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TESTS OF METHODS FOR THE COMMERCIAL STANDARDIZATION OF RAISINS
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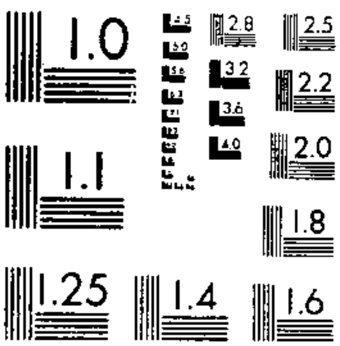

MICROCOPY RESOLUTION TEST CHART
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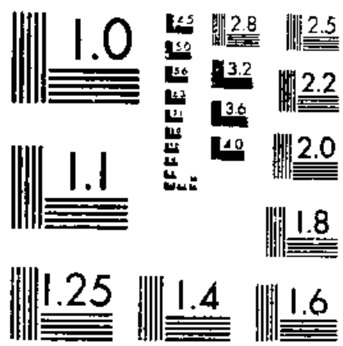

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TB 1 (1927)

TECHNICAL BULLETIN No. 1 OCTOBER, 1927

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

TESTS OF METHODS FOR THE COMMERCIAL STANDARDIZATION OF RAISINS[1]

By E. M. Chace, *Chemist*, and C. G. Church, *Assistant Chemist, Fruit and Vegetable Chemical Investigations, Bureau of Chemistry and Soils*

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THE RAISIN INDUSTRY

The raisin industry is the largest dried-fruit industry in the United States, both in tonnage and in monetary value. Up to and including 1925, the year 1923 had the largest crop—290,000 tons, with an estimated value of $20,300,000. The crops of several other years (*7, p. 677*)[2] have had higher values, however, the 1920 crop, with an estimated value of $41,000,000, being the maximum.

The tonnage of grapes converted into raisins varies inversely with the tonnage of Alexandria (muscat) and Sultanina (Thompson Seedless) sold to be eaten fresh and to be made into juice. When the demand for juice and eating grapes is largest and there is no car shortage the tonnage converted into raisins is smallest.

Formerly several varieties of grapes were used in producing raisins, but within the last few years the seedless raisins have been made from the Sultanina (Thompson Seedless) and Sultana. Seeded and cluster raisins are produced almost exclusively from Alexandria (muscat) grapes. From 60 to 75 per cent of the raisin crop is controlled by a single cooperative association, which receives and stores the dried fruit and converts it into the various merchantable products.

[1] The investigation here reported was carried out at the request and with the collaboration of the raisin interests of California. These interests defrayed part of the expenses, and one of their technologists, P. F. Nichols, was actively engaged throughout upon the problems presented. Acknowledgment is also made to W. A. Harlan, at that time head of the receiving department of the Raisin Association, and to his assistant, C. E. Byde, for assistance with the practical problems involved. F. E. Denny did most of the work on the preliminary moisture investigation.

[2] Italic numbers in parentheses refer to "Literature cited" page 23.

The commercial production of raisins is confined to one State—California. More than 350,000 acres (4), principally in the San Joaquin Valley, but also over a smaller area in the Sacramento Valley, is devoted to the industry. The area of densest production lies within a radius of 30 miles of Fresno, which is naturally the headquarters of the raisin trade. Receiving stations extend as far south as Arvin in Kern County and as far north as Yuba City in Sutter County.

CURING RAISINS

Ordinarily the grape clusters cut from the vine are placed on wooden or paper trays, which rest on the ground between the rows of vines. The bunches are turned during the drying period so that the fruit will dry evenly. When the raisins have been exposed to the sun long enough to become properly colored and lose approximately two-thirds of their moisture, the wooden trays are stacked in the vineyard and the paper trays are rolled to inclose their loads. The fruit is left in this state until it is practically dry, which may take several weeks. The contents of the trays are then dumped into sweat boxes for curing and equalization of moisture. The fruit is usually delivered to the packing plant in the sweat boxes, in which it may be stored until packed. If there is a scarcity of sweat boxes, the raisins are stored in piles or large bins.

Owing to early rains and foggy weather the drying season is shorter in the northern part of the raisin district than it is farther south. In the northern section the grapes are dipped into a hot soda or lye solution before being placed on the trays. This treatment removes the waxy bloom and may even check (slightly crack) the skin, thus hastening drying. A little olive oil is usually added to the hot soda solution to give the fruit a gloss. Fruit thus treated is called "soda dipped." Raisins receiving a similar treatment but with more oil are called "oil dipped," and raisins given a soda dip followed by sulphuring are called "sulphurs."

GRADING RAISINS BY VISUAL INSPECTION

Raisins, like other dried fruit, differ in quality from season to season, owing to climatic factors. The quality also varies with differences in soil and in methods of handling the crop. In order to promote the production of better grades, a system of grading was in vogue in California for many years. In some cases a corps of inspectors thoroughly familiar with raisin grading passed judgment upon the deliveries as they were made at the various receiving stations, and a number of traveling inspectors visited the receiving stations daily during the height of the season to check the work of local inspectors. The methods used on seedless raisins were solely visual and manual. For some years a mechanical method was used for grading muscat raisins according to size.

When the seedless raisins were delivered to the receiving station in the sweat boxes, which contained about 150 pounds, the receiving inspectors examined the load to see whether the boxes contained excessive sand or waste, or moldy, mildewed, sunburned, red, or water-damaged fruit. By visual examination they determined the grade of the raisins in each sweat box. By squeezing small samples they determined whether or not the fruit was properly dried.

Thompson Seedless raisins were usually classified in one of four grades: Extra-standard, standard, substandard, and inferior. Only the three lowest grades applied to Sultanas. Raisins in all grades but the inferior grade must be fit for manufacture and packing. These grades were based chiefly on the plumpness or meatiness of the fruit. Extra-standard berries were meaty and plump, having shallow wrinkles or creases, in contrast to "skinny" or lean berries, which had deep wrinkles characteristic of the substandard grade. The standard grade, into which the bulk of the crop fell, was between these two grades. Each lot of raisins, of course, always contained a small percentage of fruit of the other grades.

The grade of any lot of raisins may be lowered by the presence of moldy, mildewed, sunburned, off-color, or sandy fruit. Sand that does not stick to the raisins can be separated, although it increases the waste. Sand washed on by rain is often a permanent injury.

Moisture content was not considered in judging the grade. If the raisins were not properly dried, the danger of mold before final packing became very great. Such fruit was usually returned to the grower for further drying or it might be dried at the grower's expense. Raisins which had been too thoroughly dried were undesirable because they chipped during the manufacturing operations.

Moldy or mildewed berries can not be economically separated from normal berries. Boxes of raisins containing any great number of such berries were classed as inferior and used only in making by-products.

Sunburned berries are dull brown or black and have a caramel-like or burnt-sugar flavor. Lots containing substantial quantities of such berries were graded as standard or even lower. Rain or water damage causes glossy spots or areas on the berries. Usually the skin is not discolored, but it may tear and hurt the appearance of the manufactured product.

An allowance of 7 per cent of sand, stems, or red berries was usually permitted in extra-standard and standard grades. If judged to be in excess of this quantity the lot was graded as substandard or inferior.

Each year sets of standard samples were made up from the previous crop and sent out to inspectors.

CHEMICAL AND PHYSICAL METHODS OF GRADING

On the whole, the operation of the visual grading system was as successful as could be expected from a system which depends to a great extent on human agencies. Naturally many differences of opinion as to grades arose between inspectors and growers. As certain receivers were more lenient than others some growers thought that favors were being shown their competitors. Certainly a purely mechanical or chemical scheme of grading would reduce to a minimum the friction naturally occurring between growers and receivers. Accordingly, the raisin industry of California called upon the Bureau of Chemistry and Soils for assistance in devising a physical or chemical method which could be substituted for the visual method.

The success of the methods used for determining the maturity of oranges, grapefruit (*2*), cantaloupes (*3*), and grapes seemed to indicate that some simple test or set of tests which could easily be carried out might be found. The problem presented was not strictly a maturity problem for, although maturity undoubtedly plays a part in producing satisfactory raisins, there is no special incentive for gathering immature grapes. Such new features as detecting mold, sunburn, and sand, and devising rapid methods for moisture determinations were included in the problem.

It was recognized that the methods devised must be simple, as it would be impracticable to engage a highly trained staff of inspectors to carry them out, that they must not require expensive or delicate apparatus, and that the time necessary to complete any single test should be less than one-half hour. In requesting aid in solving the problem, the raisin interests had made these points clear. Anything too complicated for operation by an untrained worker was not considered.

CHEMICAL COMPOSITION

As it seemed to be generally believed that the sugar content of the raisin largely determines its grade, a fair number of authentic samples representing the various grades were examined chemically in order to ascertain whether or not differences in composition existed. The methods of the Association of Official Agricultural Chemists (*1, p. 80, No. 29; p. 153, No. 3; p. 154, Nos. 4, 6, 9*) were employed in these examinations. The average results are given in Table 1.

TABLE 1.—*Average composition of raisins (1923 crop)*

Grade	Samples	Total solids	Insoluble solids [1]	Total sugars [1]	Acidity [1]
	Number	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Thompson Seedless variety:					
Extra-standard	5	88.16±0.57	5.90±0.36	86.68±0.96	2.24±0.17
Standard	13	89.04± .37	6.71± .22	84.06± .51	[2] 2.53± .05
Substandard	9	91.12± .31	8.34± .36	80.43± .56	[3] 3.63± .09
Inferior	6	90.25± .53	8.22± .26	80.60± .43	2.76± .10
Sultana variety:					
Standard	6	90.41± .83	7.47± .32	82.97± .70	[4] 2.66± .11
Substandard	4	90.30± .77	8.90± .53	81.15± .71	[5] 3.28± .22
Inferior	4	90.92± .42	9.99± .60	79.00± .47	3.30± .06

[1] Moisture-free basis.
[2] Determined on 29 samples.
[3] Determined on 16 samples.
[4] Determined on 10 samples.
[5] Determined on 6 samples.

In considering the somewhat meager data in Table 1, it is to be remembered that samples may be degraded for special reasons, such as mildew, mold, sand, or water damage. Such defects may change the physical and chemical properties not at all or only very slightly. Possibly the table includes data on samples that were placed in the grade in which they are found because of some special defect not apparent from the records. These cases are rare, however, and would not occur in fruit of the extra-standard grade.

No marked chemical difference between the extra-standard and standard grades is apparent. According to the formula for calculating the significance of the difference (*6*), the odds are only 3½ to 1 that the extra-standard grade contains less insoluble solids, 8½ to 1 that this grade contains more sugar, and 2½ to 1 that it contains less acid. The differences between the standard and substandard grades of Thompson Seedless raisins are more pronounced. The odds are 116 to 1 that the substandard grade contains more insoluble solids, 825 to 1 that it contains less sugar, and well over 1,000 to 1 that it contains more acid. These differences between the extra-standard grade and the substandard grade would, of course, be even more pronounced. Generally smaller differences are found in the Sultana raisins.

Only a few samples were run for ash determinations, as these results are too greatly influenced by sand and trash to be of value as a means of classification. Two samples of extra-standard Thompson Seedless contained 0.37 and 0.31 per cent on the dry basis; two standard samples contained 0.48 per cent each; and two substandard samples had 0.37 and 0.67 per cent. Three inferior lots had 1.49, 1.82, and 1.42 per cent. No ash determinations were made on the Sultana group.

Specific gravity was not found to be a satisfactory means for distinguishing between grades. About 10 determinations were made by weighing in air and under toluol, with the following average results:

Thompson Seedless: Extra-standard, 1.45; standard, 1.46; substandard, 1.45; inferior, 1.44.

Sultana: Standard, 1.42.

AVERAGE WEIGHT PER BERRY

In examining the samples, it was found that, without regard to size, the number of raisins for a given weight was smaller in the higher grades than in the lower grades. The lower grades contained more deeply wrinkled and lean berries than the higher grades. A good many determinations were made by weighing lots of 100 raisins. The results are tabulated in Tables 2, 3, 4, and 5.

TABLE 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)* [1]

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
CLOVIS DISTRICT											
0.376		0.312		0.201		0.300		0.297	300.0	0.140	
.369		.257	295.0	.215		.358		.325		.224	
.321		.312		.196		.330		.264			
.367		.308	293.0	.207		.374		.233	292.0		
FRESNO DISTRICT											
0.434		0.349		0.251		0.437		0.279			
.368		.345		.210				.382			
.387		.252		.108				.274			
OLEANDER DISTRICT											
0.363		0.330		0.220		0.369		0.378	298.0		
.388	303.4	.294	284.8	.211	259.8	.416		.290	289.2		
.492	326.5	.283	289.9	.213	265.8	.419	305.9	.307	279.7		
.359	303.5	.303	280.8	.193	260.4	.360	304.5				
.419	306.8	.339	285.3	.162	226.9						

[1] All tests were made in September, October, and November, 1924. [2] 500 cubic centimeters shaken.

Table 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)*—Continued

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
SELMA DISTRICT											
0.301		0.206		0.225		0.480	307.4	0.376	291.0	0.183	225.0
.342		.339		.213		.397		.304		.199	240.0
.437	296.7	.337	288.0	.158		.373		.289			
KINGSBURG DISTRICT											
0.383	310.8	0.380		0.251		0.410	305.0	0.321		0.168	
.307	306.2	.200		.207		.391	300.5	.325	280.6	.165	
.408	300.7	.312		.194	239.0	.403	300.0				
.415	300.5	.349		.170	243.8	.435	300.0				
REEDLEY DISTRICT											
0.468		0.330		0.231		0.413	317.0	0.320	283.5		
.447		.421		.205	260.5	.377		.296	293.8		
.397		.281	272.0	.245		.420	296.8	.262	277.7		
.439	306.0	.320		.208	262.4	.380	315.0	.341	284.7		
.485	302.2	.281	271.0	.231		.370	309.6				
.320	299.3	.312		.193	246.2	.279	311.0				
.331	297.7	.325				.371	294.5				
PARLIER DISTRICT											
0.455	296.0	0.298	277.2	0.252	258.0	0.395		0.313	281.5	0.193	245.7
.382	298.3	.351	290.5	.241	254.2	.436	302.9	.323	280.2	.254	250.5
.423	309.0	.273	270.3	.250		.376	300.7				
.369	295.0	.305		.216	248.2	.303	303.0				
.381	293.0	.311	281.4	.215	255.5						
SULTANA DISTRICT											
0.385		0.355		0.269		0.365		0.296	293.2		
.381	310.0	.314	288.5	.235	255.7	.350	296.0	.336	298.0		
.363	302.2	.264	285.0			.474	306.9	.304	275.7		
SANGER DISTRICT											
0.309		0.290	289.5	0.222		0.385	313.2	0.370			
.372		.259	271.0	.193	245.7	.392	302.5	.357			
.387		.305	267.5	.185		.404	297.0	.412			
.305	314.5	.284		.178	257.2			.302			
.364	294.0	.312	267.0	.182	241.0			.376			
.384	310.5	.270	294.2					.332	281.0		
.369	305.5	.407						.345	301.0		
CARUTHERS DISTRICT											
0.358		0.290		0.234		0.384	312.5	0.284	295.5		
.440	315.0	.280	294.0	.206	255.2	.291	303.2	.332	280.0		
.280	300.0	.260	280.0	.213	255.0	.349	296.5	.291	296.5		
.293		.297	299.0	.211	261.0			.318	290.0		

Table 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)*—Continued

MONMOUTH DISTRICT

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]	Average weight per berry	Weight per volume [2]
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
0.446	--------	0.321	--------	0.201	--------	0.376	307.0	0.343	--------	--------	--------
.292	290.0	.380	298.0	.214	252.5	.434	--------	.351	287.0	--------	--------
.246	306.0	.315	286.0	.191	250.5	.409	305.0	.340	281.0	--------	--------
.400	301.5	.205	291.5	.194	--------	.307	298.0	--------	--------	--------	--------
.455	315.0	.303	283.2	.236	256.0						

FORSEY DISTRICT

0.330	--------	0.338	--------	0.196	--------	0.333	311.0	0.307	268.5	--------	--------
.35[illegible]	303.0	.304	293.0	.107	220.5	.326	280.0	.308	269.0	--------	--------
.347	290.0	.280	240.3	.100	248.5	.354	295.0	.297	289.0	--------	--------
.355	--------	.295	285.0	.148	237.5	.385	295.0	--------	--------	--------	--------
.349	--------	.310	280.5	.200	241.5						

DEL REY DISTRICT

0.404	--------	0.337	--------	0.251	--------	0.377	304.0	0.384	280.5	0.181	--------
.476	328.5	.282	262.0	.247	262.0	.393	301.5	.363	291.0	.168	--------
.440	307.5	.312	272.5	.221	247.0	.489	299.0	--------	--------	.222	253.5
.372	297.2	.301	279.0	.293	252.0	.420	307.0	--------	--------	.258	281.0
.420	300.0	.345	284.0	.197	258.0	.404	300.0	--------	--------	--------	--------
.439	324.0	.294	270.5	.207	--------						

LEMOORE DISTRICT

0.293	--------	0.322	--------	0.108	246.5	0.395	305.5	0.286	288.0	--------	--------
.304	290.0	.302	--------	.266	257.2	--------	--------	.252	284.8	--------	--------
.441	290.5	.327	--------	--------	--------	--------	--------	.323	299.5	--------	--------
.355	290.4	.256	285.5	--------	--------	--------	--------	.331	--------	--------	--------

ARMONA DISTRICT

0.428	310.0	0.331	--------	0.261	--------	0.332	--------	0.284	286.5	--------	--------
.357	300.5	.224	--------	.244	244.5	--------	--------	.229	268.0	--------	--------
.467	315.5	.349	285.0	.228	247.0	--------	--------	.265	286.0	--------	--------
.382	300.7	.304	278.0	--------	--------						

FOWLER DISTRICT

0.408	--------	0.328	--------	0.243	267.8	0.442	308.5	0.345	296.0	0.195	248.5
.381	294.0	.367	301.5	.240	267.0	.396	313.0	.289	279.0	.229	251.5
.328	299.5	.366	290.0	.180	241.5	.440	316.0	.341	285.5	.245	258.5
.391	301.2	.331	292.0	.265	260.0	--------	--------	.276	272.0	--------	--------

DINUBA DISTRICT

0.380	--------	0.346	--------	0.269	270.2	0.362	--------	0.340	291.0	--------	--------
.377	306.5	.309	287.0	.188	256.5	--------	--------	.376	300.5	--------	--------
.392	293.5	.372	306.0	.245	296.0	--------	--------	.321	295.5	--------	--------
.411	304.0	.300	279.0	.220	281.0						

TABLE 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)*—Continued

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
NAVELENCIA DISTRICT											
0.335	317.0	0.303	--------	0.245	--------	0.349	293.0	0.264	287.0	0.156	256.0
.304	--------	.225	--------	.204	--------	.333	314.5	.269	275.0	.170	255.0
.341	293.5	.254	300.0	.178	220.5	.368	312.5	.277	278.0	--------	--------
.355	307.0	.300	286.0	.218	--------	.376	315.5	--------	--------	--------	--------
LONE STAR DISTRICT											
0.453	--------	0.326	--------	0.224	--------	0.422	--------	0.335	276.5	--------	--------
.389	303.5	.364	283.0	.188	240.0	.463	310.5	.298	279.5	--------	--------
.385	290.0	.297	275.5	.179	--------	.367	304.5	.357	294.0	--------	--------
CHOWCHILLA DISTRICT											
0.350	--------	0.342	--------	0.174	295.5	--------	--------	0.275	300.8	--------	--------
.379	--------	.349	--------	.253	290.0	--------	--------	.269	--------	--------	--------
.310	297.0	.267	--------	.236	--------	--------	--------	.237	--------	--------	--------
.321	311.0	.294	--------	.232	--------	--------	--------	.316	294.5	--------	--------
.346	305.0	.342	--------	--------	--------	--------	--------	.352	295.0	--------	--------
.366	303.0	.331	302.0	--------	--------	--------	--------	.293	306.0	--------	--------
.364	317.0	.280	284.5	--------	--------	--------	--------	.352	307.5	--------	--------
--------	--------	.250	292.0	--------	--------	--------	--------	.350	300.0	--------	--------
HANFORD DISTRICT											
0.343	288.0	0.370	--------	0.223	--------	--------	--------	0.310	--------	--------	--------
.424	297.0	.375	--------	.272	267.0	--------	--------	.278	290.5	--------	--------
--------	--------	.287	279.0	.104	--------						
BIOLA DISTRICT											
0.360	--------	0.348	--------	0.234	--------	0.403	303.0	0.324	289.0	--------	--------
.301	--------	.313	--------	.372	283.0	.373	--------	.336	295.5	--------	--------
.368	--------	.339	--------	.249	268.0	.362	--------	--------	--------	--------	--------
.501	324.0	.274	283.5	.181	--------	.415	321.0	--------	--------	--------	--------
.381	299.0	.358	300.0	.197	261.0	.353	--------	--------	--------	--------	--------
.459	314.0	.408	310.5	.168	251.0	.333	309.0	--------	--------	--------	--------
.395	305.0	.346	308.5	--------	--------	.434	305.0	--------	--------	--------	--------
MADERA DISTRICT											
0.398	308.5	0.339	295.5	0.230	275.0	0.376	340.0	0.304	290.0	0.171	249.0
.411	--------	.383	310.5	.182	240.5	.460	311.5	.318	307.0	.128	268.5
.392	316.0	.311	--------	.130	--------						
CUTLER DISTRICT											
0.320	--------	0.312	--------	0.169	--------	0.333	302.0	0.335	279.5	0.185	238.0
.304	294.0	.278	266.0	.225	249.5	.348	292.5	.287	265.0	--------	--------
.343	295.0	.309	283.5	.182	245.0						

TABLE 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)*—Continued

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume
RAYO DISTRICT											
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
0.304	--------	0.304	--------	--------	--------	0.344	307.0	0.326	298.0	0.230	266.0
.438	303.5	.206	283.0	0.253	--------						
EXETER DISTRICT											
0.387	--------	0.334	--------	0.216	207.5	0.398	293.0	0.317	267.5	--------	--------
.400	289.0	.334	299.0	.281	259.5	.632	310.5	.385	292.0	--------	--------
.358	299.0	.373	302.2	.246	264.0	.421	295.0	.344	288.3	--------	--------
.472	317.5	.317	272.0	--------	--------	.510	301.5	.250	283.0	--------	--------
.300	--------	.453	305.0	--------	--------						
BURNESS DISTRICT											
0.463	310.0	0.403	295.5	0.192	250.5	0.282	281.0	0.350	303.0	--------	--------
.331	280.2	.283	281.0	.222	265.7	.350	300.5	.301	272.5	--------	--------
.408	298.0	.317	208.2	.222	--------	.388	--------	.317	205.5	--------	--------
.360	--------	.384	289.2	.228	248.0	.306	310.5	--------	--------	--------	--------
.365	306.0	.205	--------	.245	273.5	.455	310.2	--------	--------	--------	--------
.462	270.0	.358	301.5	--------	--------	.465	320.5	--------	--------	--------	--------
VISALIA DISTRICT											
0.387	293.5	0.298	278.5	0.270	257.2	0.376	302.0	0.301	300.0	--------	--------
.348	--------	.252	--------	.216	257.0	--------	--------	.290	280.0	--------	--------
.373	298.0	.307	282.0	.228	271.2						
PORTERVILLE DISTRICT											
0.397	--------	0.256	285.5	0.240	--------	0.373	318.0	0.247	--------	--------	--------
.380	314.5	.401	--------	.185	275.5	.324	295.5	--------	--------	--------	--------
.388	306.0	.305	280.0	.134	259.5	.414	--------	--------	--------	--------	--------
.471	321.0	.332	314.0	.245	270.5	.408	322.0	--------	--------	--------	--------
PIXLEY DISTRICT											
0.391	310.0	0.333	306.0	0.239	260.0	0.356	298.5	0.337	--------	--------	--------
.342	303.0	.284	--------	.230	--------	.322	305.5	.316	292.0	--------	--------
.387	305.5	.327	280.5	.244	272.5	--------	--------	.305	301.0	--------	--------
.303	--------	.280	281.0	.195	254.0	--------	--------	.338	278.0	--------	--------
.340	306.0	.242	282.0	--------	--------	--------	--------	.313	289.0	--------	--------
DELANO DISTRICT											
0.375	321.0	0.361	285.0	0.265	235.0	0.377	301.5	0.326	298.5	--------	--------
.316	284.5	.269	276.0	.232	--------	.390	297.2	.299	277.2	--------	--------
.401	304.0	.347	--------	.256	260.0	.398	312.3	--------	--------	--------	--------
.458	--------	.337	275.2	.153	243.5	.312	302.0	--------	--------	--------	--------

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TABLE 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)*—Continued

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
ARVIN DISTRICT											
0.516	333.0	0.347	308.2	--------	--------	0.387	315.5	0.314	304.0	--------	--------
.366	308.0	.345	287.2			--------	--------	.301	296.0	--------	--------
ESCALON DISTRICT											
0.358	303.0	0.298	276.2	--------	--------	0.321	290.0	--------	--------	--------	--------
WASCO DISTRICT											
0.320	302.0	0.305	291.0	0.233	274.5	0.412	305.0	0.320	293.0	--------	--------
.307	313.0	.316	287.0	--------	--------						
MAGUNDEN DISTRICT											
0.377	290.0	0.337	310.0	--------	--------	0.467	327.0	--------	--------	--------	--------
TULARE DISTRICT											
0.339	307.0	0.286	283.5	0.247	281.2	0.384	309.5	0.292	272.5	--------	--------
.356	317.0	.392	323.0	.173	200.0	.354	305.0	.325	293.0	--------	--------
.319	--------	.326	298.5	.237	261.5	--------	--------	.353	--------	--------	--------
.324	288.0	.323	--------	.162	--------						
MENDOTA DISTRICT											
0.360	290.0	0.209	--------	--------	--------	--------	--------	0.231	295.0	--------	--------
--------	--------	.202	--------	--------	--------	--------	--------	.192	291.2	--------	--------
--------	--------	.183	--------	--------	--------	--------	--------	.220	302.0	--------	--------
--------	--------	.314	--------	--------	--------	--------	--------	.238	294.5	--------	--------
--------	--------	.246	288.0	--------	--------	--------	--------	.232	290.0	--------	--------
--------	--------	.238	287.0	--------	--------						
KERMAN DISTRICT											
0.355	301.0	0.302	288.5	0.207	260.5	0.422	297.0	0.312	--------	--------	--------
.408	322.5	.223	281.5	.187	272.0	.374	298.0	.354	300.0	--------	--------
.484	318.0	.317	251.0	.195	257.0	.416	311.0	--------	--------	--------	--------
.295	298.0	.320	290.5	.188	245.0	.449	313.8	--------	--------	--------	--------
.354	307.5	.274	288.0	--------	--------						
MERCED DISTRICT											
0.400	301.5	0.330	298.5	--------	--------	--------	--------	0.350	305.5	--------	--------
PATTERSON DISTRICT											
0.423	317.0	0.333	292.0	--------	--------	--------	--------	0.264	305.5	--------	--------

TABLE 2.—*Average weight per berry and weight per volume of extra-standard, standard, and substandard Thompson Seedless raisins (1924 crop)*—Continued

Extra-standard raisins		Standard raisins		Substandard raisins		Extra-standard raisins		Standard raisins		Substandard raisins	
Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume	Average weight per berry	Weight per volume
Gram	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*	*Gram*	*Grams*
					LE GRAND DISTRICT						
0.369	316.0	0.333	299.0					0.321	291.0		
.365	312.5	.298	294.5								
					TURLOCK DISTRICT						
0.384	305.0	0.380	296.0	0.243	271.0	0.392	304.8				
.421	320.0	.294				.309	298.5				
.383	309.0	.335	293.0			.396	313.0				
.399	306.2	.345	295.0			.332	299.0				
.417	309.0	.228	297.0			.549	327.0				
.450	302.5					.420	315.0				
.442	335.5										
					LIVINGSTON DISTRICT						
0.370	309.0	0.334	284.0	0.237	240.0	0.355	296.7	0.359	295.0		
.469	336.0	.330				.538	334.0				
.322		.344				.467	323.0				
.346	309.0	.373	290.0			.384	295.0				
.547	305.5	.378	297.5			.423	309.5				
.354	303.0	.290	273.0								
					MODESTO DISTRICT						
0.462	313.0	0.356	297.0	0.192	270.0	0.392	314.0				
.388	305.0	.380	286.0			.378	313.0				
.338		.353	291.0			.308	314.0				
.360	303.0	.297	283.2			.390	312.0				
.394	288.0										
.402	309.0					.387	305.7	0.314	288.7	0.213	257
.393	309.0					±.008	±1.41	±.008	±1.42	±.003	±.83
.361	303.5										

TABLE 3.—*Average weight per berry and weight per volume of inferior Thompson Seedless raisins (1924 crop)* [1]

District	Average weight per berry	Weight per volume [2]	District	Average weight per berry	Weight per volume [2]
	Gram	*Grams*		*Gram*	*Grams*
Oleander	0.122	224.4	Burness	0.275	264.5
Reedley	.229	259.5	Delano	.171	247.0
Sanger	.110	244.5	Turlock	.327	281.0
Forsey	.354			.300	283.0
Del Rey	.330	246.0		.366	284.0
Dinuba	.452			.324	295.5
Biola	.150	257.5	Livingston	.357	291.0
	.174		Modesto	.452	
	.153	249.0			
Rayo	.106	244.0	Average	.272 ±.018	260.9 ±3.60
	.215	241.0			
	.387	263.5			

[1] All tests were made in September, October, and November, 1924.
[2] Five hundred cubic centimeters shaken.

TABLE 4.—*Average weight per berry and weight per volume of standard Sultana raisins (1924 crop)* [1]

District	Average weight per berry	Weight per volume [2]
	Gram	*Grams*
Clovis	0.259	----------
	.270	----------
	.258	----------
	.298	283.0
Fresno	.360	----------
	.288	----------
	.377	----------
	.299	----------
	.284	----------
Oleander	.258	----------
	.361	281.8
	.293	272.9
	.283	280.5
	.334	270.4
Selma	.306	----------
	.222	264.2
	.281	275.0
	.304	269.2
Kingsburg	.287	----------
	.342	271.8
	.336	----------
	.275	----------
	.282	----------
Reedley	.288	----------
	.261	254.5
	.215	266.0
	.332	273.0
	.358	271.0
Parlier	.316	280.0
	.299	273.0
	.346	----------
	.319	273.5
	.431	----------
	.313	274.0
Sultana	.279	----------
	.320	276.2
	.286	260.0
	.300	263.5
	.340	----------
Sanger	.325	----------
	.329	274.0
	.355	----------
	.340	273.5
	.357	278.2
Caruthers	.307	268.0
	.275	282.0
	.278	271.0
	.329	270.0
Monmouth	.306	----------
	.364	268.5
	.341	270.5
	.367	283.5
	.289	268.0
Forsey	.321	278.0
	.368	262.0
	.302	263.5
	.341	----------
Del Rey	.333	269.0
	.329	295.2
	.298	274.0
	.338	270.5
	.313	279.5
	.311	279.5
	.329	265.0
	.315	275.5
	.362	246.0
	.294	289.0
Lemoore	.322	----------
	.336	273.0
	.375	268.5
	.406	----------
Armona	.358	----------
	.396	267.0
	.378	272.0
	.426	259.8
Fowler	0.294	----------
	.307	282.5
	.263	278.5
	.342	287.0
	.328	277.0
	.354	----------
	.349	271.0
Dinuba	.308	----------
	.331	272.0
	.280	291.0
	.386	273.5
	.276	280.5
Navelencia	.301	----------
	.267	265.5
	.309	----------
Lone Star	.288	----------
	.179	----------
	.321	294.0
	.252	276.0
	.340	286.0
	.312	----------
	.276	277.5
Chowchilla	.337	----------
	.361	258.0
	.340	264.0
	.455	268.0
Hanford	.351	----------
	.313	264.0
	.314	----------
	.355	271.0
Biola	.273	280.0
	.313	278.5
	.350	275.0
	.348	272.0
Madera	.343	272.0
	.390	283.0
Cutler	.346	258.5
	.340	268.5
	.306	265.6
	.288	263.5
Royo	.361	281.0
	.359	272.5
	.324	275.0
Exeter	.350	250.0
	.245	264.0
	.421	----------
Burness	.376	283.0
	.300	272.0
	.363	267.7
	.293	285.0
	.331	----------
Visalia	.364	268.0
	.342	----------
	.294	263.0
Porterville	.388	----------
	.415	281.0
Pixley	.248	257.5
	.248	260.5
Delano	.274	----------
Wasco	.436	276.5
Magunden	.256	262.5
Tulare	.369	272.0
	.347	----------
	.285	----------
Korman	.263	259.0
	.332	252.0
	.318	267.0
	.358	----------
Turlock	.497	279.0
Livingston	.372	273.5
	.404	307.0
Modesto	.383	281.5
Average	.325 ±.004	272.6 ±0.58

[1] All tests were made in September, October, and November, 1924.
[2] Five hundred cubic centimeters shaken.

TABLE 5.—*Average weight per berry and weight per volume of substandard Sultana raisins (1924 crop)* [1]

District	Average weight per berry	Weight per volume [2]	District	Average weight per berry	Weight per volume [2]
	Gram	*Grams*		*Gram*	*Grams*
Clovis	0.204	----------		0.205	245.0
Monmouth	.164	----------	Rayo	.223	243.0
Del Rey	.205	254.5		.255	245.0
	.206	247.5	Visalia	.254	----------
Fowler	.141	230.0	Turlock	.384	279.5
	.197	261.0			
Lone Star	.182	268.0	Average	.214	250.1
Cutler	.165	221.5		±.010	±3.53

[1] All tests were made in September, October, and November, 1924.
[2] Five hundred cubic centimeters shaken.

Duplicate or triplicate determinations on 296 samples of extra-standard Thompson Seedless collected over the greater part of the raisin-growing district showed that the average weight of each berry was 387 milligrams, with a probable error of ±8. The 291 samples of standard Thompson Seedless gave an average of 314 milligrams, with a probable error of ±8, and the 153 samples of substandard Thompson Seedless gave an average of 213 milligrams, with a probable error of ±3. Only 20 samples of inferior Thompson Seedless were weighed. The average weight per berry was 272 milligrams, the probable error being ±18. The apparent irregularity of the inferior grade is due to the fact that any lot of fruit unfit for edible purposes is classed in this grade. Thus it may include molded, fermented, or otherwise badly damaged raisins, which except for one of these defects might have received a higher classification.

Although, as shown by the tables, the difference between the average weight of the extra-standard grade and the standard grade of Thompson Seedless is only 73 milligrams, this difference is much greater than the sum of the probable errors. According to formulas for estimating the probable significance of differences (*6*), this difference is highly significant, the odds being over 1,000 to 1. The difference between the average weights of the standard and substandard fruit was 101 milligrams, again a highly significant difference, the odds here also being over 1,000 to 1.

It is apparent that the weight of a given number of Thompson Seedless raisins is an accurate measure of their grade. Let the limits for these grades be placed as follows: Extra-standard berries shall have an average weight of 350 milligrams or more; standard berries shall have an average weight of not less than 264 nor more than 349 milligrams; substandard berries shall include all samples of edible raisins averaging less than 264 milligrams in weight. The overlapping of limits will not be serious. If 350 milligrams is the lower limit of weight of extra-standard Thompson Seedless raisins, 18.6 per cent of the samples which had been classed under the old system as extra-standard would have been lowered in grade by the new classification. Furthermore, in 17.5 per cent of the standard Thompson Seedless samples examined, the berries averaged 350 milligrams or more. Only 11 per cent of the standard Thompson Seedless samples examined gave results which were below the 264 milligram limit. Only 5.9 per cent of the substandard samples were above that limit.

But three grades of Sultana raisins are made—standard, substandard, and inferior. The average weights of the standard and substandard berries differ by 111 milligrams (Tables 4 and 5), which is highly significant, as the probable errors were but ±4 and ±10 for the two grades.

The average weight of the standard Sultana berries, 147 samples being examined, was 325 milligrams, with a probable error of ±4. Only 13 samples of substandard Sultanas were examined. The average weight per berry was 214 milligrams, with a probable error of ±10. If the lower limit for standard Sultanas is set at 270 milligrams, only 9.5 per cent of the 147 standard samples are below that limit, and only 7.7 per cent of the substandard samples are above it.

Naturally many of the samples of both Thompson Seedless and Sultana examined were close to the dividing line, and in several cases, where the error was apparently large, a reexamination of the sample might have changed its classification. Sometimes the results obtained by the new method did not agree with those obtained by inspectors. On the whole, however, there is no reason to suppose that the procedure would not give results more satisfactory than those of a mere visual examination.

In the matter of time and expense of equipment, the test is probably as satisfactory as any yet devised. An undesirable feature, however, is that it fails to discriminate between weight resulting from plumpness or meatiness of berries and that resulting from size without meatiness. Also it favors instead of penalizes excessive moisture content. Another unfavorable feature is the fact that decisions as to grade would depend on not more than 300 raisins, rendering satisfactory sampling a matter of paramount importance. It would be very difficult to convince a grower that the weight of such a small quantity of material should determine the grade of his load of raisins. The time consumed in counting a larger number of raisins would be prohibitive. A weight per volume determination would be more practical from the standpoint of satisfying the grower.

WEIGHT PER VOLUME

Laboratory tests were made on the samples used in making the average weight determinations. In each case 500 cubic centimeters of raisins were measured in a calibrated Erlenmeyer flask. The flask was then shaken, care being taken to have the shaking uniform, made up to the mark with raisins from the sample, and weighed. The weights obtained are given in Tables 2, 3, 4 , and 5.

The average weight of two hundred and twenty-eight 500-cubic centimeter samples of extra-standard Thompson Seedless raisins when shaken was 305.7 grams, with a probable error of ±1.41 grams. The average weight of 207 samples of standard Thompson Seedless raisins was 288.7 grams, with a probable error of ±1.42 grams. This is a significant difference, the odds being over 1,000 to 1. The difference between the standard and substandard Thompson Seedless raisins is even greater, the 101 substandard samples having an average weight of 257 grams, with a probable error of ±0.83.

About 18.8 per cent of the extra-standard Thompson Seedless samples were below 297.2 grams, which is the average of the means of the extra-standard and standard grades, and 21.7 per cent of the standard samples were above 297.2 grams. Only 8.2 per cent of the standard samples were below 272.8 grams, and 9.9 per cent of the substandard samples were above it.

The averages for the Sultana samples are 272.6 ± 0.58 grams, for the standard grade, and 250.1 ± 3.53 grams, for the substandard. If the dividing line is set at 261.4 grams, only 7.8 per cent of the standard samples fall below that figure and only 20 per cent of the substandard above it.

The data obtained indicated that a feasible scheme for separating the grades of both Thompson Seedless and Sultana raisins could be worked out with this method. Accordingly a device operating on the principle involved was developed.

A composite sample of over 35 pounds, consisting of equal quantities from each of the boxes in the lot, is drawn. This sample is mixed and spread evenly on a feed belt, geared to a small stemmer and shaker platform. When the motor is started the raisins are stemmed at a uniform rate and dropped into a calibrated 5-gallon milk can on the shaker platform. At the end of one and one-half minutes the motor is automatically stopped, the can is leveled off and weighed, and the grade is determined by the weight. The following preliminary grade limits were set for normal fruit. For Thompson Seedless: Extra-standard, 41 pounds and over; standard, 38 pounds and less than 41 pounds; substandard, 35 pounds and less than 38 pounds; inferior, under 35 pounds. For Sultana: Standard, 35 pounds and over; substandard, 32 pounds and less than 35 pounds; inferior, under 32 pounds. Receptacles are provided for the collection of loose sand and of other waste thrown out by the stemmer, through which it would be possible to make further grade adjustments, though this possibility was not made use of in 1925. The method is short, is easily worked by a skilled laborer, and is more accurate than the judgment of an inspector who passes on hundreds of samples a day. When the raisins are within the range of normality in respects other than size and meatiness, the test has proved very fair and satisfactory in practice. A desirable feature is that fruit with higher moisture content would be stemmed incompletely, resulting in a substitution of light, bulky stems for heavier fruit in the can, and a consequently lighter weight per volume.

MOISTURE

Experience had shown that 16 per cent of water is the upper limit at which raisins can be kept in sweat boxes without danger of sugaring or mold damage. Although a surprisingly close estimate of water content can be obtained by squeezing a handful of berries and noting their plasticity and cohesion, this practice is open to the same objections as the visual methods of grading. A rapid and simple method, which could be used by unskilled operators, was needed.

It is not necessary, perhaps not even desirable, to determine the exact percentage of moisture in the samples. It is necessary, however, to know when the moisture content is above 16 per cent, within a limit of about ±0.5 per cent.

METHODS OF DETERMINATION TESTED

Heat generated in grinding.—In preparing raisins for analysis it had been noted that the drier the sample, the harder it was to grind, and that the temperature of the ground material was well above that of the atmosphere. By holding both the sample and the grinding apparatus at a given temperature and by regulating the time of the operation, a fairly accurate determination of the moisture in the fruit could be made within a limited range. Unfortunately, the increase in temperature was greatest in samples containing little moisture, whereas those containing 16 per cent or over gave too slight differences to make it possible to overcome the errors of operation.

Heat on mixing with sulphuric acid.—By mixing a definite quantity of sulphuric acid of known water content with a definite quantity of raisin paste, the moisture content could be roughly ascertained from the rise in temperature. Here the greatest rise occurred at the highest moisture contents, which was desirable. The difficulty of properly standardizing the acid and of obtaining an intimate mixture rendered the method of doubtful value. Furthermore, the test would require more careful handling than could be expected from the operators who would use it in the field.

Plasticity.—If a rod of definite weight and size is allowed to rest upon finely-ground raisin pulp held in a cylinder, the rapidity with which it sinks into the mass is roughly proportional to the moisture content of the raisins. With proper care this test will give fair results. Both temperature and the fineness of the sample have to be considered, however. On the whole, the method was not found to be satisfactory.

Cobalt-chloride paper.—A test which depends upon the well-known change in the color of cobalt-chloride paper when dry and when moist (*5*) gives results within the desired limits. In making use of this phenomenon, filter papers soaked in solutions of cobalt chloride of varying strengths are dried and kept in a desiccator (or dried immediately before use). The sample to be tested is passed twice through a food grinder, and a small portion is spread out on a small slab of wood or piece of tin plate. Dry pieces of cobalt-chloride paper are picked up with forceps, placed on the sample, and immediately covered with a piece of glass to prevent contact with the air. The time elapsing before the paper changes from blue to pink is noted. This period varies with the moisture content of the sample and with the concentration of cobalt-chloride solution into which the paper has been dipped.

METHOD OF DETERMINATION ADOPTED

The method finally adopted for determining moisture depends upon the fact that raisins with high moisture content are soft and pliable, whereas those with a low moisture content are hard, a fact which forms the basis of the old test made by squeezing a sample in the hand.

A special apparatus designed to measure the compressibility of samples (fig. 1) consists of an upright iron stand, A, securely fastened to a platform 45 inches long, 6 inches wide, and 2 inches thick, B. The stand is 15½ inches high and has on one side two arms about 3½ inches long. These arms are accurately bored with vertical ½-inch holes to act as guides for the plunger, C. The lower edge of the lower arm is 1½ inches above the cylinder, O, when it is in place, and there is a clearance of 4 inches from the top of the upper arm to the base of the weight platform, D, when the disk, E, is at the top of the cylinder. Fastened to the upper arm is a piece of flexible metal band, K, so bent as to have the ends near the plunger on each side of the arm. By means of a small cam, these ends can be forced against the plunger, holding it stationary when it is desired to do so. The plunger, C, is 13½ inches long and of such diameter that it fits snugly into the holes in the arms. On the lower end is a disk, E, one-fourth inch thick, of such diameter as to fit snugly into the cylinder, O, and at the upper end is a similar disk, D, 3¾ inches in diameter, for holding the weights used in the operation. The hollow cylinder, O, is 5½ inches high and 2½ inches in diameter, made of ⅛-inch brass. It is portable. Six inches above the lower disk on the plunger is a ⅞-inch cube, F. This cube carries small $\frac{1}{16}$-inch knife edges, N, on two opposite sides for supporting the pointer, G. This pointer is suspended by the attached knife edges, P, from two strips, V, 3¾ inches long and one-half inch wide, that swing on knife edges, R, one on each side of the stand A. The strips,

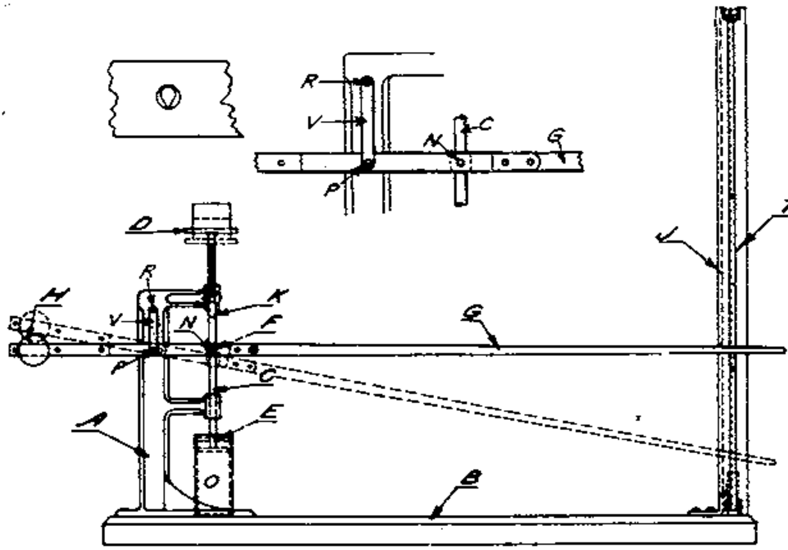

FIG. 1.—Apparatus for measuring compressibility of raisins

V, allow for the necessary side play as the plunger moves up and down. The pointer is counterbalanced by the weight H, which is 7¾ inches from P. Where the pointer rests on the two sets of knife edges, P and N, it consists of two $\frac{1}{16}$-inch steel bands seven-eighths inch wide. These bands pass on each side of the plunger and stand, and are then united, about 1 inch in front of the plunger and 2 inches behind the stand. The united bands extend about 7 inches beyond the bolts to afford a place for the counterbalance, H. A single band of the same material, held in place by the front bolts, extends for 36 inches from the knife edges above the platform. At the same distance an upright angle iron, J, about 35 inches high, is fastened to the platform, so that the end of the pointer will travel up and down the surface of one side when the plunger is raised or lowered. Small rollers are fitted behind this side, upon which a graduated tape, T, may be fastened.

In making the tests, the cylinder is filled with 400 cubic centimeters of raisins, the temperature of which has been observed. It is then placed under the plunger, and a small weight (20 grams is sufficient) is placed on the weight disk, so that the lower disk rests lightly upon the sample. The brake, K, is then set to hold the plunger in this position. The reading on the graduated tape opposite the end of the pointer is observed and a kilogram weight is placed on the weight platform. The time is noted and the brake released. After 15 seconds, the brake is again set and the reading on the tape opposite the end of the pointer is taken. The difference between the readings is an indication of the moisture content of the sample.

The apparatus must be carefully standardized at several temperatures for each type of fruit upon which it is to be used. Two readings should be taken on each of several subsamples, and several subsamples should be tested in order to determine any point on the graph. The tests should then be repeated several times at different temperatures within the range to be met in actual practice. After a series of points on the graph are fixed, the curves can be drawn. These will be accurate for that particular kind of dried fruit.

In the laboratory standardization of this test, samples representing the different grades of Thompson Seedless were chosen and the range of moisture content usually encountered in practice was used. After thorough mixing, portions of the samples were ground twice through a nut-butter grinder and their moisture content was determined at 70° C. in vacuo. The remaining major portions of the samples, kept in sealed glass jars, were placed in an incubator maintained at constant temperature by a thermoregulator and allowed to remain there at least 16 hours to effect equilibrium of temperature. They were then removed, one at a time, their temperature was observed, and they were submitted twice to the test as rapidly as possible. After all of one series had been tested at one temperature, the incubator was adjusted to another temperature and the operation was repeated. When a suitable range of temperatures had been used, the results were plotted at each temperature. Several such series were run on Thompson Seedless, one on Sultana, and one on mixed 3 and 4 crown muscat raisins. The results on one such series of Thompson Seedless are given in Table 6.

The results thus obtained showed that a constant volume of sample gave results as accurate as those obtained by constant weight. As the constant volume method is simpler and more rapid, it has been adopted. The results were made more uniform by tipping the sample upside down in the compression cylinder several times before the observations were made, by roughly leveling the top of the sample before each initial adjustment, and by using the average of the two observations. It was also found that the depression after 15 seconds was as valuable an index of moisture content as that after 60 seconds. It is necessary to exactly counterbalance the pointer and use care in bringing the plunger into contact with the sample in order to avoid serious errors when the temperature or moisture content is high.

The observations on samples tested by the compressibility method seemed to follow a straight line curve and were thus interpreted. (Fig. 2.) In all cases the average deviation from the plotted mean was approximately ±1 per cent. A few observations showed much wider variations. The samples generally behaved alike at all the temperatures used, but the cause was not ascertained. There appeared to be no correlation between such behavior and the weight per volume or average weight per berry.

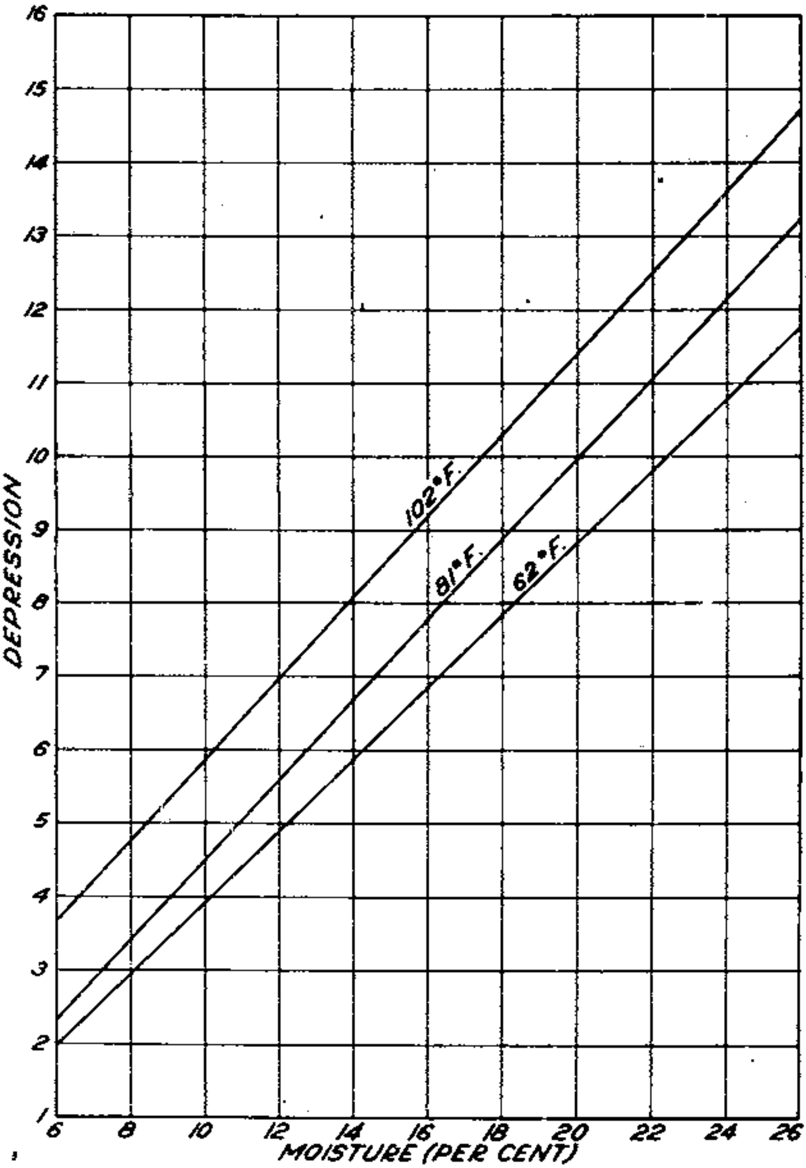

FIG. 2.—Graph for determining moisture in raisins by compression

TABLE 6.—*Moisture tests on Thompson Seedless raisins (compression cylinder)*

Moisture	District	Pointer depressions							
		62° F. (61–63°) Feb. 19, 1925		72° F. (69–74°) Mar. 9, 1925		81° F. (79–82.5°) Mar. 18, 1925		102° F. (99–106°) Mar. 12, 1925	
		15 seconds	60 seconds	15 seconds	60 seconds	15 seconds	60 seconds	15 seconds	60 seconds
Per cent									
10.8	Porterville	4.34	5.11	5.18	6.07	5.23	6.21	6.37	7.40
11.6	Selma	4.75	5.49	4.50	5.32	4.52	5.30	6.38	7.44
13.3	Reedley	5.04	5.93	6.18	7.05	6.42	7.40	7.49	8.30
14.4	Sultana	6.50	7.60	6.86	7.97	7.79	8.94	8.96	9.82
14.6	Reedley	7.11	8.28	6.81	7.90	7.56	9.23	9.21	10.35
14.7	Lone Star	6.41	7.33	6.59	7.52	[illegible]	7.73	8.40	9.47
14.8	Del Rey	5.57	6.43	6.06	6.54	6.88	7.77	7.50	8.37
15.3	Reedley	6.89	7.98	6.78	7.81	7.53	8.70	9.27	10.08
15.3	Visalia	8.31	9.69	8.69	9.95	9.60	11.04	11.26	12.51
15.4	Biola	6.87	7.86	7.30	8.12	6.98	7.90	9.25	10.25
16.5	Armona	6.41	7.30	7.50	8.38	7.53	8.54	8.83	9.90
16.7	Kerman	7.40	8.42	7.00	7.91	8.00	9.00	9.83	10.90
16.9	Monmouth	6.91	7.81	6.98	7.77	7.03	8.63	9.87	10.87
17.2	Del Rey	7.44	8.43	7.90	8.80	8.69	8.74	10.15	11.11
17.3	Dinuba	7.45	8.74	8.07	8.90	8.69	9.75	10.64	11.72
18.0	Pixley	6.61	7.42	6.36	7.20	7.55	8.50	9.52	10.52
18.1	Arvin	8.74	9.91	8.19	9.24	10.00	11.20	11.34	12.36
18.2	Turlock	8.21	9.19	7.14	7.98	8.35	9.44	10.86	11.87
18.4	Chowchilla	8.32	9.31	7.64	8.57	9.08	10.10	10.14	11.69
18.6	Dinuba	7.17	8.02	7.11	7.87	8.25	9.20	9.32	10.35
18.6	Visalia	7.32	8.27	7.15	8.07	8.35	10.45	10.16	11.26
19.0	Patterson	10.29	11.43	9.14	10.18	10.85	12.01	12.10	12.69
19.1	Del Rey	8.20	9.13	8.06	8.90	9.34	9.93	9.20	10.70
19.8	Livingston	8.74	9.71	7.81	8.76	10.25	11.33	12.19	13.20
20.2	Forsey	9.64	10.73	9.69	10.65	10.49	11.50	11.30	11.99
20.4	Livingston	8.43	9.46	8.98	10.30	9.99	11.01	10.75	11.73
21.0	do	9.59	10.62	9.74	10.69	10.72	11.73	11.87	12.78
21.2	Reedley	8.00	8.88	7.85	8.71	9.59	10.54	11.10	12.06
21.4	Lemoore	9.35	10.43	9.59	10.62	10.08	10.88	12.32	13.37
21.6	Kerman	9.55	10.54	9.42	10.42	10.80	11.83	11.55	12.61
22.7	Livingston	10.07	11.03	9.21	10.15	10.35	11.35	11.87	13.05

Interpolations for intermediate temperatures were made from the curves plotted. From the tabulations obtained in this manner, a tape was devised for use on the instruments. On this tape the temperature correction was made by adjusting the zero point. The depressions corresponding to the moisture content were laid off on the tape to read directly in terms of moisture content. The temperature corrections were so uniform in the Thompson Seedless and muscat raisins that one scale could be used for each variety through the whole temperature range without introducing serious error. In the Sultana raisins the temperature corrections varied so widely from any single line that it was necessary to divide the temperature range into an upper and a lower half, a separate scale being provided for each.

TEST FOR MOLD

Mold may place raisins of excellent quality in other respects in the inferior grade. In wet seasons, where the early rains are followed by cold, foggy weather, the loss from mold is very high. In other years it amounts to little or nothing.

Inspectors grading raisins under the old system detected the presence of mold by visual examination and by odor, but under some conditions its detection in this manner was uncertain.

As time was again essential to a satisfactory test, the usual device of soaking the raisins for several hours before examination was not feasible. Much time was spent in attempting to find a stain or mixture of stains which would color the mold and not color the bloom ofthe raisin or vice versa. Nothing satisfactory of this nature was found, owing to the fact that when raisins were torn the torn parts were stained. Tests for starch or other compounds found in molds and not in raisins were unsatisfactory, because the mold present on many samples is very slight. Finally tests for enzyme action in the fruit and mold were tried. In practically all cases of mold contamination, a well-defined test for catalase could be obtained. Fermented fruit, of course, gave a like reaction, but it is not necessary to distinguish between the two, as either usually brings the fruit into the inferior grade. A disturbing factor was encountered in that yeast cells or other source of catalase often seemed to be present on the stems though not on the berries. It was not at all difficult, however, to distinguish the catalase from this source. Normal berries, even when crushed, showed no catalase activity. Results on typical samples are given in Table 7.

TABLE 7.—*Hydrogen peroxide mold tests on raisins, June 19, 1925*

District	Thompson Seedless raisins											
	Extra-standard			Standard			Substandard			Inferior		
	Total	Moldy		Total	Moldy		Total	Moldy		Total	Moldy	
		No.	Per cent		No.	Per cent		No.	Per cent		No.	Per cent
Clovis	72	0	0	76	0	0	82	0	0			
Fresno	70	0	0	82	0	0	106	0	0+	[1] 75	[1] 14	[1] 18.7
Oleander	73	0	0	64	0	0	94	1	1.1			
Selma	71	0	0	71	0	0	88	0	0			
Kingsburg	70	0	0	90	0	0	94	0	0			
Rayo	76	0	0	90	1	1.1	91	0	0	76	5	6.6
										[1] 69	[1] 18	[1] 26.1
Delano	67	1	1.5	77	0	0	113	0	0			
Turlock	91	0	0	86	0	0	83	1	1.2	82	33	40.2
										67	1	1.5
Livingston	64	0	0	94	0	0	66	0	0	63	8	12.7
				67	1	1.5						
Modesto	60	1	1.5	78	1	1.3	102	1	1.0	50	30	53.7
Reedley										[1] 65	[1] 14	[1] 21.5
Del Rey										[1] 66	[1] 16	[1] 24.3
Dinuba										[1] 61	[1] 14	[1] 22.9
Maximum			1.5			1.5			1.2			53.7
Minimum			0			0			0			1.5
Average			.3			.4			.3			22.8

District	Sultana raisins					
	Standard			Substandard		
	Total	Moldy		Total	Moldy	
		No.	Per cent		No.	Per cent
Clovis	90	0	0	88	0	0
Fresno	60	2	3.3			
	61	2	3.3			
Oleander	87	3	3.5			
Selma	97	0	0			
Kingsburg	78	3	3.8			
Rayo	75	2	2.7	89	1	1.1
Delano	81	0	0			
Turlock				50	1	1.8
Livingston	72	0	0			
Modesto	64	2	3.1			
Maximum			3.8			1.8
Minimum			0			0
Average			2.0			1.0

[1] Tested in 1923.

As finally carried out, the test consists in placing a definite number of berries in a crystallizing dish and covering them with a 3 per cent hydrogen peroxide solution. The moldy berries can be readily detected by the streams of oxygen bubbles rising from them. Placing the dish over black glazed paper or using a dark enameled pan is helpful. Usually the activity caused by yeast colonies attached to stems is not great, for the formation of oxygen bubbles is slow and seldom do streams of bubbles rise to the surface as they do when mold is present. This test will be found generally applicable for the detection of mold on vegetable matter where the original substance is poor in catalase.

TEST FOR SAND

Sand on raisins may be in the form of a light dust carried by the wind or in the form of soil mixed with the fruit through careless handling, or even purposely added to increase the weight, or it may be an accompaniment of rain damage. Sand washed in by rain may be difficult or even impossible to remove without special treatment.

Inspectors formerly detected the presence of sand by the appearance and gritty feeling of the sample. If too much sand was thought to be present, the grower might be required to screen the fruit before delivery, or the grade of the lot was reduced. When sand firmly adhered to the fruit, no attempt was made to determine the amount.

This problem is simple. A sample of 100 grams of stemmed raisins is placed in a beaker or cup, covered with water, and vigorously agitated for 60 seconds with a test-tube brush. The contents of the cup are dumped on a conical screen placed in a large funnel and the cup and fruit are rinsed until the sand is removed. The sand is allowed to settle out through the stem of the funnel into a calibrated tube. After settling for three minutes, the volume of sand is read. More than 0.4 cubic centimeter disqualifies for the extra-standard grade. Although some débris other than sand will settle, the sand tends to settle first, hence the reading after three minutes and the disregard of further sedimentation.

TEST FOR SUNBURN

Samples of approximately 100 berries against a white background were exposed to powerful and constant artificial light and were examined through selected light filters. An illuminating box, provided with reflectors, and two 100-watt Mazda light bulbs were used. In the order of their effectiveness, the filters were Wratten filters No. 35 and No. 12 combined and Nos. 97, 97A, 97B, 88, and 70. These filters transmitted light common only to normal berries, making them appear light, whereas sunburned berries looked nearly black. A difficulty with the test is that the variation in color of normal berries may require a choice among two or more filters for sharpest contrast. As practically no fruit was sunburned in 1925, the test was not submitted to routine use.

SUMMARY

Several methods of standardizing raisins have been tested. The weight per volume test, moisture estimation by compression, mold test, and sand test were placed in practical operation during the 1925 crop season by the raisin interests. Although, as in the case of

every innovation, there was some adverse criticism, most of the raisin growers believe firmly that these methods are a marked advance in grading raisins.

An outstanding advantage of the system devised is that each test can readily be used on a sliding scale, permitting adjustment of the grade lines to correspond with seasonal variations in quality, or to stimulate improvement in quality by raising standards, or to divert into conversion channels a larger proportion of the crop in seasons of great overproduction. The system also permits the adoption of the more rational plan of classifying the crop on the basis of numerous narrow gradations rather than into a few classes, each containing a wide range of quality with inherently exaggerated discriminations between lots of adjacent quality but on opposite sides of the grade lines.

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