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Studies of Factors Influencing Separation of Dried Prunes Into Quality Grades

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CONTENTS

SUMMARY

1. Present standards in the grading of dried prunes do not take into account sufficiently factors which determine quality.
2. Initial tests on flotation indicated that dried fruit can be separated by a gravity method.
3. It was found that regrading of dried prunes into maturity grades was possible.
4. From a physical standpoint, the fruit separated by the gravity method in the more dense solutions proved to be of better quality.
5. In large-sized prunes the pit percentage was found to be nearly constant, while in the small sizes considerable variation existed. The fractions indicated considerably more flesh in fruit from the dense solutions.
6. The hydrogen-ion concentration was fairly constant for all fractions. There seemed, however, to be a slight increase from the large- to small-sized fruit.
7. Sucrose varied in an indefinite manner. It was found, however, that the fruit from the heavier fractions was considerably higher in sugar content than that from the light gravity fractions.
8. The pit of the dried prunes influences to a marked degree the separation into gravity fractions of fruit in the dried form.
9. The first work with dried prunes clearly indicates the possibilities of regrading commercial size-grades into gravity grades by flotation.
10. Work on the 1926 crop indicated that the application of the flotation principle to the grading of fresh fruit was feasible. It was continued on the crops of 1927-28.
11. Methods of harvesting used for investigations on 1927 crop are similar to those used commercially.
12. Salt solutions of densities ranging from 40 to 60 degrees salometer were used as a separating medium.
13. Fractions separated from the three pickings indicated that the combined weight of the last two fractions of the first picking was the greatest.
14. Soluble solids verified conclusions reached that maturity was further advanced in prunes separated by heavy gravity solutions.
15. Further verification of the fact that prunes of advanced maturity are found in the heavy-gravity fractions lies in the increase-in-weight record per unit volume.
16. Speed of drying and drying-ratios are influenced by gravity separations. Fruit floated out in light gravity solutions must remain in the drier longer than fruit separated by the more dense solutions, to attain same degree of dryness.

17. Chemical work confirms the results of physical examination of separations which show that gravity grading separates the fruit on a maturity basis.

18. Results of 1927 analytical data resemble closely those on the 1926 samples. In the fresh fruit the pit percentages of the various fractions are nearly the same, with the heavier fractions showing slightly higher. Upon drying the relationship is reversed. On the dried product the pit percentages are highest in the lightest fractions. This is due to the difference in moisture content of the flesh of the various fractions.

19. The acid content in all fractions shows an increase with the decrease in the gravity of the fruit.

20. It was further found that the sugar content of the fresh flesh decreases in just as regular a manner as the moisture content increases. This again bears out the conclusion that gravity separations segregate the fruit according to stage of maturity.

21. Mechanical grading with a machine using solutions of different densities separated the fruit into maturity grades automatically. The final grades had different drying-ratios indicating different moisture contents and stages of maturity.

22. The mechanically separated fruit when dried and graded to size indicated that the riper fruit predominated in all the larger sizes.

23. Chemical work on 1928 crop confirms that on 1927 crop with one exception. The moisture differences between the two crops change the sugar relationship when calculated on a moisture-free basis. The acid content, however, is lower in the heavier gravity fractions.

24. The solution of greatest density separates out those fruits which possess the most desirable physical characteristics.

25. The experiments indicate that infected fruit must be eliminated by hand sorting.

26. Experiments have shown that burnt and fermented fruits can be separated by flotation in boiling water during processing.

Studies of Factors Influencing Separation of Dried Prunes Into Quality Grades

By

ERNEST H. WIEGAND and D. E. BULLIS

INTRODUCTION

That present market standards should be revamped in justice to the prune industry has often been brought home by criticisms offered by buyers and market specialists. Because of this situation a thorough study was undertaken in 1925 to determine the possibilities of evolving eventually a basis for the standardization of dried prunes in which quality of product should be given greater consideration than is now the case. This bulletin is a report of that work and the conclusions it seems to warrant.

At present, dried prunes are graded and packed by purely size-grade standards. The largest fruit is supposed to constitute the best and so command the highest price; the smaller sizes bring correspondingly lower prices.

Inspection by the standards that now exist is under the direction of the Northwest Dried Fruit Association. This inspection covers such factors as conformity to size, moisture content, general appearance, and physical defects. An allowance is made to cover such defects as cracks, crushed fruit, brown rot, and scab. These standards have a tolerance for blemishes but involve no requirements in the matter of quality.* The purpose back of the work recorded here is the creation of some basis for a standard in which quality is one of the main considerations for determining grade and price differentials.

PREVAILING SYSTEM OF HARVESTING AND PACKING THE PRUNE CROP

Harvesting. Prunes differ from most fruits in that they are harvested directly from the ground. As the prune matures it becomes heavier and eventually must drop from the tree of its own weight. In some years excessive soil moisture causes prolonged growth which results in very uneven ripening of fruit. In that case vigorous shaking of trees must be resorted to in order to dislodge the fruit if picking is to be accomplished within a reasonable length of time. It will be seen that harvesting naturally results in the mixing of varying quantities of under-mature and over-ripe fruits, with those of proper maturity for drying.

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*Quality may be said to be derived from all those characteristics which bring satisfaction to the consumer. They are: appearance, color, size, flavor, texture, firmness, sugar and acid content of the fruit.

From three to four pickings are usually made, although many growers go over their orchards oftener. All the fruit, good and bad, is picked from the ground and placed in field boxes. It is then hauled to the drier, where it is washed, or lye-dipped and washed, and dried.

Drying. The prunes are dried in two types of drying units: the natural-draft tunnel drier and the mechanical-draft recirculated-air dehydrater. Either drying unit gives satisfactory results when properly managed. Not infrequently, however, owing to negligence on the part of the operator, the fruit is scorched by excessive heat. In the natural-draft unit, moreover, fermentation also occurs when there is insufficient circulation. Thus careless and inefficient operation of the drying unit may also seriously impair the quality of the fruit.

Size grading. After drying, the prunes are graded to the prevailing size-grades of 20 to 30 (20/30s) and 30 to 40 (30/40s) prunes per pound and down.

Processing and packing. After grading, the prunes are processed by subjecting them to steam at 212° Fahrenheit or to boiling water for a given time. This processing cleanses and sterilizes the fruit. It must be properly done or the appearance and texture of the product are injured.

As the fruit comes from the processor, it is packed in 25-pound boxes. These boxes, when cool, are ready for shipment.

Whatever may be said in support of this system of harvesting, grading, and packing the prune crop of the Pacific Northwest, one might readily surmise that inherent in it are numerous chances for impairment of the quality of the final product.

From what has immediately preceded it might appear that any investigation that had for its object improvement in market grades could start logically in one place only—the orchard. As a matter of fact, that conclusion ultimately was reached.

This work was initiated between harvests, however, and it appeared at the time that everything needful might be accomplished in evolving quality grades from the commercial size-grades of the packers. In that event there would be no need for radical changes in the present method of harvesting and drying the crop. As subsequent events proved, this procedure was found to be impracticable; nevertheless, the initial work on the dried product is worth recording inasmuch as it substantiates conclusions based upon considerations of harvesting practices.

WORK WITH DRIED PRUNES

The first attempts to regrade on the basis of quality dried prunes already commercially graded to size were with prunes obtained from the various packing plants of the Northwest. In all cases the samples were obtained from the large storage bins of the packers. For shipment the samples were packed in air-tight tins to prevent change in moisture content.

Small-scale operations in the laboratory with a few of these samples indicated clearly the possibility of regrading into gravity fractions by the use of sugar solutions of varying degrees of density. Chemical examination of the gravity fractions, moreover, indicated plainly such differences in composition as must be reflected sharply in quality.

A brief explanation will make clear the procedure followed in obtaining these first gravity fractions.

Initial method of separation. The original samples were immersed in a pan containing a sugar solution having a density of 40 degrees Balling.*

TABLE I. RESULTS OF FIRST ATTEMPTS TO REGRADE COMMERCIAL SIZE-GRADES OF DRIED ITALIAN PRUNES INTO GRAVITY FRACTIONS

Number of fruits in original sample	Number of fruits in the fraction	Sugar solution degrees Balling	Packers' grade size	pH*	Oven-dry basis Acid as malic	Oven-dry basis Total sugar
					%	%
100	18	40F†	20-30	4.04	2.20	51.50
	21	55F	20-30	3.87	2.53	51.10
	49	60F	20-30	3.89	2.52	54.50
	12	60S†	20-30	3.89	2.41	55.75
111	49	40F	30-35	3.92	2.38	51.10
	34	55F	30-35	3.79	2.57	53.50
	26	60F	30-35	3.70	2.83	52.10
	2	60S	30-35	3.84	2.46	54.35
98	6	40F	35-40	3.82	2.88	53.60
	25	55F	35-40	3.96	2.30	56.40
	41	60F	35-40	3.94	2.41	57.60
	26	60S	35-40	3.79	2.65	58.50
100	28	40F	40-50	3.89	2.46	52.85
	45	55F	40-50	3.79	2.73	53.20
	23	60F	40-50	3.69	2.71	55.70
	4	60S	40-50	3.84	2.20	55.80
111	38	40F	50-55	3.85	2.62	52.70
	32	55F	50-55	3.79	2.62	52.15
	27	60F	50-55	3.79	2.72	54.30
	4	60S	50-55	3.89	2.19	60.20

*See appendix for chemical methods employed in obtaining the analytical results of this and subsequent tables and for explanation of chemical terms employed.
†F indicates floating fruit. S indicates sinking fruit.

The fraction which floated was designated as "40° floats." Those prunes which sank in the 40° solution were immersed in a 55° solution, and the fraction which floated was designated as "55° floats." The fruit which sank in this solution was thrown into a 60° solution, from which two fractions were obtained, one called "60° floats" and the other "60° sinks." Thus four gravity grades from each commercial size-grade were obtained. In Table I are given the results of the chemical examinations of these gravity fractions.

In Table I it will be noticed that each original sample of commercial size-grades contributed substantially to each of the various gravity fractions derived by this flotation process. With increase in the specific gravity of the fruit goes increase in the content of sugar. Since maximum sugar content is the result of complete maturity in fruit it would seem that here is substantial proof of the fact that commercial size-grading of prunes results in a mixture of mature and immature fruits which can, however, with reasonable facility be separated into fractions of even quality.

*Degrees Balling is the percentage by weight of sugar in solution.

Physical examination of gravity fractions. Results of the physical examination of these gravity fractions also should be noted. Fruits which floated in the lighter-gravity sirups were porous, and in many there were large gas-pockets. Color of the flesh was greenish yellow, an indication of under-maturity, or dark brown and black, an indication of fermentation and burning. The fruit of this fraction lacked that characteristic deep purple luster which is associated with a well-matured and properly dried product.

Prunes which were separated by the heavier-gravity solutions were very attractive in color. They were characterized by a deep golden yellow or reddish brown flesh and a deep purple skin. The flesh in all cases was firmer and fewer gas-pockets were in evidence.

Subsequent examination of commercial size-grades. The foregoing examinations indicated the advisability of more extensive work with these commercial size-graded prunes to establish the feasibility of regrading them by a gravity process to obtain a product of more uniform quality. All remaining samples collected from the packing plants were therefore run through varying densities of sugar solutions. The solutions adopted for Italian prunes were 45°, 55°, and 60° Balling densities. For the Petite variety it was found that an additional solution, greater in density by five degrees Balling, could be used. These four sugar solutions gave for the Petites five instead of four gravity fractions. The procedure used in effecting the separations was identical with that already given. In Table II are condensed the results of the chemical examination of the gravity fractions. Such contrasts as are thought to be of first importance are graphically presented.

Again there is a distinct correlation between the physical and chemical characteristics of the prunes and the densities of the solution used for separating them into their distinctive gravity fractions or maturities. These more complete examinations show even a closer correlation between composition and physical properties than were shown by the preliminary experiments with gravity grading.

Relation of packers' grades to pit percentage for the different fractions. The curves of Fig. 5 are plotted from the average of samples of the various packers' grades. For the larger sizes of Italian prunes the pit percentage is found to be nearly constant for all fractions but for medium and small sizes the variation is considerable, being 2.3 percent for 40/50's, 4.5 percent for 50/60's, and 7.3 percent for 60/70's, with indications of even greater differences in prunes of smaller sizes. This means that medium- and small-sized prunes have from 2 to 7 percent more flesh in the heavy fraction than in the light fraction of the same size-grade. The consumer may note that, other factors being equal, the purchase of the heavier gravity fractions will, therefore, be more economical.

Fig. 6 is plotted from the same data used in plotting Fig. 5, but for the curves on it the data were arranged to show more clearly the differences in pit percentages occurring in the various grades for each gravity fraction. For any one gravity fraction, the large prunes have less weight of pit than the small fruits and the variation becomes greater as the specific gravity of the fractions becomes less.

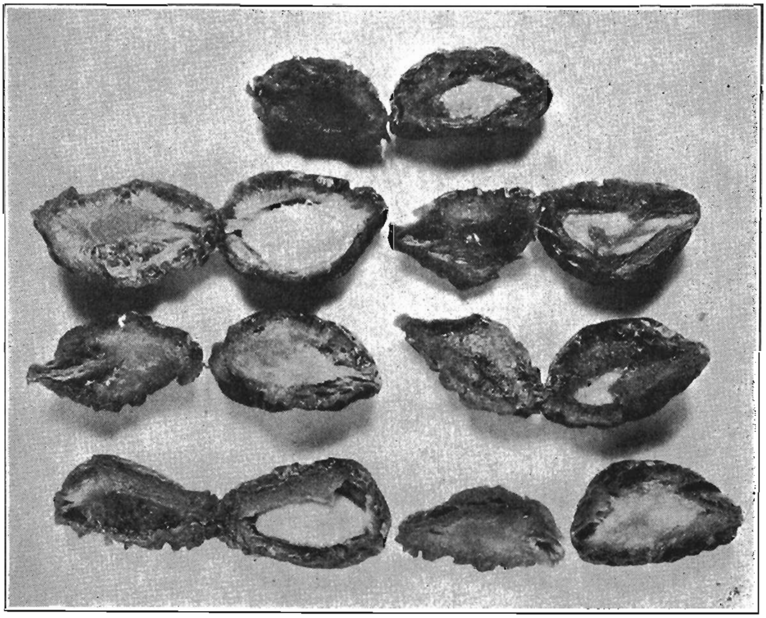

Fig. 1. Forty-degree floats showing porosity.

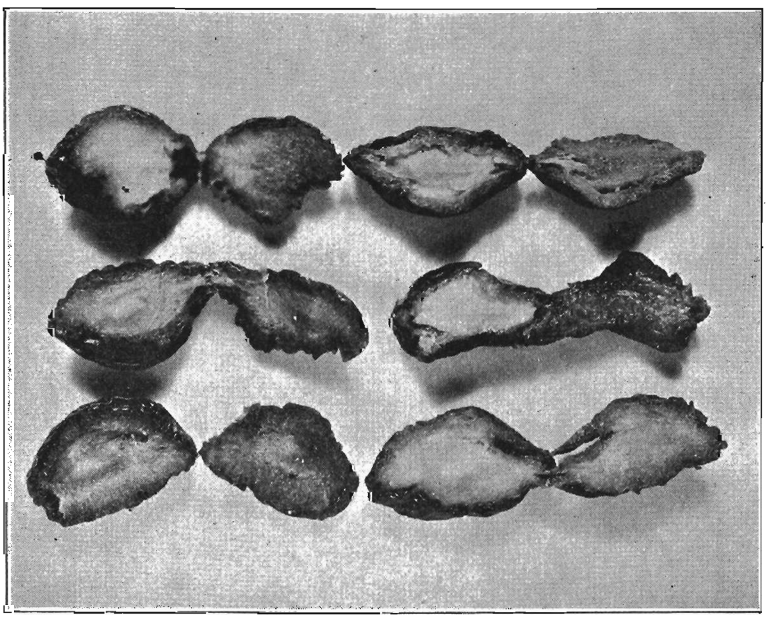

Fig. 2. Fifty-five-degree floats show decrease in amount of porosity.

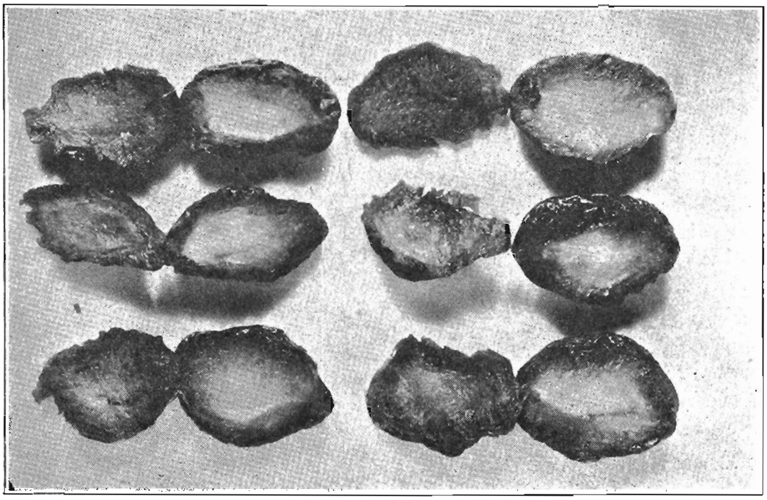

Fig. 3. Sixty-degree floats showing further improvement in flesh of fruit.

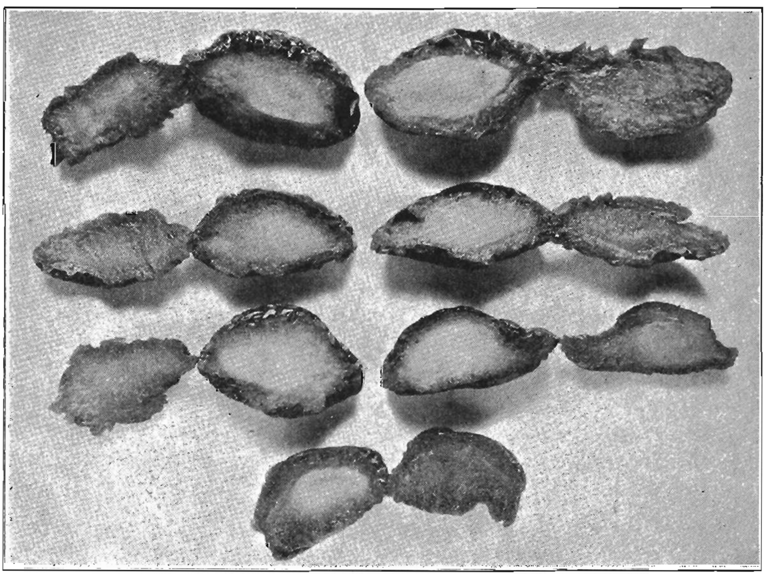

Fig. 4. Sixty-degree sinks show much improved flesh, better texture, and greater firmness.

Fig. 7 indicates that for the Petite variety much the same relationships exist between percentage of pit and size and gravity as in the Italian. Analytical data on Petite prunes indicate that the average percentage of pits is slightly less than is the case for Italian prunes. As will be shown later, the pits in both varieties, Italian and Petite, exert a marked influence on gravity separations.

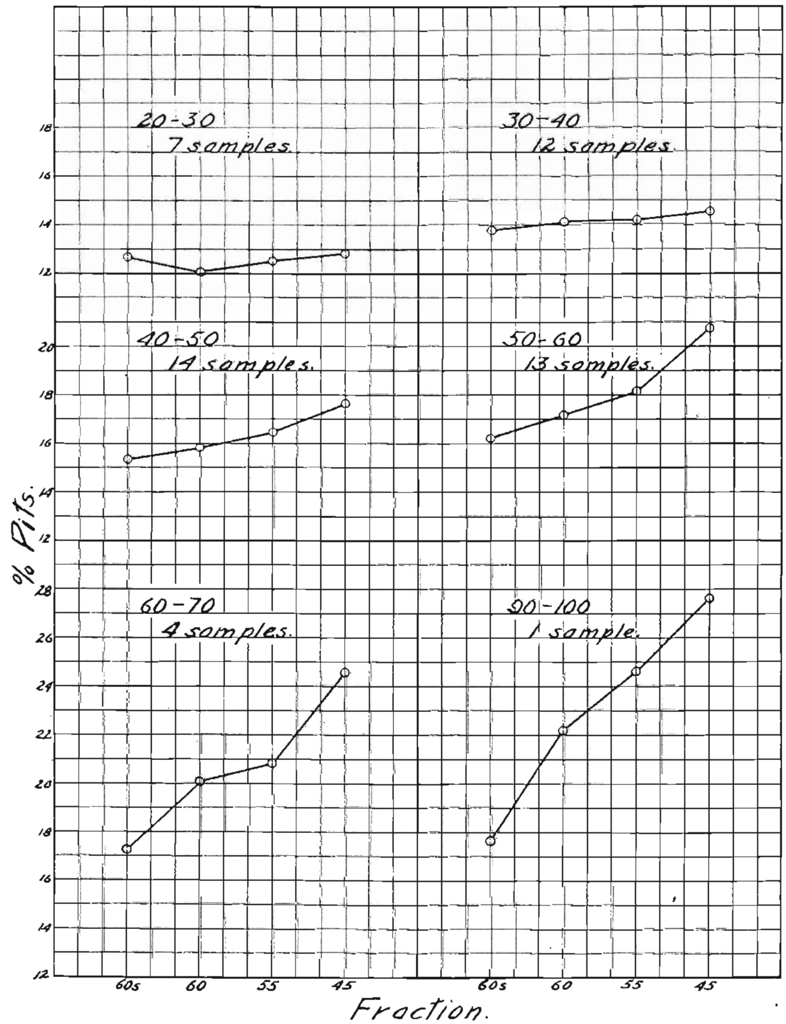

Fig. 5. Pit percentage in Italian prunes by packers' grades. Variation by gravity fractions.

Moisture in pit and flesh. There seems to be no correlation between pit and flesh moisture of the Italian prune and the various gravity fractions after separation. It is probable that during storage in bins the moisture content becomes more or less equalized. In the drier fruits, the pit moisture ranges between 50 and 60 percent of the flesh moisture, while in prunes of 20 to 30 percent water content the pit moisture may range between 35 and 40 percent of that in the flesh. The moisture relationship between pit and flesh of the dried Petite prune is in general similar to that of the dried Italian prune.

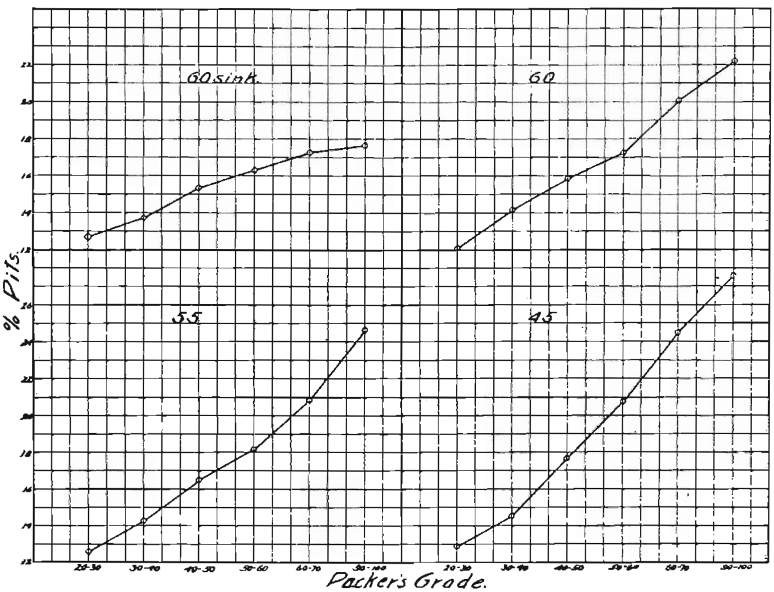

Fig. 6. Variations in percentages of pit in Italian prunes for packers' grades by comparison of gravity fractions.

Hydrogen-ion concentration and total acidity. Within any one size-grade the hydrogen-ion concentration is fairly constant for all gravity fractions, but it increases slightly as the fruit size varies from large to small as shown by the curves in Fig. 8. As might be expected from the increase in hydrogen-ion concentration,* there is also an increase in total acid with the decrease in size of fruit for any given gravity fraction. Likewise the uniformity of hydrogen-ion concentration for all fractions of a certain grade is reflected in the more or less uniform total acid content of the fractions of that grade with the exception that in most cases the total acid for the 45° fractions is somewhat higher than for the other fractions.

It will be noted from Table II that for the Petite prune, the hydrogen-ion concentration and total acid are fairly constant, regardless of the gravity fraction or size of the fruit. The hydrogen-ion concentration is

*See Appendix, p. 47.

not markedly different from that of the Italian prune. This difference in total acid is responsible for the general impression that the Petite prune contains much more sugar than the Italian prune. The total sugar content of the two varieties favors the Petite prune only slightly, but the lack of

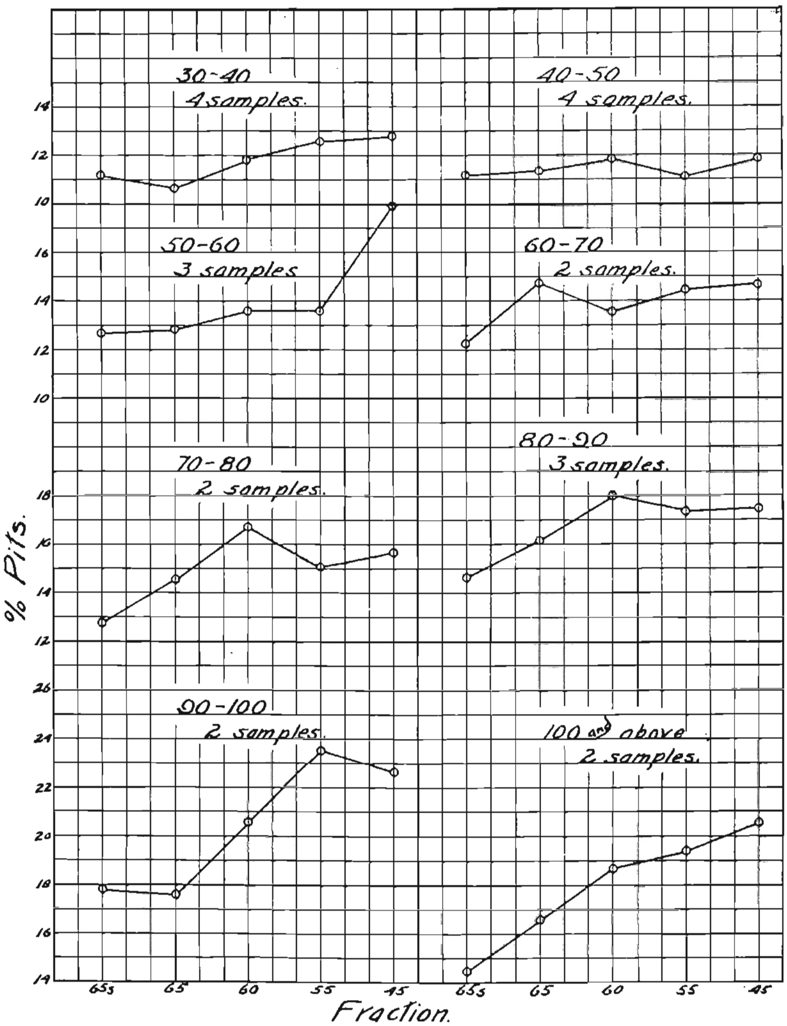

Fig. 7. Pit percentage in Petite prunes by packers' grades. Variation by gravity fractions.

acid in the Petite prune imparts to it a more or less subacid, date-like flavor which makes it taste much sweeter than an Italian prune of the same sugar content. The higher acidity of the Italian prune gives a tart flavor, which is much preferred by many consumers.

Total sugar in flesh. Sucrose varied in such an indefinite manner, owing, no doubt, to such factors as length of drying time and temperature, acidity, and state of maturity, that it seems best to mention in this connection the relationship of total sugar only to size-grades and gravity fractions. An examination of the curves on Fig. 9 shows that the large- and medium-sized prunes contain somewhat less total sugar than the small sizes of the same gravity fraction. This difference is especially prominent in the lighter gravity fractions. As shown by the curves of Fig. 10, however, within the same size-grade of fruit the heavier gravity fractions are considerably higher in sugar content than the lighter fractions. While the curves for 60/70's and 90/100's are not as uniform as might have been expected, consideration must be given the fact that they represent the averages of only a few samples.

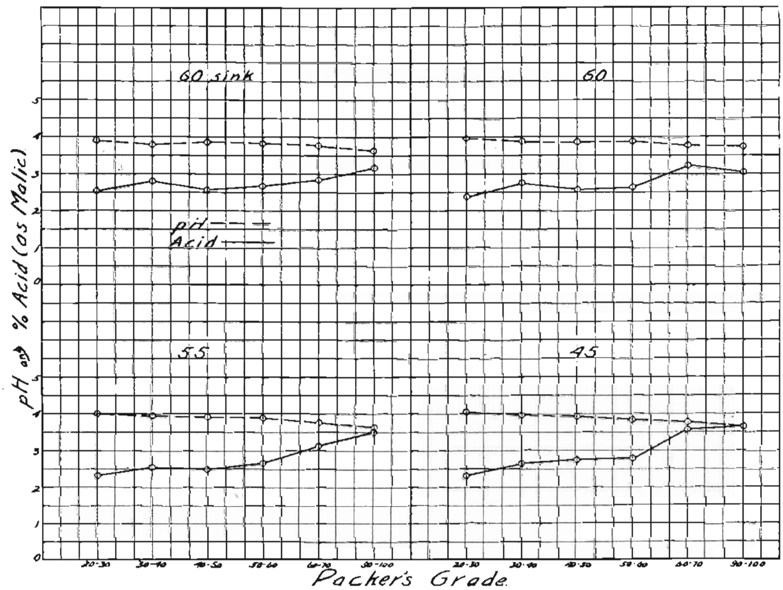

Fig. 8. Acidity and hydrogen-ion concentration of Italian prunes. Variation with packers' size-grades.

No curves are given for sugar in the Petite prune. A study of the averages in Table II shows no orderly variation of the sugar content with the size-grade or with the gravity fractions. For two or three of the smaller sizes, however, the sugar content of the 45F gravity fraction is slightly below that of the 65 sink or 65 float fractions.

Effect of the pit on gravity separation. In the course of the examination and separation of the fruit into the various gravity fractions perfectly good fruit was often found in the lower gravity grades. The physical examination of this fruit indicated that it rightfully belonged in a higher gravity fraction. The flesh was firm in texture, no porosity of any consequence existed, and the fruit was of excellent color. Unable to account at

TABLE II. AVERAGES FOR ACID, pH, AND TOTAL SUGAR

Petite

Fraction—		65 Sink			65 Float			60 Float			55 Float			45 Float		
Grade	No. of samples	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar
30/40........	4	1.46	3.89	69.89	1.35	3.89	69.79	1.29	3.96	69.90	1.24	3.97	69.97	1.33	3.97	69.98
40/50........	4	1.40	3.83	67.31	1.38	3.85	70.00	1.26	3.93	69.60	1.31	3.90	69.79	1.22	3.96	70.25
50/60........	3	1.46	3.90	67.35	1.38	3.92	68.55	1.37	3.96	70.13	1.33	4.00	68.83	1.21	4.04	69.12
60/70........	2	1.28	3.86	69.63	1.37	3.80	69.57	1.33	3.86	67.63	1.40	3.83	68.93	1.46	3.84	71.10
70/80........	2	1.44	3.76	67.93	1.52	3.76	66.98	1.63	3.71	66.28	1.30	3.85	66.63	1.28	3.93	63.95
80/90........	3	1.34	3.77	69.53	1.45	3.73	68.27	1.59	3.68	69.27	1.57	3.80	67.98	1.81	3.75	66.55
90/100......	2	1.49	3.73	68.93	1.87	4.45	67.60	1.99	3.74	64.02	2.20	3.70	64.70	2.79	3.64	59.88
100-up........	2	1.68	3.62	71.60	1.78	3.66	69.10	2.12	3.62	65.43	2.05	3.72	68.03	2.00	3.76	65.38

Italian

Fraction—		60 Sink			60 Float			55 Float			45 Float					
Grade	No. of samples	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar	Acid, malic	pH	Total sugar
20/30........	6	2.53	3.92	57.34	2.39	3.99	56.86	2.34	4.02	55.48	2.34	4.05	51.50			
30/40........	13	2.81	3.81	55.61	2.74	3.86	55.03	2.53	3.96	53.31	2.63	3.97	51.50			
40/50........	14	2.58	3.87	56.38	2.61	3.88	54.40	2.49	3.92	54.59	2.75	3.93	53.05			
50/60........	13	2.70	3.83	56.88	2.65	3.94	56.29	2.66	3.89	55.55	2.81	3.84	52.72			
60/70........	4	2.85	3.79	60.94	3.25	3.78	56.85	3.13	3.78	59.91	3.58	3.77	55.79			
90/100......	1	3.19	3.65	62.75	3.06	3.75	60.00	3.51	3.65	59.60	3.65	3.62	59.90			

once for this variation, an examination of the pit was made, with the following results. The fruit which had sunk in a 60° Balling sugar solution was pitted and the pits were floated separately.

45° solution—50% of the pits floated
50° solution—40% of the pits floated
60° solution—10% of the pits floated

Tests conducted on the flesh from prunes that floated in a 40° solution gave the following results:

55° solution—10% of the prune flesh floated
60° solution—20% of the prune flesh floated
60° solution—70% of the prune flesh sank

The effect of the pits on quality grading of the fruit by gravity separation is indicated by the above results of physical tests. This occasional lightness of good fruits was due principally to a low moisture content of kernels and to air pockets caused by the shrinkage of the kernel in the

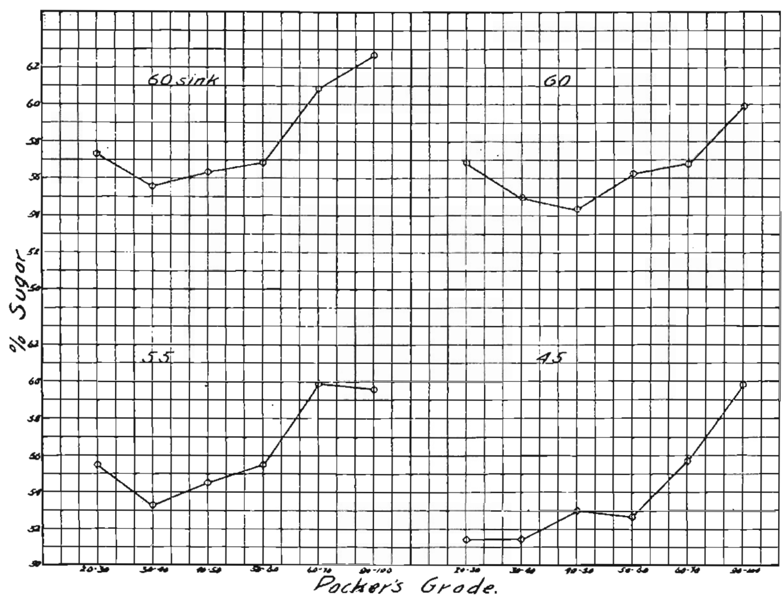

Fig. 9. Comparison of the sugar content of dried Italian prunes by size-grades for each gravity fraction.

process of drying. This fact was really responsible for the suggestion that possibly gravity separation in the fresh state might be productive of better results and make regrading of the dried fruit unnecessary.

From work on the 1925 crop two facts developed. The criticisms of buyers and market specialists were just, and dried prunes of the Northwest were not being marketed on a quality basis. Methods in vogue in harvesting, drying, and packing operate against uniformity of quality in market grades. On the other hand, it was clear that the situation was far from hopeless. Practical procedures could be devised for grading the prune crop on the basis of quality.

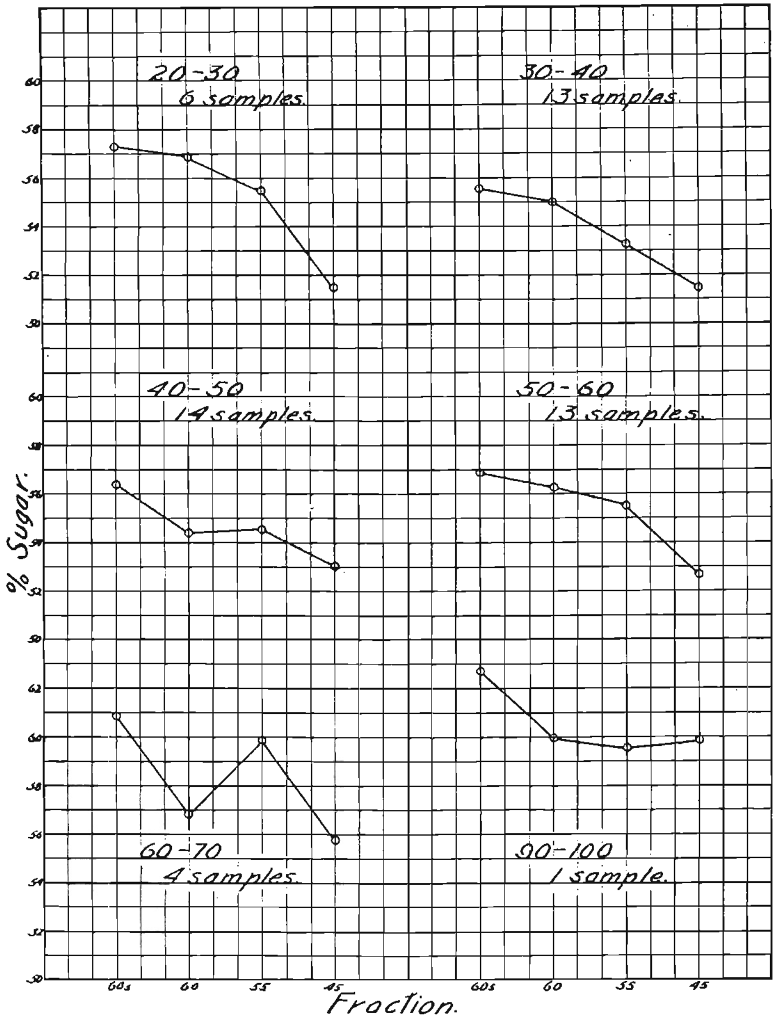

Fig. 10. Variation of sugar content of dried Italian prunes by gravity fractions for each size-grade.

GRAVITY SEPARATIONS APPLIED TO FRESH FRUIT

The trend to be followed in an investigation of the kind undertaken in this case cannot always be foretold. Had the Northwest prune crop of 1926 been one of even moderate proportions, it is quite probable that there would have been a continuance of the program of investigation initiated on the 1925 crop. It has been shown by work on the 1925 crop that regrading of commercial size-grades by a flotation process produced gravity grades that had much to recommend them in the matter of uniformity of quality in so far as quality can be judged by results of physical and chemical tests. The 1926 crop was extremely light. As harvest time approached the probability of obtaining representative commercial size-grades of dried fruit of the 1926 crop in amounts suitable for work seemed very remote. Altogether there appeared to be sufficient reason to abandon temporarily the attempt to perfect a flotation process for the regrading of commercial size-grades of dried prunes and to try out that process in a small way on fresh fruit of the 1926 crop. Subsequent events proved the wisdom of that course, for not until the flotation system was applied to the grading of fresh fruit did the impractical features of regrading commercial size-grades of the dried crop with sugar solutions appear. In spite of changes which the procedure in harvesting operations must involve, it is now clear that grading prunes for quality must begin in the orchard. Gravity grading there is both possible and feasible as results of work on the 1927 and 1928 crops in particular will show.

Because it was decidedly limited in scope the work done on the 1926 crop proved to be of greatest value in developing technique for the management of gravity grading work on fresh fruit of the 1927 crop.

As harvest approached in 1927 sole right to the fruit on a small block of trees in an orchard not far from Corvallis was purchased. Its yield eventually proved to be one and one-quarter tons of fresh fruit.

Instructions were given the grower to harvest this fruit strictly in accord with prevailing methods. A total of three pickings was made and the fruit of each delivered to the laboratory, where provisions had been made for gravity grading by the flotation process.

The first picking, made September 20, 1927, consisted of a harvest entirely from the ground. No fruit was shaken from the trees and all fruit found on the ground was gathered. The rotten or decomposed fruit, unfit for handling, was discarded. Partly infected fruit, however, was harvested with the perfect fruit and was taken with it to the graders.

On September 22, 1927, two days later, the second picking was made. At the start the trees were given a light shaking to cause the nearly ripened fruit to drop.

The third and last picking, made September 29, 1927, consisted of a complete harvest of all the remaining fruit. Much of it had to be shaken from the trees and a very vigorous shaking was necessary to loosen it.

At the laboratory salt solutions ranging in density from 40° to 60° salometer* had been prepared for use in the flotation part of the work. The fresh fruit as received on the day of picking was first immersed in a salt solution of 40° salometer; those prunes which floated to the surface were skimmed off. The prunes which sank in this 40° solution were next immersed in a 50° salometer salt solution from which the floats were likewise removed. The prunes which sank in the 50° solution of salt were again immersed; this time in a 60° salometer salt solution where sinks and

*Degrees salometer represents the percent of saturation of the solution with respect to salt.

floats were again obtained. These four gravity fractions thereafter were known as 40° floats, 50° floats, 60° floats, and 60° sinks.

Results of fresh fruit separations. Results tabulated below show the proportions of fruit which fell into each of the different gravity fractions. The conditions prevailing as to maturity of fruit at the time of each picking are plainly to be correlated with the weight of each gravity fraction.

Fraction salometer	1st picking Weight	1st picking Percent of total	2d picking Weight	2d picking Percent of total	3d picking Weight	3d picking Percent of total
	lbs.	%	*lbs.*	%	*lbs.*	%
40F	150	25.22	361.5	36.80	413	52.12
50F	245	41.21	460.5	46.95	259	32.68
60F	134.5	22.63	145.75	14.85	111	14.00
60S	65	10.94	13.75	1.40	9.5	1.20

The combined weight of the 60 float and 60 sink fractions for the first picking was greater than that for any of the later pickings. The fruit harvested first, having fallen of its own weight, was ripest. A portion of the 40° floats of this picking doubtless results from the inclusion of over-mature and somewhat decayed fruits.

From second and third pickings, there were substantially larger amounts of fruit floated out by the 40° salt solution. This fact, however, is traceable to the inclusion of many immature fruits that had been loosened from the trees by the vigorous shakings given them. It will be noticed that the total time covered by the three pickings is short, too short in fact, to make possible a uniformly mature crop.

The weather conditions prevailing during the harvest of the 1927 crop were not peculiar. The grower of prunes in the Willamette Valley is usually confronted with unfavorable weather conditions at harvest time. Harvesting operations are therefore hastened, with results to the crop that have just been pointed out. It is particularly necessary here in the Willamette Valley to adopt a system of grading that will put preferably riper fruits into grades by themselves.

Relation of maturity to soluble solids. The physical examination of the various gravity fractions showed at once that all the red fruits, whose color was due to under-development, had been floated out in the 40° salt solution. Verification of that conclusion is to be found in the results of tests applied to the extracted juice from the several gravity fractions. The expressed juices from portions of the first and second pickings were tested with a Balling hydrometer for soluble solids, with results shown below. The pectinous nature of the extracted juice from the last picking prevented satisfactory readings on the hydrometer scale, for which reason they are not included.

Fraction salometer	1st picking degrees Balling	2d picking degrees Balling
40F	18.4	19.4
50F	21.5	20.0
60F	26.2	26.0
60S	20.2	34.0

In all cases but one, increase in density of fruit is accompanied by increase in percentage of sugar. In the 60° salt solution the prunes from the first picking gave a juice with soluble solids of only 20.2 percent Balling. It was assumed that this one exception to the general rule was due to the large number of over-mature fruits present in this fraction. It has already been noted that many of that kind had been on the ground for some time previous to the first picking and had passed the perfect stage of maturity for drying.

These results tabulated above suggest the possibility of making use of weight-volume relationships in the commercial grading of dried prunes for quality.

The three pickings of fresh fruit which were floated in varying densities of salt solutions were dried in the usual way. A uniform volume of each flotation of the dried product was taken, carefully weighed, and the prunes counted. The results given in Table III are of extreme importance as they suggest a possible application in the hands of inspectors of dried prunes.

TABLE III. SHOWING RESULTS OF WEIGHT-VOLUME RELATIONSHIP OF 1927 PICKINGS, DRIED ITALIAN PRUNES

Solution density	Uniform volume* measure, average weight in pounds	Uniform volume measure, average count	Count per lb.
	First picking		
	lbs.		
40F	4.406	274	62
50F	4.630	245	53
60F	4.790	235	49
60S	4.690	227	48
	Second picking		
40F	4.403	232	53
50F	4.726	222	47
60F	4.880	221	45
60S	4.620	203	43
	Third picking		
40F	4.243	243	57
50F	4.556	226	50
60F	4.713	229	49
60S	5.120	203	40

*A No. 10 tin can was used as a measure in order to obtain uniformity of size of sample.

It will be noticed that the volume weight for all the flotations increases from the 40° salt solution up to the 60° salt solution. The prunes in the first two pickings which sank in the 60° salt solution, after drying have less weight per unit volume than those in the next gravity fraction. Fermentation in the more mature fruits of the 60° sink fractions of the first two pickings before and during the early stages of drying may be responsible for their somewhat lower weight per unit volume in comparison with that of the 60° floats. It will be noted that the 60° sinks of the third picking are heaviest, as one might reasonably expect them to be.

Influence of gravity separation on speed of drying and drying ratio. Gravity separation of the fruit into varying maturities also affected the "dry-away." When fruit is dried as it is normally with all maturities mixed, the variation in the dry-away are not noticeable. When fruits of different degrees of maturities are separated, as by the flotation method, the difference in drying ratios (ratios of fresh fruit to dry fruit) becomes at once apparent (Figs. 11 and 12).

Fig. 11 illustrates the effect of shaking the tree on drying ratio. In the third picking it will be noticed that the drying ratio is much wider than it is in the first picking where no shaking was resorted to. It will also be noticed that the second picking showed a more uniform condition in moisture content. Results from the last picking with a drying ratio of 4 to 1 for the 40F fraction bring out clearly the deleterious influence of the shaking of trees on the "dry-away."

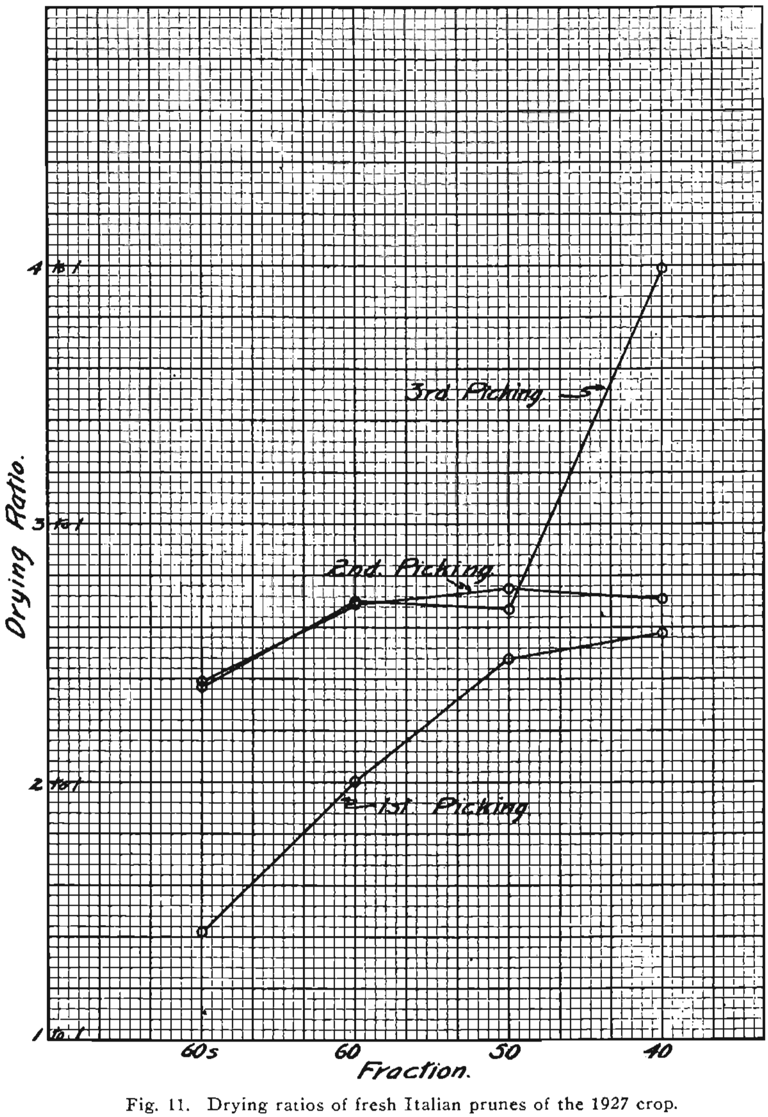

Fig. 11. Drying ratios of fresh Italian prunes of the 1927 crop.

These wide drying ratios, it should be noted, have a distinct bearing on the dehydrater operation. Fruit having a dry-away as low as that indicated in Fig. 12 where the ratio is 1.1 to 1, obviously will move through the dehydrater faster than fruit having a drying ratio of 3 to 1. For the sake of speed and economy in drying, the tunnels should contain only fruit of the same degree of maturity.

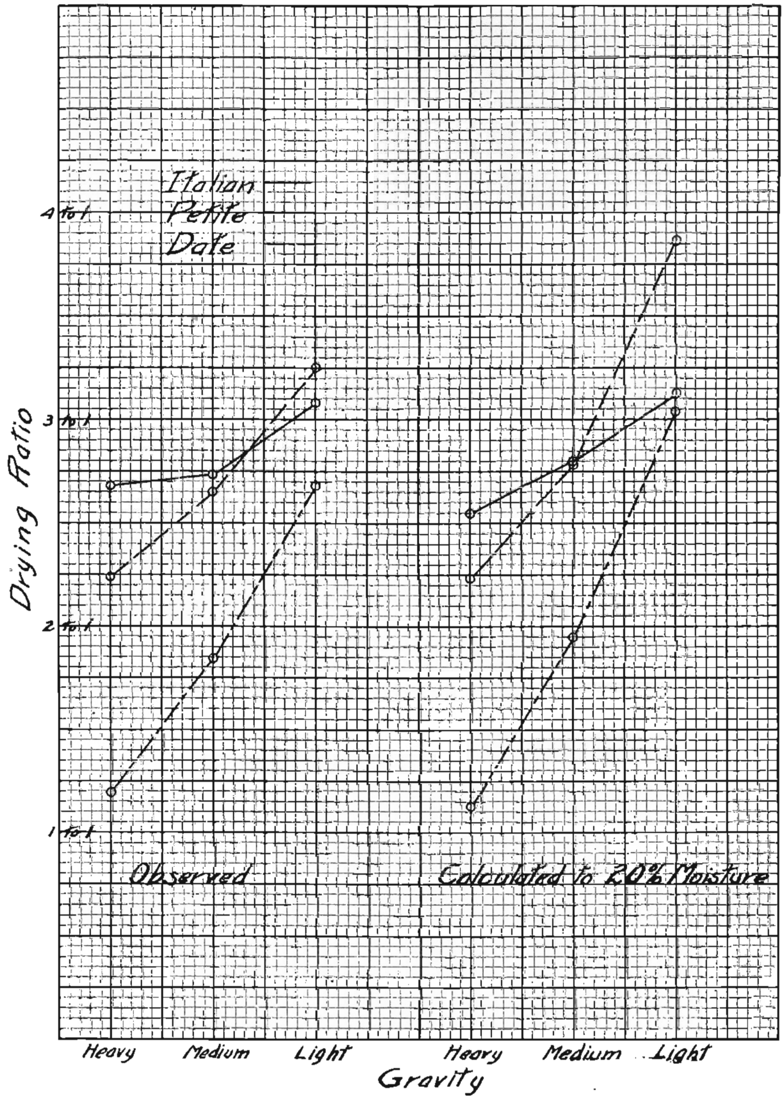

Fig. 12. Drying ratios of Italian, Petites, and Date prunes, separated mechanically, 1928 crop.

The segregation of fruit according to stage of maturity in separate tunnels during the drying operation has the further effect of producing a more uniform dried product. Obviously, when fruits of varying moistures are all placed on the same tray or car, the mature fruits, relatively low in moisture, are over-dried in the effort to obtain the proper degree of dryness for the under-mature fruit.

A mixture of fruit of all degrees of maturity on the same tray or car, moreover, results in the unevenness of moisture content shown by Fig. 13. The size-grades represented are prunes which were gathered at the various packing plants throughout the state earlier in these investigations. The most noticeable thing about the results is that in all cases fruit of largest size has the greatest amount of moisture. Fruit of the smallest size shows a moisture content as low as 16 percent. Such low moisture percentages are obviously due to over-drying, as many fully matured prunes were found in the smaller sizes.

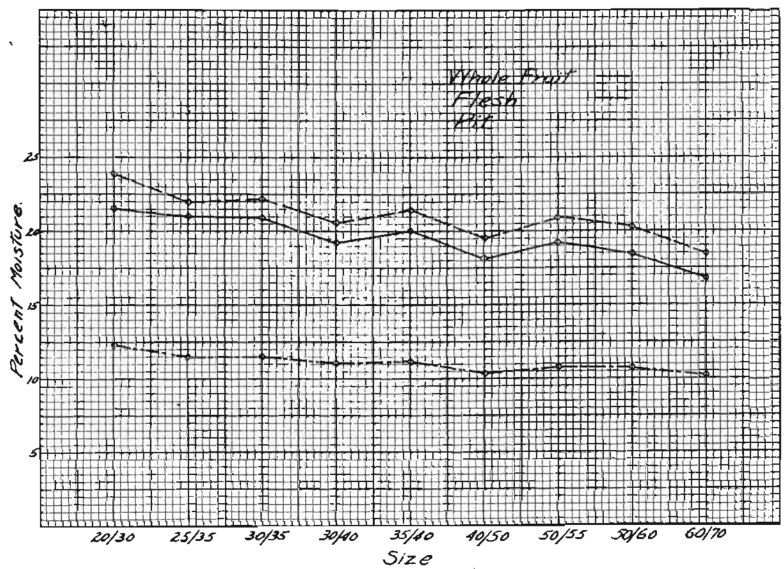

Fig. 13. Moisture content of dried Italian prunes according to size-grades.

CHEMICAL EXAMINATION OF FRUIT SUPPORTS CONCLUSIONS DRAWN FROM PHYSICAL EXAMINATION AND TESTS

From purely physical considerations and tests applied to the products resulting from gravity grading of the fresh fruit of the 1927 crop, one might safely conclude that close correlation prevails between degree of maturity and quality as that term has heretofore been used. It will now be shown that the results of rather extensive chemical work on the several gravity separations of the fresh fruit of the 1927 crop and the commercially dried products resulting from them confirm in every essential the conclusions arrived at from purely physical data and field observation. Chemical methods used on fresh fruit samples were the same as those previously employed on commercial grades of dried fruit with such minor changes only in size of samples and aliquots as appeared to be advisable or essential in routine analytical work.

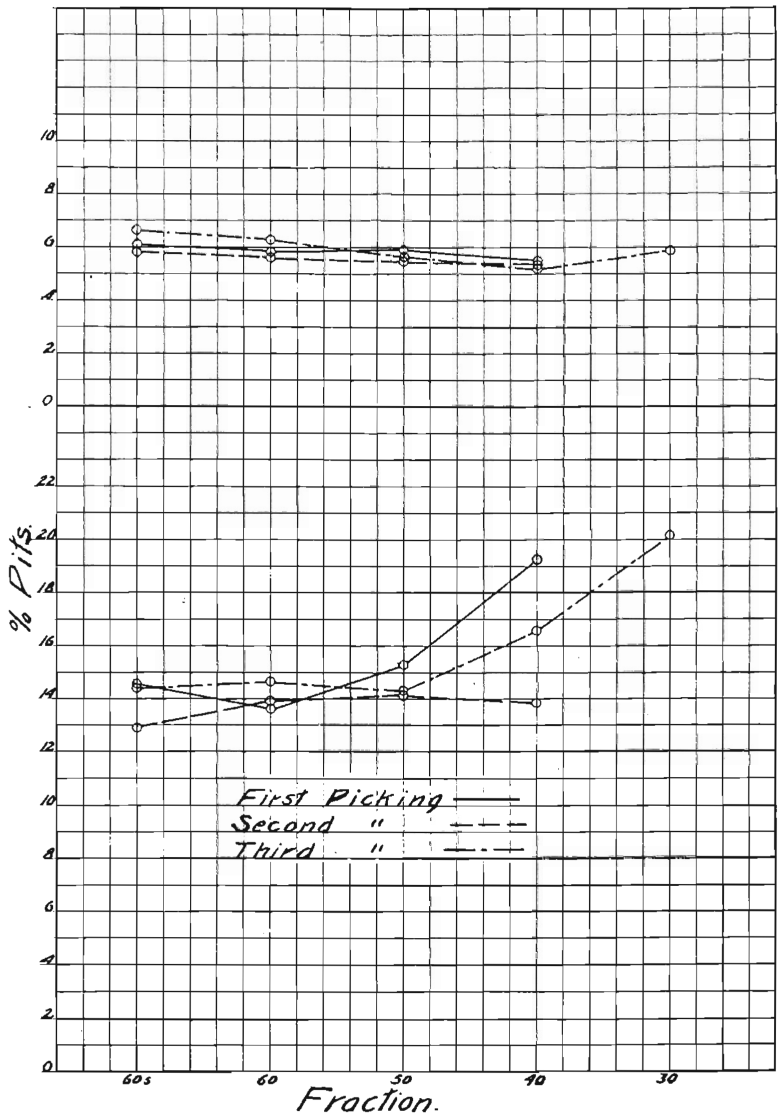

Fig. 14. Pit percentages in fresh and dried Italian prunes of the 1927 crop.

Pit-flesh ratios and moisture contents. The percentage of pits in the fresh fruit as compared with that of the same prunes after drying is given by Fig. 14 from analytical data on the 1927 crop. The results closely resemble those obtained from the 1926 samples. In the fresh fruit the pit percentages of the various fractions are nearly the same, with the heavier fractions generally showing slightly higher. Upon drying, this relationship

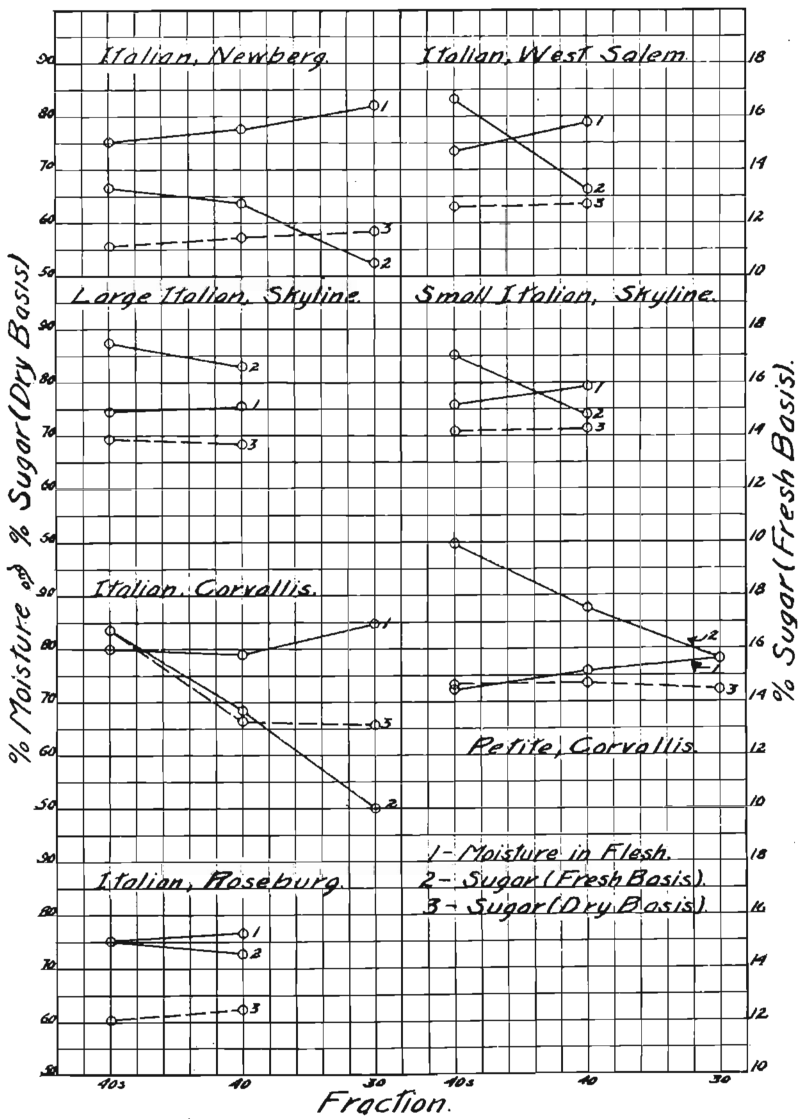

Fig. 15. Sugar-moisture relationship on fresh Italian prunes. 1926 crop.

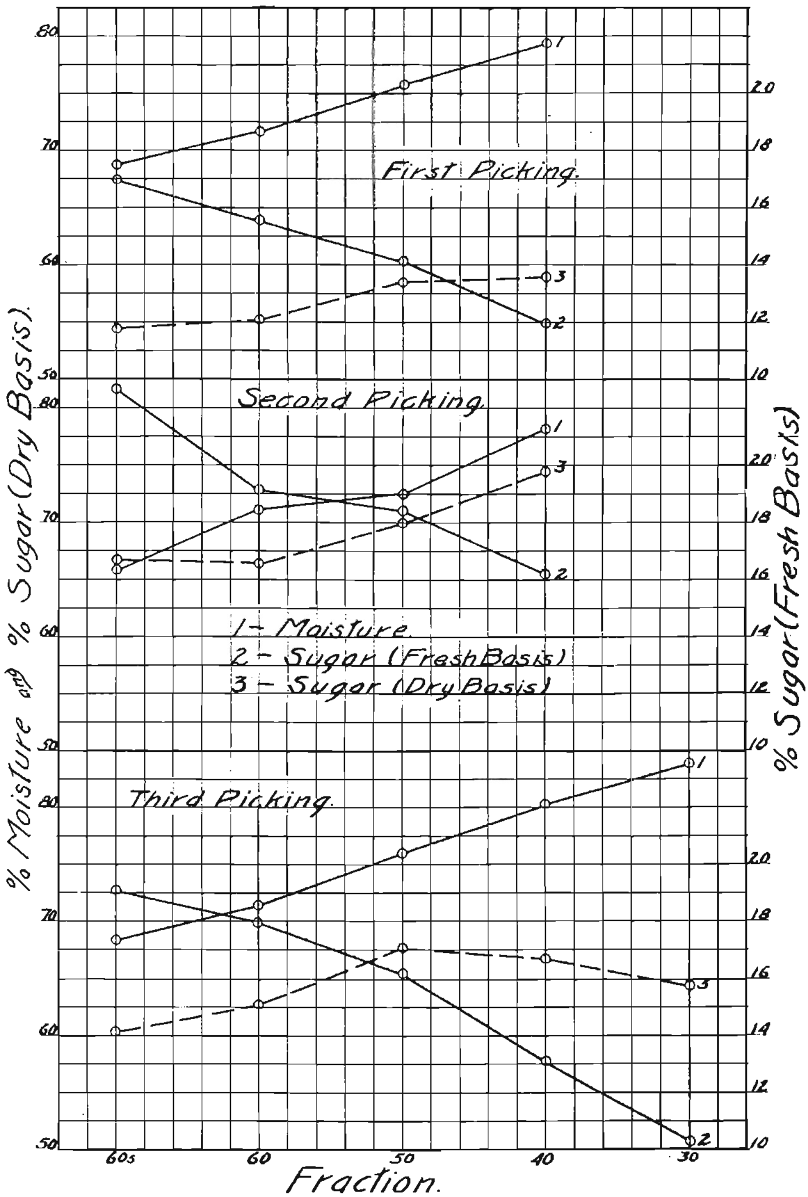

Fig. 16. Sugar-moisture relationship. Italian prunes. 1927 crop.

is reversed. In the dried product the percentage of pits is highest in the lightest fractions. This apparent reversal in the ratio of pit to flesh after drying is explained by a consideration of the moisture contents of the flesh and pits of the fresh fruit. The pits carry about equal amounts of moisture with slightly more in the pits of the light fractions, but the flesh of the light fractions is much higher in moisture than that of the heavy fractions

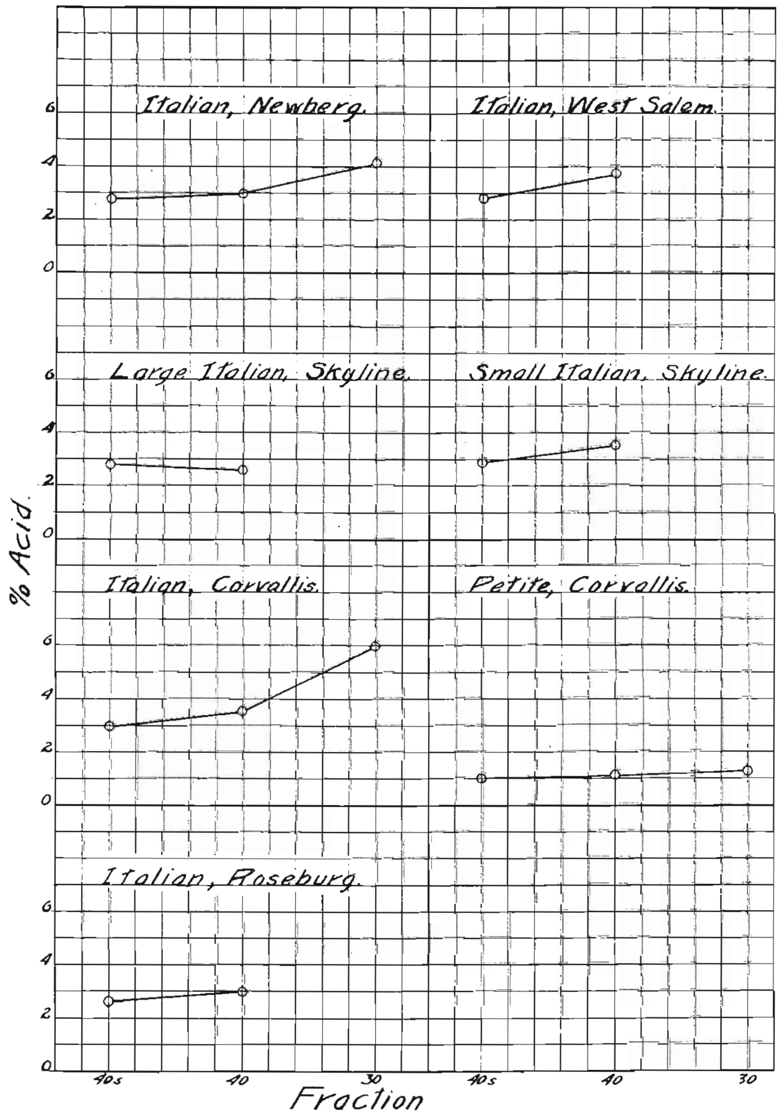

Fig. 17. Acid in fresh fruit of 1926 crop.

(see Figs. 15 and 16). Upon drying, the loss from the pits is about the same for all the fruit, but the loss in weight from the flesh is much greater in the light fractions. This results in a much smaller amount of dry matter and a correspondingly higher proportion of pit to flesh. The difference is greatest in the light fractions from the third picking, which contained the most immature fruit. Again it should be stated in explanation that separa-

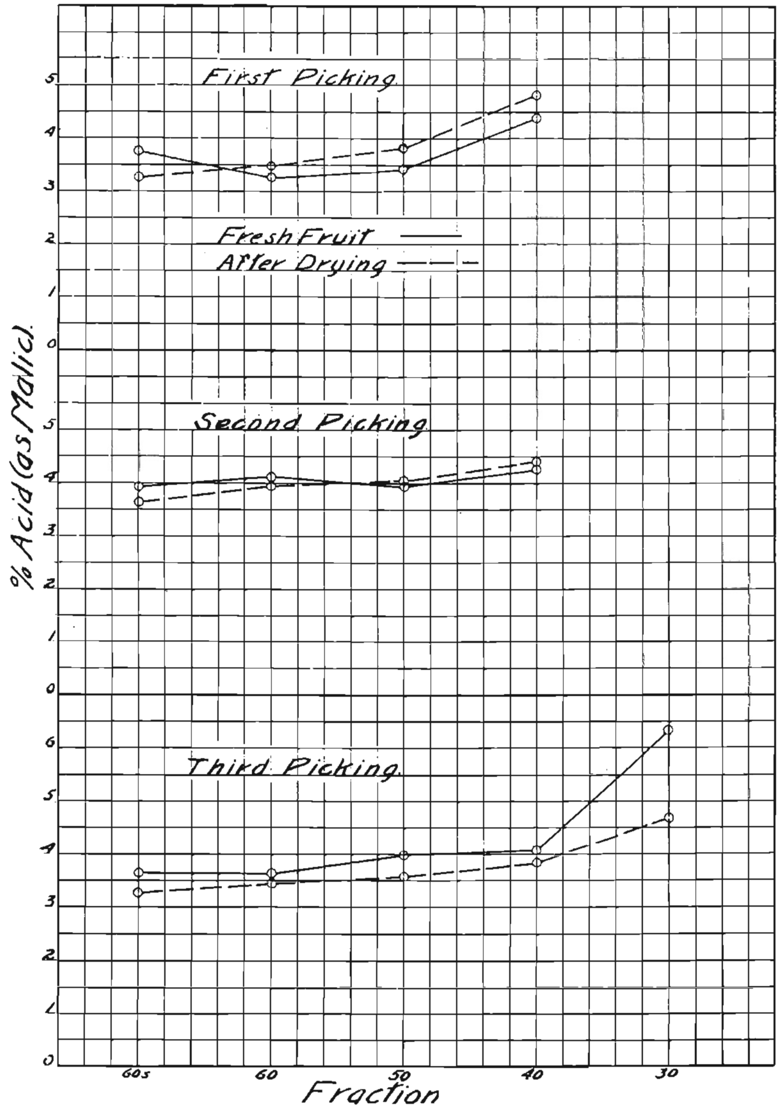

Fig. 18. Acid in Italian prunes before and after drying. 1927 crop.

tion of the fresh fruit into gravity fractions seems to grade it according to its stage of maturity. The ripe fruit, high in sugar and low in acid and moisture—in other words, the fruit having high soluble solids—is found in the heavy fractions, while the immature, green fruit, high in acid and water and low in sugar, separates into the lighter fractions.

Acid and hydrogen-ion concentration. Figures 17 and 18 respectively show the acid content of the gravity fractions from the 1926 and the 1927 fresh fruit. In practically all instances there is an increase in acid with a decrease in gravity of the fruit, and the same was true after the fruit had been dried. While sampling errors in this type of work are large, it would seem safe to say that drying does not alter the acid content of the fruit to an appreciable extent.

Sugar content of fresh and dried fruit. The facts relating to sugar in the fresh fruits are brought out by the curves of Fig. 15 and Fig. 16. The moisture content, as noted in the discussion on pit relationship, invariably increases as the gravity of the fruit decreases. This is shown by curve 1 in each graph. Curve 2 shows that the sugar content of the fresh flesh decreases in just as regular a manner as the moisture content increases. This correlation furnishes further evidence for the assumption that the gravity separation of the fresh fruit results in a segregation into grades according to the stage of maturity of the fruit. The fact that the acidity of the fresh fruit increases with decrease in gravity lends support to this view since it is a generally accepted fact that the ripening process of nearly all fruits involves an increase in sugar and a decrease in acid and moisture content.

Calculation of the sugar content of the fresh flesh on an oven-dry basis suggests a somewhat anomalous behavior since the values in general increase with decrease in gravity of the fruit. This seeming inconsistency in curve 3 is explained, however, by the large difference in moisture content of the heavy and light fractions of the fresh fruit. Although the oven-dry flesh of the light prunes contained pound for pound somewhat more sugar than that of the heavy ones, still the fact remains that a hundred pounds of fresh fruit from the heavy fractions yielded a decidedly greater amount of oven-dry flesh than an equal weight of fresh prunes from the lighter fractions.

GRAVITY GRADING OPERATIONS OF 1928 CROP

With such gratifying results from the application of the flotation principle to the grading of fresh fruit in 1927, operations on a larger scale on the crop of 1928 were decided upon.

In the spring of 1928 a machine was designed and built for handling that season's crop of fresh fruit by the flotation principle. Its operation was highly satisfactory. It is shown in Figs. 19 and 20. It was operated in a semi-commercial manner in the dehydrating plant of the Springbrook Cooperative Prune Growers on fruit delivered by its members.

The crop of 1928 was short, for which reason many of the Italian prunes which would otherwise have gone through the commercial driers, were sent to the canneries. The result unfortunately was an inferior lot

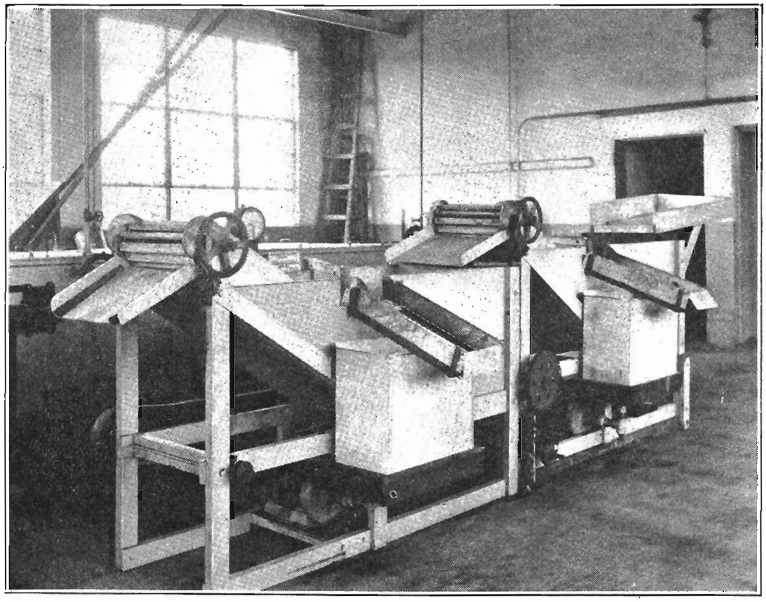

Fig. 19. Side view. Machine for the mechanical separation of prunes into their various maturities.

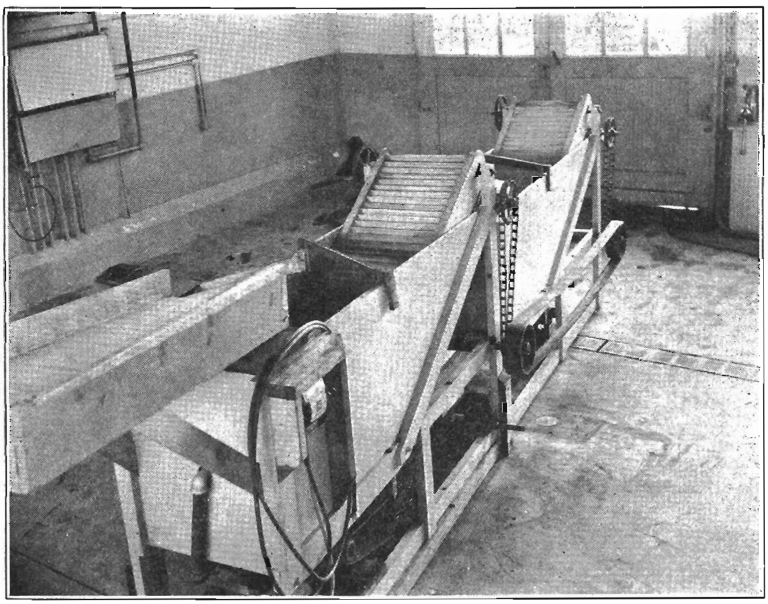

Fig. 20. Top view. Machine for the mechanical separation of prunes into their various maturities.

of that variety for dehydrating purposes. The quality of Petite and Date varieties handled was more satisfactory.

The amount of fresh fruit made up of these three varieties graded by this machine amounted to approximately ten tons. As the machine was designed to use but two solutions, three gravity grades only were made. They are designated as light, medium, and heavy. The solutions used were of calcium chloride with a density of 40° salometer for the first tank and 60° salometer for the second tank. For Petite and Date prunes, a 65° calcium chloride solution was used in the second tank because of the higher sugar content of these varieties as compared to Italian prunes.

All the fruit was carefully weighed before and after separating and after dehydrating. The drying ratios are indicated by Fig. 12.

It will be noticed that the results were tabulated as "observed," which were the actual drying ratios, and "calculated," which were the actual results standardizing to a 20-percent moisture basis. The data in Table IV show why this procedure was advisable. So many lots were so small in quantity as to make it impossible to fill the drier cars with any one gravity separation. This condition made for uneven drying and a variable moisture content of the dried product.

TABLE IV. SHOWING MOISTURES FOR THE DIFFERENT FRACTIONS ITALIAN FRESH PRUNES, SEPARATED 1928

Name	Date	Solution density	Grade quality	Moisture content of dry product
Barron I	9/6	40F	Green	18.62
	9/6	60F	Medium	20.60
Barron II	9/6	40F	Green	18.76
	9/6	60F	Medium	21.27
	9/6	60S	Ripe	19.81
Jones	9/19	40F	Green	22.02
	9/19	60F	Medium	23.74
	9/19	60S	Ripe	20.04
Schmeltzer	9/19	40F	Green	18.61
	9/19	60F	Medium	20.03
	9/19	60S	Ripe	18.08
Beeman	9/20	40F	Green	23.21
	9/20	60F	Medium	22.66
	9/20	60S	Ripe	20.48
Aibischer	9/20	40F	Green	21.98
	9/20	60F	Medium	22.91
	9/20	60S	Ripe	17.64
Schmeltzer	9/21	40F	Green	24.06
	9/21	60F	Medium	23.78
	9/21	60S	Ripe	19.96

Gravity method again separates fresh fruit according to degree of maturity. That fresh fruit sent through this machine was graded according to fractions of different degrees of maturity, as was the crop of 1927, handled by cruder methods, is indicated by differences in sugar content of those fractions after drying.

Fig. 21 shows a steady increase in sugar from the lightest to the heaviest fractions.

Because of the small number of lots, this variation of sugar in gravity fractions of the Date prune is not as plainly indicated as it is for the Italians and Petites.

Effect of flotation on size-grades. The prunes separated and dried as above explained were next graded to standard sizes over the regular

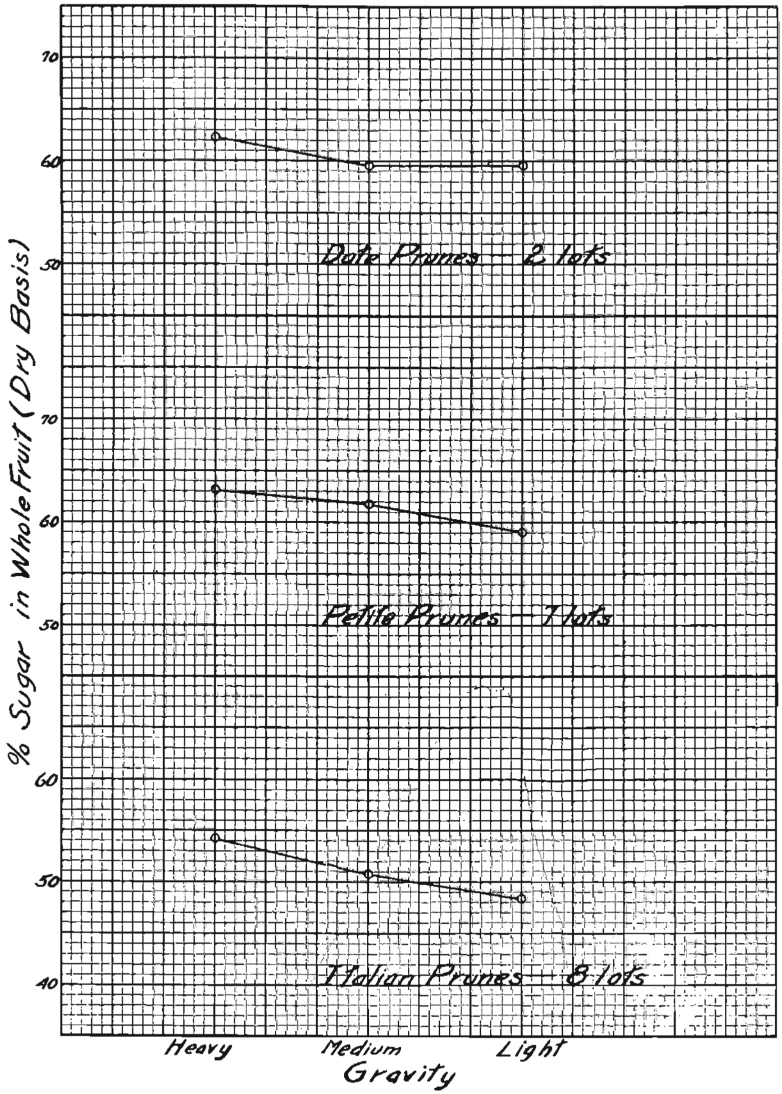

Fig. 21. Relation of gravity to sugar content.

screens used by the Springbrook Cooperative Packing Association (Fig. 22).

The screens used were the following sizes: 20/16, 19/16, 18/16, 17/16, 16/16, 15/16, 14/16, 13/16, 12/16 inch. They produced the following size-grades: 20/30, 30/40, 40/50, 50/60, 60/70, 70/80, 80/90, 90/100, 100 over. These size-grades were not blended in any way as might have been the case in commercial size-grading.

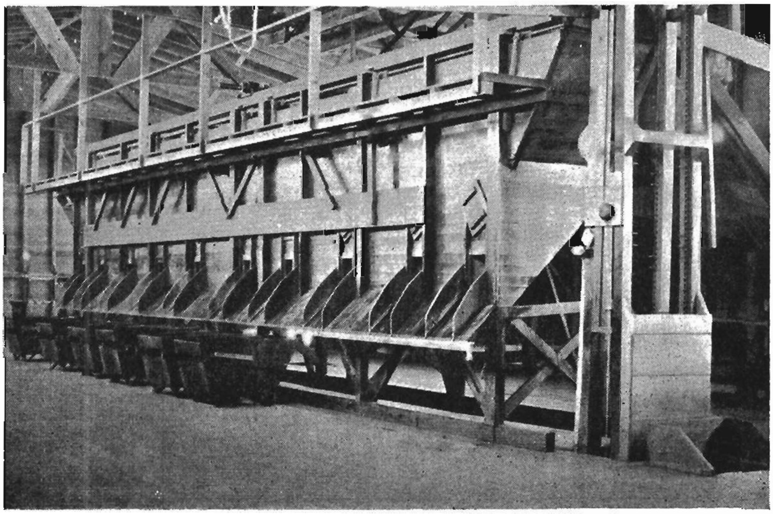

Fig. 22. Type of size-grader used in separating fruit to size-grade.

The weights for each fraction of the different lots were averaged so that all prunes representing any one of the three gravity grades were kept separate from any others. The percent of the total weight represented by each size-grade was then calculated. These results are clearly shown by Figs. 23, 24, and 25.

The results clearly show that the riper fruit predominates in all the larger sizes. The intermediate gravity fraction which is the most uniform of all the lots takes the lead in quantity except in the Date prunes. Here the 30/40 and 40/50 size-grades have a preponderance of ripe prunes.

Owing to the short crops very few Italian prunes were available. The fruit of that variety used in this test was very green, as shown by the drying ratios plotted in Fig. 12. As previously noted, this fruit was culls from cannery stock and was not in proper condition for drying; consequently, the results were not in line with those covering the Date prunes, which were the most nearly normal of the three varieties tested. Grading results with the Italian prunes, however, were quite gratifying when the condition of the original fruit is taken into consideration.

The last three size-grades of the Petite prunes show a very large amount of green fruit. Results with the Dates are similar to those of the Petites with this difference, that the larger size-grades show heavier yields of ripe fruit.

Chemical work on 1928 crop. Only a few chemical analyses of green fruit were made in 1928. They confirm the findings of the previous work. All dried fractions of the gravity grades of fresh fruit were analyzed, however, and the information obtained parallels that from the dried samples of the 1927 crop with one noticeable exception. The moisture differences in fractions were so much less in the 1928 crop than in the 1927 crop that when

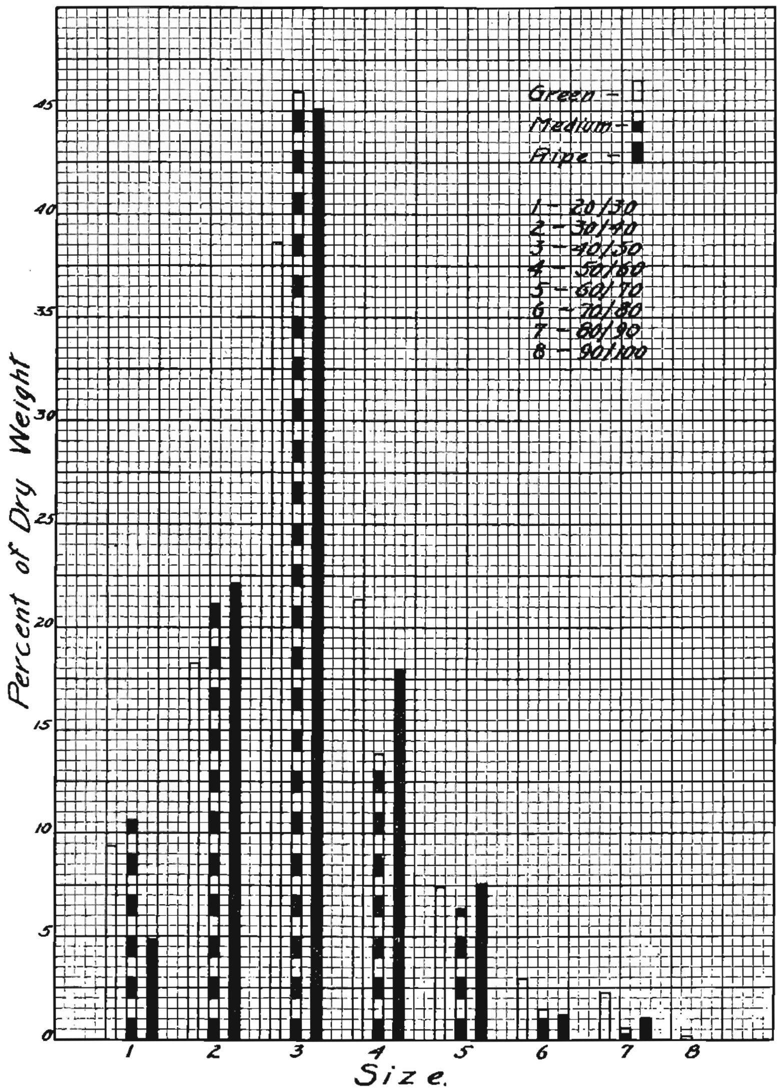

Fig. 23. Percent of maturities in various size-grades. Italians.

calculated to a moisture-free basis the sugar relationship between fractions is not reversed as in the 1927 crop. (Compare Fig. 26 with Curve 3 of Fig. 16.)

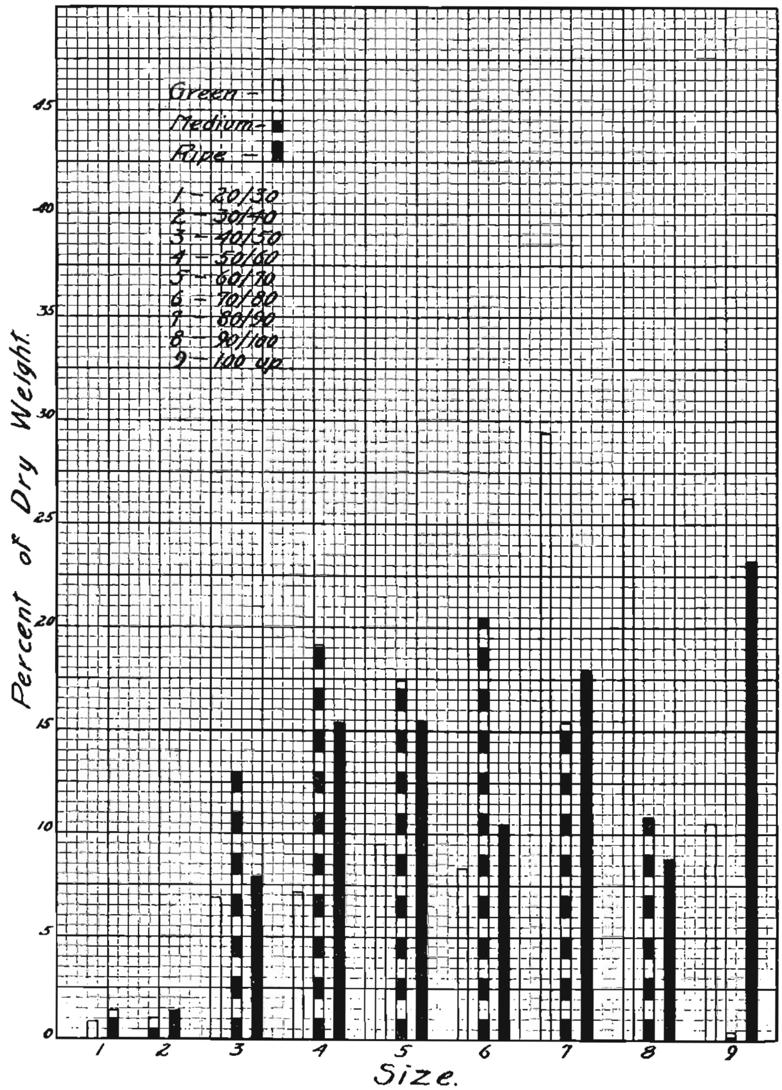

Fig. 24. Percent of maturities in various size-grades. Petites.

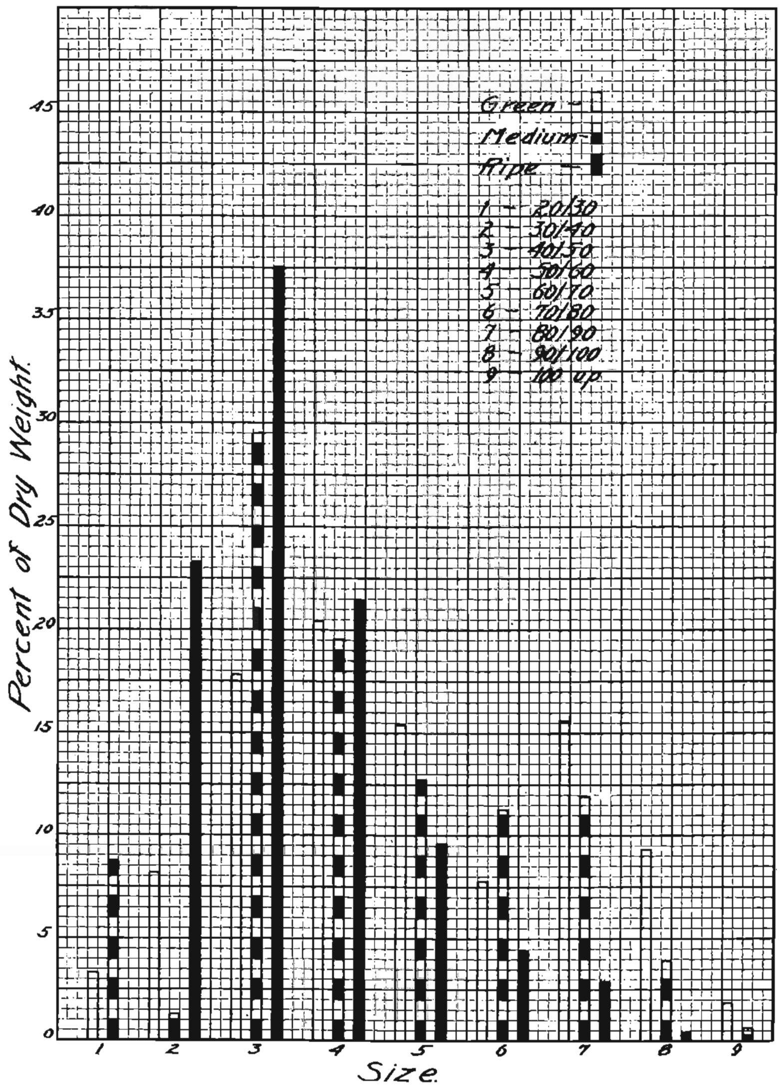

Fig. 25. Percent of maturities in various size-grades. Dates.

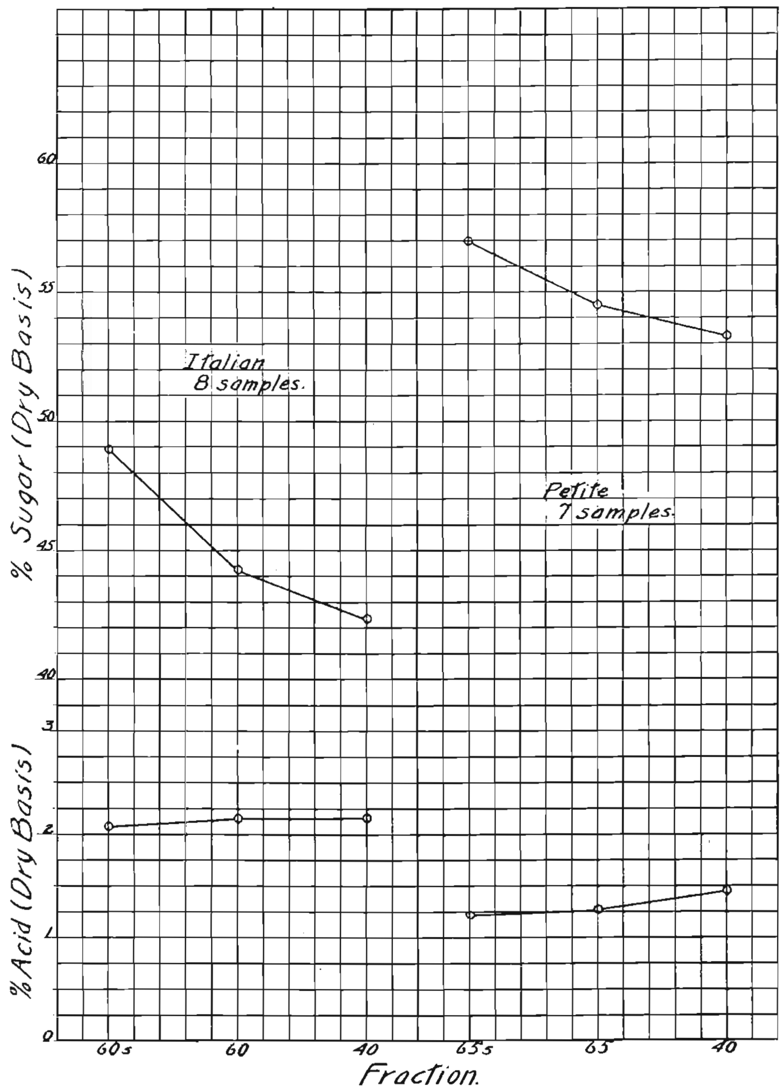

Fig. 26. Acid and sugar averages for dried samples. 1928 crop.

The acid content, as before, is lower in the heavier gravity fractions. Table V gives in more detail the chemical data for the individual lots which were separated mechanically before drying.

TABLE V. ANALYSIS AFTER DRYING OF PRUNES SEPARATED FRESH
1928 CROP

Variety	Lot. No.	Fraction	Pit	Flesh	Moisture in flesh	Moisture-free flesh Malic acid	Moisture-free flesh Sugar
			%	%	%	%	%
Date	John Reese	60° salt sink	12.98	87.02	20.55	1.88	57.92
		60° salt float	11.03	88.97	24.28	1.24	54.40
		40° salt float	12.22	87.78	19.55	1.34	56.48
Date	Ferril	60° salt float	15.83	84.17	26.34	1.58	51.12
		40° salt float	15.71	84.29	21.94	1.74	55.60
Petite	1	65° salt sink	9.92	90.08	23.68	1.47	54.60
		65° salt float	11.23	88.77	26.55	1.34	50.88
		40° salt float	12.60	87.40	27.03	1.54	49.76
Petite	2	65° salt sink	11.22	88.78	19.76	1.24	55.84
		65° salt float	11.70	88.30	23.48	1.14	54.88
		40° salt float	12.60	87.40	27.03	1.54	49.76
Petite	5	65° salt sink	10.74	89.26	20.69	1.22	57.60
		65° salt float	11.86	88.14	25.74	1.41	52.00
		40° salt float	11.92	88.08	24.20	1.54	52.80
Petite	2820 B R J	65° salt sink	10.58	89.42	18.78	1.22	58.00
		65° salt float	10.18	89.82	21.00	1.21	56.36
		40° salt float	11.83	88.17	18.52	1.37	57.04
Petite	3820 B R	65° salt sink	9.93	90.17	18.13	1.14	60.00
		65° salt float	10.89	89.11	20.38	1.26	57.92
		40° salt float	13.64	86.36	23.93	1.44	52.16
Petite	1820 B B F	65° salt sink	9.57	90.43	21.76	1.11	57.76
		65° salt float	10.35	89.65	22.91	1.34	55.84
		40° salt float	11.70	88.30	22.26	1.61	52.80
Petite	1812 A W	65° salt sink	12.23	87.77	22.32	1.11	55.12
		65° salt float	12.65	87.35	23.30	1.14	53.76
		40° salt float	11.85	86.15	20.19	1.14	55.12
Italian	1	60° salt float	10.68	89.32	21.72	2.48	44.08
		40° salt float	11.67	88.33	19.77	2.58	42.88
Italian	2	60° salt sink	11.43	88.57	20.90	2.30	48.96
		60° salt float	11.71	88.29	22.52	2.45	43.20
		40° salt float	11.00	89.00	19.75	2.68	42.40
Italian	3	60° salt sink	9.64	90.36	24.71	1.81	47.60
		60° salt float	10.36	89.64	26.55	1.84	42.32
		40° salt float	10.20	89.80	33.54	1.91	36.32
Italian	1820 B B	60° salt sink	10.00	90.00	21.51	1.86	47.44
		60° salt float	10.12	89.88	23.86	1.72	44.88
		40° salt float	10.15	89.85	24.22	1.93	40.56
Italian	1820 B A	60° salt sink	12.62	87.38	18.66	2.26	52.64
		60° salt float	11.61	88.39	24.31	2.23	47.20
		40° salt float	11.55	88.45	23.09	2.45	46.72
Italian	1820 B J	60° salt sink	10.17	89.83	21.00	2.14	46.88
		60° salt float	10.42	89.58	25.12	2.70	43.84
		40° salt float	11.30	88.70	23.40	1.77	43.60
Italian	1820 A Sch	60° salt sink	11.78	88.22	19.12	2.28	51.04
		60° salt float	11.73	88.27	21.24	2.04	47.68
		40° salt float	11.45	88.55	19.66	2.31	46.40
Italian	2821 B Sch	60° salt sink	10.90	89.10	21.06	1.91	47.60
		60° salt float	11.48	88.52	25.25	1.78	40.80
		40° salt float	12.02	87.98	25.74	1.68	40.08

PHYSICAL CHARACTERISTICS INDICATIVE OF QUALITY

Up to this point observations and analytical results have been discussed practically in the order of their occurrence. Some relationships, however, particularly those based upon physical properties of fresh and dried prunes, can best be presented without regard to the chronological order of the work.

It will be recalled that dried fruit of the 1925 crop where separated into gravity fractions by the use of sugar solutions always possessed certain definite physical characteristics. The red colored dried fruit was floated out by the lighter gravity solutions as was fruit characterized by flesh of greenish yellow hue and that which had been more or less scorched during the drying process. The results were interpreted as meaning that fruit of inferior quality grade was being eliminated by the lighter gravity solutions.

In contrast, fruit separated in the solutions of greater density was brighter in color. Its flesh was reddish brown throughout, which is characteristic of well-ripened fruit. It might be remarked that it is coming to be recognized by commercial packers generally that red colored skins and greenish yellow flesh should be associated with under-maturity of fruit and that dark brown and burnt-appearing flesh is indicative of fermentation and careless operation in drying.

TABLE VI. RESULTS OF PHYSICAL EXAMINATIONS OF DRIED ITALIAN PRUNES

									Colors in flesh			Firmness and porosity of flesh	
Plant No.	Date	Prunes in sample	Quality No.	Size-grade	Mold	Brown Rot	Scab	Burned	Greenish yellow	Reddish brown	Muddy brown	Firm, small gas-pockets	Porous, large gas-pockets
5	3/19	20	1	20-30	0	0	2	3	6	2	12	5	15
5	3/19	20	2	20-30	0	0	1	0	5	3	12	7	13
5	3/19	20	3	20-30	0	0	1	6	3	7	10	7	13
5	3/19	20	4	20-30	0	0	1	1	5	11	4	14	6
14	3/25	20	1	30-40	0	0	3	0	3	2	15	3	17
14	3/25	20	2	30-40	0	0	2	3	2	4	14	4	16
14	3/25	20	3	30-40	0	0	2	1	4	4	12	8	12
14	3/25	20	4	30-40	0	0	0	0	8	10	2	16	4
5	3/18	20	1	40-50	0	0	0	2	8	1	11	8	12
5	3/18	20	2	40-50	0	0	1	2	7	2	11	7	13
5	3/18	20	3	40-50	0	0	0	0	8	0	12	8	12
5	3/18	20	4	40-50	0	0	1	0	5	10	5	12	8
4	3/25	20	1	50-60	0	0	0	8	8	0	12	6	14
4	3/25	20	2	50-60	0	0	1	8	8	1	11	6	14
4	3/25	20	3	50-60	0	0	0	5	6	4	10	7	13
4	3/25	20	4	50-60	0	0	0	0	4	14	2	17	3
1	4/15	20	1	60-70	0	1	1	2	4	6	10	8	12
1	4/15	20	2	60-70	0	2	0	2	5	6	9	8	12
1	4/15	20	3	60-70	0	2	1	2	8	5	7	12	8
1	4/15	20	4	60-70	0	1	0	0	3	10	7	11	9

TABLE VII. RESULTS OF PHYSICAL EXAMINATIONS OF DRIED PETITE PRUNES

									Colors in flesh			Firmness and porosity of flesh	
Plant No.	Date	Prunes in sample	Quality No.	Size-grade	Mold	Brown Rot	Scab	Burned	Greenish yellow	Reddish brown	Muddy brown	Firm, small gas-pockets	Porous, large gas-pockets
5	3/14	25	1	30-40	0	0	0	0	4	3	18	8	17
5	3/14	25	2	30-40	0	0	0	0	8	4	11	15	10
5	3/14	25	3	30-40	0	0	0	0	12	4	9	14	11
5	3/14	25	4	30-40	0	0	0	0	13	5	7	15	10
5	3/14	25	5	30-40	0	0	0	0	16	5	4	20	5
5	5/29	20	1	40-50	0	0	1	0	8	3	9	9	11
5	5/29	20	2	40-50	0	0	1	0	11	2	7	12	8
5	5/29	20	3	40-50	0	0	0	0	10	2	8	13	7
5	5/29	20	4	40-50	0	0	0	0	12	2	6	13	7
5	5/29	20	5	40-50	0	0	1	0	14	1	5	14	6
5	5/18	20	1	50-60	0	0	0	0	11	1	8	12	8
5	5/18	20	2	50-60	0	0	0	0	12	2	6	12	8
5	5/18	20	3	50-60	0	0	0	0	12	2	6	14	6
5	5/18	20	4	50-60	0	0	1	0	15	1	4	15	5
5	5/18	20	5	50-60	0	0	0	0	15	1	4	14	6
5	6/18	20	1	90-100	0	0	0	0	5	3	12	5	15
5	6/18	20	2	90-100	0	0	0	0	5	2	13	4	16
5	6/18	20	3	90-100	0	0	0	0	7	2	11	6	14
5	6/18	20	4	90-100	0	0	0	0	6	3	11	8	12
5	6/18	20	5	90-100	0	0	0	0	11	2	7	12	8

The grading of fresh fruit by flotation in salt brines produced results of the same kind. The lighter solutions (40° salometer) separated out the hard green fruit with skins of light bluish hue and flesh of greenish yellow tint. Both characteristics were carried over into the dried products. The more mature fruit, separated in 60° salt solutions, showed skins of deep purple and flesh uniformly dark golden or red, and these characteristics were likewise carried over into the dried products.

Texture and porosity of flesh. The texture of the dried fruit separated in light gravity solutions before drying was hard owing to under-ripeness; that of fruit which came from the solutions of greater density was far more pliable. Softness and pliability of flesh are then also characteristic of advanced maturity.

The most noticeable characteristic of dried fruit when separated by flotation was variation in porosity. Fruit which floated out in lighter gravity solutions (45° Balling) nearly always contained many gas-pockets, both large and small. Sponginess of the flesh was especially noticeable. The fruit which sank in 60° Balling sugar solutions was very firm and often contained no gas-pockets of any consequence. The flesh was fine textured and of a distinctly pleasing appearance. Weight was indicated by the difference in count per pound as will be seen by the data in Table VIII. The slight differences sometimes indicated in the count may be due to porosity developed during the drying process.

TABLE VIII. VARIATION IN WEIGHT OF THE FRUIT INDICATED BY THE COUNT PER POUND. ITALIAN PRUNES SEPARATED IN SOLUTIONS BY HAND. SEPTEMBER, 1927

Fractions	1st picking Count per pound Green	Dry	2d picking Count per pound Green	Dry	3d picking Count per pound Green	Dry
40F	16.5	62	14.5	52	15.5	57
50F	17.0	52	14.5	47	14.5	49
60F	17.5	49	16.5	45	17.5	48
60S	17.5	48	19.5	43	17.5	48

Italian prunes mechanically separated
Dry count per pound. September, 1928

	Lot	40F	60F	60S
Springbrook Packing Co.	1	34	32	—
Springbrook Packing Co.	2	32	32	32
Springbrook Packing Co.	3	33	30	28
C. H. Jones	1	33	31	29
Mr. Schmeltzer	1	36	35	33

Petite prunes mechanically separated
Dry count per pound. Separated, 1928

	Lot	40F	60F	60S
Victor Reese	1	67	49.5	44.5
John Reese	1	—	69.5	64.0
F. R. Barron	1	78.5	66.0	65.0
Mr. Whitcomb	1	76	67.0	—
Victor Reese	2	57	51.0	45.0
John Reese	2	66	63.0	59.0
F. R. Barron	2	67	51.0	49.0
Victor Reese	3	66	57.0	50.0

Date prunes mechanically separated
Dry count per pound. Separated 1928

	Lot	40F	60F	60S
A. W. Ferril	1	60.0	58.0	—
John Reese	1	41.0	40.0	36.0

Infected prunes. The prunes handled throughout these experiments contained much infected fruit. Unfortunately for the industry, that situation prevails generally. The infection was due principally to scab and brown rot. The separation of scabby fruit can not be accomplished by any method of gravity separation. It was thought that by the decomposition occurring in prunes affected by brown rot their composition would be sufficiently changed as to influence their specific gravity. It was found, however, that fresh fruit infected with brown rot had to be in an advanced state of decomposition to make possible its separation from non-infected fruit by the flotation process. Only when the brown rot had advanced so far that the fruit had become partly mummified could it readily be separated out in the lighter gravity solutions. It would seem, therefore, that separation of this type of infected fruit from perfect fruit must be accomplished mostly by hand sorting over belts before running any lot through a gravity separator.

Separating burned or fermented fruits. Separation into quality grades by the flotation process seems most feasible when applied to fruit in the fresh state. The results are sure, the cost is low, and many advantages are gained by this method from a drying standpoint. But notwithstanding the advantages gained by gravity separations, it must be remembered that good fruit can be ruined by careless operations in the drying process and thereby all the effort spent on separations go for naught.

In recognition of this fact, some attempt has been made to ascertain whether fruit affected with various forms of spoilage might not be successfully separated out from the good by some change in the usual method of processing. A simple experiment shows that it can be.

The dried fruit affected with these various forms of spoilage was processed in boiling water instead of live steam, which is one of the common commercial methods. Fruit with large gas-pockets and that which was badly burned or poorly dried, floated to the surface of the boiling water, where it was readily skimmed off. The firm-textured product remained beneath the surface. It is evident that improvement in the design of processing boxes might be made to accomplish the same result on a commercial scale.

CONCLUSIONS

Thus have been stated the facts regarding dried prunes produced in the Pacific Northwest as those facts have developed from observations on methods of harvesting and drying and from close examination of the physical and chemical properties possessed by the fruit itself.

In the main the criticisms which started this series of investigations are just. Dried prunes are being sent to market under grade standards that do not sufficiently emphasize uniformity in quality as that term is employed by the consumer.

It has been shown that the application of the flotation principle to the dried product as that is now produced can be made to accomplish a greater degree of uniformity in quality of output than is now possessed by the size-grades of the packing houses. Grading for uniformity in quality of output, however, can be far more effectively accomplished by the application of the flotation principle to the fresh fruit. No argument should be necessary to establish the wisdom of eliminating at the orchard all over-mature and infected fruit. There is no place for it on the dried fruit market. As shown by the results of experimental work, the fresh fruit can be graded with precision at the driers. A machine has been designed that successfully employs the flotation principle in separating fresh fruit into gravity fractions that show distinctive physical and chemical properties. These same characteristics show up strongly in the dried product. Harvesting operations necessarily result in the mixing of fruits of various degrees of maturity. Grading by employment of the flotation principle separates individual fruits according to degree of maturity. Ripe prunes are heaviest. When dried and processed they are the best from the standpoint of appearance and by the most exacting physical and chemical tests. Properly directed efforts in the orchard alone can be made to turn a large fraction of the crop into the heaviest fraction of dried fruit.

With this work as a basis, evolving definite grade standards is work for the immediate future. It must involve for the use of inspectors and packing-plant managers some simple tests for checking up on the grade standards decided upon.

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Appendix

CHEMICAL EXAMINATION

Below is given in some detail an explanation of the chemical methods used in this bulletin.

Sample preparation. After gravity separation, samples of 10 to 25 fruits were weighed out, after which the flesh was carefully removed from the pits and passed through the fine grinder of an ordinary food-chopper. The ground flesh was well mixed and with the weighed pits was placed in cans with tight-fitting covers. These weighings were made to .1 gram on a pulp balance.

Moisture. Ten grams of flesh were weighed into a tared, flat-bottomed, porcelain, evaporating dish. Enough pits were cracked up and the kernels broken into several pieces, to give a sample of 8 to 12 grams, which was weighed into tared dishes similar to those used for flesh moisture. Weighings were made to one milligram in both flesh and pit samples. A vacuum oven heated to between 60° C. and 70° C. for 20 to 24 hours was used for drying the samples. While constant weight was not attained in 20 hours, it was found that samples dried as long as 46 hours lost very little weight after the 20- to 24-hour period.

Extraction of sugar and acid. Twenty-five grams of ground flesh were weighed into a beaker and stirred with 150 to 200 c.c. of hot water, after which the mass was poured into a 500 c.c. volumetric flask by means of a funnel having a short stem of large diameter. The flask was filled up to a total of about 400 c.c. and digested on a steam bath for 12 hours or longer with occasional shaking, after which it was cooled, made to volume, mixed well, and centrifuged. This method of extraction was considered satisfactory after some preliminary determinations given below.

Constancy of extractions. Eighty-five prunes were passed three times through a food chopper and from this mass four samples were analyzed for total sugar, using the extraction method outlined above.

Sample 1. 44.90% of total sugar in flesh
Sample 2. 45.90% of total sugar in flesh
Sample 3. 45.45% of total sugar in flesh
Sample 4. 44.70% of total sugar in flesh
Average 45.11%

Completeness of extraction. Four samples of 25 grams each were weighed from the prunes prepared for the preceding extractions. Extractions were made as follows: Two samples were treated with water and two with 50 percent alcohol by adding enough solvent to the samples to make about 250 c.c. of suspension. They were then heated for ½ to 1 hour on a steam bath, centrifuged, and the supernatent liquid poured off. About the same amount of solvent was again added to the pulp and the process repeated six times, when the extracts indicated no sugar. The total extract for each solvent was made to 1 liter and suger determinations were made on suitable aliquots with the following results:

	Percentage of total sugar on flesh
Alcohol extract	44.40 44.90 average 44.65
Water extract	45.40 45.45 average 45.43

The water extract gives slightly more sugar and compares favorably with the results given by the single digestion given above.

Variation of sugar content of individual prunes. To obtain an indication of the variation in sugar content between individual fruits from the same lot, four single fruits were analyzed for total sugar.

	Percentage of total sugar on flesh
1	39.97
2	45.90
3	42.20
4	47.30

This range of more than 7 percent emphasizes the necessity of grinding and mixing as large a number of fruits as practicable for the sample from each lot.

Hydrogen-ion concentration and total acid. The pH unit of Sorensen is commonly used to express hydrogen-ion concentration. The pH of a solution is defined as the logarithm of the denominator of the fraction representing the actual hydrogen-ion concentration. The use of pH units thus makes it possible to express all hydrogen-ion concentrations as whole numbers instead of fractions, but it must be remembered that the *higher* the hydrogen-ion concentration the *lower* is the corresponding pH value.

Twenty c.c. of the centrifuged extract, equivalent to 1 gram of flesh, were placed in a suitable electrode vessel and the pH determined electrometrically, using a Hildebrand type hydrogen-electrode, calomel electrode, and the simple voltmeter-galvanometer circuit for the determination. A special millivoltmeter with a range of 0-1000 millivolts and accurate to 2 millivolts or about .03 pH was used for the readings. Schmidt and Hoagland's table* was used to convert voltmeter readings to pH units. For total acidity the same sample used for hydrogen ion was titrated electrometrically to neutrality with n/10 NaOH, and the total acid calculated as malic acid.

Sugar. The total sugar was determined on a suitable aliquot of the centrifuged extract, according to the official methods† after clarification with neutral lead acetate solution and inversion with hydrochloric acid. The cuprous oxide was titrated with standard sodium thiosulfate solution.

*University of California Publications in Physiology 5 No. 4 pp. 23-69. 1919.

†Official and tentative methods of analysis of the Association of Official Agriculture Chemists. 1924 Second Edition.