HILGARDIA

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOLUME 33 NOVEMBER, 1962 NUMBER 8

PHYSICAL AND CHEMICAL CHANGES IN FRENCH PRUNES DURING MATURATION IN COASTAL VALLEYS

L. L. CLAYPOOL, W. H. DEMPSEY, PAUL ESAU and M. W. MILLER

THE INFLUENCE OF HARVESTING PROCEDURES AND STORAGE ON THE QUALITY OF DRIED FRENCH PRUNES FROM COASTAL REGIONS

L. L. CLAYPOOL, M. W. MILLER, W. H. DEMPSEY and PAUL ESAU

UNIVERSITY OF CALIFORNIA · BERKELEY, CALIFORNIA

H I L G A R D I A

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOL. 33 NOVEMBER, 1962 NO. 8

PHYSICAL AND CHEMICAL CHANGES IN FRENCH PRUNES DURING MATURATION IN COASTAL VALLEYS[1,2]

L. L. CLAYPOOL,[3] W. H. DEMPSEY,[4] PAUL ESAU[5] and M. W. MILLER[6]

INTRODUCTION

IN 1951 AND 1952, physical and chemical changes of French prunes during maturation on the tree were studied in the Sacramento Valley (Claypool and Kilbuck, 1956).[7] In the warm interior valleys of California, French prunes usually remain firmly attached to the tree long after they attain maturity and, since shaking removes fruits of all maturities with about equal facility, a tree is completely harvested in one operation. For dried prunes of good quality, however, shaking must be delayed until all or nearly all fruits are mature.

In the cooler, coastal valleys attachment of French prunes to the tree usually becomes less firm as the fruits mature and therefore considerable numbers of ripe prunes may drop to the ground. Mature fruit is readily harvested by lightly shaking the main branches. Commercial harvesting operations involve two to four pickings, in contrast to the single picking in the interior valleys.

During 1956 and 1957, extensive tests on the effect of various harvesting procedures on quality of dried fruit were conducted in seven coastal valley orchards. In addition, fruits were tagged for study of physical and chemical changes during maturation. The latter study is reported here and compared with the previous study on interior valley prunes by Claypool and Kilbuck (1956).

PROCEDURE

Two orchards were selected for study: in 1956, one in the southern part of the

[1] A report of work done under contract with the U. S. Department of Agriculture and authorized by the Research and Marketing Act of 1946. The contract was supervised by the Western Utilization Research and Development Division of the Agricultural Research Service.

[2] Submitted for publication January 6, 1961.

[3] Professor of Pomology and Pomologist in the Experiment Station, Davis.

[4] Associate Professor of Agriculture, Chico State College, California.

[5] Laboratory Technician IV in the Experiment Station, Davis.

[6] Assistant Professor of Food Science and Technology and Assistant Food Technologist in the Experiment Station, Davis.

[7] See "Literature Cited" for citations referred to in the text by author and date.

Santa Clara Valley; in 1957, one in the Russian River Valley of Sonoma County. In each year, 600 fruits located randomly were tagged on each of four trees. Each fruit was given a number and calipered for size of cheek diameter. The 2400 fruits were randomized into eight lots including all four trees. Thus, each tree had 75 fruits of the 300 in the lot. Average prune size at the beginning of the experiment was essentially the same for each lot. When commercial harvest was begun in the district the first lot of tagged fruits was also harvested. Subsequent harvests were semi-weekly, at 3 and 4-day intervals, so that all test prunes were harvested in 24 to 25 days—a span closely approaching that of commercial harvesting in any one orchard.

At harvest, individual fruits were again measured for size and those from each tree were composited for further tests, including weight, volume, flesh firmness, soluble solids, flesh color, pH, and titratable acidity. Volume was determined by water displacement, usually that of 50 prunes from each tree at each harvest. Flesh firmness of 25 prunes composited from all four trees was determined with a 0–10 pound Ballauf pressure tester having a $\frac{5}{16}$-inch point. The skin of the prune cheek was first removed. Longitudinal segments of the same 25 prunes were pressed for determination of soluble solids with a refractometer. The pressed sample used for determining soluble solids was also used for determining pH and titratable acidity with a Beckman pH meter with glass electrode.

Flesh color was evaluated on a 20-fruit sample from the composite of all tagged fruit harvested at each sampling period. Pared cheek tissue, sliced to $\frac{1}{8}$-inch thick with a sharp knife or razor blade, was trimmed to the approximate size of a color chip in the Maerz and Paul "Dictionary of Color" (1930). Each tissue sample was immediately placed on a moisture-proof white card adjacent to a window cut to the size of a Maerz and Paul color chip. Flesh color was recorded as the nearest match of a color chip. The Maerz and Paul data were converted to the Munsell system of color as described by Esau (1958). All comparisons were made under artificial light from paired fluorescent tubes, one 40-watt 3600°K and one 40-watt 5500°K.

RESULTS

Table 1 summarizes data collected during the two seasons. In 1956, no fruit dropped before the fourth harvest. Then natural drop was rapid, particularly between the fourth and fifth harvests, and continued through the final harvest, by which time only 47 per cent of the fruit originally tagged for the eighth harvest remained on the tree. In 1957, fruits were tagged and segregated into lots more than a month ahead of the first harvest, so some fruits were lost before the first harvest. Some natural drop occurred between the second and third harvests and continued slowly until after the seventh harvest; the drop then accelerated and only about 64 per cent of the fruit tagged for the final harvest remained on the tree. Each year fruits missed in other harvests were harvested with the last lot. It is thought that this procedure did not influence the results in any undesirable way, and that it had the advantage of increasing the size of the sample in the final lot.

A loss of any considerable number of prunes between harvests is almost certain to skew the curves representing some physical and chemical measure-

TABLE 1

PHYSICAL AND CHEMICAL CHANGES IN FRENCH PRUNES DURING MATURATION AND RIPENING. 1956 DATA FROM ORCHARD NEAR GILROY, SANTA CLARA VALLEY; 1957 DATA FROM ORCHARD NEAR SANTA ROSA, SONOMA COUNTY

Lot	Number of fruits harvested	Harvest date	Average prune diameter when assigned to lots*	Average prune size at harvest			Specific gravity	Flesh firmness	Soluble solids	Flesh weight times per cent soluble solids†	pH	Acidity‡	Flesh color§
				Diameter	Weight	Volume							
			mm	*mm*	*gms*	*cc*		*lbs*	*per cent*				
1	298	8/21/56	30.7	31.3	19.9	18.9	1.052	3.6	18.0	3.49	4.6	1.6	6Y 7.3/6.3
2	298	8/24/56	30.9	30.8	19.8	18.6	1.063	3.1	19.1	3.59	4.8	...	5Y 7.6/7.1
3	280	8/28/56	30.5	30.4	19.3	18.1	1.066	2.5	19.7	3.61	4.6	2.0	5Y 7.5/7.1
4	299	8/31/56	30.7	30.2	19.5	18.2	1.068	1.8	21.1	3.90	5.0	1.2	5Y 7.3/6.6
5	226	9/4/56	30.6	30.1	19.0	17.6	1.073	1.8	24.5	4.40	4.7	1.5	5Y 7.3/6.6
6	199	9/7/56	30.3	29.7	18.7	17.4	1.072	2.1	23.5	4.16	4.9	1.4	5Y 7.6/7.2
7	166	9/11/56	30.3	28.3	17.6	16.4	1.076	2.1	22.7	3.77	4.3	3.0	5Y 7.4/6.3
8	182‖	9/14/56	30.6	29.3	17.8	16.5	1.078	1.4	25.0	4.20	4.3	2.6	2Y 7.0/6.6
1	286	8/27/57	29.9	30.9	21.2	19.4	1.092	4.8	26.2	5.29	4.5	3.0	5Y 7.6/7.2
2	288	8/30/57	30.1	31.2	21.7	19.9	1.091	4.6	27.0	5.59	4.4	3.7	5Y 7.7/7.4
3	267	9/3/57	30.1	30.8	21.1	19.1	1.104	4.3	27.2	5.47	4.6	2.7	4Y 7.0/6.1
4	258	9/6/57	30.3	30.3	20.9	18.8	1.112	2.9	29.2	5.81	5.0	2.3	4Y 7.1/6.6
5	257	9/10/57	30.2	29.4	19.5	17.4	1.121	2.0	32.1	5.94	4.6	3.0	4Y 6.2/5.4
6	235	9/13/57	30.4	29.7	20.0	17.8	1.124	2.4	30.9	5.87	4.9	2.2	3Y 6.7/5.7
7	220	9/17/57	30.2	28.9	18.8	16.8	1.122	2.2	31.7	5.64	4.8	2.1	3Y 6.7/6.1
8	228‖	9/20/57	30.2	28.9	19.2	17.1	1.126	0.9	32.0	5.82	5.1	1.4	4Y 7.1/5.9

* Fruits assigned to lots August 14, 1956, and July 24, 1957.
† Approximately dry weight value; weight of pit excluded.
‡ Milliliters n/10 NaOH to 10 milliliters juice titrated to pH 7.
§ Munsell color system.
‖ Lot 8 gained 41 fruits in 1956, and 44 in 1957, from lots overlooked at scheduled harvest.

ments. Prunes most likely to drop were riper fruit, which were softer, more advanced in color, and probably higher in soluble solids content; this offers a logical explanation for results that otherwise might seem irregular.

Size. In 1956 prunes attained full physical size by the first harvest (table 1) and diminished in size thereafter. In 1957 the pattern was the same (table 1 and fig. 1) except that size seemed to be maximum at the second

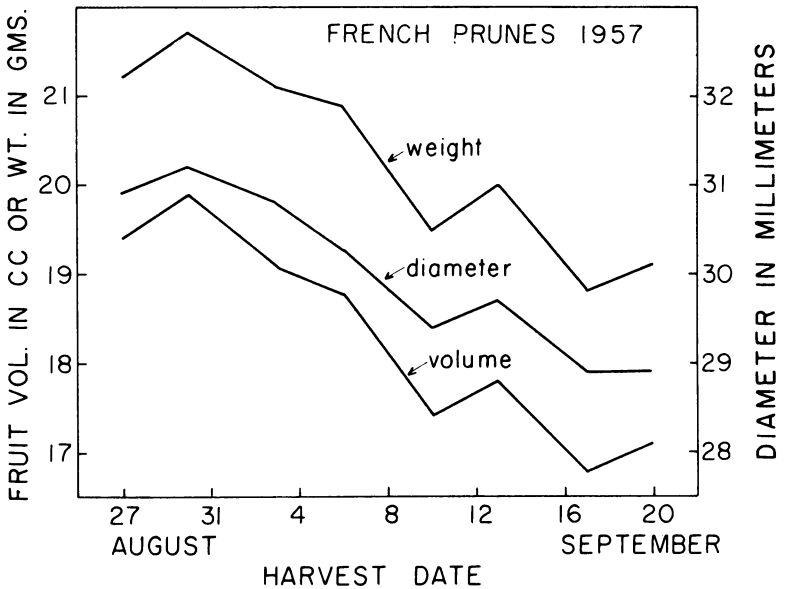

Fig. 1. Size of French prunes from tagged fruit lots, 1957.

harvest. The slight difference in original size between Lots 1 and 2 accounts for nearly all of the difference in size at their harvest dates. Prunes that dropped prior to their scheduled harvest were random in size; this is indicated by the similarity in initial size of the harvested prunes in each lot and the average size of all prunes selected originally for the lot. Fluctuations during the last four harvest dates can be partially accounted for by initial size variation, but in any case they were minor and trends of size data appear to be clear cut.

Flesh Firmness. Flesh firmness declined as the harvest season progressed (figs. 2 and 3), then leveled off and became irregular, at times even seeming to increase again. The decline was continuous and fairly uniform until there was a perceptible loss of prunes from a lot. Loss of the softer prunes apparently caused the remainder of the lot to appear to change little in firmness until all fruits reached advanced maturity and softness. Continued softening of the prune during maturation on the tree is normal. In the interior valley, where a higher percentage of fruit remains on the tree, the firmness curve continues to drop in a regular manner (Claypool and Kilbuck, 1956).

Soluble Solids Content. As prunes mature, the soluble solids content increases. Soluble solids content is one of the indexes suggested (Claypool and Kilbuck, 1955) and presently used as a maturity index. In tagged prune

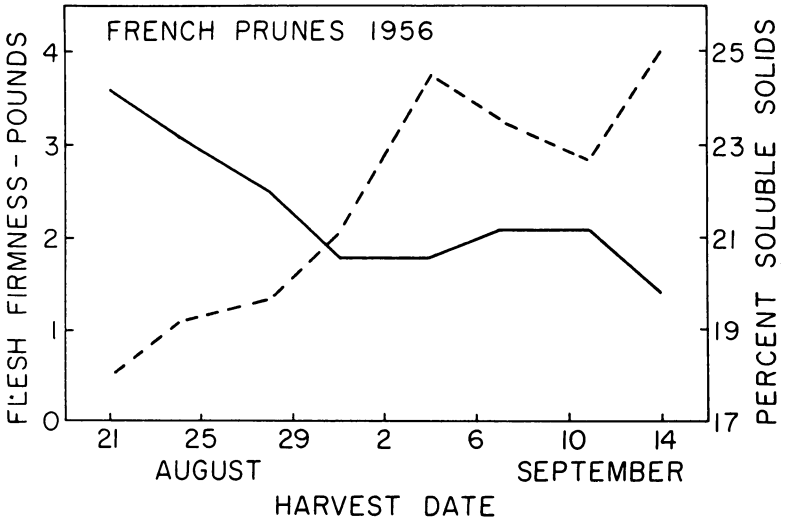

Fig. 2. Changes in firmness (solid line) and soluble solids (broken line) in tagged French prune lots, 1956.

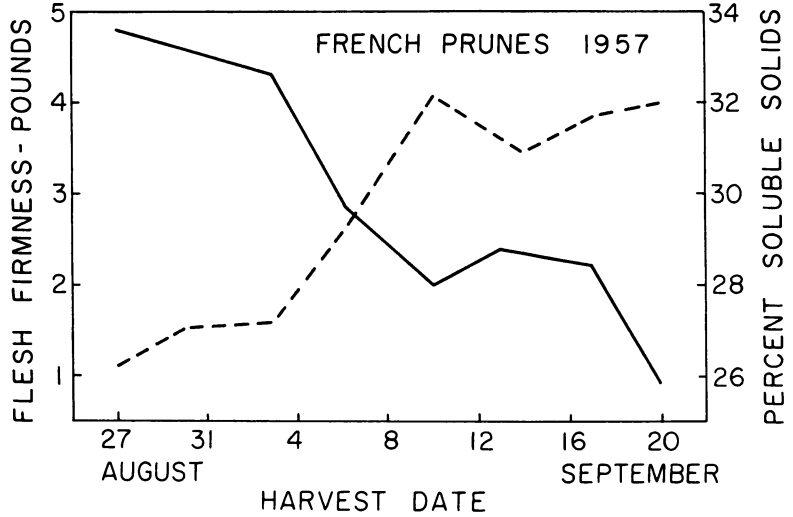

Fig. 3. Changes in firmness (solid line) and soluble solids (broken line) in tagged French prune lots, 1957.

lots from the coastal valleys (figs. 2 and 3) soluble solids content continued to increase during harvest season much the same as firmness declined. During the last several harvests in each year the soluble solids content was irregular; with interior valley prunes the increase was continuous in all lots (Claypool and Kilbuck, 1956). The contrast is further indication that the lot itself was changing, through losses of prunes with higher solids content.

The soluble solids content of the prunes was much lower in 1956 than in

1957 and the difference could be due in part to natural differences between the two orchards and the production areas. However, it has been shown (Claypool, Miller, Dempsey, and Esau, 1962) that a large crop depresses the soluble solids content of prunes. The average crop was much heavier in 1956 than in 1957.

Specific Gravity. Specific gravity changed with soluble solids content. All of the points for the two years' data would fit well on a curve plotting specific

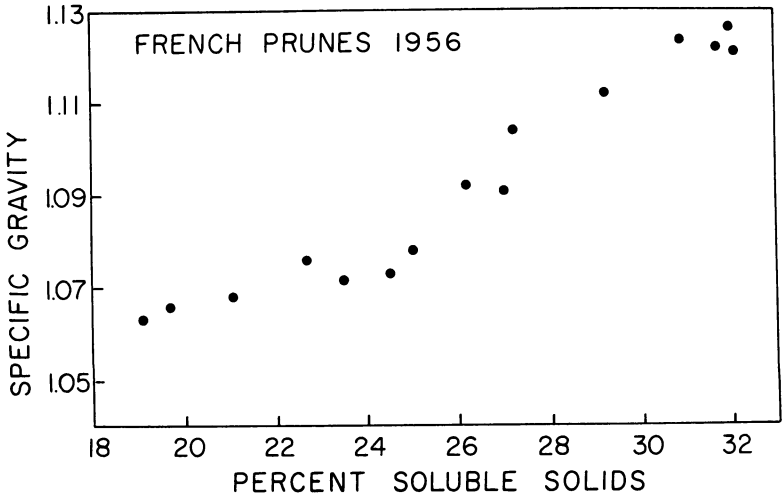

Fig. 4. Specific gravity versus soluble solids content of French prunes from tagged fruit lots, 1956–1957.

gravity against per cent soluble solids (fig. 4). Specific gravity readings were usually based on 200 prunes, and soluble solids readings on 25 prunes. The lower end of the curve is skewed, probably because a lower proportion of the solids in the juice are sugars. Table 2 gives a more detailed breakdown of the 1956 data. Since greater specific gravity has been shown to indicate higher soluble solids content, it is obvious that prunes from the more heavily cropped trees, which produced smaller fruit, had lower soluble solids content throughout the harvest season.

Dry Weight of Flesh. Changes in the per cent soluble solids do not accurately indicate change in soluble solids per fruit on a weight basis, as fresh fruit was diminishing in weight during most of the harvest season. Nevertheless, soluble solids readings, even when based on an arbitrary scale in relation to light refraction, are quite indicative of total solids content of prunes. Therefore, multiplying the average weight of flesh per prune by the average soluble solids content gives a reasonably close figure for total solids per prune. Table 1 shows that in both seasons the total solids per prune continued to increase through approximately the fifth harvest, despite the diminishing fruit size. The increase supports the previous contention that solids continued to move into interior valley prunes after water movement was so restricted that the prunes lost size (Claypool and Kilbuck, 1956). Attainment of

maximum solids in individual fruits is not elucidated by these data, though they indicate that average solids were increasing until natural fruit drop became a significant factor.

pH and Acidity. The pH data seem to follow no pattern. The two seasons are quite comparable except for the last two readings in 1956, when pH dropped perceptibly. The pH readings are quite high, exceeding by more than one pH unit the readings obtained on interior valley prunes (Claypool

TABLE 2

RELATIONSHIP BETWEEN SIZE OF FRESH PRUNES* AND SPECIFIC GRAVITY (1956)

Lot	Harvest date	Tree A		Tree B		Tree C		Tree D	
		Prunes per pound	Specific gravity	Prunes per pound	Specific gravity	Prunes per pound	Specific gravity	Prunes per pound	Specific gravity
1.....	8-21	23	1.054	20	1.059	23	1.052	27	1.045
2.....	8-24	26	1.065	19	1.068	24	1.056	24	1.063
3.....	8-28	24	1.065	20	1.074	25	1.060	27	1.065
4.....	8-31	24	1.067	19	1.079	24	1.067	27	1.059
5.....	9-4	24	1.069	20	1.088	26	1.068	28	1.067
6.....	9-7	27	1.074	19	1.077	26	1.066	28	1.068
7.....	9-11	27	1.079	21	1.082	27	1.076	30	1.065
8.....	9-14	26	1.082	21	1.097	28	1.078	30	1.054
Averages...		25.1	1.069	19.9	1.078	25.4	1.065	27.6	1.061

* Segregated by tree.

and Kilbuck, 1956). Acidity followed no pattern in 1956, but in 1957 there was a trend toward less acidity with advancing maturity, as reported with interior valley prunes. In both years the acidity was low—about 25 to 30 per cent that of interior valley fruit.

Flesh Color. Table 1 shows flesh color averages in terms of the Munsell system of color. In 1956, hue remained the same from the second through the seventh harvest; first harvest was greener or lighter yellow, and the last redder. The Munsell values were so similar, except for the last one, that little can be concluded except that the per cent of reflectance was good in all lots. Differences were greater in 1957: flesh color at the start was less green (more yellow) than in 1956, and moved steadily toward the red (amber) except at the last harvest, and reflectance (a measure of darkening) also diminished more or less consistently until the last harvest. Other data collected during these same two years show that riper fruits which drop to the ground have a redder flesh and a lower reflectance. The dropping of riper fruit after the fourth harvest in 1956 is believed to account for the lighter color and high reflectance in the fifth, sixth, and seventh harvests and the relatively high reflectance in the eighth harvest. Fruit drop doubtless had some influence on the 1957 data, too, but was less marked except in the eighth harvest, by which time 16 per cent of the fruit present at the seventh harvest had dropped.

SUMMARY

Tagged lots of prunes from two coastal valley orchards were harvested selectively at semiweekly intervals during a 4-week harvest period. The individual prunes attained maximum physical size early in the harvest period and then diminished in size progressively with time due to loss of water. Flesh firmness diminished as maturation advanced until natural fruit drop became a factor. Since fruits that dropped were ripest and softest, the average firmness of prunes remaining on the tree after natural drop occurred was reasonably constant until the last harvest. The soluble solids picture was similar, with curves ascending until drop began and then leveling off. The increase in soluble solids, while partly due to concentration resulting from water loss, was also due to movement of organic materials into the fruit during much of the time that water intake was insufficient to maintain the physical size of fruits. This was accompanied by an increase in specific gravity that was greatest in fruits on trees with moderate crops, in comparison to more heavily cropped trees. Flesh color of fresh prunes darkened some as the season advanced. Flesh color was darker in 1957 than in 1956.

LITERATURE CITED

CLAYPOOL, L. L., and JOHN KILBUCK
1955. Quality of dried French prunes. California Agriculture **9**(8):13–14.

CLAYPOOL, L. L., and JOHN KILBUCK
1956. The influence of maturity of interior valley French prunes on the yield and quality of the dried product. Proc. Amer. Soc. Hort. Sci. **68**:77–85.

CLAYPOOL, L. L., M. W. MILLER, W. H. DEMPSEY and PAUL ESAU
1962. The influence of harvesting procedures and storage on the quality of dried French prunes from coastal regions. Hilgardia **33**(8):319–48.

ESAU, PAUL
1958. Procedures for conversion of color data from one system to another. Food Technology **12**:117.

MAERZ, A., and M. REA PAUL
1930. A dictionary of color. McGraw-Hill Book Co., Inc., New York.

The journal *Hilgardia* is published at irregular intervals, in volumes of about 600 pages. The number of issues per volume varies.

Subscriptions are not sold. The periodical is sent as published only to libraries, or to institutions in foreign countries having publications to offer in exchange.

You may obtain a single copy of any issue free, as long as the supply lasts; please request by volume and issue number from:

Agricultural Publications
Room 207 University Hall
2200 University Avenue
Berkeley 4, California

The limit to nonresidents of California is 10 separate issues on a single order. A list of the issues still available will be sent on request.