavor?" This test has been used extensively with meats according to Cover (12, pp.379-394) and Boggs and Hanson (3, pp.219-285).

The triangle or triple comparison test has been reviewed very well by Helm and Trolle (37, pp.181-194). Three samples are examined, two of which are duplicates. Judges are asked to select the identical samples and determine if there are any differences between samples. Chance selection alone will give one correct answer in every three trials. To determine if the results are significant, it is necessary to know how far the numbers of correct answers must exceed 33 per cent before it can be considered certain that guessing is compensated for.

Dilution tests determine the smallest amount of unknown that can be detected when it is mixed with a standard material. It appears to be best when working with a homogenous substance. It has been used very successfully with milk and scrambled eggs according to Trout and Sharp (62, pp.1-60) and Bohren and Jordan (4, p.397).

Difference-preference tests were useful in detecting differences and in determining which difference was preferred according to Dove (19, pp.39-50).

The constant stimulus method is used in which two stimuli are presented and the judge is told to state which stimulus of the two is most intense. Random order is considered necessary for this method since the second impulse will be judged greater than the first when the two are of equal intensity according to Metzner (49, pp.5-18).

Panel members are checked for performance by several different methods: deviations in scores on replicates, control chart method, correlation and regression coefficients on duplicates, and analysis of variance of individual scores (17, pp.1-134).

Other factors to take into consideration when conducting taste and color panels were size, temperature, method of cooking and other preparations, and serving of the samples. Time of day, utensils used, coding, time after smoking, discussion at judging session, time allowed for tasting, methods of removing flavors from mouth, location of judging room, seating arrangement, provisions for ventilation, lighting and temperature controls and many other factors appeared to affect the results of the taste and color tests (17, pp.1-134).

Taste and color test data may be analyzed by average, range, percentage, ratio, Chi-square, t-test, analysis of variance, regression, correlation, standard deviation, control chart, over-all ratings, discriminate functions and missing values (17, pp.1-134).

For a very complete review of taste testing procedures and principals, refer to the work by Boggs and Hanson (3, pp.219-283).

Color Measurements. Color of the canned or frozen product is an important factor to consider when working with consumer acceptability of food. Experience has taught that color is often directly related to some other aspect of quality; for example, redness is an index of ripeness in tomatoes; and the development of a brown color as flavor develops in baking bread (60, pp.190-193). It has been the purpose of the food industry to seek a quantitative method of measuring color as it is seen by the consumer's eye.

Color measurement methods can be divided into two main groups: psychological and physical.

Psychological methods entail comparisons with standard samples of food products or with the various color handbooks. These include the Munsell system (11, pp.1-42) and the Maerz and Paul "Dictionary of Color" (45, pp.1-207). These systems are generally considered qualitative. A slight advancement in this system is the use of the Lovibond tintometer. This instrument's method consists of direct visual color comparisons, and the results are expressed numerically. A recent example of its use is that of Pederson, Beattie and Stots (52, pp.1-32).

The transformation of the Munsell color system into the I.C.I. system gives basis for a quantitative analysis. Though these systems approximate the response of the human eye they do not completely solve the problem of quantitative, objective and reproducible measure of appearance.

The second system is the measurement of the physical characteristics of color. These color differences can be evaluated indirectly in terms of some physical characteristics of the sample or some extracted fraction which is largely responsible for the color characteristics.

Spectrophotometers are important types of instruments in this field. A very complete review of the application of the spectrophotometer to the determination of food colors up to 1950 has been made in Shah's masters thesis (57, pp.1-49). The chief drawback of this instrument appears to be that it does not measure color as the eye sees it.

Another physical method is by abridged spectrophotometry in which measurements are made only at critical wave lengths or wave length bands. In this type it is possible to measure the per cent transmittance of light in the region of maximum absorption as in the Lumetron.

The Photovolt Reflectometer used by Worthington, Cain and Wiegand (70, pp.274-277) makes possible the objective measurement of color of foods and a designation in standardized psychophysical terms. The data of the Photovolt Reflectometer can be computed in I.C.I. or Munsell terms. Munsell terms evaluate the three psychological color attributes: hue, value and chroma. These Munsell color charts can be used by the worker to visualize the approximate ranges of color differences involved.

The Hunter Multipurpose Reflectometer (40, pp.581-618) is somewhat similar in principle to the Photovolt Reflectometer but is now being superceded by the excellent new Hunter Color-Color Difference Meter. This instrument is a tristimulus colorimeter measuring color on three scales which give uniform measures of the visual perceptibility of differences between colors (22, pp.1-10). In the new apparatus photocell windows and the measuring circuits have been selected so that the three values of color are read directly from 10-turn potentiometer rheostats. These three rheostats are set to the calculated values of some standard color and a specimen of a closely approximating color is placed in exposure position, deflections of the current-detecting galvanometer then show the magnitude on the three scales of color difference between the specimen and the standard.

The instrument will give three numbers for each color measured. The worker may choose either the Rd (45° 0° luminous reflectance) or L (visual lightness) circuit. The other two scales of the instrument measure "a" which is redness when plus, gray when zero and greenness when minus; and "b" which is yellowness when plus, gray when zero and blueness when minus (22, pp.1-10).

Kramer (42, p.1897), using the Hunter Color-Color Difference Meter on tomato products, found that the correlation coefficients of the Hunter Rd, "a" and "b" singly gave very poor relationships with the organoleptic panel of eight judges. A multiple correlation of Rd, "a" and "b" gave the correlation of .904 and Hunter "a" and "b" by use of the formula $\frac{3b-15}{a}$ gave the correlation of .903. He felt that the Hunter Color-Color Difference Meter was a very accurate instrument and that its superiority in the measurement of tomato juice color was due to its ability to reproduce results with great precision.

Pederson and Robinson (51, pp.46-49), working with the quality of sauerkraut preserved in tin and glass, found that the Hunter "a" readings compared with color ratings showed good correlation in case of many of the samples, considering the variability in different kraut samples and the human element in grading. The r was -0.75. They felt the Hunter Color-Color Difference Meter offered an objective method of measurement of color quality of kraut. Hunter "a" and Rd values correlated well with both color and flavor scores. In their work statistical analysis of the results indicated that the a value may carry about four times the weight of the Rd value in determining color score.

Buck and Sparks (8, pp.122-124) worked with the relation of ketchup color to tomato color as determined by the Hunter Color-Color Difference Meter. In their work, they used Kramer's hue formula $\frac{3b-15}{a}$ to combine Hunter "a" (red) and "b" (yellow) values into one numerical figure indicative of the over-all hue with special reference to tomato grades. Their work indicated as the color index decreased showing better color, the Rd value usually decreased. Hue was decided on as the basic factor. The Hunter Color-Color Difference Meter comparing raw tomato color with ketchup color gave accurate determinations which could be expressed numerically. The reports on the use of the Hunter instrument mentioned above are a limited sampling of such applications to foods. Since the instrument is being so extensively investigated, it is impractical to review here the very latest of such reports (10, pp.121-128), (54, pp.314-319), (55, pp.269, 275), (60, pp.190-193).

pH. pH of canned fruit products appeared to be important only in determining the length of cook needed to get complete sterilization (61, pp.52-54). Hydrogen-ion concentration was measured in Jonathan apples by Griswold (27, pp.1-19) but she worked out no quality grades from this data.

Total Acidity. In work with prunes, Hartman (34, pp.1-24) determined the per cent malic acid in the syrup of the canned fruit. Through ten harvest dates, he found an acid range from .99 to .59 per cent malic. At .60 and .59 per cent malic he determined the fruit had the best flavor characteristics.

Harding and Wadley (33, pp.510-517) determined the total acid on the composited juice of 25 orange fruit. Palatability ratings showed a close negative association with acidity in the month-to-month changes but not between rootstocks. The relationship was -.95.

Garnatz (23, pp.1133-1136) found a 1.14 per cent citric acid content was as high as consumers would accept orange juice.

Cut-Out Soluble Solids. Hartman (34, pp.1-24), working with canned prunes, determined the per cent syrup cut-out soluble solids and found a range from 26 to 28.9 per cent. The most desirable prune flavors were determined at 28.7 and 28.6 per cent soluble solids. Harding and Wadley (33, pp.510-517) found a ≠.87 correlation between total water-soluble solids and palatability in their work with orange juice. They found total water-soluble solids were more consistent than total acidity.

In apple sauce Garnatz (23, pp.1133-1136) found that soluble solids should not be less than 19 per cent and not exceed 21 per cent for general consumer acceptance.

Blanchard and Maxwell (2, pp.105-115) found correlation .73 and .74 between the sugar content and subjective scores obtained on two groups of peas.

Cut-Out Soluble Solids of Juice - Titratable Acidity Ratio. The author finds no reference using this method to check the canning quality of a fruit product.

MATERIALS AND METHODS

Samples of Italian prunes of the 1951 crop which were used throughout the experimentation were grown at the Lewis-Brown Horticulture farm of the Oregon State College which is located just five miles due east of the school. The prune orchard furnishing the fruit for the study is approximately twenty years old and has been producing good crops every frost-free year. The soil is Chehalis silty clay loam and appears to be very uniform throughout the orchard. At no time during the experimentation were the prune trees irrigated.

STATISTICAL DESIGN OF THE EXPERIMENT. Five Italian prune trees which appeared to be average in every respect, in comparison with the rest of the orchard, were selected for sampling and tagged A-B-C-D and E. The trees bloomed well and produced an excellent crop of prunes.

The harvesting was set up so that each of the five trees and its resultant fruit could be considered as a replication and that the trees could be harvested nine times throughout the ripening season. In this case then each harvest date was considered to be a slightly different "treatment" on the harvested fruit. Each objective and subjective test was applied to the fruit from each individual tree. Harvesting was carried out in the morning of every third day from August 22, 1951 to September 15, 1951.

The experiments are set up as nine by five factorial analyses of variance studies with the number of observations in a replication depending upon the factor being studied. The least significant differences have been determined for each objective and subjective test if the F values were significant between harvest dates. The correlation coefficients are calculated between each objective test and the taste test scores as measured by a statistically selected panel. In cases where the "r" values were determined as significant by the t-test and appeared high enough for prediction purposes, the standard error of estimate and 90 per cent confidence limits were calculated for the regression line.

METHOD OF FRUIT HARVESTING. Sampling procedure was as follows: Limbs were chosen at each harvest on each of the five trees; each limb or part of a limb was harvested clean (excluding, of course, obvious rotten and withered fruit); about 200 fruit were harvested from each individual tree; as soon as the limb or part of a limb was harvested it was immediately tagged with a yellow cardboard as to date and number of fruit picked. This limb was never to be picked again.

Toward the end of the harvest season many perfect fruit were dropped to the ground. In the experimental harvesting it was felt that some allowance should be made for whole ripe fruit dropped to ground. A count of 50 fruit stems at random on the tree was made and those fruit stems which had borne fruit and recently dropped them were calculated into a percentage dropped fruit for that tree that individual harvest date. Additional fruit from the ground based on the percentage drop was added to each box. The grower will shake as many prunes as possible off the trees and pickers will pick up everything but rotten fruit and place them in their boxes. The experimental harvesting therefore attempts to simulate actual condition of harvesting where the grower shakes all fruit off the tree. Therefore, some perfect fruit on the ground were included in the yield of the orchard. Below is the data showing the per cent drop for the five trees during the last four harvest dates of the harvesting period. Fruit dropped before these dates were generally imperfect fruit.

Table 1. Per cent fruit drop for the five Italian prune trees during the last four harvest dates.

	Tree A	Tree B	Tree C	Tree D	Tree E
September 6	7%	3%	5%	5%	2%
September 9	6%	4%	5%	4%	3%
September 12	8%	4%	5%	4%	4%
September 15	10%	5%	5%	5%	5%

The fruit in boxes were then brought to the laboratory at the Food Technology Department for fresh fruit analysis.

The trees were harvested in random order throughout the picking season.

FRESH FRUIT ANALYSIS. In the Food Technology Laboratory, fruit boxes one at a time were emptied into a large tub of water and thoroughly washed. The prunes were mixed and a sample of 40 fruit were withdrawn at random for use in the study of the fresh fruit quality factors. Each of the five harvest groups were treated in a similar manner. The remaining fruit from each tree were placed back into their individual boxes and stored in a 34° F. room for processing the next day.

Recording Data. It was decided that data from each objective test should be entered into a permanent table and recorded for statistical analysis without copying into another table. This procedure helps to cut down on the accidental errors. The coding for the table is as follows: The first letter of the code A-B-C-D and E refers to the tree designation and the number refers to the harvest date 1-2-3-4-5-6-7-8 and 9. The following sheet was used to record all data.

Weight of Fruit. Each randomly drawn sample of 40 fruit was dried and weighed. This test was used to determine the yield of the orchard by trees as it progressed throughout the season.

Visual Grading. The fruit were then graded visually by

Table 2. Data sheet to record information collected in the experiment.

CANNED (OR RAW) PRUNES TEST____

Harvest Date	1	2	3	4	5	6	7	8	9
Tree A									
Tree B									
Tree C									
Tree D									
Tree E									

the author, according to outer skin appearance alone, into acceptable blue-purple and non-acceptable greenish groups. These figures were later converted into per cent acceptable prunes. This was used to simulate the conditions that would be found on a grading belt at a commercial cannery.

Pressure Test. After visual grading the fruit were subjected to the Ballauf pressure tester with a 5/16" rounded point. Each of the fruit was held firmly in the palm of the hand and punctured first on one side, recorded and punctured on the other side and recorded. This figure is the pounds of resistance the skin and flesh of the fruit exhibit to the point of the pressure tester. There was a total of 80 punctures for the 40 fruit and a total of 400 readings for the five trees for one particular harvest date.

As soon as they were punctured they were immediately immersed in a pan of water containing a weak solution of ascorbic acid which greatly aided in the prevention of browning.

Color Test. When the pressure test was completed, the prunes were dried, peeled, and pitted and 10 prunes at a time placed into a $3\frac{1}{2}$ x $2\frac{1}{2}$ x $1\frac{1}{4}$ transparent plastic box for use in connection with the Hunter Color-Color Difference Meter. The machine was previously standardized with a N.B.S. Maize standard with the assigned value of Rd 54.0, "a" -1.0, "b" -32.0. This standard was chosen because it was the closest in color to the color of the prune flesh. The color readings of the prune flesh were made throughout the study in reference to this Maize standard using the Rd circuit arrangement. Refer to Hunter Bulletin (22, pp.1-10) for complete details in the operation of the Hunter Color-Color Difference Meter. The process was continued until all 40 of the prunes were peeled, pitted and exposed to the Hunter Color-Color Difference Meter. This gave four individual color readings which were later averaged and used for calculations. All five trees were treated in this manner.

Per Cent Soluble Solids. The peels and peeled fruit of each tree were placed together in an individual pan and mixed thoroughly for the next test. Approximately 80 grams of the peelings and flesh were placed into a Succulometer cup and subjected to 500 pounds pressure. The juice extracted in this manner was placed on the lens of a Bausch and Lomb 0-60 Hand Refractometer and read after correction for temperature for its per cent soluble solids. This procedure was repeated four times for each tree each harvest date.

pH. The remaining fruit skin and flesh mixture were then placed in a Waring Blendor and blended for three minutes into a uniform pulp. Two 100 gram samples were weighed out and placed in contact with the electrodes of a Beckman Model H-2 line operated pH meter. Two pH readings for each tree were taken.

Titratable Acidity. As soon as the pH was recorded the titratable acidity was determined by electrometric titration. Enough distilled water was added to make the prune pulp easy to stir, then .9914 N NaOH was added until the pH reached 7.2. Two determinations were made on each of the five trees.

pH 7.2 was decided on as the end point for the electrometric titration from the data presented in Tables 3 and 4 and Figures 1 and 2. Figure 1 shows that at pH 7.2 there was almost a straight line increase in pH as the addition of NaOH continued. Figure 2 shows an end point of pH 7.12 using prunes of tree No. 1 and pH 6.76 using prunes of tree No. 2. The titratable acidity was calculated as per cent

Table 3. pH changes of 100 grams of prune purée from tree No. 1 with the addition of 0.993 N NaOH and calculations for exact end-point of titratable acidity determination.

ml. NaOH	pH	Δml. NaOH	ΔpH	$\frac{\Delta pH}{\Delta ml.\ NaOH} \times 10$
0	3.20	----	----	----
3.01	3.70	3.01	0.50	
5.30	4.11	2.29	0.41	
6.73	4.36	1.43	0.25	
7.52	4.50	0.79	0.14	
8.01	4.59	0.49	0.09	
8.92	4.75	0.91	0.16	
9.45	4.85	0.53	0.10	
9.73	4.89	0.28	0.04	
10.16	4.99	0.43	0.10	2.33
10.68	5.12	0.52	0.13	2.50
11.47	5.41	0.79	0.29	3.67
11.94	5.63	0.47	0.22	4.68
12.46	6.07	0.52	0.44	8.46
12.83	6.60	0.37	0.53	14.32
13.06	7.12	0.23	0.52	22.60
13.50	7.90	0.44	0.68	15.45
13.98	8.37	0.48	0.47	9.79
14.50	8.70	0.52	0.33	6.35
15.44	9.28	0.94	0.58	6.17

Table 4. pH changes of 100 grams of prune purée from tree No. 2 with the addition of 0.993 N NaOH and calculations for exact end-point of titratable acidity determination.

ml. NaOH	pH	Δml. NaOH	ΔpH	$\frac{\Delta pH}{\Delta ml.\ NaOH} \times 10$
0	3.06	----	----	-----
2.00	3.33	2.00	0.27	
4.08	3.69	2.08	0.36	
5.92	3.93	1.84	0.24	
7.12	4.13	1.10	0.20	
7.65	4.22	0.53	0.09	
8.45	4.38	0.80	0.16	
10.33	4.70	1.88	0.32	
11.05	4.84	0.72	0.14	
11.95	5.03	0.90	0.19	2.11
12.53	5.20	0.58	0.17	2.93
13.18	5.42	0.65	0.22	3.39
13.58	5.59	0.40	0.17	4.25
13.99	5.87	0.41	0.28	6.83
14.25	6.13	0.26	0.26	10.00
14.49	6.42	0.24	0.29	12.08
14.65	6.76	0.16	0.34	21.25
14.88	7.22	0.23	0.46	20.00
15.00	7.46	0.12	0.24	20.00
15.24	7.88	0.24	0.42	17.50
15.60	8.25	0.44	0.37	8.41
16.01	8.56	0.41	0.31	7.56
16.97	9.20	0.96	0.64	6.67

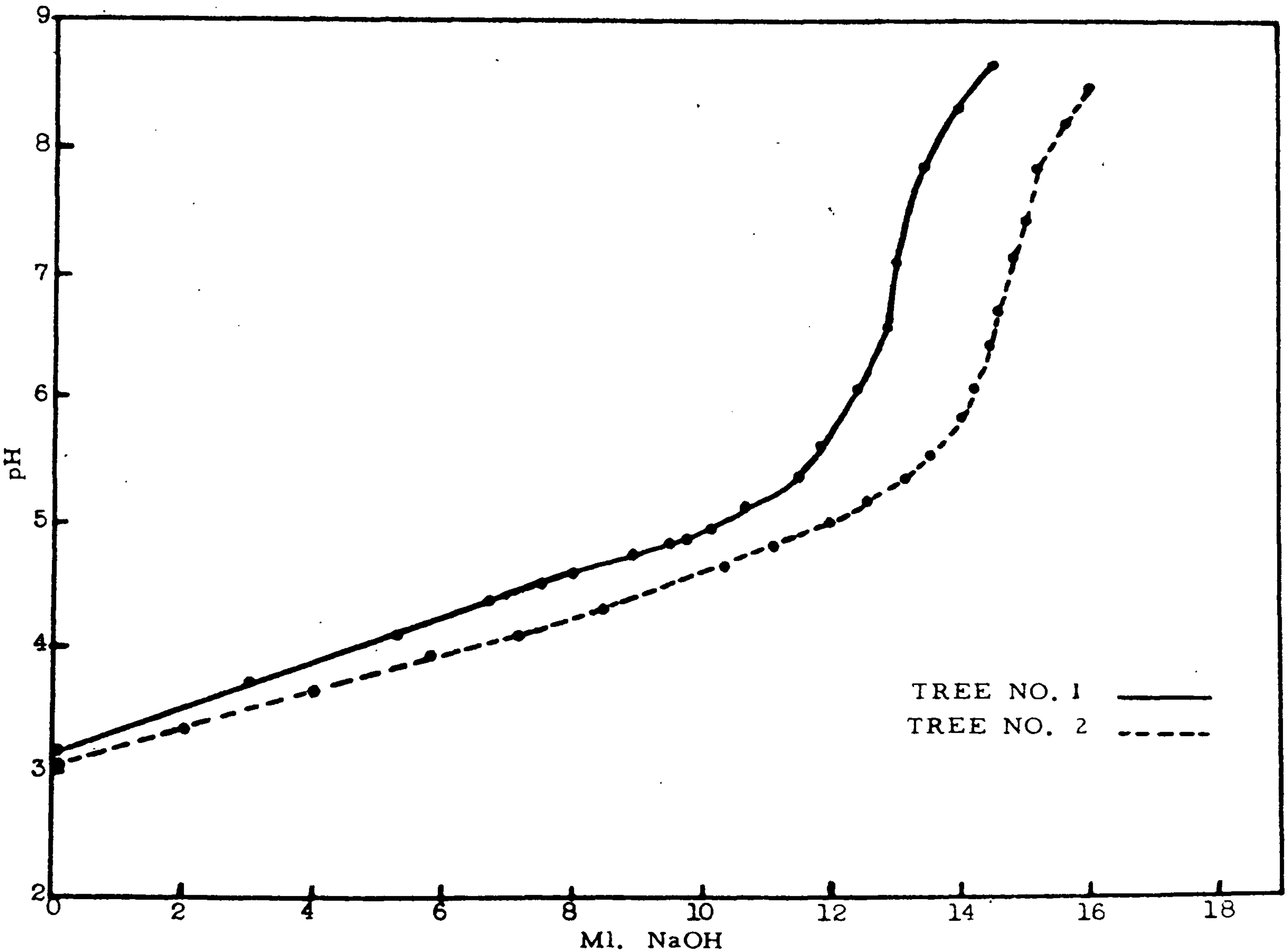

Figure 1. Titration curve of raw prunes at the beginning of the study.

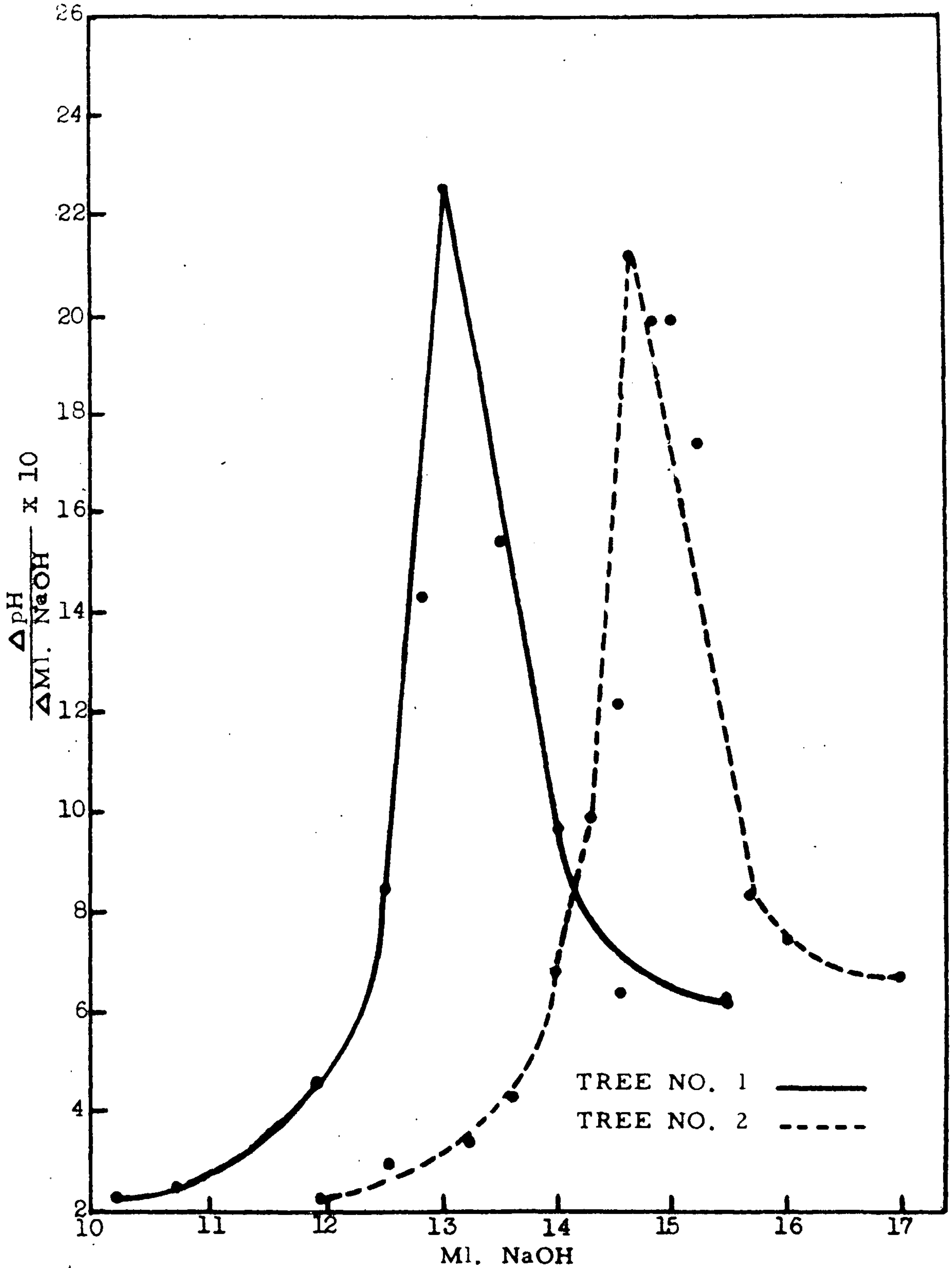

Figure 2. Exact end-point of titratable acidity determination of raw prunes as shown by differential plotting.

malic acid by the following formula:

$$\frac{\text{ml. NaOH x Normality NaOH x .067}}{\text{Weight of Sample}} \text{ x } 100 = \text{per cent malic acid}$$

.067 = millequivalent weight for malic acid.

Soluble Solids-Acid Ratio. Data determined from per cent soluble solids of the fruit and titratable acidity were used to calculate per cent soluble solids-acid ratio.

RESPIRATION STUDY. During the course of the experimentation, a study of the respiration of the fruit was being conducted by two methods: (a) production of CO_2 in a closed system, constant pressure O_2 atmosphere, and consequent possible accumulation of ethylene; and (b) production of CO_2 at intermittent periods from an air-flow system. The first tests were conducted from August 28 to September 6. Lots of 1563 and 1525 grams of prunes were tested in a 70° F. constant temperature room. The fruit were brought to the temperature of the room by a 24-hour conditioning period. The first group of 1563 grams were placed in an air-tight desiccator containing a drying dish with 100 ml. of 4 N KOH (46, pp.1-38). This system was connected to a flask which contained O_2 gas, that was in turn connected to a bottle of water which was drawn into the O_2 flask as the O_2 was used up in the respiration of the fruit. The carbon dioxide formed during respiration was absorbed by the 4 N KOH. This absorption was allowed to go on about 24 hours. The 100 ml. sample of 4 N KOH was then removed and titrated in the following manner against .967 N HCl. A ten ml. aliquot was removed from the 100 ml. sample, ten ml. of $BaCl_2$ was added, and 25 ml. of distilled water, then 3 drops of Phenophthalein indicator were added. These were mixed and then titrated while stirring with .967 N HCl. The end point was a clearing of the solution. The resultant amount of HCl used was subtracted from the blank reading of 53.8 which contained no carbon dioxide. This figure was substituted in this formula:

$$\frac{\text{Ml. of HCl used} \times 10.45 \times 2}{\text{Weight of Fruit in Kg.} \times \text{Hrs.}} = \text{Mg. of } CO_2 \text{ per Kg. per Hour}$$

10.45 = milligrams of CO_2 equivalent to 1 ml. HCl.

Respiration in all samples were expressed in these terms.

The second group of 1525 grams were allowed to become conditioned to the 70° F. temperature. They were aerated continuously after being placed in a dessicator especially built for this purpose. The air was drawn in from the outside. Then in the morning of each day the air was drawn through scrubbing bottles to remove CO_2, through the dessicator containing prunes, and then through a bead-filled Reiset tower (7, pp.29-112) containing 20 ml. of 4 N KOH. The flow of the air through the system was controlled by a manometer so that the same rate would flow daily. After about 7-8 hours of air flow, the column would be taken out of the system and the samples were placed back on regular aeration. The 20 ml. of KOH which absorbed the CO_2 out of the bubbling air, was titrated in a similar manner as described earlier and expressed in Mg. of CO_2 per Kg. per hour.

On September 9 another sample of 1130 grams of prunes were aerated and checked again to see if the fruit were approaching the climacteric. This test was conducted until September 14 and expressed in the same manner as above.

PROCESSING TECHNIQUES. The boxes containing prunes which had been previously placed in the 34° F. room over night were removed the next morning and processed. The processing procedure included taking the prunes from the boxes, rewashing in a tub of water, and randomly placing them in 12 No. 2 fruit enamel cans for every code mark such as A-1, B-1, C-1, D-1 and E-1. Eleven ounces of prunes were added to each can. This made 60 cans of prunes for one particular harvest date and 540 coded cans for the complete harvesting season.

After the prunes were weighed into cans, 180° F., 30° Brix Syrup was added to each can allowing one-half inch head space. The cans were then exhausted for four minutes at 180° F. They were immediately closed on a No. 2 closing machine and processed in boiling water at 212° F. for 12 minutes. After processing, the cans were cooled to 100° F. or about skin temperature and allowed to dry. As soon as they were sufficiently dried and cooled they were packed 24 to a box and carefully coded. These boxes were stored in an approximately 60° F. storage room until canned fruit analysis was to be started.

About midway in the harvesting season, ten cases of prunes were processed by the above method. These cans were labeled "Standard" and were to be used as the reference samples of standard prunes for later work in the taste and color evaluations.

CANNED FRUIT STUDIES. Flavor and Color Evaluations. Starting in November 1951 a series of flavor and color evaluations were conducted. A panel of about 15 judges was tried at the beginning of the work. Prunes which were not to be used in the actual experimental evaluation were tested by the group for both color and flavor. Specially constructed taste test booths were used in the flavor evaluation study. The booths were about 2½ feet wide, 3 feet deep, 7 feet high, equipped with a bench, stool, sink with running water, and overhead lighting. To alleviate the effects of differences in the color of the prune samples, the overhead lighting was of a dark red color which made all samples, both light and dark, appear identical in color. This procedure allowed the judge to taste for flavor alone and allowed practically no chance of bias to enter into his flavor decisions. Strict silence was required from the judges during the tasting.

The samples to be tested for color were placed in large white China bowls. Three prunes and 100 ml. of prune juice were placed in the bowl as a sample. The bowls were numbered from one to four and one bowl was marked "Standard". The four numbered bowls and the "Standard" bowl were placed on the bench in the cutting room. The taste test ballot illustrated herewith was used throughout the work. Lighting was a difficult problem and in most instances samples were judged under a combination daylight-artificial light environment. It was fairly uniform throughout the tests.

Table 5. The Oregon Agricultural Experiment Station taste test ballot.

Test No.______

Date__________________ Canned Prunes Taster__________

SAMPLE	FLAVOR	COLOR	COMMENTS
STANDARD	7	7	
1			
2			
3			
4			
5			

(If any sample is rated 4 or lower, please state reason).

Score: 10 - ideal, 9 - excellent, 8 - very good, 7 - good, 6 - fairly good, 5 - acceptable, 4 - fair, 3 - poorly fair, 2 - poor, 1 - very poor

Samples for the taste test were prepared after the color samples were readied. Two sets of identically coded dishes were filled with prunes and juice. The prunes were then cut into small pieces and mixed. This aided the judges in getting a good uniform taste. As each judge entered the booth to taste he would take two clean spoons, then with one spoon he would take up a bit of the sample and transfer it to the other spoon and taste. This method was used because other judges would later also taste this same series of samples.

In both color and flavor evaluation, the judges were given a "Standard" sample, which was considered to be homogenous throughout the whole series of organoleptic tests. The "Standard" sample was drawn from the ten cases of "Standard" samples canned in the mid-season period. In both flavor and color judging the "Standard" was set at a score of seven and held that way throughout the experimentation. The "Standard" sample had been pregraded by a group of experts as both seven in color and in flavor. Judges in each color and flavor test were asked to compare the unknown samples with the "Standard" sample marked seven and state if the color or flavor of the unknown sample was more desirable than "Standard" by marking 8-9-10, or less desirable than "Standard" by marking 6-5-4-3-2-1 or the same as the "Standard" by marking seven. As much as possible, testers were asked to taste the samples before they judged the color.

Although the samples in the color bowls and the flavor bowls were coded differently, this procedure made sure that the judges had no preconceived ideas about the flavor samples. Each judge evaluated each series of the prunes for both color and flavor four different and unrelated times.

The judges were selected at the beginning of the work by a modified statistical method of determining the "three sigma" limits for their answers. For example, the ten to fifteen judges tasted coded samples ten different taste test sessions. The average was calculated for each individual sample. Then the "three sigma" limits were calculated (1, pp.1-33). The judges whose scores did not fall within the "three sigma" limits 65% of the time were eliminated and the remaining scores were reaveraged. This assumes that the panel average is the correct scoring of the sample in mind. The system was used on scores of both color and flavor evaluation. This system was tried for ten successive color and flavor taste tests containing groups of four and five samples, and it was soon found that certain judges were good in judging color, some good in judging flavor, and some that did an excellent consistent job of judging both color and flavor. After the series of ten tests, the judges which were found to be inconsistent and unable to stay within the "three sigma" limits of the panel average were eliminated from the panel and from that time on, only six to eight judges which had shown good precision were asked to judge more experimental samples. The experimental data were sorted out from the taste tests and substituted into a nine by five factoral table. Four complete color and flavor evaluations on each experimental sample were completed.

Cut-Out Soluble Solids of Juice. Four cans from each code were opened and poured into beakers. The cut-out per cent soluble solids were taken on the juice with a Bausch and Lomb 0-60 Hand Refractometer. The fruit and juice were shown by tests to have come to a complete equilibrium as far as per cent soluble solids were concerned.

Color of Canned Juice. A sample of juice was taken from the beakers and diluted, three parts of distilled water to one part of juice. The sample was then placed in a Beckman Spectrophotometer cuvette and the absorption curve through the visual spectrum was determined. The lightest sample of juice from harvest date 1 and the darkest sample of the juice from harvest date 8 were checked by the Beckman Spectrophotometer (48, pp.68-102). The absorption was checked from 375 to 630 mμ. as shown in Table 6. Figure 3 shows that the point of greatest absorption was in the infra-red range and from 510 to 520 mμ. for both the lightest and the darkest juice. With these points determined on the Beckman Spectrophotometer, it was decided to use the

Table 6. Per cent transmittance data for early and late harvest dates canned prune juice samples measured by the Beckman Spectrophotometer.

Wave lengths in mμ.	Per cent transmittance Harvest Date 1	8
375	23	26
400	67	59
410	71	62
420	72.5	62
440	74	60
460	76	59.5
480	71	50.5
500	64	39.5
510	59.5	36.5
520	60	36.5
540	67	44
560	67	52
580	80	70
600	86	81
630	95	93

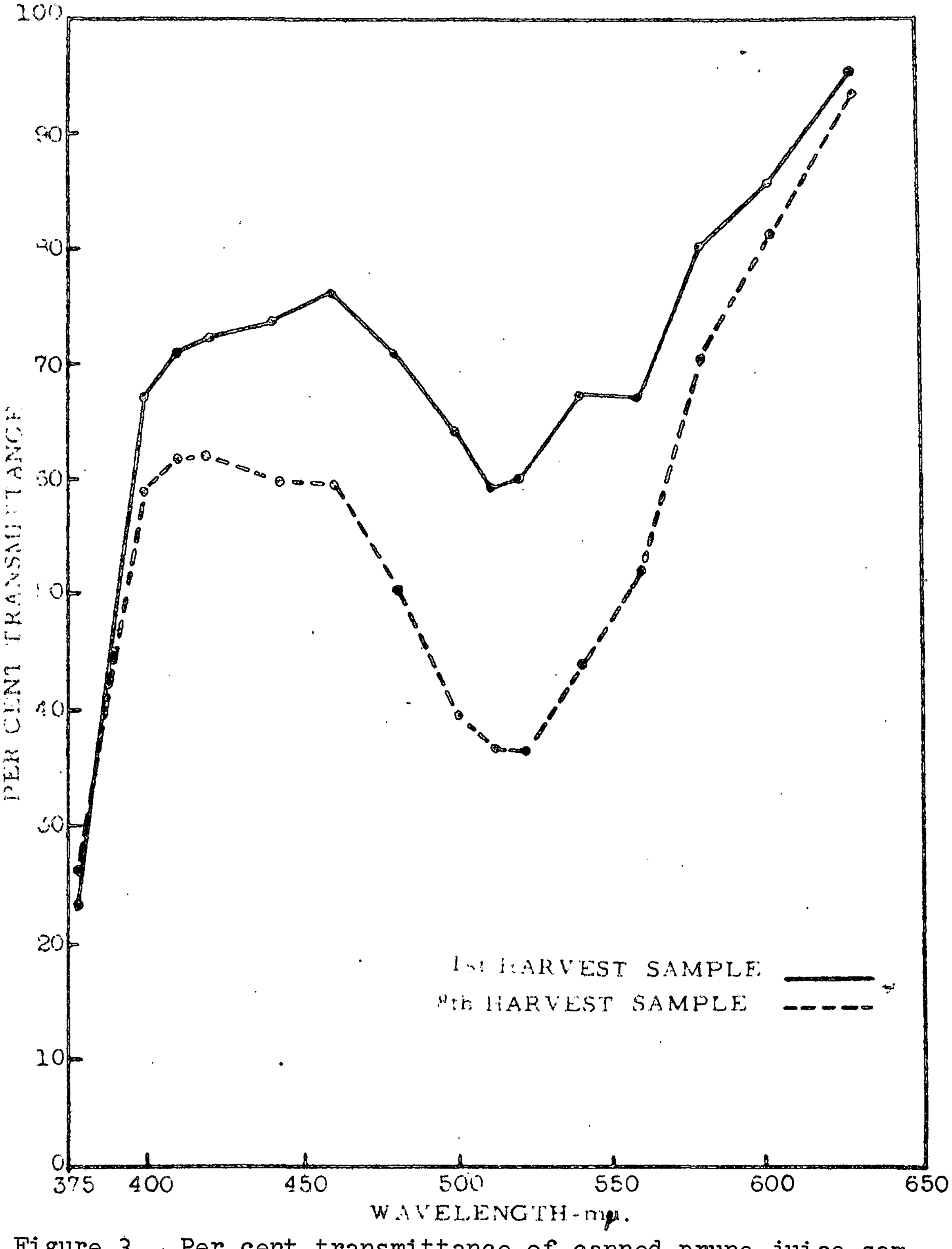

Figure 3. Per cent transmittance of canned prune juice samples of first and eighth harvest dates as measured by the Beckman spectrophotometer.

yellow-green filter (530 mμ.) to determine the per cent transmittance of the 3 to 1 water dilutions of juice in the Lumotron test tube Colorimeter.

Color of Outer Skins. The prunes from the four cans were then broken in half carefully, pitted and placed skin down in a plastic dish for reflectance measurement by the Hunter Color-Color Difference Meter. The red H.B.S. color standard Rd 73.0, "a" +61.5, "b" +20.6 was used throughout the work. The container of prunes were exposed twice to insure a uniform and thorough reading. This process was carried out on all of the prunes from each of the four cans for each coded date.

pH of Canned Fruit. Pitted prunes and juice were then placed in a Waring Blendor and blended for 40 seconds to insure a good blended mixture. After blending the pH of the contents, the cans were measured with a Beckman line operated pH meter.

Titratable Acidity of Canned Fruit. As soon as the pH readings were completed, a hundred gram aliquot was weighed into a 400 ml. beaker. This sample was placed under the electrodes of the pH meter. Enough water was added to make the pulp easily manageable and the solution was titrated up to pH 7.2 as was described in the method of the raw prunes. This gave the per cent acid expressed as malic acid.

Cut-Out Soluble Solids - Titratable Acidity Ratio. Data from the per cent cut-out soluble solids and the titratable acidity were used to determine a per cent cut-out soluble solids - titratable acidity ratio, (approximately a sugar-acid ratio).

DISCUSSION OF RESULTS

The results will be presented in the following manner: discussion of the results for each fresh quality test, and the statistical analysis of these data; and then the data for each canned quality test and its resultant statistical analysis. In this work each correlation coefficient between the objective and flavor test were found to be significant at the 5 per cent level by the t test (26, pp. 72-73).

The standard error of estimate referred to throughout the discussion of results is more or less the standard deviation of the points on the graph from the regression line.

An error of one unit in the objective measurements will have an effect on the flavor score. This is determined by "b" or slope of the regression line as shown in the regression equation $\bar{Y}_x = a + bx$.

FRESH FRUIT QUALITY TESTS. Weight Changes in the Fruit. During the harvesting period of the five Italian prune trees, the average weight of 40 fruit from the trees increased steadily from 2.29 pounds on the first harvest date to 2.60 pounds on the fourth and then decreased steadily again to 2.40 pounds on the last harvest date. From the data in Table 7, fruit on the fourth harvest date appear to have the greatest fresh weight.

Statistical analysis of variance of the data show the L.S.D. between harvest date means at the 5 per cent level is .09. Only fruit of harvest dates 2 and 3 differed in weight significantly. Fruit of harvest dates 3, 4, 5, 6 and 7 did not differ significantly in weight. The fruit of harvest dates 1 and 2 at one end and those of harvest dates 8 and 9 at the other end of the harvest period showed significantly less weight than the fruit of harvest date 4 which has the greatest numerical fresh fruit weight. This indicates that sometime during the middle of the harvest period the greatest fresh fruit weight was attained.

The fresh fruit weight was correlated with flavor scores of the canned fruit and the correlation coefficient is +.5433. This correlation, although significant at the 5 per cent level, does not appear to be high enough to predict the flavor of the canned prunes.

Other workers, Vincent, Verner and Blodgett (67, pp.1-19), have pointed out in their work that harvested prune weight reached a peak at a pressure reading of 8.5 and then decreased until the end of the season.

The present work shows these same trends but does not appear to confirm the work of others who have found the weight of the fruit increased by a certain percentage each day throughout the harvesting season. This orchard was not irrigated, causing a diminishing moisture supply which was

Table 7. Mean weight (in pounds) of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	2.22	2.22	2.59	2.57	2.59	2.44	2.38	2.41	2.32
B	2.43	2.40	2.52	2.78	2.72	2.75	2.62	2.64	2.49
C	2.23	2.21	2.48	2.51	2.52	2.46	2.67	2.47	2.43
D	2.14	2.22	2.52	2.54	2.53	2.62	2.59	2.38	2.39
E	2.43	2.34	2.42	2.58	2.55	2.56	2.53	2.52	2.37
Column Means	2.29	2.28	2.51	2.60	2.58	2.57	2.56	2.48	2.40

Mean Harvest L.S.D. at 5% level = .096

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	.9648	-----	-----
Trees	4	.183	.4575	82.73** Highly sig.
Harvest dates	8	.6046	.7557	136.65** Highly sig.
Error	32	.1772	.00553	-----

a possible reason for this trend.

Visual Grading of Raw Fruit. A visual grading by the outer skin appearance of the fruit showed a steady increase in per cent acceptable blue-purple prunes as the harvesting season progressed. The L.S.D. between harvest date means at the 5 per cent level is 8.7. As shown in Table 8 there are no significant outside color differences between fruit of harvest dates 1 and 2; the fruit of harvest date 3 differ significantly from those of harvest dates 2 and 4. There are no significant visual differences between fruit of harvest dates 4 and 5. Fruit of harvest dates 5 and 6, and those of harvest dates 7, 8 and 9 do not appear to be visually different. From Table 8 it appears the use of visual grading methods to show significant differences between fruit harvested every three days is not too precise. The graders cannot tell differences in fresh fruit quality from outer appearance alone when picked three days apart.

The correlation coefficient between visual grading percentages and flavor scores of the canned product is +.7678. This is a fairly high correlation but is not precise enough for predicting flavor of the canned fruit.

Pressure Test. As shown in Table 9 the mean pressure test readings of the fruit show a consistent and continued decrease during the nine harvest periods. The readings decreased from the average of 10.61 the first to 3.76 the

Table 8. Mean per cent acceptability by visual grading of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	22	32	70	88	78	92	98	100	100
B	40	32	68	64	90	92	98	100	100
C	35	30	54	68	68	76	100	100	100
D	18	30	58	66	72	76	100	98	100
E	38	25	70	82	90	90	92	92	100
Column Means	30.6	29.8	64.0	73.6	79.6	85.2	97.6	98.0	100

Mean Harvest L.S.D. at 5% level = 8.72

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	31,382	-----	-----
Trees	4	436.00	109.00	2.384 Not sig.
Harvest dates	8	29,483	3685.375	80.61102** Highly sig.
Error	32	1,463	45.718	-----

last harvest date. The L.S.D. of harvest date means at the 5 per cent level is .51. It can be seen that fruit from each individual harvest date are significantly different in resistance to the pressure tester from those of the next harvest date, except fruit of harvest dates 5 and 6. This indicates that the pressure tester readings will show significant differences between prunes harvested every three days in an orchard in an individual season.

The correlation coefficient between the pressure test readings and the flavor scores of the canned fruit is -.9100. This is a high correlation and indicates the use of pressure tester readings to predict canned fruit flavor is highly precise. The standard error of estimate of .354 as shown in Figure 4 is relatively low. Refer to Appendix Table 1 for the regression line equation. Checking the regression line and the 90 per cent confidence limits, the value of predicting final fruit flavor from pressure test readings can be clearly seen.

Since pressure tester readings of the fruit were significantly different between harvest dates throughout the harvesting season and since they appear to be precise in predicting canned fruit flavor, the pressure tester appears to be valuable in quality work with Italian prunes, except that soil, climatic, and cultural effects were not examined.

Table 9. Mean pressure test data of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	10.54	8.75	9.28	7.59	6.52	5.99	5.04	4.32	3.45
B	10.35	9.21	7.91	7.83	5.64	5.90	5.34	4.18	3.62
C	10.39	9.73	9.07	7.48	6.45	6.68	5.22	4.71	3.55
D	10.55	8.88	8.43	7.26	6.78	5.79	4.89	4.70	3.54
E	11.24	10.87	9.65	8.66	6.94	6.60	5.88	5.58	4.66
Column Means	10.61	9.49	8.87	7.76	6.47	6.19	5.27	4.70	3.76

Mean Harvest L.S.D. at 5% level = .51

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F	
Total	44	226.13	-----	-----	
Trees	4	7.37	1.84	12.26**	Highly sig.
Harvest dates	8	214.06	26.76	178.4 **	Highly sig.
Error	32	4.70	.15	-----	

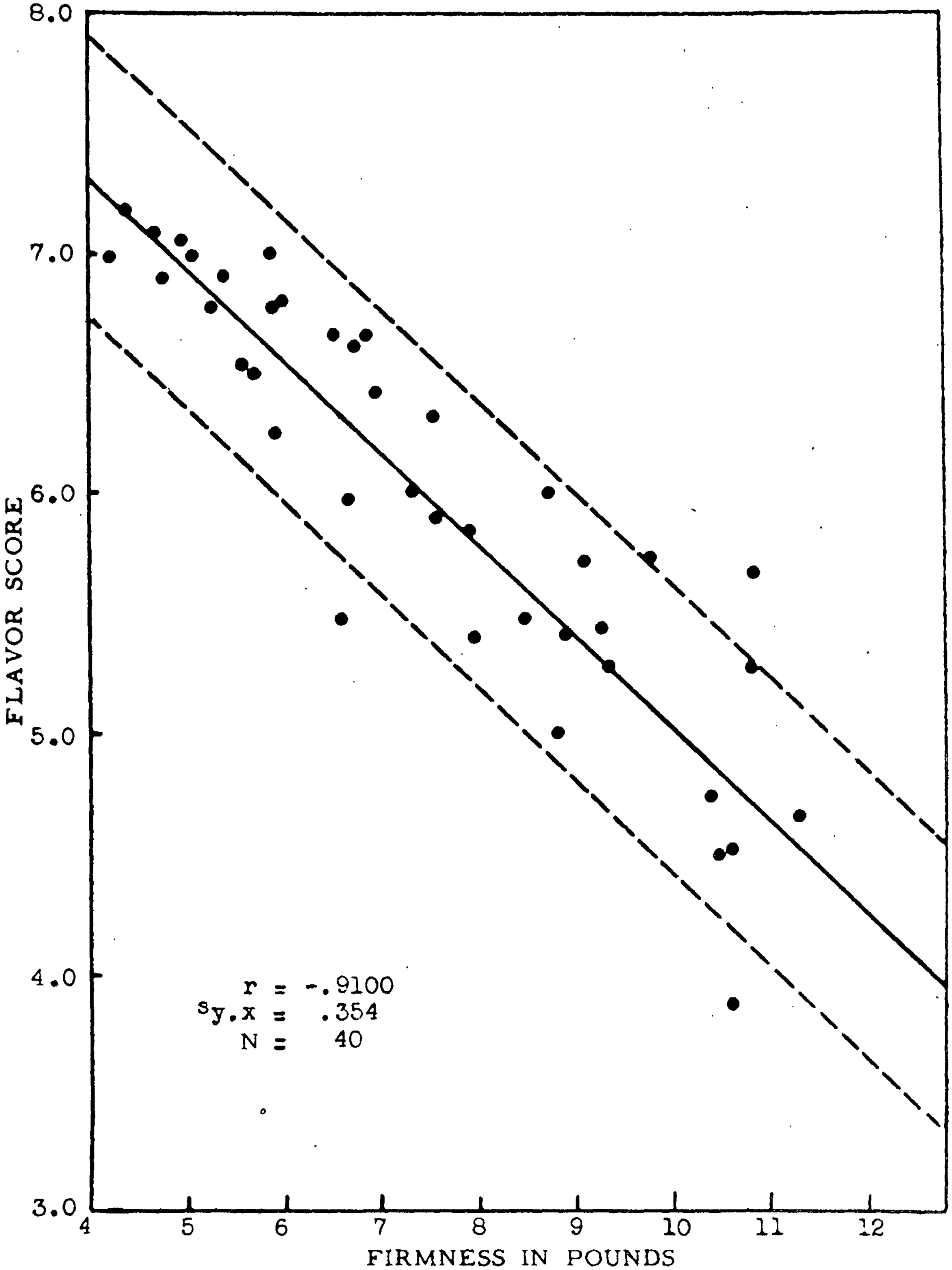

Figure 4. Regression line of flavor score on firmness of fresh fruit and 90 per cent confidence interval.

Color of Raw Prune Flesh. The color changes in raw prune flesh as measured by the Hunter Color-Color Difference Meter showed little, if any, variation in the Rd and "b" color scales. Rd showed a very slight darkening in fruit flesh of the last two harvest dates and "b", which measures redness, was essentially the same in all fruit throughout the season. The Hunter "a" scale which is greenish when minus and yellowish when plus showed a consistent color change in the fruit throughout the ripening period. Since this was the only factor which showed any amount of color change, the statistical analysis of variance was calculated only for the Hunter "a" data as shown in Table 10.

Hunter "a" color readings of the fruit range from -4.9 which is greenish the first to +6.0 which is yellow for fruit on the last harvest date. Refer to Appendix Table 2 for non-converted mean Hunter "a" values. For calculation purposes, to convert all Hunter "a" readings into plus values, a factor of 10 was added to all readings. The L.S.D. between harvest dates means at the 5 per cent level amounts to 1.66 as shown in Table 10.

Under the conditions of the experiment, color changes in fruit between harvest dates 1 and 2 were not significant but fruit of harvest dates 2, 3, 4 and 5 were significantly different in color at the 5 per cent level. The fruit of harvest dates 5, 6 and 7 fell within the same color grouping.

The fruit of harvest dates 8 and 9 fell within the same statistical grouping.

This indicates that the changes in color of the fruit flesh were much greater in the early part of the harvesting season, but after harvest date 5, it took about a nine-day period for the Hunter "a" to detect significant differences in fruit flesh color. The changes in flesh color of the fruit were significant in the first part of the season but in the latter part of the harvesting season, color changes in the fruit did not appear to be significant.

The correlation coefficient between Hunter "a" +10 readings and the flavor scores of the canned fruit is +.8139. This is a fairly high correlation so that Hunter "a" +10 readings may be used to predict flavor of the canned fruit as shown in Figure 5. The standard error of estimate is .364 and the 90 per cent confidence limits were calculated. Refer to Appendix Table 1 for the regression line equation.

Per Cent Soluble Solids. The per cent soluble solids of the fruit during the experiment increased from the average of 11.7 on the first to 16.5 on the last harvest date as shown in Table 11. The per cent soluble solids of the fruit increased consistently from the first to the last harvest date. Per cent soluble solids raw data are found in Appendix Table 3.

The analysis of variance was applied to the data and

Table 10. Mean Hunter "a" +10* data of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	+4.65	+6.85	+9.95	+12.53	+12.53	+13.18	+14.88	+15.23	+18.23
B	+6.45	+6.00	+8.67	+ 8.87	+14.10	+15.45	+16.08	+15.05	+14.80
C	+4.82	+6.97	+8.60	+12.83	+12.63	+15.30	+16.05	+14.58	+16.13
D	+3.92	+5.42	+7.70	+ 9.85	+10.95	+14.05	+14.43	+15.58	+15.15
E	+5.92	+6.72	+7.37	+ 8.30	+14.73	+11.65	+11.63	+15.15	+15.83
Column Means	+5.15	+6.39	+8.46	+10.48	+12.99	+13.93	+14.61	+15.12	+16.03

Mean Harvest L.S.D. at 5% level = 1.66

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	707.399	-----	-----
Trees	4	13.698	3.4245	2.0613 Not sig.
Harvest dates	8	640.541	80.06762	48.1972** Highly sig.
Error	32	53.16	1.66125	-----

* A factor of +10 was added to Hunter "a" values for calculation purposes.

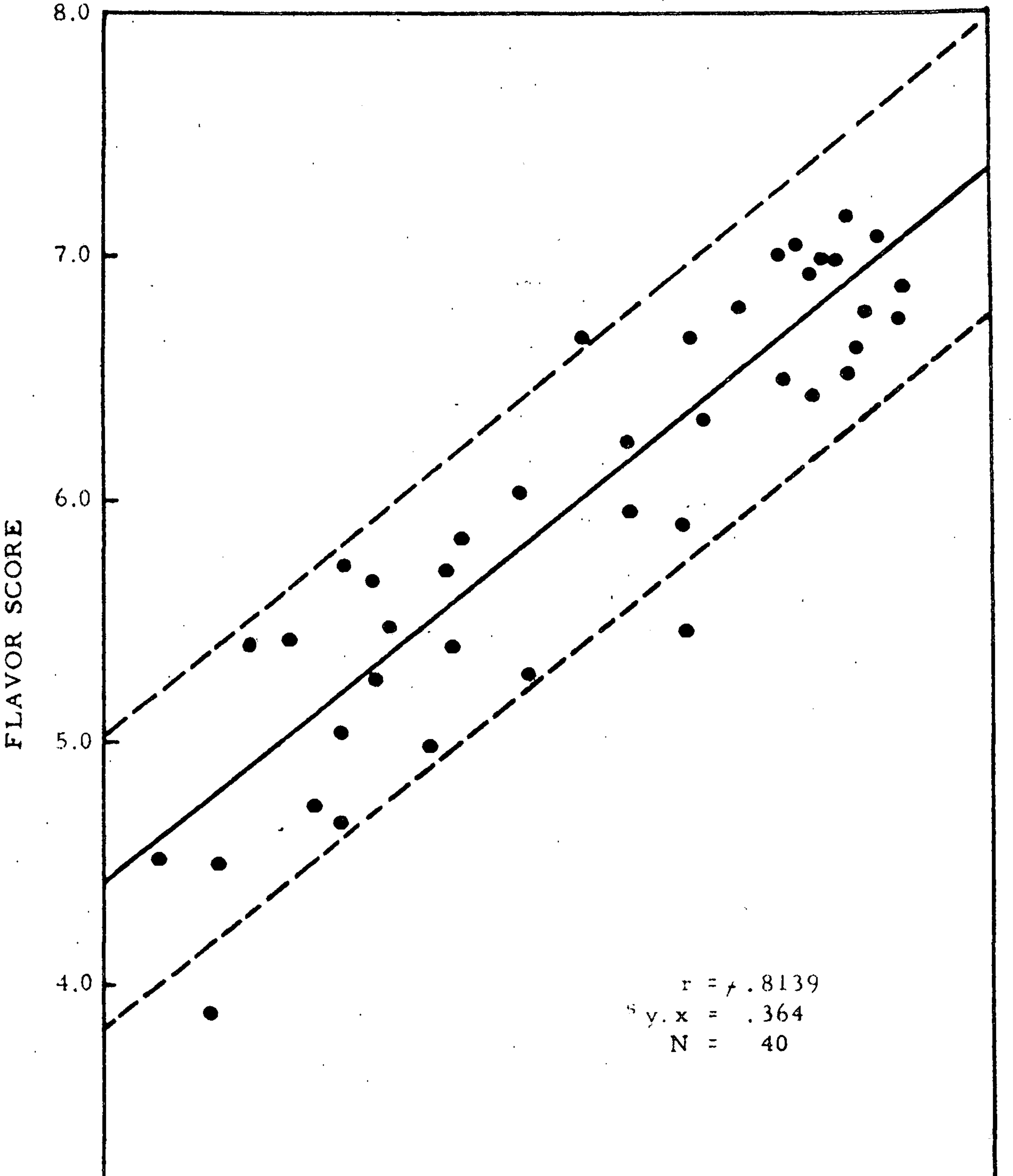

Figure 5. Regression line of flavor score on Hunter "a" ≠10 of fresh fruit flesh and 90 per cent confidence interval.

the L.S.D. on harvest date means at the 5 per cent level was found to be .98. Fruit of harvest dates 1 and 2 and those of harvest dates 2 and 3 were not significantly different in per cent soluble solids. Fruit of harvest dates 3 and 4 and those of harvest dates 4 and 5 were significantly different in per cent soluble solids. Those of harvest dates 6, 7, 8 and 9 showed no significant differences in per cent soluble solids.

These data indicate that the use of per cent soluble solids of the fruit to determine significant differences between groups of prunes every three days was poor throughout most of the season. The differences in per cent soluble solids in most cases are not significant.

The correlation coefficient between per cent soluble solids and the flavor scores of the canned fruit is +.9020. As shown in Figure 3, the standard error of estimate is .372. The correlation between the two tests is high and the standard error of estimate comparatively low. Refer to Appendix Table 1 for the regression line equation. From the regression line in Figure 6, it can be seen that the use of per cent soluble solids to predict canned fruit flavor is very precise in the trees from this one orchard.

The differences in per cent soluble solids between fruit of various harvest dates are not significant and this appears to be the main drawback in using this test.

Table 11. Mean per cent soluble solids data of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	10.8	12.2	12.2	14.4	14.6	16.5	15.0	17.1	16.4
B	12.3	12.0	12.4	14.2	14.6	16.6	16.8	17.9	18.3
C	11.6	12.3	13.5	13.3	15.4	15.8	16.6	16.4	16.3
D	11.2	12.1	12.7	13.8	15.3	15.4	15.7	14.7	15.9
E	12.6	12.8	13.4	13.7	14.6	14.4	14.8	15.5	15.4
Column Means	11.7	12.3	12.8	13.9	14.9	15.7	15.8	16.3	16.5

Mean Harvest L.S.D. at 5% level = .98

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	155.00	-----	-----
Trees	4	5.12	1.28	2.264 Not sig.
Harvest dates	8	131.79	16.47375	29.141** Highly sig.
Error	32	18.09	.56531	-----

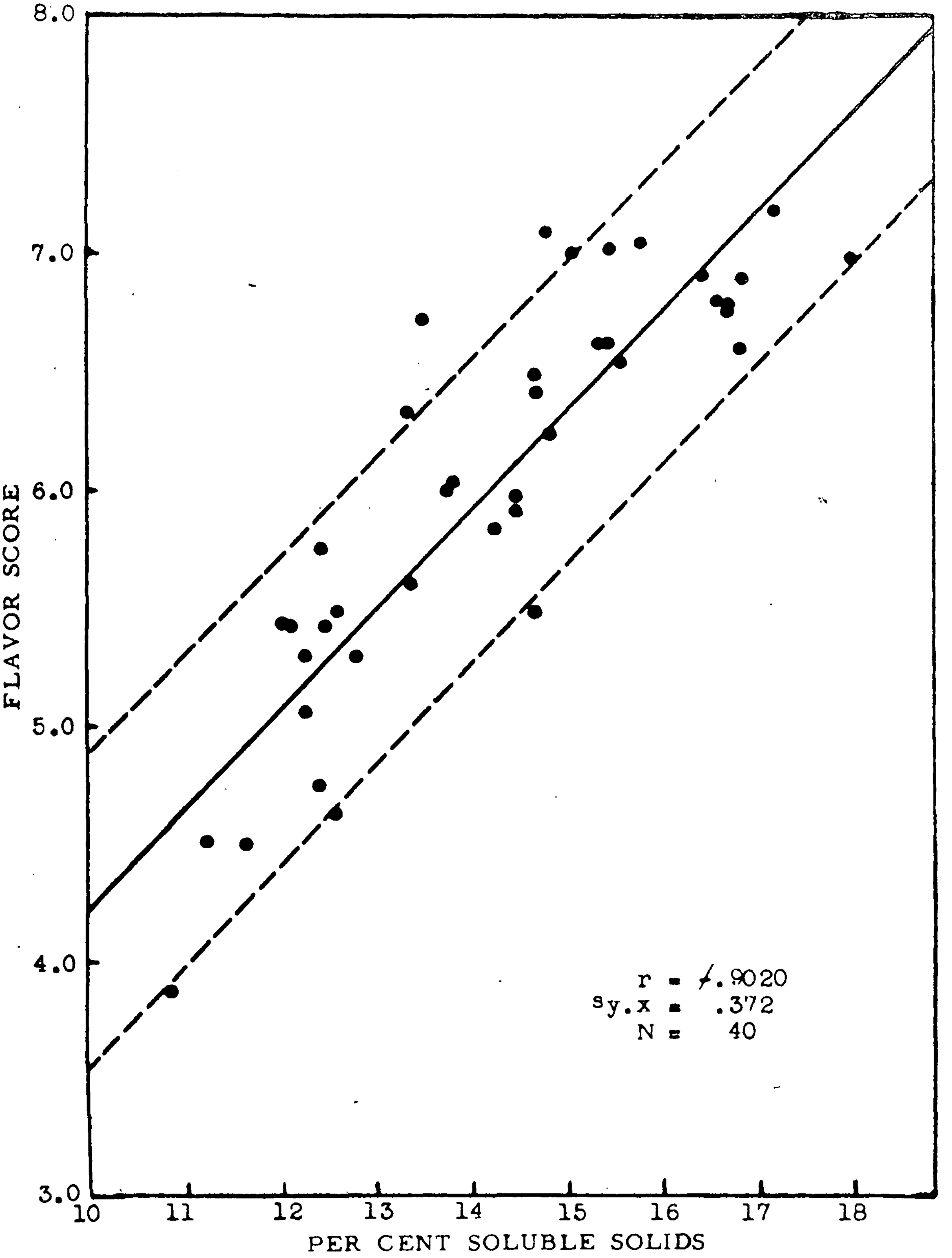

Figure 6. Regression line of flavor score on per cent soluble solids of fresh fruit and 90 per cent confidence interval.

pH. The use of pH values of the raw prunes as a means to tell differences in fresh fruit quality at individual harvest dates appears to be of no value. There were unexplainable variations in pH values and no consistent trend of any kind throughout the harvesting season.

From Table 12 the L.S.D. between harvest date means at the 5 per cent level is .07. Between the fruit of harvest dates 1 and 2 there was a significant different in pH. It appears from the data that use of pH tests to show significant differences in fruit between harvest dates is poor. Raw pH values are found in Appendix Table 4.

The pH values were correlated with the flavor scores of the canned prunes; r equals ≠.6808. This correlation coefficient, though significant at the 5 per cent level, does not seem sufficiently high for prediction purposes.

Titratable Acidity. The titratable acidity of the fruit expressed as per cent malic acid showed a gradual decline from 1.041 in the fruit of the first harvest to .683 in those of the last harvest date.

Upon application of statistical analysis of variance to the data, the L.S.D. between harvest date means at the 5 per cent level equaled .147. Fruit of harvest date 1 were significantly different in acidity from harvest date 3. Fruit of harvest date 2 were significantly different in acidity from those of harvest date 5. Fruit of harvest

Table 12. Mean pH data of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	3.18	3.40	3.31	3.38	3.49	3.39	3.48	3.43	3.51
B	3.18	3.35	3.36	3.38	3.43	3.48	3.46	3.55	3.51
C	3.11	3.40	3.35	3.41	3.41	3.39	3.48	3.50	3.54
D	3.17	3.40	3.50	3.51	3.48	3.40	3.50	3.40	3.60
E	3.41	3.51	3.35	3.38	3.51	3.48	3.50	3.52	3.58
Column Means	3.21	3.41	3.37	3.41	3.46	3.43	3.48	3.48	3.55

Mean Harvest L.S.D. at 5% level = .072

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	.5027	-----	-----
Trees	4	.0362	.00905	2.938 Not sig.
Harvest dates	8	.3616	.0452	14.67** Highly sig.
Error	32	.1049	.00308	-----

dates 5, 6, 7, 8 and 9 fell within the same acidity grouping.

It can be seen from the data in Table 13 that the differences in titratable acidity between fruit of the various harvest dates were for the most part not significant. Appendix Table 5 contains raw per cent malic acid data. It appears that the decreases in acidity were too small between harvest dates to be of any significance, especially in fruit of the last five harvest dates.

The correlation coefficient between per cent malic acid of the raw prunes and the flavor scores of the canned fruit is -.8592. This is a high correlation. As a method to predict flavor from per cent malic acid of the raw prunes, refer to the regression line in Figure 7. Refer to Appendix Table 1 for the regression equation. The standard error of estimate, .442, is relatively high and using the 90 per cent confidence limits the per cent malic acid appears to be useful in predicting the canned fruit flavor.

Although the use of per cent malic acid of the raw fruit appears fair to predict flavor, there appears to be only occasional significant acidity differences between readings of the various harvest dates, probably because the dates are too close together.

<u>Soluble Solids-Acid Ratio</u>. As shown in Table 14, the average soluble solids-acid ratio readings of the fruit ranged from 11.33 for the first to 24.15 in fruit of the

Table 13. Mean per cent malic acid data of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	.983	.969	.855	.848	.863	.830	.795	.752	.661
B	1.010	.964	.878	.860	.827	.799	.770	.765	.754
C	1.070	1.000	.922	.827	.812	.795	.787	.797	.711
D	1.190	.992	.913	.853	.831	.803	.772	.754	.616
E	.952	.936	.873	.826	.796	.817	.783	.724	.672
Column Means	1.041	.972	.888	.843	.826	.809	.781	.758	.683

Mean Harvest L.S.D. at 5% level = .147

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	.530397	-----	-----
Trees	4	.00905	.0022625	.17509 Not sig.
Harvest dates	8	.47999	.05999875	4.643194** Highly sig.
Error	32	.04135	.01292187	-----

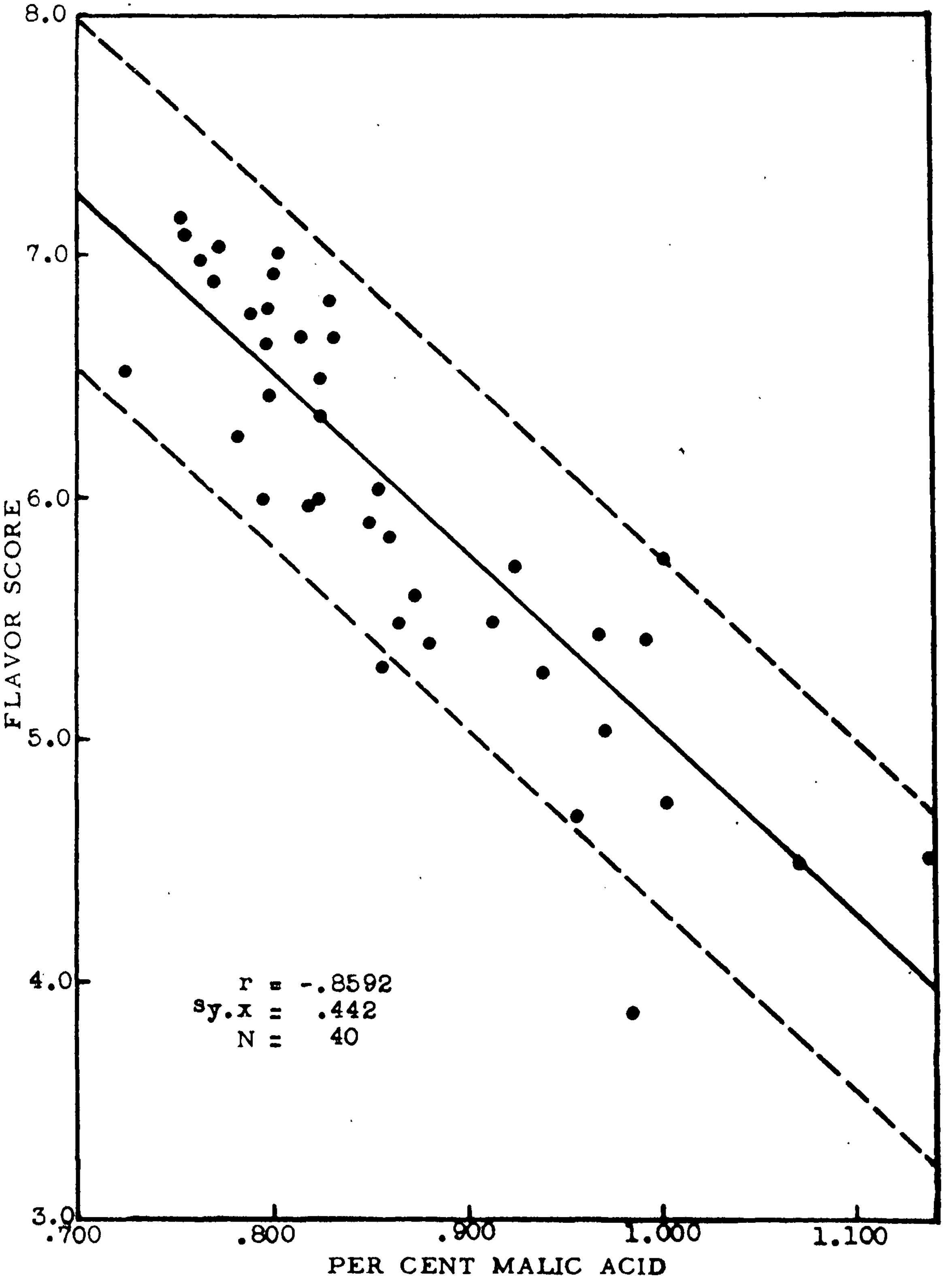

Figure 7. Regression line of flavor score on per cent malic acid of fresh fruit and 90 per cent confidence interval.

last harvest date. The increase in the ratio was steady and consistent through all harvest dates.

Statistical analysis of variance of the data show the L.S.D. between harvest date means at the 5 per cent level is 1.41. In all cases but three, fruit from each successive harvest date was significantly different in soluble solids-acid ratio from those of the next. Even toward the end of the season when other fruit characteristics showed no significant differences between fruit of the various harvest dates, this ratio shows differences were present.

The correlation coefficient between soluble solids-acid ratio of the raw fruit and canned fruit flavor scores is +.9215. Upon calculation of a regression line as shown in Figure 8, the standard error of estimate was found to be relatively low, .334 flavor score units. Refer to Appendix Table 1 for the regression equation. The use of soluble solids-acid ratio within the 90 per cent confidence limits to predict canned fruit flavor is satisfactorily precise.

Coupled with its precision of showing significance between fruit of various harvest dates and its precision in predicting the canned fruit flavor, the soluble solids-acid ratio appears to have merit for use by the cannery field man.

RESPIRATION STUDIES. The two groups of prunes placed under separate conditions August 28 showed slightly different

Table 14. Mean per cent soluble solids-acid ratio of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	10.99	12.59	14.27	16.99	16.92	19.88	18.87	22.74	24.81
B	12.18	12.45	14.12	16.51	17.65	20.78	21.81	23.34	24.27
C	10.84	12.30	14.64	16.08	18.97	19.77	21.09	20.58	22.93
D	9.41	12.19	13.91	16.18	18.41	19.18	20.34	19.50	25.81
E	13.24	13.68	15.35	16.59	18.34	17.63	18.90	21.41	22.92
Column Means	11.33	12.64	14.46	16.47	18.06	19.45	20.20	21.51	24.15

Mean Harvest L.S.D. at 5% level = 1.41

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	760.476	-----	-----
Trees	4	3.979	.99475	.8277 Not sig.
Harvest dates	8	718.039	89.754	74.6829** Highly sig.
Error	32	38.458	1.2018	-----

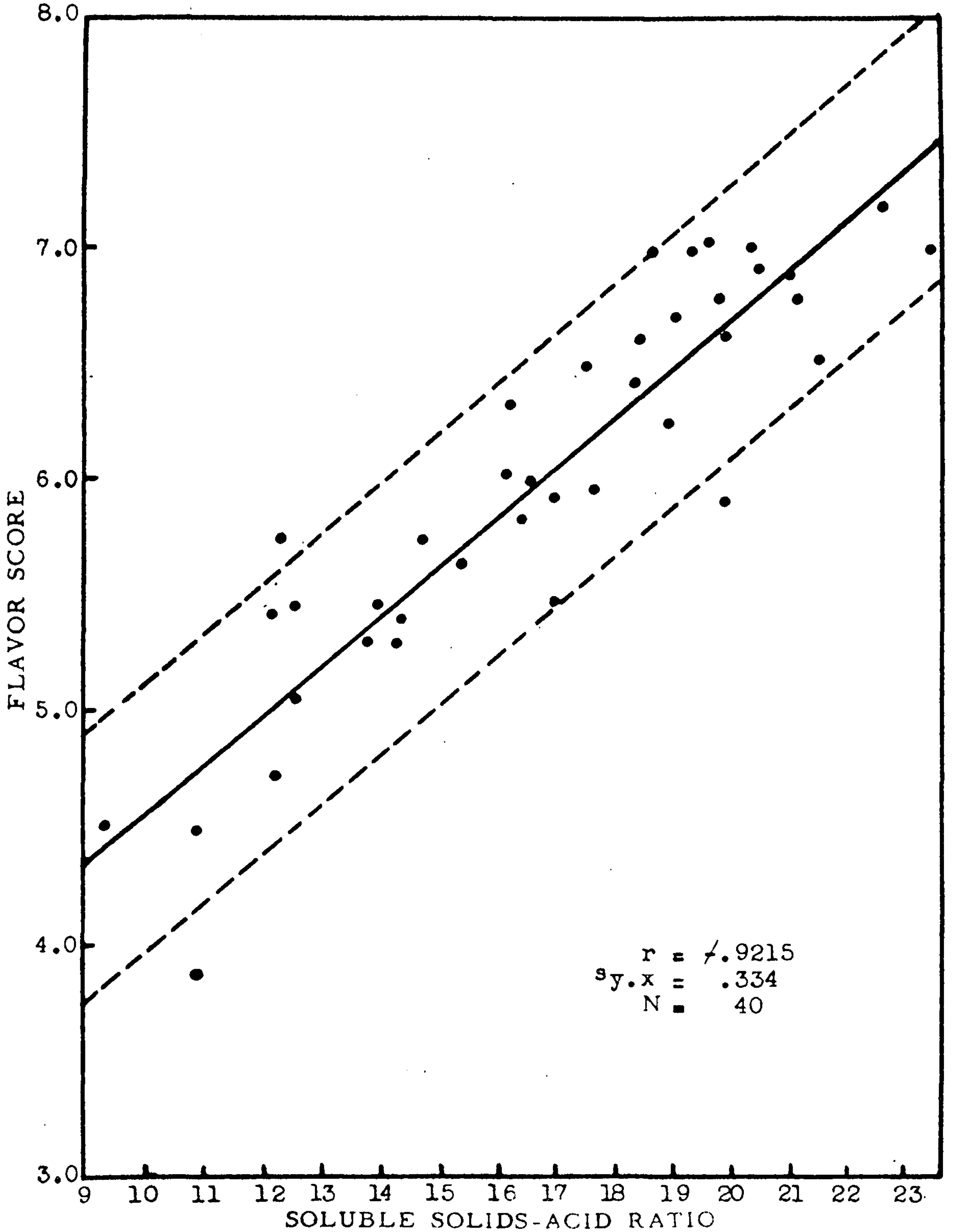

Figure 8. Regression line of flavor score on soluble solids-acid ratio of fresh fruit and 90 per cent confidence interval.

changes in the evolution of CO_2 per Kg per hour. Data is shown in Table 15. The samples placed in a dessicator, non-aerated as shown in Figure 9, show quite an increase in respiration the second day of measurement, August 29, but then decrease on August 30. The fruit here show a climacteric rise to the peak on September 2 and then start to decrease. The fruit at this point started to deteriorate.

In the aerated sample the fruit show a gradual decline in respiration until August 31 and then they rise in two days to the climacteric peak, September 2. Both samples of prunes show a definite climacteric the same calendar day, six days after the measurements were started.

September 9, when the fruit on the tree appeared to be in a prime shape as far as fresh fruit flavor and color were concerned, the fruit were harvested and the respiration was measured starting September 10. The fruit as shown in Figure 9 are in the climacteric rise and reach the peak September 12. The next two days they show a definite decrease, indicating the climacteric peak was passed. This climacteric peak coincides with harvest date 8, the date showing the highest numerical flavor and color scores of the canned fruit. Harvest date 8 was September 12.

CANNED FRUIT QUALITY TESTS. Color Measurement by Subjective Panels. The color evaluation of the canned fruit by the color panel ranged from canned fruit scores of 3.69

Table 15. Data showing respiration changes in aerated and non-aerated samples during the latter part of the harvesting period.

Mg. CO_2 per Kg. per Hr.	August 28	29	30	31	September 1	2	3
Non-aerated	31.7	36.8	34.0	36.4	38.3	39.1	36.1
Aerated	24.8	20.1	18.9	17.9	26.1	29.3	26.1

	September 10	11	12	13	14
Aerated	35.6	41.0	43.9	35.4	32.0

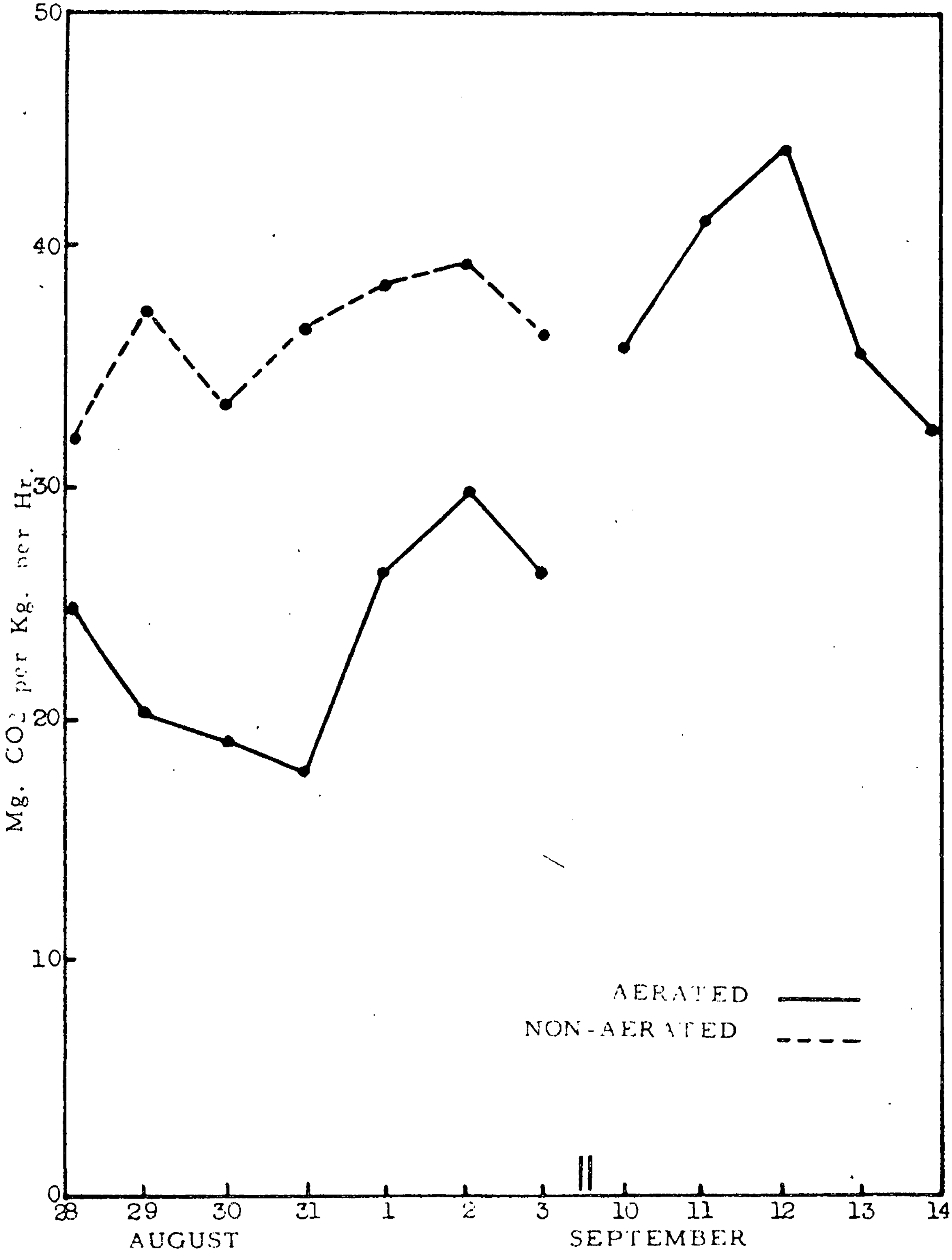

Figure 9. Respiration changes in aerated and non-aerated samples of fresh prune fruit during the latter part of the harvesting period.

on the first harvest date to 7.15 on the eighth and then dropped slightly to 7.00 for fruit on the last harvest date. The canned prune color showed a rather consistent and regular increase in desirability to the eighth harvest date.

Statistical analysis of variance of the data shows the L.S.D. between means at the 5 per cent level is .60. As shown in Table 16, the canned fruit in harvest dates 1 and 2 showed no significant color differences, canned fruit of harvest date 2 was significantly different in color from those of harvest date 3. Canned fruit of harvest date 3 was significantly different in color from harvest date 4. Canned fruit of harvest dates 4 and 5 were significantly different in color from those of harvest date 8 which showed the numerical peak in fruit color. Canned fruit of harvest dates 6, 7, 8 and 9 were not significantly different in color. This indicated that even though some physical tests may show significant differences between fruit of the various harvest dates, the color test panel could not discern them in those fruit harvested late in the season.

Color panel raw data are found in Appendix Table 6. Color scores by individuals are found in Appendix Table 7.

The correlation coefficient between the flavor scores and subjective color test scores is +.9458 and as shown in Figure 10, the standard error of estimate, the lowest in this study, is .273. This shows that with high probability

Table 16. Mean subjective color panel scores of canned prunes for nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	2.67	3.72	4.94	5.83	5.02	7.78	7.31	7.47	7.02
B	4.45	4.01	4.91	5.80	5.87	7.07	7.34	7.29	6.86
C	3.94	5.00	5.15	6.80	6.60	7.22	7.16	6.86	6.79
D	4.10	4.45	5.03	6.43	6.68	6.85	6.93	7.30	7.34
E	3.29	3.80	4.25	5.60	6.16	5.53	6.35	6.81	6.99
Column Means	3.69	4.19	4.85	6.09	6.07	6.89	7.01	7.15	7.00

Mean Harvest L.S.D. at 5% level = .60

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	80.08	-----	-----
Trees	4	3.389	.8472	3.8579* Sig.
Harvest dates	8	69.662	8.7077	39.6525** Highly sig.
Error	32	7.029	.2196	-----

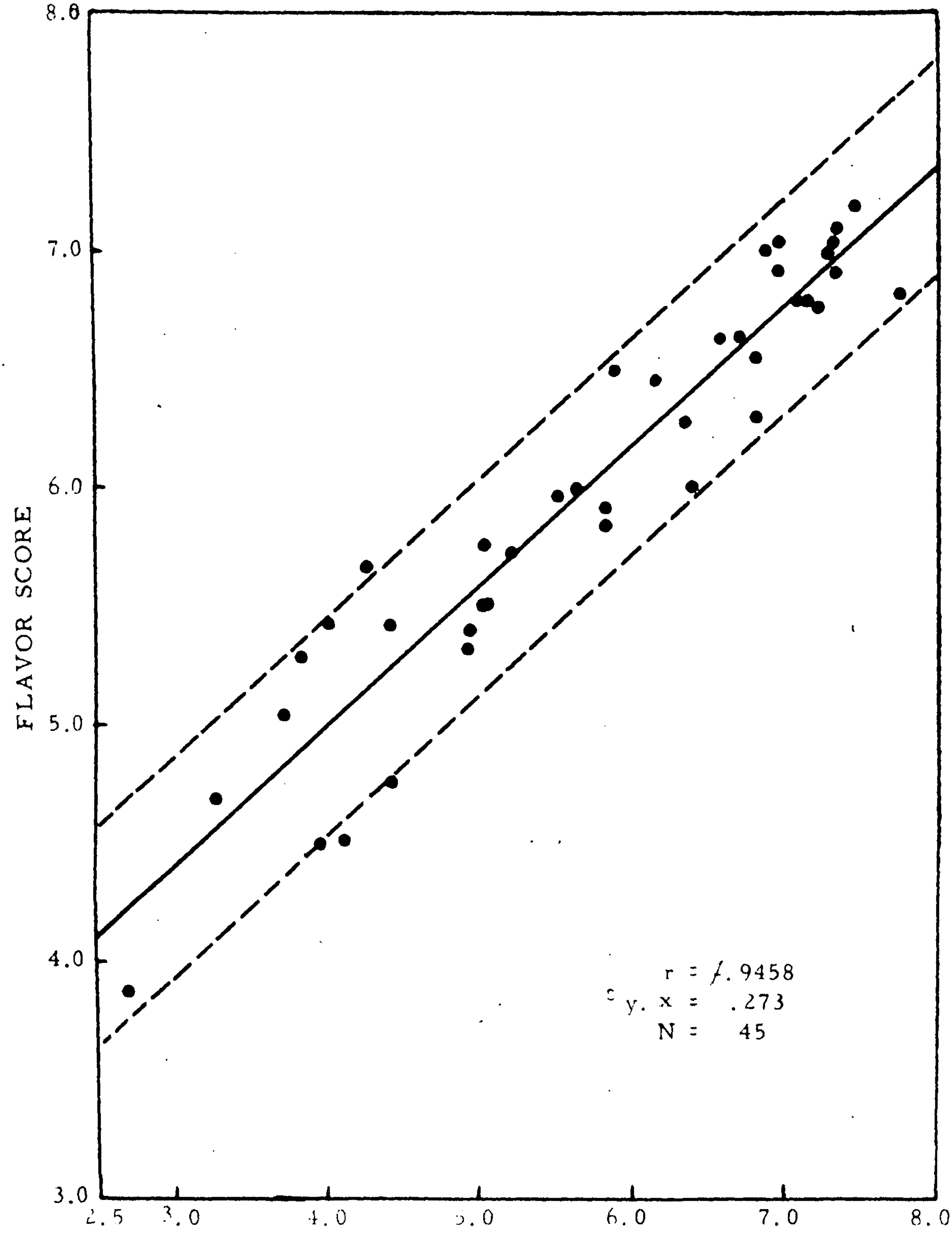

Figure 10. Regression line of flavor score on subjective color score of canned fruit and 90 per cent confidence interval.

you may predict flavor scores of a canned prune from its subjective color scores. The regression line and 90 per cent confidence limits of these two tests are shown in Figure 10. Refer to Appendix Table 1 for the regression equation.

Flavor Evaluation. The average flavor scores of the canned fruit as judged by the flavor panel are shown in Table 17. The range is from 4.46 to 6.93. The increase in canned fruit flavor was rather steady in trend and reached a numerical peak of 6.93 in fruit of the eighth harvest date and then declined slightly in flavor to 6.75 on the ninth harvest date.

As shown in Table 17, the statistical analysis of variance shows the L.S.D for means at the 5 per cent level as .37. Canned fruit of harvest date 1 were judged significantly different in flavor from those of harvest date 2. Fruit of harvest dates 2 and 3 fell into the same flavor grouping. Canned fruit of harvest date 3 was significantly different in flavor from those of harvest date 4. Canned fruit of harvest dates 4 and 5 fell within the same flavor grouping. Canned fruit of harvest dates 6, 7, 8 and 9 fell within the same flavor grouping although harvest date 8 showed the highest numerical flavor score.

Flavor panel raw data are found in Appendix Table 8. Flavor scores by individual testers are found in Appendix

Table 17. Mean subjective flavor panel scores of canned prunes for nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	3.87	5.03	5.29	5.90	5.48	6.81	6.99	7.17	6.29
B	4.75	5.44	5.41	5.84	6.49	6.79	6.89	6.99	7.01
C	4.50	5.75	5.73	6.33	6.68	6.63	6.77	6.91	6.84
D	4.52	5.42	5.48	6.03	6.68	7.01	7.04	7.08	6.68
E	4.68	5.28	5.66	5.99	6.42	5.97	6.25	6.53	6.95
Column Means	4.46	5.38	5.51	6.02	6.35	6.64	6.79	6.93	6.75

Mean Harvest L.S.D. at 5% level = .37

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	31.13	-----	-----
Trees	4	.98	.245	2.95* Sig.
Harvest dates	8	27.48	3.44	41.45** Highly sig.
Error	32	2.67	.083	-----

Table 9.

Since flavor of the canned prune is felt to be the most important single canned fruit quality factor, all other scores from objective and subjective tests of the fruit are correlated with flavor scores. If the correlation coefficients were above .800 the regression line, the standard error of estimate and 90 per cent confidence limits were constructed between flavor scores and the particular test values.

Cut-Out Soluble Solids of the Juice. The cut-out per cent soluble solids of the canned juice ranged, as shown in Table 18, from 22.94 for fruit canned the first harvest date to 25.72 for those canned on the eighth harvest date and then fell slightly to 25.60 in those canned the last harvest date.

The L.S.D. from the statistical analysis of variance between means at the 5 per cent level is 1.05. Canned fruit juice of harvest date 1 was significantly different in soluble solids from that of harvest date 4. Canned fruit juice of harvest date 2 was significantly different in soluble solids from that of harvest date 6. Canned fruit juice of harvest date 6 was significantly different in soluble solids from that of harvest date 8 which has the greatest numerical soluble solids reading. Canned fruit juice of harvest dates 7, 8 and 9 showed no significant differences in per cent soluble solids.

Appendix Table 10 contains cut-out per cent soluble solids raw data.

It can be seen that significant differences in per cent soluble solids of canned fruit juice from the various harvest dates are on the basis of six or nine-day intervals so that the method does not appear to be sufficiently precise for three-day intervals.

The correlation coefficient between cut-out soluble solids of the juice and flavor scores is ≠.7017, which appears too low to predict with any precision the flavor of the canned fruit.

Per Cent Transmittance of the Canned Prune Juice. As seen in Table 19 the per cent transmittance of the canned prune juice using the yellow-green filter 530 mμ. ranged from 71.5 on juice of the first harvest date to 36.8 on juice of the last harvest date. The per cent transmittance of the canned fruit juices showed a long gradual decline as the fruit ripened and the color became more intense.

The L.S.D. for means at the 5 per cent level is 7.39. Prune juice of harvest date 1 and that of harvest date 2 were not significantly different in color intensity. Canned juice of harvest date 2 and that of harvest date 3 was significantly different in color. Fruit juice of harvest date 3 and that of harvest date 4 differed significantly

Table 18. Mean cut-out soluble solids data of the canned prunes for nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	23.03	22.40	23.20	23.48	23.83	25.13	24.25	23.38	26.08
B	22.93	23.35	23.48	24.63	24.08	24.45	25.69	26.93	25.45
C	23.50	24.23	23.93	23.78	24.08	24.70	25.99	27.28	25.30
D	22.30	24.18	23.30	24.48	24.73	24.35	25.63	26.90	25.80
E	22.95	23.50	24.35	24.43	25.93	24.63	24.38	24.13	25.30
Column Means	22.94	23.53	23.65	24.16	24.53	24.65	25.19	25.72	25.59

Mean Harvest L.S.D. at 5% level = 1.05

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	61.246	-----	-----
Trees	4	3.157	.78925	1.18189 Not sig.
Harvest dates	8	36.720	4.59	6.873508** Highly sig.
Error	32	21.369	.6677812	-----

in color. Canned fruit juice of harvest dates 4 and 5 were not significantly different in color. The fruit juice of harvest dates 6, 7, 8 and 9 showed no significant differences in color. This method of testing canned fruit juice color appears to parallel very closely the results found by the color and flavor panels.

Appendix Table 11 contains per cent transmittance raw data.

The correlation coefficient between per cent transmittance of the canned juice and canned fruit flavor scores is -.9004. This is the highest correlation between an objective test on the canned fruit and the canned fruit flavor. Refer to Figure 11 for the regression line and the 90 per cent confidence limits. The standard error of estimate is .373. Appendix Table 1 contains the regression line equation.

It appears that color intensity changes expressed as per cent transmittance of the canned fruit juices show some significant differences at three-day intervals and closely parallel subjective color and flavor scores. Thus, changes in per cent transmittance of the canned fruit juice appears to be a good method to predict flavor of the canned fruit.

Color of the Skin of the Canned Fruit. 1. Rd Values. The Rd color values of the canned prunes studied ranged

Table 19. Mean per cent transmittance data of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	80.25	75.75	62.00	46.75	60.50	29.25	38.00	32.00	31.50
B	63.75	74.25	66.25	48.00	47.00	38.00	39.50	39.25	43.00
C	66.25	67.75	53.50	40.75	43.50	41.50	38.75	39.25	36.50
D	75.75	70.50	64.00	44.75	38.75	49.00	38.00	35.50	33.25
E	71.50	76.00	71.50	54.00	54.00	58.50	47.00	48.00	39.75
Column Means	71.50	72.85	63.45	46.85	48.55	43.25	40.25	38.80	36.80

Mean Harvest L.S.D. at 5% level = 7.39

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	9577.83	-----	-----
Trees	4	529.5	132.38	4.03** Highly sig.
Harvest dates	8	7998.52	999.82	30.47** Highly sig.
Error	32	1049.81	32.81	-----

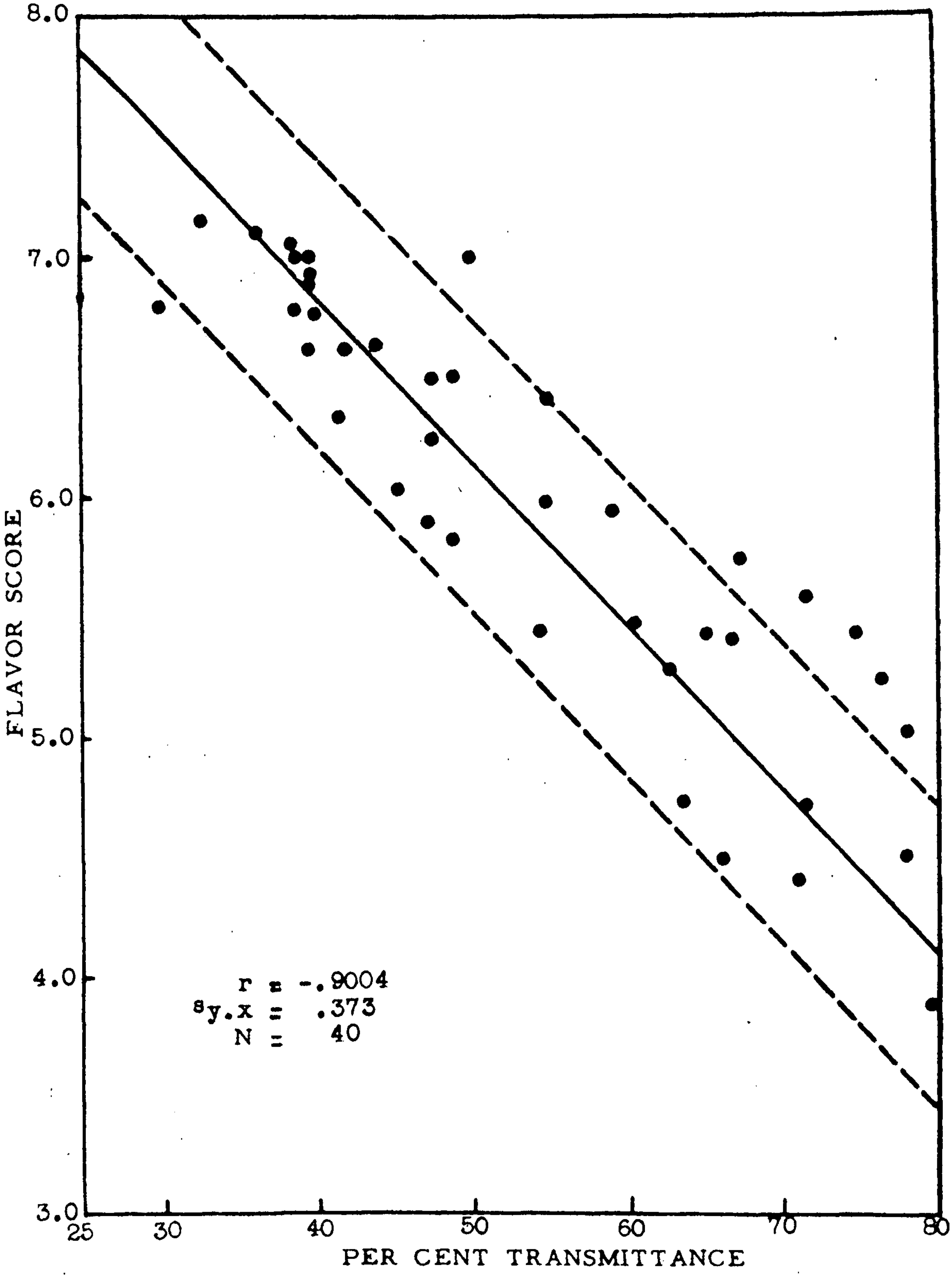

Figure 11. Regression line of flavor score on per cent transmittance of canned prune juice and 90 per cent confidence interval.

from 5.13 for fruit of the first harvest date to 1.83 for fruit of the last harvest date. The changes in Rd color values of the fruit were not particularly consistent as seen in Table 20.

Statistical analysis of variance shows L.S.D. for means at the 5 per cent level as .61. The Rd values of fruit from harvest date 1 were significantly different in color from those of harvest date 2. Canned fruit of harvest dates 2 and 3 fell within the same color grouping and were significantly different in color from those of harvest date 4. Canned fruits of harvest dates 4, 5, 6, 7, 8 and 9 fell statistically into the same color grouping as measured by the Hunter Rd scale.

The correlation coefficient between Hunter Rd values and flavor of the canned fruit is -.8971, and the standard error of estimate is .384. The 90 per cent confidence limits and regression line were calculated to aid in predicting canned fruit flavor from Hunter Rd values. Refer to Appendix Table 1 for the regression line equation. As seen in Figure 12 the use of Rd values to predict flavor of the canned fruit is precise.

The use of the Hunter Rd scale to determine significant differences between canned fruit samples of different harvest dates was poor and accordingly, either the differences were not present or the Hunter Rd value was unable to discern

Table 20. Mean Hunter Rd values of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	6.58	3.45	3.43	2.35	2.70	1.58	1.40	2.50	1.95
B	3.80	3.08	3.10	2.20	1.90	1.88	1.80	1.78	2.08
C	4.88	3.38	2.75	2.00	2.10	2.38	2.63	1.50	1.63
D	5.23	3.33	3.40	2.60	1.93	2.55	2.35	1.80	1.58
E	5.15	3.90	3.28	2.35	2.05	2.85	2.18	2.38	1.93
Column Means	5.13	3.43	3.19	2.30	2.14	2.25	2.07	1.99	1.83

Mean Harvest L.S.D. at 5% level = .61

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	53.108	-----	-----
Trees	4	1.00	.25	1.122 Not sig.
Harvest dates	8	44.98	5.6225	25.2356** Highly sig.
Error	32	7.13	.2228	-----

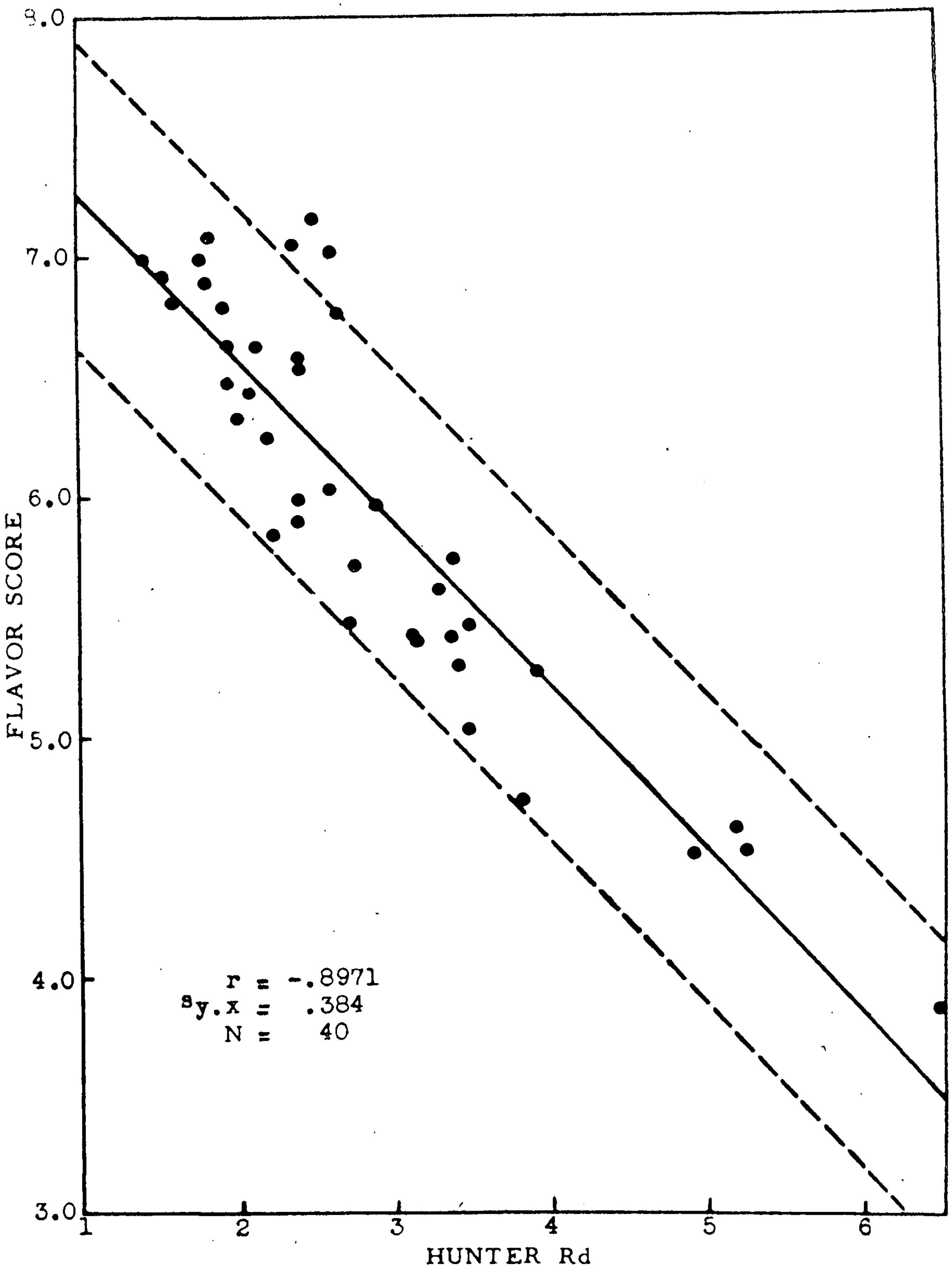

Figure 12. Regression line of flavor score on Hunter Rd of canned fruit skin and 90 per cent confidence interval.

them.

2. Hunter "b" Values. As seen in Table 21, the Hunter "b" values for the canned fruit ranged from 12.81 for canned fruit at the beginning of the harvest period to 4.73 for fruit at the end of the harvest period. The largest color changes on the "b" scale appeared in the canned fruit of the first few harvest dates.

The L.S.D. of means at the 5 per cent level is 1.63. Canned fruit of harvest dates 2 and 3 were not significantly different in color but were significantly different from those of harvest date 4. Canned fruit of harvest dates 4, 5, 6, 7, 8 and 9 fell within the same statistical color grouping and showed no differences among themselves.

The correlation coefficient between canned flavor scores and Hunter "b" values is -.8147. The standard error of estimate is .506 which is relatively high. The regression line and 90 per cent confidence limits aid in determining the prediction properties of the Hunter "b" scale in terms of canned fruit flavor. Refer to Appendix Table 1 for the regression line equation.

This method is fairly accurate in predicting the canned fruit flavor but does not appear to show significant differences between fruit of the later harvest dates as do some other tests. This appears to be a considerable drawback in the use of the Hunter "b" scale to determine canned prune

Table 21. Mean Hunter "b" values of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	15.75	9.55	8.40	5.60	6.18	3.10	3.00	5.43	4.48
B	9.95	8.60	8.60	6.35	4.60	4.05	4.28	3.83	5.65
C	12.20	9.90	7.95	4.98	5.65	5.65	6.13	3.30	4.25
D	13.15	9.18	9.68	7.05	4.78	6.43	8.18	4.35	3.45
E	12.98	10.63	9.23	6.65	6.33	8.00	6.30	7.15	5.83
Column Means	12.81	9.57	8.77	6.13	5.51	5.45	5.58	4.81	4.73

Mean Harvest L.S.D. at 5% level = 1.64

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	375.07	-----	-----
Trees	4	19.27	4.817	2.978* Sig.
Harvest dates	8	304.05	38.006	23.50** Highly sig.
Error	32	51.75	1.617	-----

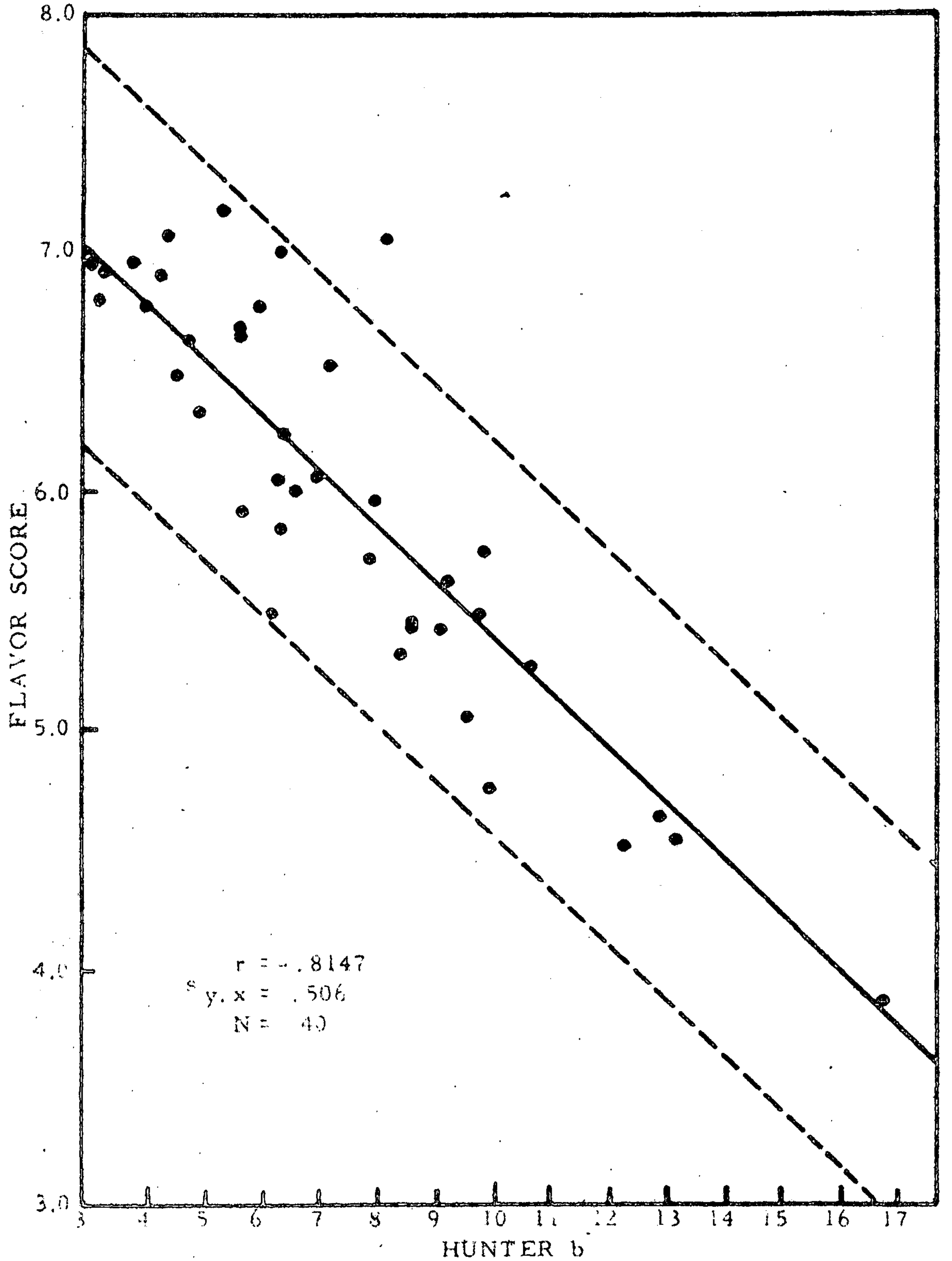

Figure 13. Regression line of flavor score on Hunter "b" of canned fruit skin and 90 per cent confidence interval.

color.

<u>pH of Canned Prunes.</u> As shown in Table 22, the pH values of the canned fruit for the nine harvest dates ranged from 3.19 to 3.45. There seems to be no consistency or pattern in pH changes between the canned fruit during the season.

Appendix Table 13 contains the raw pH data.

The F values from the statistical analysis of variance were not significant.

The correlation coefficient between pH values of the canned fruit and canned fruit flavor is +.5410. This is very low and is not useful for prediction purposes.

<u>Titratable Acidity of Canned Prune Pulp.</u> The titratable acidity of the canned juice and fruit blended together ranged from .558 per cent malic acid for fruit of the first harvest date to .366 in those of the last harvest date. The reduction of acidity in the canned fruit appears to be steady and uniform in canned fruit throughout the harvesting season.

Upon the statistical analysis of variance as shown in Table 23, the L.S.D. of means at the 5 per cent level was .032. Canned fruit of harvest date 1 were significantly different in acidity from those of harvest date 2. Canned fruit of harvest dates 2 and 3 were not significantly different in acidity. Canned fruit of harvest date 2 were

Table 22. Mean pH data of canned prunes for nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	3.26	3.37	3.30	3.34	3.33	3.31	3.33	3.31	3.36
B	3.34	3.28	3.33	3.33	3.36	3.39	3.39	3.36	3.46
C	3.02	3.38	3.37	3.35	3.41	3.39	3.50	3.38	3.50
D	3.04	3.18	3.29	3.36	3.30	3.44	3.50	3.38	3.61
E	3.29	3.35	3.36	3.39	3.19	3.36	3.36	3.16	3.30
Column Means	3.19	3.31	3.33	3.35	3.32	3.38	3.42	3.32	3.45

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	.4935	-----	-----
Trees	4	.0226	.00565	.007 Not sig.
Harvest dates	8	.2150	.026875	.336 Not sig.
Error	32	.2559	.079968	-----

significantly different in acidity from those of harvest date 5. Canned fruit of harvest date 4 differed significantly in acidity from those of harvest date 6. Canned fruit of harvest dates 6, 7 and 8 fell within the same acidity grouping. Canned fruit of harvest date 9 were significantly less acid than those of harvest date 8. The differences in acidity of the fruit of the various harvest dates were significant in more cases than some of the other measured canned fruit characteristics.

Appendix Table 13 contains the titratable acidity raw data.

The correlation coefficient between titratable acidity of the canned fruit and the canned fruit flavor is -.8960 which was rather high. From Figure 14 the regression line, the standard error of estimate of .384 and the 90 per cent confidence limits show per cent malic acid of the canned prune is a precise way to predict canned fruit flavor though the range is very short. Refer to Appendix Table 1 for the regression line equation.

<u>Cut-Out Soluble Solids - Titratable Acidity Ratio of Canned Fruit.</u> The soluble solids-acid ratio of the canned fruit in Table 24 ranged from 41.2 for those of the first harvest date to 70.0 for those of the last harvest date. The increase of the soluble solids-acid ratio in the canned fruit is consistent in direction and fairly uniform in

Table 23. Mean per cent malic acid data of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	.519	.510	.496	.485	.498	.441	.430	.421	.360
B	.527	.484	.474	.476	.430	.423	.410	.409	.370
C	.550	.471	.481	.451	.436	.434	.424	.414	.363
D	.606	.473	.498	.478	.474	.404	.396	.433	.344
E	.589	.563	.454	.498	.471	.501	.504	.464	.395
Column Means	.558	.500	.481	.478	.462	.441	.433	.428	.366

Mean Harvest L.S.D. at 5% level = .032

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F	
Total	44	.1475	-----	-----	
Trees	4	.0137	.003425	5.6799**	Highly sig.
Harvest dates	8	.1145	.0143125	23.7354**	Highly sig.
Error	32	.0193	.000603	-----	

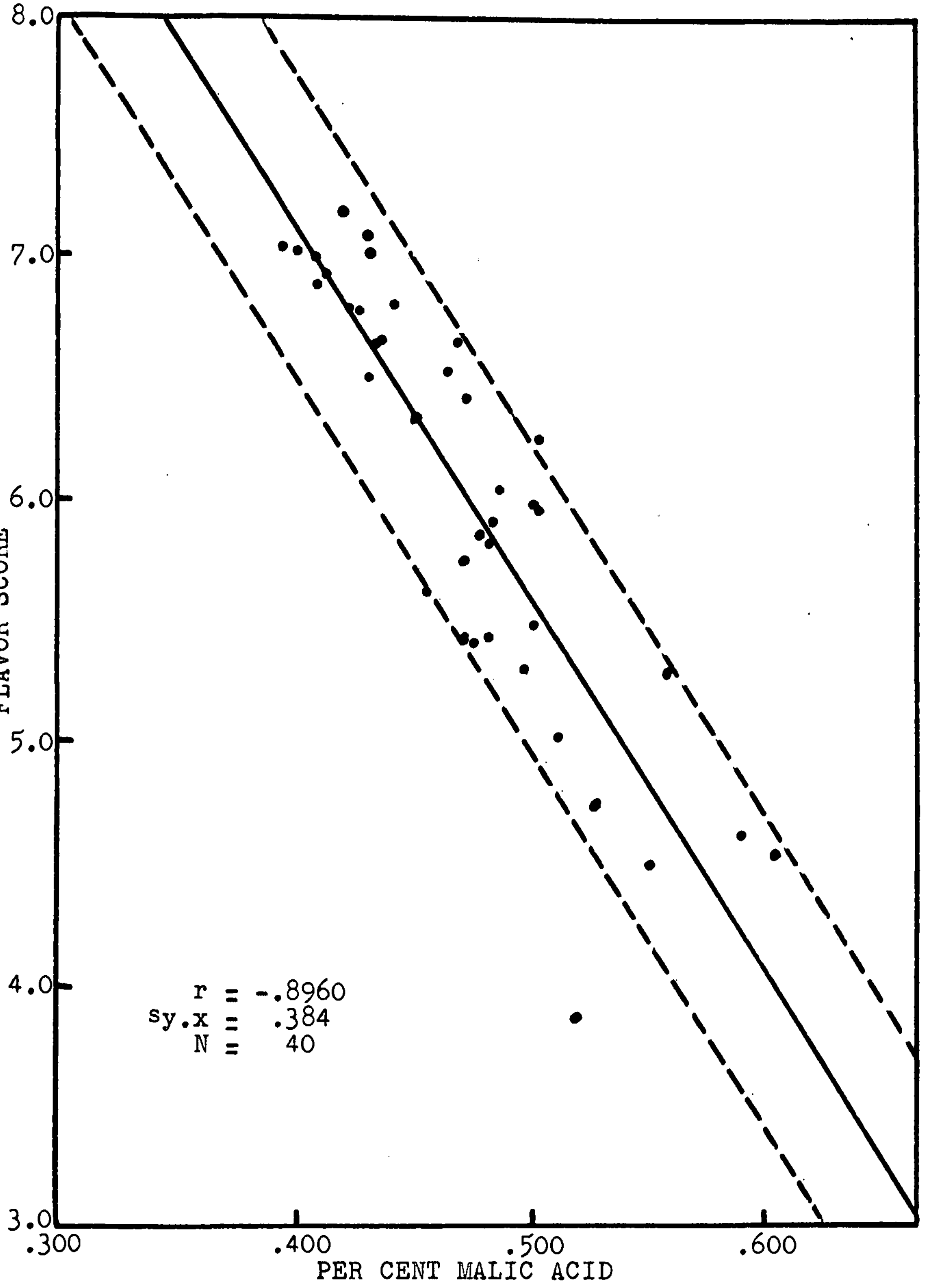

Figure 14. Regression line of flavor score on per cent malic acid of canned fruit and 90 per cent confidence interval.

magnitude all the way through the harvesting period.

After statistical analysis of variance, the L.S.D. of the means at the 5 per cent level is 4.4. Canned fruit of harvest date 1 were significantly different in ratio from those of harvest date 2. Canned fruit of harvest dates 2, 3 and 4 had statistically the same soluble solids-acid ratio. Canned fruits of harvest date 2 were significantly lower in soluble solids-acid ratio than were fruit of harvest date 5. Canned fruit of harvest date 5 were significantly different in soluble solids-acid ratio than those of harvest date 7. Canned fruit of harvest dates 6, 7 and 8 did not appear to show significant differences in soluble solids-acid ratio. Differences in soluble solids-acid ratio in many cases were not significant but the ratio did show a good range in the canned fruit studies and probably merits a closer study.

The correlation coefficient between canned fruit flavor and the soluble solids-acid ratio is +.7794. This appears to be a fairly good correlation but not high enough to make predictions as to the flavor of individual cans of prunes.

Table 24. Mean cut-out soluble solids-acid ratio of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	44.3	43.9	46.8	48.5	47.8	56.9	56.1	55.3	72.5
B	43.5	48.3	49.6	51.7	56.0	57.9	61.9	65.8	68.9
C	42.7	51.4	49.7	52.8	55.3	56.9	61.4	65.9	69.7
D	36.8	51.2	46.8	51.3	52.1	60.4	61.3	62.1	75.0
E	38.9	41.7	53.7	49.0	54.9	49.1	50.5	51.9	64.1
Column Means	41.2	47.3	49.3	50.7	53.2	56.2	58.2	60.2	70.0

Mean Harvest L.S.D. at 5% level = 4.42

Analysis of Variance Calculations

Source of variation	d.f.	Sum of Sqs.	Variance	F
Total	44	3406.04	-----	-----
Trees	4	227.89	56.9725	4.82551** Highly sig.
Harvest dates	8	2800.34	350.0425	29.648** Highly sig.
Error	32	377.81	11.8065	-----

SUMMARY AND CONCLUSIONS

Approximately 200 raw prunes were harvested from each of five Italian prune trees every three days for nine consecutive harvest dates. Thus, the harvesting period was 24 days in length. Forty individual fruit from each tree were drawn at random and subjected to a series of fresh fruit quality tests.

For each quality factor which was measured, the experiments were set up as nine by five factorial analysis of variance studies with the number of observations in a replication depending upon the factor being studied.

The correlation of each objective and subjective test with canned fruit flavor was then calculated. The regression line, standard error of estimate and the 90 per cent confidence limits were calculated for each test which had a correlation of 0.80 or better with canned fruit flavor.

Since the investigation included Italian prunes harvested during only one growing season and in one orchard, the results justify that conclusions be drawn with some probability but with no certainty of their being entirely applicable after a more complete study of the subject.

OBJECTIVE TESTS USED ON RAW PRUNES. Several fresh fruit quality factors are acceptably precise in predicting the canning quality of the Italian prune.

Soluble Solids-Acid Ratio. The soluble solids-acid ratio of the raw prune shows the high correlation of +.9215 with flavor scores of the canned fruit. The standard error of estimate is .334 flavor score units on a 1 to 10 scale. An average soluble solids-acid ratio of 21.5 gave the best canned prune flavor but a range of from 21 to 23 will probably give the most desirable canned fruit. This method will enable the cannery field man to predict the future canning quality of the crop.

Soluble solids-acid ratio of the raw prunes shows excellent three-day precision as a guide to harvest maturity.

Pressure Test. The mean pressure test readings of 40 prunes measuring the firmness of the raw fruit show the high correlation of -.9100 with flavor scores of the canned fruit. The standard error of estimate is .354. A mean pressure test reading of 4.7 on the Ballauf 5/16" tester gave the best canned fruit flavor. The range of pressure test readings from 4.5 to 5.5 should give good canned fruit flavor. The pressure tester has merit for use by the cannery field man as a quick and easy method to predict canned fruit flavor.

Only mean scores of harvest dates 5 and 6 were not significantly different, which indicate this method shows high three-day precision as a guide to harvest maturity.

Per Cent Soluble Solids. The per cent soluble solids of the raw fruit show a high correlation of +.9020 with the canned fruit flavor scores. The standard error of estimate is .372 flavor score units on a 1 to 10 scale. A mean per cent soluble solids value of 16.3 gave the best canned fruit flavor. Per cent soluble solids is a quick and easy method to predict canned fruit flavor.

The only drawback to the use of per cent soluble solids is that it does not seem to be precise as a guide to picking maturity on a three-day basis. It could possibly be used for determining the maturity of fruit harvested at intervals greater than every three days.

Titratable Acidity of the Raw Fruit. The per cent malic acid of the raw prune has the relatively high correlation of -.8592 with canned fruit flavor, but also has a relatively high standard error of estimate of .442.

Its three-day harvesting precision is poor since there is no significant difference in fruit acidity between fruit of harvest dates 5, 6, 7, 8 and 9. Thus, this test has little merit as a guide to harvesting though there is a fairly uniform reduction of per cent malic acid from about 1.10 to .70 in the fresh prune throughout the harvesting season.

Color of the Raw Prune Flesh. The color of the raw prune flesh showed consistent changes on the Hunter "a" scale. These were from -4.9 which is green to +6.0 which is yellow; the other Hunter Color-Color Difference Meter scales, Rd and "b", showed almost no color changes.

The Hunter "a" +10 (the +10, a factor for calculation purposes) readings of the fresh fruit flesh shows a fairly high correlation of +.8139 with canned fruit flavor. The standard error of estimate is .364.

Its use as a guide to harvest by three-day periods is poor but it has possibilities for use on fruit harvested over a greater interval of time.

pH Values. The correlation coefficient between pH values and canned fruit flavor scores is +.6808 which does not appear high enough for flavor prediction purposes.

The three-day precision of pH values to check fresh fruit quality changes proved to be of little value.

Fresh Fruit Weight. The correlation coefficient between fresh fruit weight and the canned fruit flavor scores is +.5433 which is not sufficient for prediction purposes.

The fresh fruit weight of 40 fruit showed a trend toward a numerical peak of 2.6 pounds on the fourth harvest date at pressure test reading of 7.7. Since there were no significant differences between fresh fruit weights of fruit from the third to the seventh harvest dates, it may be said the greatest fresh fruit weight was obtained with a pressure test range of 8.9 to 5.3. The peak of fresh fruit weight on the fourth harvest date had a soluble solids-acid ratio of 16.5. The range of soluble solids-acid ratio with the highest fresh fruit weight was from 14.5 to 20.2. The three-day precision of this test as a guide to maturity is very poor.

SUBJECTIVE TESTS USED ON RAW PRUNES. The method of grading raw prunes by outer skin appearance alone shows a correlation of +.7686 with the canned fruit flavor. This method which attempts to simulate cannery grading belt conditions does not seem a precise way to predict canned fruit quality. As a guide to harvest maturity, the three-day precision appears very low.

RESPIRATION STUDIES. The respiration of the fresh fruit was measured by the CO_2 evolved. The respiration cycle in the Italian prune shows a definite climacteric and this climacteric appears at approximately the same time the fruit harvested exhibit optimum canned fruit flavor and color.

CANNED FRUIT QUALITY TESTS. The remaining lot of fruit after the fresh fruit samples were removed was placed in 32° F. cold storage for processing the next day. Fruit from each tree each harvest date were processed in twelve No. 2 fruit enameled cans for use in canned fruit analysis studies.

OBJECTIVE TESTS USED ON CANNED PRUNES. Several canned quality factors can be used to predict or specify the canned fruit flavor.

Per Cent Transmittance of the Canned Juice. The per cent transmittance of the diluted juice (1 part canned juice to 3 parts distilled water) using a Lumetron filter with a dominant wave length of 530 mμ. shows a high correlation of -.9004 with canned fruit flavor. The standard error of estimate is .373. An average per cent transmittance reading of 38.8 was determined on fruit with the highest flavor score. The mean per cent transmittance for the study ranged from 72.9 to 36.6. This method has merit for use by a company grader desiring to measure the flavor acceptability of canned prunes.

This quality factor has a relatively high precision in showing color differences between fruit harvested every three days.

Canned Fruit Skin Color as Measured by the Hunter Color-Color Difference Meter. The Hunter Rd taken on the skin of canned fruit shows a correlation of +.8971 with canned fruit flavor. The standard error of estimate is .384. Prunes with a mean Hunter Rd value of 2.0 had the most desirable flavor. A company grader could use this value to measure the flavor acceptability of canned prunes.

Its use to show color differences between fruit harvested every three days is poor but it may have application on fruit harvested at greater time intervals, such as four or five days.

The Hunter "b" readings of the canned fruit skin show a correlation of -.8147 with canned fruit flavor. The standard error of estimate, .506 flavor score units, seriously limits the use of this method to predict canned fruit flavor.

This test shows very little difference in skin color of canned fruit harvested every three days.

Titratable Acidity of the Canned Prune Pulp. The per cent malic acid of the canned fruit show a correlation of -.8960 with the canned fruit flavor. The standard error of estimate is .384. Though this is a relatively high correlation coefficient, the short range of the per cent malic acid change, from about .600 to .300, limits the use of this method to predict canned fruit flavor.

Canned fruit harvested every three days for the most part are not significantly different in per cent malic acid.

pH Values, Cut-Out Soluble Solids and Cut-Out Soluble Solids-Acid Ratio. These tests show lower correlations with canned fruit flavor and for the most part show no significant differences between fruit harvested every three days. The cut-out per cent soluble solids-acid ratio may merit closer study because of the wide range, 41.2 to 70.0, shown between the first and last harvest dates.

SUBJECTIVE TESTS USED ON CANNED PRUNES. Color of the Canned Fruit. The mean color score of the fruit as judged by an organoleptic panel, described in section on flavor, on the basis of 1 to 10 ranged from 3.69 the first to 7.15

the eighth harvest date. The ninth harvest date mean score dropped to 7.00. Differences in fruit color of canned fruit between the earlier harvest dates were found to be significant. The panel denoted no significant differences in color between canned fruit of the last four harvest dates but a definite trend is noticeable. Harvest date 8 showed the highest numerical color rating of 7.15.

The correlation coefficient between panel color scores and canned fruit flavor scores is ≠.9458. This is the highest correlation between any quality test and flavor. The standard error of estimate is relatively low, .273 flavor score units, and thus indicates the flavor of canned prunes can be well predicted from color of the canned fruit.

Flavor of the Canned Fruit. The mean flavor score of the canned fruit on the basis of ten points for a "perfect" score ranged from 4.46 the first to 6.93 the eighth harvest date. The ninth harvest date mean score dropped to 6.75. There were significant differences in flavor of the fruit the first few harvest dates but fruit from the last four harvest dates were found not to be significantly different in flavor although the trend showed harvest date 8 had the highest numerical flavor score. There were six to eight judges on each panel. Each tree-harvest sample was tasted four separate times and averaged. The judges were selected by being within the "three sigma" limits of the average of the whole panel each separate tree-harvest date 65 per cent or more of the time. These limits were calculated for the first ten taste-testing periods. After the first ten periods only the qualified judges were asked to taste.

The other subjective and objective tests carried out on the raw and canned prunes were correlated with canned fruit flavor because this factor was felt to be of singular importance in canned prune quality.

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APPENDIX

APPENDIX

Appendix Table 1. Regression equations for Figures 4-8 and Figures 10-14.

<u>Figure 4</u>. Regression line of flavor score on firmness of fresh fruit and 90 per cent confidence interval.
Flavor score = $-.376x + 8.79$.

<u>Figure 5</u>. Regression line of flavor score on Hunter "a" +10 of fresh fruit and 90 per cent confidence interval.
Flavor score = $.1992x + 3.84$.

<u>Figure 6</u>. Regression line of flavor score on per cent soluble solids of fresh fruit and 90 per cent confidence interval.
Flavor score = $.425x - .02$.

<u>Figure 7</u>. Regression line of flavor score on per cent malic acid of fresh fruit and 90 per cent confidence interval.
Flavor score = $-7.39x + 12.4$.

<u>Figure 8</u>. Regression line of flavor score on soluble solids-acid ratio of fresh fruit and 90 per cent confidence interval.
Flavor score = $.216x + 2.39$.

<u>Figure 10</u>. Regression line of flavor score on subjective color score of canned fruit and 90 per cent confidence interval.
Flavor score = $.589x + 2.63$.

<u>Figure 11</u>. Regression line of flavor score on per cent transmittance of canned prune juice and 90 per cent confidence interval.
Flavor score = $.0681x + 2.39$.

<u>Figure 12</u>. Regression line of flavor score on Hunter Rd of canned fruit skin and 90 per cent confidence interval.
Flavor score = $.683x + 7.93$.

<u>Figure 13</u>. Regression line of flavor score on Hunter "b" of canned fruit skin and 90 per cent confidence interval.
Flavor score = $.231x + 7.7$.

<u>Figure 14</u>. Regression line of flavor score on per cent malic acid of canned fruit and 90 per cent confidence interval.
Flavor score = $15.35x + 13.27$.

Appendix Table 2. Mean Hunter "a" data of 40 raw prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	-5.35	-3.15	-0.05	+2.53	+2.53	+3.18	+4.88	+5.23	+8.23
B	-3.88	-4.00	-1.33	-1.13	+4.10	+5.45	+6.08	+5.05	+4.80
C	-5.18	-3.03	-1.40	+2.83	+2.63	+5.30	+6.05	+4.58	+6.13
D	-6.08	-4.58	-2.30	-0.15	+0.95	+4.05	+4.43	+5.58	+5.15
E	-4.08	-3.28	-2.63	-1.70	+4.73	+1.65	+1.63	+5.15	+5.83
Column Means	-4.91	-3.61	-1.54	+0.48	+2.99	+3.93	+4.61	+5.12	+6.03

Appendix Table 3. Raw per cent soluble solids data of fresh prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	10.9	12.2	12.3	13.8	14.4	16.4	14.5	17.1	16.4
	10.4	12.5	12.1	14.4	14.5	16.4	15.2	17.5	16.4
	10.8	11.7	12.0	14.4	14.5	16.4	14.8	17.0	16.5
	10.9	12.3	12.3	14.5	14.9	16.9	15.3	16.8	16.3
Tree B	12.4	12.4	12.3	15.4	14.6	16.4	16.5	18.4	18.5
	12.0	11.6	12.5	14.5	14.6	16.9	17.3	17.8	18.5
	12.2	12.0	12.2	13.4	14.5	16.4	16.6	16.8	18.5
	12.4	12.0	12.4	13.6	14.5	16.5	17.0	17.2	17.6
Tree C	11.8	12.2	14.2	12.9	15.5	15.6	16.9	16.3	16.5
	11.6	12.3	13.4	13.2	15.1	15.9	15.7	16.0	16.3
	11.4	12.4	13.1	13.5	15.4	15.8	16.1	16.8	16.2
	11.4	12.3	13.1	13.5	15.5	15.8	16.8	16.4	16.3
Tree D	11.4	12.3	12.5	13.4	14.5	15.2	15.6	14.9	15.5
	11.4	11.9	12.7	13.6	15.4	15.4	15.7	14.4	15.8
	10.9	12.2	12.8	13.9	15.4	15.3	15.6	14.7	15.9
	12.0	11.9	12.9	14.2	15.9	15.5	15.9	14.8	16.3
Tree E	12.9	12.5	13.2	13.4	14.5	14.5	14.8	15.3	15.3
	12.7	12.8	13.6	13.5	14.3	14.1	14.4	15.4	15.7
	12.4	12.9	13.3	13.6	14.3	14.4	14.8	15.5	15.3
	12.4	12.8	13.4	14.1	15.1	14.4	15.0	15.9	15.2

Appendix Table 4. Raw pH data of fresh prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	3.19 3.17	3.40 3.40	3.31 3.31	3.40 3.35	3.50 3.48	3.39 3.39	3.48 3.48	3.40 3.45	3.52 3.50
Tree B	3.17 3.18	3.39 3.31	3.35 3.36	3.35 3.40	3.45 3.40	3.50 3.45	3.42 3.50	3.54 3.55	3.51 3.50
Tree C	3.10 3.12	3.40 3.40	3.35 3.35	3.40 3.42	3.40 3.41	3.40 3.38	3.48 3.48	3.50 3.50	3.51 3.56
Tree D	3.15 3.18	3.40 3.40	3.50 3.50	3.51 3.51	3.51 3.45	3.40 3.40	3.50 3.50	3.39 3.41	3.60 3.60
Tree E	3.41 3.41	3.60 3.41	3.35 3.50	3.46 3.30	3.50 3.51	3.50 3.45	3.50 3.50	3.51 3.52	3.58 3.58

Appendix Table 5. Raw per cent malic acid data of fresh prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	.985	.981	.848	.852	.867	.842	.792	.764	.660
	.981	.958	.862	.844	.859	.818	.798	.740	.662
Tree B	1.040	.986	.898	.852	.821	.790	.776	.771	.762
	.980	.942	.858	.868	.833	.808	.764	.759	.746
Tree C	1.090	1.010	.913	.829	.814	.799	.786	.798	.701
	1.050	.999	.931	.825	.810	.791	.787	.796	.721
Tree D	1.230	1.010	.916	.860	.834	.798	.772	.759	.610
	1.150	.975	.910	.846	.828	.808	.772	.749	.622
Tree E	.946	.930	.880	.832	.797	.819	.790	.729	.673
	.958	.942	.865	.820	.795	.715	.760	.719	.671

Appendix Table 6. Subjective color scores of canned prunes during the nine harvest dates by panel averages.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	3.00	3.56	5.17	5.56	5.50	7.78	7.83	7.83	7.78
	3.00	4.11	4.38	6.11	4.69	8.11	6.94	7.44	6.88
	2.17	4.14	5.56	5.78	5.15	7.93	7.25	7.64	6.67
	2.50	3.05	4.66	5.87	4.74	7.30	7.23	6.96	6.76
Tree B	4.43	3.89	5.28	7.00	6.33	7.22	6.86	7.33	6.71
	4.70	4.50	4.90	4.88	5.25	6.81	7.55	7.25	7.30
	4.61	3.90	4.90	6.12	6.20	7.20	7.52	7.39	6.67
	4.04	3.76	4.57	5.20	5.71	7.06	7.44	7.17	6.74
Tree C	4.43	5.29	5.14	6.29	6.57	7.86	7.00	6.86	6.71
	4.50	5.50	4.83	6.75	6.54	7.19	7.19	7.00	7.19
	3.50	4.60	5.11	6.93	6.92	7.14	7.26	7.14	6.67
	3.33	4.62	5.50	7.22	6.46	6.67	7.19	6.44	6.59
Tree D	4.21	4.75	4.86	6.31	5.86	6.38	7.14	7.63	7.86
	4.21	4.30	5.40	6.35	7.20	6.80	6.10	7.00	7.50
	4.05	3.81	4.50	6.20	6.41	6.57	6.90	7.19	7.14
	3.93	4.94	5.36	6.87	7.26	7.66	7.57	7.37	6.87
Tree E	2.13	3.33	3.50	4.89	5.81	5.06	6.25	6.78	7.25
	3.55	3.75	4.65	5.55	6.80	5.44	6.23	7.00	6.78
	3.35	3.56	4.43	6.06	5.94	6.00	6.65	6.55	6.65
	4.11	4.54	4.43	5.89	6.07	5.61	6.26	6.89	7.27

Appendix Table 7. Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree A Harvest	1	2	3	4	5	6	7	8	9
Judge 1	1.0	2.0	4.0	5.0	5.0	8.0	9.0	8.0	8.0
	3.0	4.0	5.0	6.0	5.5	8.0	6.5	7.0	7.0
	3.0	4.0	5.0	6.0	5.5	8.0	6.5	7.0	8.0
	1.0	4.0	6.0	6.0	5.0	8.0	6.0	8.0	6.0
Judge 2	3.0	5.0	5.0	6.0	5.0	9.0	8.0	8.0	8.0
	4.0	5.0	5.0	6.0	5.0	8.0	7.0	7.0	6.0
	4.0	4.0	5.0	6.2	5.0	7.6	7.0	8.0	8.0
	4.0	---	6.6	---	8.0	---	8.0	8.0	---
Judge 3	4.0	4.0	5.0	5.0	6.0	8.0	8.0	8.0	8.0
	3.0	3.0	4.0	6.0	4.0	8.0	6.0	8.0	6.0
	3.0	3.0	4.0	6.0	4.0	8.0	6.0	8.0	8.0
Judge 4	3.0	4.0	5.0	5.0	6.0	7.0	8.0	7.0	8.0
	3.0	4.0	4.0	6.0	5.0	8.0	8.0	7.0	6.0
	3.0	4.0	4.0	6.0	5.0	8.0	8.0	7.0	6.0
	2.0	4.0	5.0	5.5	4.5	7.5	8.0	8.0	7.2
Judge 5	4.0	4.0	5.0	6.0	5.0	8.0	7.0	7.0	7.0
	5.0	5.0	6.0	6.0	6.0	8.0	8.0	7.5	6.0
	4.0	5.0	5.0	6.0	5.0	8.0	7.0	7.0	7.5
	3.0	4.0	---	6.0	---	8.0	---	---	7.5
Judge 6	---	4.0	3.0	5.0	4.0	6.0	7.0	7.0	6.0
	---	3.0	5.0	5.0	5.0	7.0	6.5	6.0	5.0
	---	---	4.0	---	4.0	---	7.0	---	6.0
	---	---	---	---	---	---	---	---	6.0

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree A Harvest	1	2	3	4	5	6	7	8	9
Judge 7	4.0	5.0	5.0	6.0	5.0	8.0	6.0	8.0	6.0
	4.0	4.0	5.0	5.0	5.0	7.0	7.0	7.0	6.0
	4.0	3.0	5.0	5.0	4.0	6.0	7.0	7.0	6.0
	---	---	4.0	---	5.0	---	7.0	6.0	---
Judge 8	2.0	4.0	4.0	5.0	4.0	10.0	7.0	8.0	10.0
	---	4.0	---	6.0	---	8.0	---	---	8.0
	---	3.0	---	7.0	---	8.0	---	---	---
Judge 9	---	3.0	4.0	6.0	4.0	9.0	8.0	8.0	6.0
	---	3.0	---	6.0	---	8.0	---	8.0	---
Judge 10	---	---	6.0	---	6.0	---	8.0	8.0	8.0
Judge 11	1.5	2.0	4.0	5.0	5.0	7.0	7.0	7.0	7.0
	1.0	---	4.0	---	3.0	---	7.0	5.0	6.0
	---	---	3.5	---	---	---	---	---	---
Judge 12	3.0	3.0	6.0	5.0	8.0	8.0	7.0	7.0	8.0
	4.0	3.0	---	7.0	---	8.0	---	8.0	8.0
Judge 13	---	3.0	---	4.0	---	8.0	---	8.0	7.0
	---	5.0	---	6.0	---	7.0	---	7.0	---
Judge 14	3.0	5.0	6.0	7.0	4.0	9.0	7.0	8.0	5.0

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree B Harvest	1	2	3	4	5	6	7	8	9
Judge 1	5.0	2.0	5.5	6.0	6.0	7.0	7.5	7.0	7.0
	4.0	3.0	5.0	4.0	4.0	5.0	7.5	7.0	6.0
	6.0	4.0	5.5	6.0	5.5	7.0	8.0	7.5	7.0
	---	---	---	---	6.5	---	---	---	---
Judge 2	5.0	5.0	6.0	8.0	6.0	7.0	7.0	8.0	7.0
	5.0	5.0	5.0	5.0	6.0	8.0	8.0	8.0	8.0
	6.0	6.0	6.0	7.0	7.0	8.0	7.0	8.0	7.0
	6.5	6.0	5.0	6.6	7.0	7.6	8.0	7.6	8.0
Judge 3	4.0	4.0	5.0	8.0	7.0	7.0	7.0	8.0	7.0
	4.0	5.0	4.0	5.0	5.0	7.0	8.0	8.0	8.0
	4.0	3.0	4.0	5.0	6.0	7.0	7.0	8.0	8.0
Judge 4	4.0	4.0	5.0	8.0	5.0	8.0	6.0	7.0	7.0
	5.0	4.1	5.0	6.1	6.0	7.8	8.0	8.0	7.0
	3.5	4.3	5.0	5.8	5.5	7.8	8.2	7.6	6.5
	2.8	---	4.0	---	---	---	7.1	---	6.0
Judge 5	5.0	5.0	5.0	7.0	6.0	8.0	6.0	7.0	7.0
	5.0	4.0	5.0	7.0	6.8	8.0	8.0	7.5	7.0
	6.0	---	5.0	---	---	---	8.0	6.0	7.0
Judge 6	4.0	5.0	4.0	7.0	7.0	7.0	5.0	6.0	7.0
	---	4.0	5.0	7.0	---	6.0	---	6.0	---
	---	3.0	---	5.0	---	6.5	---	---	---

Appendix Table 7. (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree B Harvest	1	2	3	4	5	6	7	8	9
Judge 7	5.0	4.0	6.0	5.0	6.0	7.0	7.0	8.0	7.0
	5.0	4.0	5.0	5.0	6.0	6.0	6.0	7.0	7.0
	5.0	4.0	4.5	6.0	6.0	7.0	7.0	6.0	5.2
	---	3.0	4.5	5.0	---	7.0	---	6.0	---
Judge 8	5.0	3.0	5.5	7.0	8.0	7.0	8.0	7.0	7.0
	---	5.0	5.5	5.0	6.0	7.5	---	7.0	---
Judge 9	4.0	4.0	5.0	5.0	5.0	7.0	7.0	8.0	6.0
	4.0	3.0	4.0	5.0	6.0	7.0	8.0	8.0	5.0
	3.0	---	---	---	5.0	---	8.0	---	5.0
Judge 10	5.0	4.0	---	5.0	6.5	7.5	7.0	8.0	8.0
Judge 11	4.0	3.0	3.0	6.0	5.0	7.0	7.0	7.0	5.5
	5.0	3.0	---	4.0	4.0	6.0	7.0	7.0	7.0
Judge 12	4.0	5.0	4.0	5.0	5.0	8.0	9.0	7.0	8.0
	---	3.0	4.0	5.0	---	---	---	8.0	---
Judge 13	5.0	---	5.0	---	7.0	7.0	8.0	---	7.0
	3.0	---	---	---	---	---	7.0	---	7.0
Judge 14	5.0	6.0	---	---	---	---	8.0	---	7.0
	---	6.0	---	---	---	---	---	---	---

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree C Harvest	1	2	3	4	5	6	7	8	9
Judge 1	3.0	5.0	5.0	6.0	7.0	8.0	9.0	7.0	6.0
	3.5	6.0	4.0	7.0	6.0	7.0	7.0	7.0	7.5
	4.0	5.0	5.0	6.5	6.5	6.5	7.5	7.0	6.0
	3.0	5.0	6.0	7.0	6.0	7.0	6.5	6.5	7.5
Judge 2	5.0	5.0	6.0	7.0	8.0	8.0	7.0	6.0	7.0
	5.0	6.0	6.0	8.0	8.0	8.0	8.0	7.0	7.0
	5.0	6.0	6.5	7.0	---	7.0	7.0	7.0	6.5
	5.0	6.6	---	7.6	---	7.0	---	7.0	---
Judge 3	3.0	6.0	4.0	8.0	6.0	8.0	8.0	7.0	7.0
	4.0	3.0	4.0	7.0	6.0	8.0	7.0	7.0	8.0
	---	---	6.0	---	8.0	---	8.0	---	7.0
Judge 4	4.0	6.0	4.0	5.0	6.0	8.0	8.0	7.0	7.0
	4.0	5.0	5.0	6.0	6.0	7.5	7.0	7.0	8.0
	3.0	4.2	5.0	6.6	6.8	7.0	7.8	7.5	7.0
	3.0	4.0	5.0	7.0	6.6	6.6	7.2	6.8	6.2
Judge 5	4.0	4.0	5.0	6.0	7.0	7.0	6.0	7.0	7.0
	5.0	4.0	5.5	7.0	6.0	7.5	7.0	7.0	6.5
	4.0	6.0	---	7.0	6.5	6.0	---	7.5	---
	4.0	4.0	---	---	---	---	---	---	---
Judge 6	---	5.0	7.0	6.0	7.0	7.0	5.0	7.0	5.0
	---	5.0	5.0	7.0	7.0	7.0	7.0	7.0	5.0
	---	5.0	6.0	7.0	8.0	7.0	6.0	7.0	7.0
	---	5.0	---	6.0	---	7.0	6.0	---	6.0

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree C Harvest	1	2	3	4	5	6	7	8	9
Judge 7	6.0	5.0	5.0	6.0	6.0	8.0	8.0	6.0	7.0
	5.0	4.5	4.0	8.0	6.0	7.0	6.5	7.0	6.0
	---	---	5.0	---	7.0	---	7.0	6.0	5.5
	---	---	5.0	---	6.0	---	---	---	---
Judge 8	6.0	7.0	6.0	8.0	7.0	9.0	5.0	8.0	8.0
	---	6.0	---	7.0	---	6.0	7.5	---	8.0
Judge 9	---	---	5.0	---	7.0	---	8.0	---	6.0
	---	---	5.0	---	6.0	---	8.0	---	5.0
Judge 10	6.0	5.0	6.0	7.5	8.0	7.0	7.5	7.0	8.0
	---	4.5	5.0	7.5	7.0	6.0	7.0	6.5	7.5
	---	---	5.0	---	6.0	---	---	---	---
Judge 11	3.0	3.0	4.0	7.0	6.0	6.0	7.0	7.0	6.0
	3.0	---	4.0	---	5.0	---	---	6.0	8.0
	3.5	---	5.0	---	6.0	---	---	---	---
Judge 12	5.0	5.0	---	7.0	---	7.0	8.0	---	7.0
	5.0	---	---	---	---	7.0	---	---	---
Judge 13	5.0	5.0	5.0	5.0	6.0	7.0	7.0	7.0	7.0
	---	5.0	---	8.0	6.0	7.0	---	7.0	---
Judge 14	---	---	---	---	---	---	---	---	---

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree D Harvest	1	2	3	4	5	6	7	8	9
Judge 1	3.0	5.0	5.0	6.5	6.0	6.0	7.0	7.0	8.0
	3.0	2.0	6.0	7.5	7.5	7.0	6.5	7.0	8.0
	4.0	5.0	5.0	6.5	6.5	7.0	7.5	7.5	7.0
	5.0	4.0	5.5	7.5	7.5	7.5	---	8.0	6.0
Judge 2	5.0	6.0	5.0	7.0	6.0	7.0	8.0	8.0	8.0
	5.0	6.0	6.0	7.0	8.0	7.0	7.0	7.0	8.0
	5.0	6.0	6.0	6.8	6.4	7.4	6.8	8.0	7.5
	5.0	6.4	6.0	7.0	7.0	8.0	7.0	7.8	7.0
Judge 3	3.0	3.0	4.0	5.0	4.0	5.0	7.0	7.0	8.0
	4.0	5.0	---	7.0	8.0	8.0	7.0	6.0	---
	3.0	---	---	---	---	---	---	---	---
Judge 4	3.5	4.0	5.0	7.0	6.0	7.0	7.0	8.0	8.0
	3.5	4.0	5.0	6.0	7.0	7.0	8.0	7.0	8.0
	4.5	3.5	4.5	6.8	6.5	7.1	7.0	7.5	8.0
	2.5	4.5	5.0	5.6	6.8	7.6	7.5	6.9	6.1
Judge 5	4.0	5.0	5.0	6.0	6.0	7.0	7.0	8.0	7.0
	4.0	4.0	5.0	6.0	7.0	7.0	8.0	7.0	8.0
	4.0	4.0	4.0	6.5	6.5	7.0	7.0	7.5	7.5
	4.0	---	5.0	---	7.5	---	7.0	---	8.0
Judge 6	4.0	5.0	6.5	7.0	6.0	7.0	6.0	7.0	5.0

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree D Harvest	1	2	3	4	5	6	7	8	9
Judge 7	5.0	5.0	5.0	6.0	6.0	6.0	7.0	7.0	8.0
	5.0	4.0	5.0	5.0	7.0	6.0	6.0	7.0	8.0
	4.0	4.0	5.0	5.0	6.0	7.0	8.0	6.0	7.0
	5.0	5.7	---	6.5	---	7.5	---	6.4	---
Judge 8	6.0	5.0	6.0	7.0	7.0	7.0	7.0	8.0	8.0
	5.0	---	---	---	---	---	---	---	---
Judge 9	3.0	3.0	5.0	7.0	9.0	6.0	7.0	6.0	6.0
	---	---	5.0	---	7.0	---	8.0	---	---
Judge 10	5.0	5.0	5.5	7.0	6.0	6.0	6.0	7.0	6.0
	3.0	5.0	4.0	7.5	6.0	8.0	6.0	7.0	---
Judge 11	4.0	3.0	6.0	6.0	7.0	6.0	7.0	7.0	8.0
	3.0	2.0	3.0	6.0	7.0	6.0	7.0	7.0	6.0
	---	---	5.0	---	6.0	---	7.0	---	6.0
Judge 12	---	4.0	---	5.0	---	6.0	---	6.0	7.0
Judge 13	---	3.0	4.0	5.0	6.0	5.0	6.0	8.0	7.0
	---	4.0	---	7.0	---	7.0	---	8.0	---
Judge 14	---	5.0	6.0	6.0	8.0	6.0	9.0	8.0	9.0
	---	6.0	---	7.0	---	8.0	---	8.0	9.0

Appendix Table 7 (Continued). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree E Harvest	1	2	3	4	5	6	7	8	9
Judge 1	2.0	2.0	3.0	4.0	6.5	6.0	6.5	6.0	7.0
	2.0	4.0	4.0	5.5	6.5	5.5	6.0	6.5	7.0
	5.0	2.0	5.5	6.0	6.0	5.5	6.0	6.0	6.5
	5.0	5.0	---	6.0	---	5.0	---	7.0	---
Judge 2	3.0	4.0	5.0	5.0	6.0	6.0	6.5	7.0	7.0
	5.0	6.0	6.0	6.8	7.0	6.0	7.0	7.0	7.0
	4.0	6.0	5.0	6.4	6.4	6.8	7.0	7.5	7.0
	5.0	---	6.0	---	7.0	---	7.0	---	8.0
Judge 3	3.0	3.0	4.0	5.0	5.0	6.0	6.0	8.0	7.0
	3.0	---	4.0	---	7.0	5.0	5.0	8.0	8.0
	3.0	---	4.0	---	6.0	---	7.0	---	7.0
Judge 4	3.0	3.0	5.0	4.0	7.0	6.0	7.0	7.0	8.0
	3.5	3.5	4.5	5.8	7.0	6.0	6.5	7.0	8.0
	3.0	3.0	4.3	6.2	6.0	6.0	7.5	6.8	7.0
	3.5	3.8	3.5	4.8	5.8	6.2	6.8	7.0	7.5
Judge 5	4.0	4.0	5.0	6.0	7.0	6.0	6.0	7.0	7.0
	3.5	4.0	4.5	6.0	6.0	6.0	6.0	7.0	6.5
	4.0	4.0	5.0	6.0	7.0	6.0	7.0	6.5	7.5
	---	4.0	---	6.0	---	5.0	---	6.5	---
Judge 6	2.0	4.0	3.0	5.0	4.0	5.5	5.0	6.5	7.0
	3.0	3.0	4.0	5.0	6.5	6.0	7.0	6.0	6.0
	3.0	---	4.0	---	6.0	6.5	6.5	6.5	6.0

Appendix Table 7 (Concluded). Subjective color scores of canned prunes for each tree-harvest date by individual judges.

Tree E Harvest	1	2	3	4	5	6	7	8	9
Judge 7	4.0	4.0	5.0	5.0	6.0	6.0	7.0	7.0	8.0
	4.0	4.0	5.0	5.0	7.0	5.0	6.0	8.0	7.0
	4.0	4.0	5.0	7.0	6.0	6.0	6.0	7.0	7.0
	5.3	5.0	5.5	6.0	6.2	5.5	7.0	6.0	7.4
Judge 8	2.0	3.0	3.0	5.0	6.0	5.0	6.0	6.0	7.0
Judge 9	3.0	3.0	4.0	5.0	6.0	5.0	6.0	7.0	7.0
	2.0	---	3.0	---	6.0	---	5.0	---	6.0
	---	---	4.0	---	7.0	---	---	---	---
Judge 10	5.0	4.0	6.0	6.0	7.0	6.0	8.0	7.0	7.0
	3.0	3.0	5.0	6.5	6.5	6.0	---	6.5	6.5
	4.0	4.5	---	6.0	---	6.0	---	7.0	7.5
Judge 11	3.0	3.0	4.0	5.0	7.0	4.0	5.0	6.0	6.0
	3.0	---	4.0	6.0	5.0	6.0	6.5	7.0	6.0
	3.0	---	3.0	---	6.0	---	---	---	7.0
Judge 12	2.0	3.0	5.0	5.0	6.0	5.0	6.0	7.0	7.0
Judge 13	---	4.0	---	6.0	---	5.0	---	7.0	---
Judge 14	---	---	---	---	---	---	---	---	---

Appendix Table 8. Subjective flavor scores of canned prunes during the nine harvest dates by panel averages.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	4.20	4.63	5.00	5.89	5.00	6.63	6.80	7.20	5.88
	4.25	4.70	5.00	6.00	5.29	7.20	7.11	7.37	7.00
	3.60	5.58	6.06	6.10	5.96	7.27	6.95	6.83	6.15
	3.43	5.22	5.09	5.62	5.66	6.34	7.10	7.29	6.11
Tree B	5.33	5.00	5.67	6.88	7.25	7.25	6.70	6.75	7.17
	5.00	5.43	5.78	5.43	6.57	6.86	7.00	7.00	7.28
	4.62	5.56	5.67	5.87	6.44	6.91	6.88	7.25	6.83
	4.04	5.75	4.51	5.17	5.71	6.13	7.00	6.95	6.74
Tree C	4.91	5.83	5.33	6.17	7.00	6.17	6.60	7.33	6.83
	5.44	6.13	6.13	6.19	7.00	6.75	6.77	6.25	7.00
	4.03	5.36	5.81	6.86	6.63	7.09	6.88	7.31	7.03
	3.60	5.69	5.63	6.11	6.08	6.50	6.85	6.75	6.50
Tree D	4.33	5.00	5.33	5.57	6.00	6.86	7.00	7.43	7.33
	4.58	6.22	5.67	6.33	7.22	7.33	7.08	6.83	6.44
	4.50	4.61	5.13	5.98	6.50	6.79	7.06	6.64	6.47
	4.68	5.86	5.77	6.24	6.99	7.04	7.02	7.41	6.46
Tree E	3.85	4.88	5.71	6.00	6.86	5.00	6.27	6.50	7.07
	5.52	5.50	6.00	5.90	6.14	6.13	6.30	6.23	6.69
	4.84	5.37	5.12	5.40	6.17	6.36	6.20	6.20	6.68
	4.52	5.38	5.79	6.65	6.50	6.37	6.24	7.19	7.37

Appendix Table 9. Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree A Harvest	1	2	3	4	5	6	7	8	9
Judge 1	5.0	6.0	5.0	7.0	5.0	5.0	4.0	7.0	6.0
	5.0	6.0	6.0	6.0	6.0	7.0	6.5	7.0	8.0
	1.0	4.0	5.0	6.0	5.0	7.0	6.0	7.0	7.0
	1.0	6.0	5.0	7.0	6.0	7.0	6.5	8.0	5.0
Judge 2	4.0	5.0	5.0	6.0	5.0	7.0	6.0	8.0	4.0
	5.0	6.0	6.0	6.6	6.7	7.6	6.5	8.0	7.2
	5.6	6.5	5.8	6.0	6.8	7.0	6.2	6.4	---
	5.6	---	---	---	---	---	---	8.0	---
Judge 3	4.0	4.0	4.0	5.0	4.0	8.0	7.0	9.0	8.0
	2.0	4.0	3.0	6.0	4.0	7.0	6.0	8.0	8.0
Judge 4	3.0	5.0	5.0	4.0	5.0	8.0	8.0	7.0	6.0
	4.0	5.0	4.5	5.6	6.0	8.0	7.5	7.0	6.2
	3.0	3.6	4.8	4.5	6.2	8.0	7.8	7.5	6.1
	3.0	4.5	---	6.0	---	7.1	---	7.6	---
Judge 5	5.0	5.0	6.0	6.0	7.0	7.0	5.0	6.0	7.0
	5.0	5.0	7.0	7.0	6.0	7.0	4.0	6.0	6.0
	5.0	5.0	5.0	6.0	6.0	6.0	6.0	7.0	8.0
	---	---	---	---	---	---	6.0	---	---
Judge 6	---	4.0	6.0	7.0	6.0	7.0	6.0	7.0	5.0
	---	4.0	5.0	6.0	6.0	7.0	4.0	---	7.0
	---	6.0	---	---	---	---	---	---	5.0
Judge 7	Did not judge flavor.								

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree A Harvest	1	2	3	4	5	6	7	8	9
Judge 8	5.0 ---	5.0 5.0	6.0 ---	7.0 6.0	3.0 ---	7.0 7.0	5.0 ---	7.0 ---	7.0 8.0
Judge 9	--- --- ---	4.0 3.0 ---	4.0 --- ---	5.0 5.0 ---	4.0 --- ---	6.0 7.0 ---	4.0 --- ---	8.0 6.0 ---	7.0 --- 7.0
Judge 10	---	---	---	---	---	---	---	---	---
Judge 11	4.0 6.0	5.0 ---	7.0 6.0	3.0 ---	6.0 4.0	4.0 ---	3.0 7.0	6.0 ---	7.0 5.0
Judge 12	7.0 6.0	5.0 4.0	5.0 ---	5.0 5.0	4.0 ---	6.0 6.0	6.0 ---	8.0 ---	8.0 8.0
Judge 13	--- --- ---	5.0 5.0 7.0	8.0 --- ---	7.0 7.0 6.0	8.0 --- ---	7.0 8.0 6.0	8.0 --- ---	6.0 8.0 ---	3.0 5.0 ---
Judge 14	5.0	6.0	---	6.0	---	7.0	---	9.0	---

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree B Harvest	1	2	3	4	5	6	7	8	9
Judge 1	5.0	7.0	7.0	6.0	7.0	7.0	7.0	8.0	7.5
	4.0	5.0	7.0	6.0	8.0	6.0	6.5	7.0	5.0
	6.5	5.0	6.0	6.0	6.5	6.0	7.0	7.0	7.5
	---	---	---	---	7.0	---	---	---	---
Judge 2	7.0	5.0	5.0	6.0	8.0	6.0	5.0	6.0	8.0
	5.0	5.0	6.0	7.0	7.0	7.0	6.0	8.0	8.0
	8.0	6.0	6.6	6.0	7.5	6.5	6.0	7.0	8.0
	---	7.0	5.0	6.2	---	6.8	---	7.6	---
Judge 3	7.0	7.0	7.0	4.0	8.0	8.0	4.0	4.0	7.0
	4.0	7.0	4.0	8.0	7.0	8.0	6.0	7.0	8.0
	4.0	4.0	4.0	4.0	5.0	8.0	8.0	8.0	8.0
Judge 4	3.0	4.0	5.0	4.0	8.0	7.0	8.0	7.0	6.0
	5.0	4.5	4.0	6.0	7.0	6.8	6.0	8.0	7.0
	4.1	4.5	5.0	5.5	6.4	6.5	7.8	7.6	6.0
	1.0	---	6.1	---	---	---	7.2	---	7.1
Judge 5	6.0	6.0	5.0	8.0	7.0	8.0	5.0	6.0	6.0
	5.0	5.0	7.0	6.0	7.0	7.0	6.0	6.0	6.0
	5.0	---	6.0	---	---	---	7.0	---	---
Judge 6	5.0	5.0	6.0	6.0	7.0	6.0	6.0	7.0	5.0
	---	5.0	6.0	7.0	---	6.0	---	7.0	5.0
	---	6.0	---	7.0	---	6.5	---	7.0	---
Judge 7	Did not judge flavor.								

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree B Harvest	1	2	3	4	5	6	7	8	9
Judge 8	6.0 ---	5.0 3.0	6.0 6.0	5.0 7.0	8.0 7.0	9.0 6.0	7.0 ---	9.0 6.0	9.0 ---
Judge 9	5.0 4.0 5.0	4.0 4.0 ---	7.0 4.0 ---	6.0 6.0 ---	5.0 7.0 6.0	6.0 7.0 ---	4.0 6.0 7.0	7.0 8.0 ---	8.0 8.0 6.0
Judge 10	5.0 ---	5.0 ---	--- ---	7.0 ---	6.0 7.0	6.0 ---	6.5 4.0	6.5 ---	7.0 7.0
Judge 11	4.0 6.0	7.0 ---	3.0 ---	3.0 ---	7.0 ---	5.0 ---	6.0 ---	6.0 ---	6.5 ---
Judge 12	5.0 ---	6.0 5.0	6.0 5.0	5.0 4.0	6.0 ---	8.0 6.0	5.0 ---	7.0 7.0	7.0 ---
Judge 13	6.0 6.0	--- ---	5.0 ---	--- ---	6.0 7.0	--- ---	7.0 5.0	--- ---	8.0 8.0
Judge 14	5.0 ---	--- ---	6.0 7.0	--- ---	--- ---	--- ---	6.0 ---	--- ---	8.0 ---

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree C Harvest	1	2	3	4	5	6	7	8	9
Judge 1	5.5	4.0	6.0	6.0	7.0	6.0	6.0	9.0	8.0
	5.0	6.0	5.0	6.0	6.0	7.0	6.0	7.0	7.5
	3.0	6.0	6.0	7.0	7.0	7.0	7.0	7.0	8.0
	3.0	6.0	6.0	6.5	6.5	6.5	---	7.5	5.0
Judge 2	6.0	7.0	5.0	6.0	4.0	5.0	6.0	8.0	9.0
	5.0	7.0	6.0	6.0	7.0	7.0	5.0	6.0	8.0
	6.2	7.0	6.0	6.0	---	7.0	6.0	8.0	8.5
	5.0	6.0	---	6.8	---	6.2	6.6	7.2	---
Judge 3	4.0	7.0	4.0	7.0	8.0	7.0	5.0	7.0	7.0
	5.0	3.0	4.0	8.0	8.0	8.0	7.0	8.0	8.0
	---	4.0	6.0	4.0	8.0	---	6.0	---	8.0
Judge 4	4.5	4.0	5.0	5.0	7.0	6.0	6.0	8.0	8.0
	4.5	5.0	5.0	6.5	7.0	7.0	7.0	6.0	6.0
	4.0	4.5	4.5	6.5	6.0	7.6	7.5	7.2	6.2
	4.0	4.5	5.5	6.1	6.3	6.8	7.3	7.2	6.5
Judge 5	5.0	7.0	6.0	6.0	7.0	5.0	5.0	7.0	6.0
	5.0	6.0	6.0	7.0	7.0	6.0	7.0	6.0	5.0
	6.0	6.5	6.0	7.0	7.0	7.0	---	7.0	5.5
	5.0	---	---	---	---	---	---	6.5	---
Judge 6	---	8.0	6.0	8.0	6.0	6.0	7.0	7.0	5.0
	---	5.0	6.0	5.0	7.0	7.0	7.0	7.0	4.0
	---	5.0	---	7.0	---	7.0	5.0	7.0	7.0
Judge 7	Did not judge flavor.								

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree C Harvest	1	2	3	4	5	6	7	8	9
Judge 8	4.5	5.0	5.0	6.0	7.0	9.0	5.0	5.0	7.0
	---	6.0	---	7.0	---	7.0	6.0	---	8.0
Judge 9	---	4.0	5.0	---	7.0	---	8.0	---	5.0
	---	---	4.0	---	5.0	---	5.0	---	6.0
Judge 10	6.0	6.0	8.0	6.5	5.0	7.0	6.5	7.0	8.0
	---	4.0	6.0	6.5	7.0	6.0	5.5	7.0	7.5
	---	---	5.0	---	6.0	---	---	7.0	---
Judge 11	7.0	6.0	7.0	4.0	7.0	7.0	6.0	5.0	8.0
	5.0	---	7.0	---	4.0	---	7.0	5.0	6.0
	5.5	---	6.0	---	5.0	---	---	---	---
Judge 12	5.0	4.0	---	5.0	---	6.0	6.0	---	8.0
	4.0	5.0	---	6.0	---	---	---	---	---
Judge 13	6.0	7.0	9.0	7.0	9.0	6.0	7.0	6.0	5.0
	---	7.0	---	6.0	---	5.0	---	7.0	5.0
Judge 14	---	5.0	---	---	---	---	---	---	---

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree D Harvest	1	2	3	4	5	6	7	8	9
Judge 1	5.0	6.0	6.0	6.0	6.0	7.0	6.0	8.0	8.0
	5.0	5.0	5.0	6.0	7.0	6.0	6.0	5.5	7.0
	4.0	6.0	5.0	7.0	6.5	7.0	6.0	7.5	5.0
	5.0	5.0	6.0	6.5	7.0	7.0	6.5	8.0	6.0
Judge 2	5.0	5.0	6.0	6.0	6.0	6.0	5.0	7.0	8.0
	5.0	6.0	6.0	7.0	7.0	7.0	6.0	7.0	7.0
	5.0	6.0	6.0	6.7	7.0	6.8	7.0	8.0	8.0
	5.6	7.2	6.2	6.4	7.0	---	6.1	8.0	8.5
Judge 3	3.0	4.0	4.0	4.0	4.0	7.0	7.0	8.0	8.0
	4.0	7.0	6.0	5.0	8.0	5.0	5.0	8.0	---
	3.0	---	---	---	---	---	---	---	---
Judge 4	4.0	4.0	5.0	5.0	7.0	8.0	6.0	7.0	6.0
	4.0	5.0	5.0	6.5	7.0	5.5	6.5	6.0	6.0
	3.5	4.3	4.8	6.7	6.5	7.5	7.1	7.0	6.8
	3.0	4.0	5.2	6.3	6.8	7.0	7.3	7.8	6.2
Judge 5	5.0	5.0	5.0	6.0	7.0	6.0	7.0	7.0	6.0
	5.0	5.0	6.0	6.0	7.0	7.0	6.0	7.0	5.0
	5.0	5.0	5.0	7.0	7.0	7.0	7.0	6.0	5.5
	6.5	---	5.5	---	7.0	---	7.0	6.0	---
Judge 6	5.0	7.0	6.0	7.0	7.0	8.0	6.0	6.0	6.0
Judge 7	Did not judge flavor.								

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree D Harvest	1	2	3	4	5	6	7	8	9
Judge 8	4.0 4.5	6.0 ---	6.0 ---	6.0 ---	6.0 ---	8.0 ---	7.0 ---	7.0 ---	8.0 ---
Judge 9	4.0 ---	4.0 ---	6.0 5.0	5.0 ---	8.0 7.0	6.0 ---	5.0 6.0	6.0 ---	5.0 ---
Judge 10	8.0 4.0	8.0 6.0	7.0 ---	7.0 5.5	7.0 ---	8.0 6.5	7.5 ---	7.0 7.5	6.0 ---
Judge 11	4.0 4.0 ---	8.0 3.0 ---	5.0 4.0 6.5	5.0 4.0 ---	7.0 5.0 6.0	7.0 6.0 ---	6.0 7.0 5.0	8.0 6.0 ---	4.0 6.0 7.0
Judge 12	---	---	---	---	---	7.0	---	7.0	8.0
Judge 13	--- ---	4.0 6.0	6.0 ---	6.0 7.0	7.0 ---	7.0 8.0	6.0 ---	7.0 8.0	8.0 ---
Judge 14	--- ---	7.0 ---	6.0 ---	5.0 6.0	8.0 ---	6.0 7.0	8.0 ---	8.0 8.0	9.0 7.0

Appendix Table 9 (Continued). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree E Harvest	1	2	3	4	5	6	7	8	9
Judge 1	5.0	6.0	6.0	4.0	7.0	5.0	6.0	6.0	8.0
	4.0	5.0	5.0	5.5	7.0	5.0	7.0	6.0	7.5
	5.0	6.0	6.0	6.5	6.0	6.0	6.0	6.0	7.0
	5.0	---	5.0	---	7.0	7.0	---	8.0	---
Judge 2	4.0	5.0	6.0	6.0	6.0	5.0	5.0	5.0	7.0
	5.7	6.4	7.0	6.0	6.7	6.0	6.0	6.0	7.0
	5.6	6.0	6.0	6.8	7.0	6.8	6.4	8.0	6.6
	5.0	---	6.0	---	8.0	---	6.6	---	8.8
Judge 3	3.0	5.0	5.0	7.0	8.0	5.0	5.0	8.0	8.0
	7.0	---	7.0	---	3.0	---	3.0	---	7.0
	4.0	---	4.0	---	7.0	---	---	---	---
Judge 4	3.0	4.0	4.0	6.0	6.0	5.0	8.0	8.0	7.0
	4.0	4.5	5.0	6.0	6.5	5.5	8.0	7.5	6.0
	5.0	4.1	4.1	5.2	6.5	6.8	7.5	6.9	7.0
	3.0	3.8	3.0	5.6	4.5	6.1	7.6	7.0	7.8
Judge 5	5.0	5.0	5.0	8.0	7.0	6.0	6.0	6.0	6.0
	5.0	6.0	6.0	6.0	6.0	7.0	4.0	7.0	8.0
	6.0	5.0	7.0	7.0	6.0	6.0	7.0	6.0	6.5
	---	7.0	---	7.0	---	6.0	5.0	5.0	7.0
Judge 6	4.0	6.0	6.0	5.0	6.0	5.0	5.0	6.5	7.0
	5.0	7.0	6.0	6.0	7.0	6.0	5.0	6.0	7.0
	---	---	6.0	---	5.0	6.0	6.0	6.0	6.0
Judge 7	Did not judge flavor.								

Appendix Table 9 (Concluded). Subjective flavor scores of canned prunes for each tree-harvest date by individual judges.

Tree E Harvest	1	2	3	4	5	6	7	8	9
Judge 8	3.0	3.0	6.0	6.0	7.0	4.0	7.0	6.0	8.5
Judge 9	4.0 4.0 ---	6.0 --- ---	6.0 5.0 6.0	5.0 --- ---	5.0 5.0 7.0	7.0 --- ---	5.0 5.0 ---	6.0 --- ---	8.0 9.0 ---
Judge 10	8.5 4.0 3.5	5.0 5.0 4.5	7.0 5.0 4.5	6.0 4.5 6.5	7.0 6.5 7.0	8.5 6.0 ---	8.0 8.0 5.5	7.0 7.0 7.5	6.0 7.0 8.5
Judge 11	6.5 6.0 4.0	4.0 5.0 ---	6.0 4.0 6.0	3.0 6.0 ---	6.0 6.5 7.0	7.0 5.0 ---	7.0 7.0 3.0	5.0 7.0 ---	6.0 5.0 5.0
Judge 12	---	5.0	---	6.0	---	5.0	---	7.0	---
Judge 13	---	6.0	---	4.0	---	7.0	---	8.0	---
Judge 14	---	---	---	---	---	---	---	---	---

Appendix Table 10. Raw cut-out soluble solids data of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	22.7	22.4	23.3	23.1	24.3	25.1	24.3	23.4	25.9
	23.1	22.4	23.2	23.5	23.8	25.1	24.2	23.7	25.8
	23.2	22.2	23.1	24.0	23.7	25.3	24.5	22.9	26.3
	23.1	22.6	23.2	23.3	23.5	25.0	24.1	23.5	26.3
Tree B	23.1	23.1	23.7	25.0	23.0	24.2	25.7	25.1	25.3
	23.1	23.8	23.4	24.3	23.9	24.7	25.8	26.9	25.5
	22.4	23.2	23.4	24.7	24.7	24.6	25.6	25.9	25.5
	23.1	23.3	23.4	24.5	24.7	24.3	25.7	25.8	25.5
Tree C	23.4	24.0	23.9	23.5	24.3	24.8	26.0	27.4	25.4
	23.4	24.3	23.8	24.0	23.5	24.4	26.1	27.4	25.2
	23.8	24.3	24.2	23.6	24.3	24.9	25.8	27.9	25.4
	23.4	24.3	23.8	24.0	24.2	24.7	26.1	26.4	25.2
Tree D	22.1	24.3	23.4	24.4	23.7	24.3	25.7	27.3	26.1
	22.4	24.0	23.4	24.4	25.4	24.3	25.6	26.4	25.6
	22.3	24.2	23.4	24.6	24.6	24.5	25.6	26.7	26.2
	22.4	24.2	23.5	24.5	25.2	24.3	25.6	27.2	25.3
Tree E	23.2	23.4	24.1	24.6	27.3	24.8	24.4	24.1	25.3
	23.1	23.2	24.5	24.1	27.5	24.3	24.3	24.3	25.3
	22.8	24.0	24.3	24.5	24.4	24.9	24.5	24.1	25.2
	22.7	23.4	24.5	24.5	24.5	24.5	24.4	24.0	25.4

Appendix Table 11. Raw per cent transmittance data of canned prune juice during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	84	74	64	50	60	29	39	32	30
	79	70	64	46	60	31	39	32	30
	79	79	65	44	58	28	36	34	35
	79	70	55	47	64	29	38	30	31
Tree B	62	74	67	47	44	33	38	33	44
	67	72	66	49	50	43	40	41	45
	64	76	66	49	47	42	42	43	43
	62	75	66	47	47	34	38	40	40
Tree C	67	70	57	44	43	37	36	38	38
	63	64	54	43	42	38	40	41	36
	70	70	48	38	45	45	41	38	36
	65	67	65	38	44	46	38	40	36
Tree D	73	71	65	50	34	55	41	34	35
	78	68	67	41	44	48	38	37	31
	76	72	62	46	42	46	36	35	36
	76	71	62	42	35	47	37	36	31
Tree E	68	77	70	47	56	61	46	49	42
	73	77	72	57	54	60	47	48	38
	73	73	74	56	54	56	48	47	39
	72	77	70	56	52	57	47	48	40

Appendix Table 12. Raw pH data of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	3.25	3.35	3.30	3.34	3.33	3.30	3.35	3.30	3.38
	3.25	3.40	3.30	3.34	3.33	3.32	3.31	3.30	3.38
	3.27	3.40	3.30	3.34	3.33	3.32	3.31	3.32	3.34
	3.27	3.35	3.30	3.35	3.33	3.30	3.35	3.32	3.34
Tree B	3.34	3.28	3.33	3.33	3.36	3.40	3.40	3.36	3.46
	3.34	3.28	3.33	3.35	3.37	3.40	3.40	3.36	3.46
	3.34	3.29	3.33	3.31	3.36	3.38	3.38	3.36	3.46
	3.34	3.27	3.33	3.33	3.35	3.38	3.38	3.36	3.46
Tree C	3.00	3.40	3.35	3.35	3.41	3.41	3.50	3.38	3.52
	3.00	3.40	3.35	3.35	3.41	3.38	3.50	3.40	3.48
	3.04	3.36	3.40	3.35	3.41	3.39	3.50	3.36	3.50
	3.04	3.36	3.40	3.35	3.41	3.39	3.50	3.38	3.50
Tree D	3.05	3.18	3.29	3.36	3.30	3.45	3.50	3.38	3.61
	3.04	3.18	3.30	3.36	3.30	3.40	3.50	3.40	3.62
	3.03	3.18	3.28	3.36	3.30	3.45	3.50	3.37	3.60
	3.04	3.18	3.30	3.36	3.30	3.45	3.50	3.38	3.61
Tree E	3.30	3.35	3.36	3.38	3.20	3.36	3.36	3.14	3.30
	3.30	3.35	3.37	3.40	3.18	3.36	3.36	3.18	3.30
	3.28	3.35	3.36	3.39	3.18	3.36	3.34	3.16	3.31
	3.29	3.35	3.35	3.39	3.20	3.36	3.35	3.16	3.28

Appendix Table 13. Raw per cent malic acid data of canned prunes during nine harvest dates.

Harvest	1	2	3	4	5	6	7	8	9
Tree A	.578	.516	.482	.489	.476	.466	.436	.442	.348
	.441	.503	.506	.482	.503	.462	.434	.429	.328
	.533	.523	.506	.486	.499	.387	.423	.429	.392
	.523	.496	.491	.483	.513	.448	.426	.385	.371
Tree B	.553	.489	.503	.507	.442	.389	.422	.409	.342
	.534	.484	.469	.476	.442	.459	.405	.405	.369
	.466	.484	.462	.449	.425	.429	.409	.412	.399
	.553	.477	.460	.472	.410	.413	.405	.409	.370
Tree C	.556	.476	.432	.446	.462	.427	.422	.412	.338
	.549	.476	.526	.459	.422	.434	.429	.419	.402
	.546	.469	.503	.448	.446	.423	.421	.415	.365
	.549	.462	.462	.449	.413	.452	.422	.409	.348
Tree D	.623	.472	.492	.489	.462	.402	.402	.433	.351
	.596	.472	.513	.459	.469	.405	.392	.433	.344
	.583	.476	.489	.489	.489	.405	.395	.430	.351
	.590	.472	.496	.476	.476	.403	.395	.437	.330
Tree E	.588	.564	.472	.486	.440	.501	.518	.469	.412
	.582	.589	.454	.497	.504	.497	.497	.458	.383
	.596	.533	.433	.508	.462	.501	.504	.465	.387
	.589	.564	.458	.501	.479	.504	.497	.462	.398