MARKETING RESEARCH REPORT NO. 451

SORTING RAISINS by the AIRSTREAM METHOD

An Evaluation of Mechanical Sorting of Natural-Condition Raisins for Maturity and Trash Content

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
MARKET QUALITY RESEARCH DIVISION

PREFACE

Construction of the first experimental airstream-sorting unit for raisins was financed by the California Raisin Advisory Board. Construction of the second unit and the research on testing and sampling were conducted under research contracts between the Agricultural Marketing Service of the U. S. Department of Agriculture, and the Coast Laboratories, of Fresno, Calif., a private research company.

The study of an improved method of sorting samples of natural-condition raisins, reported here, is part of a national research program to improve efficiency and maintain quality in marketing farm products.

Contents

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SUMMARY AND CONCLUSIONS

An "airstream sorting machine" was developed and tested for sorting samples of natural-condition raisins on the basis of maturity and trash content. The machine sorts a 1,000-gram sample of raisins in 10 minutes, whereas the usual hand-sorting requires more than an hour. Results from the machine are more precise than those from hand-sorting.

The machine made satisfactory separations of immature raisins and vine trash from mature, acceptable raisins.

Construction and testing of two machines showed that the two could produce equivalent results if air velocity and temperature were controlled accurately.

Information basic to designing a sampling plan for the airstream-sorting technique was collected. Study of these data indicated a wide range in the percentage of immature raisins among growers' loads. Mechanical sorting might make it economically feasible to determine the percentage of immature raisins in each load instead of the present determination that is limited to ascertaining whether the load has more than or less than 10 percent immature raisins.

An attempt was made to sort raisins of higher maturity quality (minimum grade B or better) from the Standard grade. The airstream sorter showed some promise in making this separation, but further study is necessary before final conclusions can be drawn.

SORTING RAISINS BY THE AIRSTREAM METHOD

An Evaluation of Mechanical Sorting of Natural-Condition Raisins for Maturity and Trash Content

by Charles D. Fisher, Coast Laboratories, Fresno, Calif., and Arthur P. Sidwell, food technologist, Horticultural Crops Branch, and Calvin Golumbic, chief, Field Crops and Animal Products Branch, Market Quality Research Division, Agricultural Marketing Service

INTRODUCTION

In determining the quality of raisins, such factors as size, moisture content, defects, soundness, and maturity are considered. Most of these quality characteristics can be determined with reasonable accuracy and rapidity. However, a better method for sorting immature raisins and trash from inspection samples of natural-condition raisins has been desired for many years. The Processed Products Inspection Branch of the U. S. Department of Agriculture, in inspection for compliance with Federal marketing order regulations, employs hand separation into Standard and Substandard portions by a visual and "feel" procedure. The Substandard portion contains the lightweight "immature (skinny) raisins." The product must be "fairly free" of these raisins to comply with the marketing order.[1] A second method used for commercial quality evaluation determined the weight of a unit volume of raisins, the unit container being filled under a standard condition of raisin flow and container agitation. This method is based on the research of Chace and Church.[2]

The hand-sorting method requires careful training of technicians and takes considerable time. For this reason, samples are usually limited to half-pound subsamples, which in some instances may be too small to represent accurately the load of raisins delivered by a grower.

The weight-per-unit-volume procedure provides a general index of maturity quality but does not indicate definitely the percentage of immature raisins in the sample.

For these reasons, the raisin industry and the U. S. Department of Agriculture have sought a better method for sorting inspection samples on the basis of maturity. In 1952, the California Raisin Advisory Board financed a research program for this purpose at the Coast Laboratories, Fresno, Calif., a private research company. An airstream sorting machine to separate the lightweight immature raisins and vine trash from natural-condition raisin samples was developed. In 1957, the U. S. Department of Agriculture, through the Marketing Quality Research Division of Agricultural Marketing Service, entered into research contracts with Coast Laboratories to test and further develop this principle and equipment. This research is reported here.

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[1] U. S. Dept. Agr., Agr. Mktg. Serv., Marketing Order No. 89, as amended, regulating the handling of raisins produced from raisin-variety grapes grown in California. Article 989.97, exhibit B: Minimum grade and conditions for natural-condition raisins. Fed. Reg. 20:6435 (1945).

[2] Chace, E. M., and Church, C. G., Tests of Methods for the Commercial Standardization of Raisins. U. S. Dept. Agr., Tech. Bull. No. 1 (1927) 23 pp.

EXPERIMENTAL PROCEDURE AND RESULTS

Development of the Airstream Sorter

It has long been known that the so-called "skinny" raisins result from immature grapes. H. E. Jacob,[3] in a report published by the California Agricultural Experiment Station, found that, as the sugar content of grapes increased, the proportionate recovery of raisins increased. Raisins from low-sugar, immature grapes were found to be lower in weight per 100 raisin berries and in weight per unit volume than those prepared from mature grapes. His research showed the magnitude of these effects precisely.

This is the scientific basis for the air-blowing technique used to discard light, immature raisins and vine trash at raisin finishing and packaging plants. After careful consideration, this airstream sorting principle was chosen as the one offering most promise as a sample-sorting technique.

However, experiments showed that precise separation of high-maturity from low-maturity quality raisins would require a more complicated apparatus than that used in raisin packaging plants; that the airstream must have uniform velocity and temperature; and that the raisins should be fed into the airstream at a slow, regular rate. To separate the heavy raisins, which sank in the airstream, completely from the light ones which were carried in the airstream, it was necessary to build an enclosed, airtight apparatus.

The method of separation in the final machine is simple (fig. 1). A sample of raisins from chamber A is fed slowly into an updraft airstream in the vertical shaft B. Heavy raisins sink in this airstream and fall into the chamber D sample drawer, while the lightweight ones and any vine trash present are carried over the inverted U-tube to fall through the air shaft C into chamber E sample drawer. After the sample has been fed into the airstream, the raisins in drawers D and E are weighed and the percentage of lightweight, immature raisins (plus vine trash) is calculated.

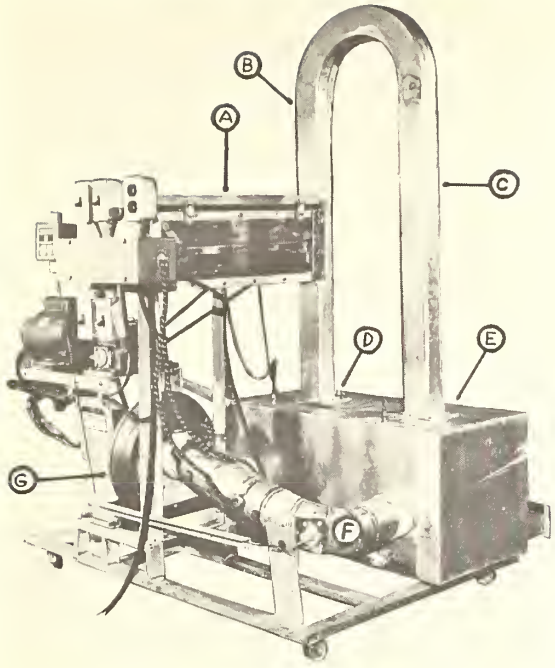
Certain features of the airstream sorter (fig. 1) permit adjustment of the air velocity, which makes it possible to adjust the level of maturity quality at which the separation is made. The moisture contents of all samples are taken and the results shown by the airstream sorter are adjusted to a standard 16 percent moisture level to compensate for differences. For example, a sample testing 5.6 percent "rejects" at 13.0 percent moisture would show only 5.0 percent "rejects" if the moisture content of the sample was 16 percent. This "corrected-for-moisture" result is obtained from specially developed tables (appendix, exhibit A).

The machine sorts a 1,000-gram sample in about 10 minutes. Hand-sorting a 1,000-gram sample requires more than an hour, the exact time depending on the condition of the sample.

Testing the First Airstream Sorter, 1957 Season

The first step in testing this machine was to attempt sorting of raisin samples at the minimum grade C maturity level (separation of Standard acceptable raisins from Substandard ones). Samples which had been previously hand-sorted by technicians of the Processed Products Inspection Branch of the Agricultural Marketing Service were run, and mechanical adjustments then made to separate the raisins at the minimum C level of maturity quality. After the proper machine settings had been found, 176 samples collected by inspectors were sorted by both the airstream and hand-sorting techniques, using the procedure described in the appendix, exhibit B.

[3] Jacob, H. E., The Relation of Maturity of the Grape to the Yield, Composition and Quality of Raisins. Hilgardia 14(6):321-345 (1942).



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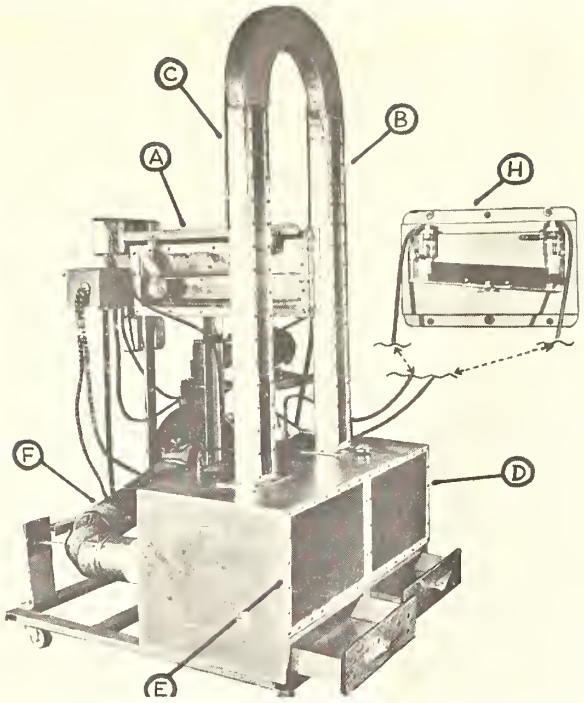
Rear view



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Front view

Figure 1.--Airstream sorter for raisins. A. Enclosed sample feed belt. Holds 1,000-gram sample. B. Sample is slowly fed into vertical updraft airstream in column B. C. Lightweight, immature raisins and vine trash are carried over and down column C. D. High-pressure plenum chamber. The meaty or heavy, good-quality raisins descend through airstream and this plenum to sample drawer. E. Low-pressure plenum. Lightweight raisins and vine trash are carried over and drop out into sample drawer. F. Low-pressure air return pipe. Contains thermostat bulb and strip heaters for temperature control. G. Blower with direct motor drive. Blower supplies air to high-pressure plenum D and pulls air from low-pressure plenum E (rear view only). H. Micromanometer. Differential pressure between plenums is measured and is proportional to air velocity in vertical column B (front view only). Thermometer to check air temperature in closed system can be seen in top of plenum D.

When the results of the first 60 samples of this series run by the two methods were compared, the results from airstream sorting were not consistently higher or lower than those from hand-sorting, although individual sample results often varied from each other (fig. 2). The average of the hand-sorting determinations for the total 176 samples was 2.24 percent (Substandard and vine trash), and of the airstream determinations, 2.18 percent.

The capability of the airstream sorter to reproduce its results on duplicate samples also was tested. A 1,000-gram sample was split from about 2,000 grams of raisins, then run on the airstream sorter. After the weight data had been taken, the 1,000-gram sample was reblended into the original quantity. Later, a second sample was split out and run on the airstream machine.

A total of 123 such duplicate determinations was made. The standard deviation between them was 0.17 percent. This includes some sampling error in addition to error of machine reproducibility.

A similar test of the reproducibility of hand-sorting was made using 47 duplicate determinations. The procedure was the same as that used for machine testing, except that 227-gram (half-pound) samples were used to comply with the official inspection procedure. The standard deviation for these duplicate determinations was 0.68 percent. Since the sizes of the samples for the two methods (airstream sorting and hand-sorting) were different, the 0.68 was multiplied by the square root of 227/1000, to correct for sample size. This corrected standard deviation between duplicate hand-sorting results was 0.32 percent. The comparable value for the airstream technique was 0.17, which indicates that this method has better precision than hand-sorting.

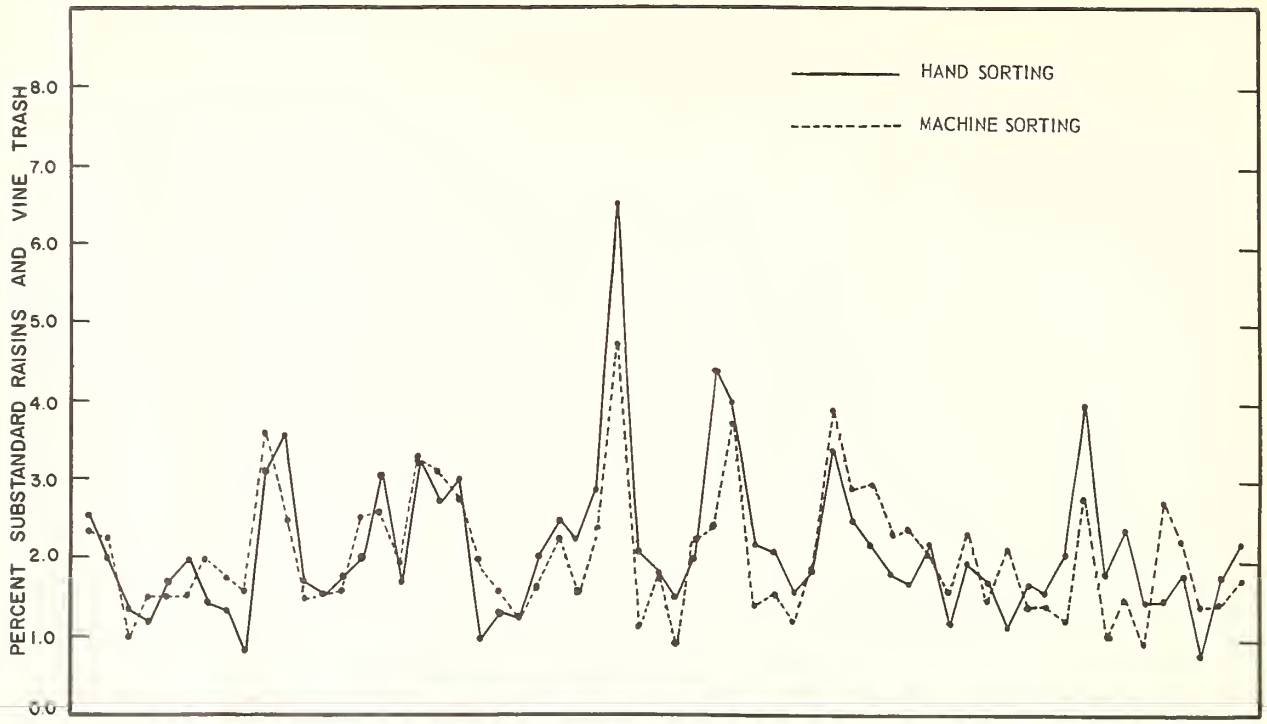

Figure 2.--Comparison of hand and machine sorting of 60 raisin samples.

Comparison of Sorting by Two Airstream Sorters and Hand Sorters, 1958

A second airstream sorter was constructed to study problems which would be expected to occur if numerous machines were used in raisin inspection. The experimental plan for the second year's research included a study of (1) the agreement in results between two machines with the same trained operator and with different operators, (2) reproducibility of results when a sample was run a second time on the same machine by the same trained operator, (3) the agreement in results between two hand-sorting technicians, and (4) the reproducibility of results when a sample was sorted a second time by a hand-sorting technician.

The procedure included also a study of the variation between and within sweat boxes of raisins taken from the "Meeting"[4] portion of growers' loads. In addition, some experiments were run to try to separate out raisins of higher maturity quality from within the accepted, Standard portion, or specifically to separate Grade B (or better) from C maturity-level raisins.

The complete experimental plan for the 1958 season is given in the appendix, exhibit C.

Comparison of Airstream-Sorting Machines

The second airstream sorter built for this research during the late summer of 1958 was a copy of the first except for minor improvements. However, the second model did not duplicate the performance of the first until adjustments were made in the dimensions of the inverted U tube (fig. 1). A flexible adjustable metal plate was fitted into this tube and comparisons then were made. After some further adjustment, the two machines were tested on 40 duplicate 1,000-gram samples. The average difference in results between

[4] The "Meeting" portion of a load is that part which passes inspection ("meets" the requirement) for moisture content and freedom from damage and contamination. See appendix, exhibit C.

them was not statistically significant (fig. 3). The standard deviation between the two machines was 0.20 percent, approximately equal to that between duplicate samples run on the same machine (fig. 4). To achieve this degree of precision between machines, it was necessary to control air velocity and temperature precisely by mechanical controls. Performance on samples of identical raisins was used to check the performance of the two machines, because the operation did not damage the raisins.

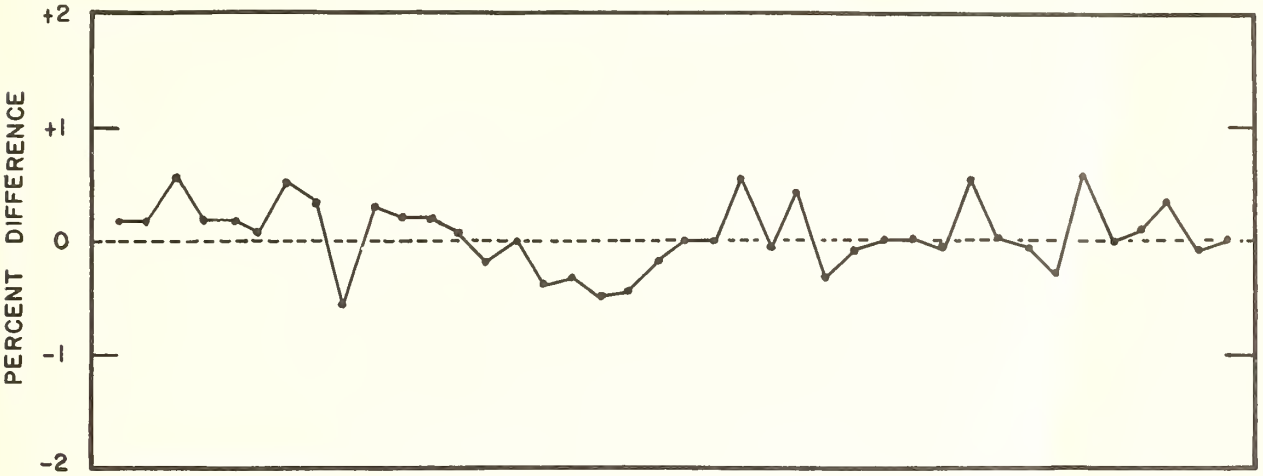

Figure 3.--Agreement between two airstream sorters on identical raisin samples run by the same operator (results from first machine set at zero, straight line).

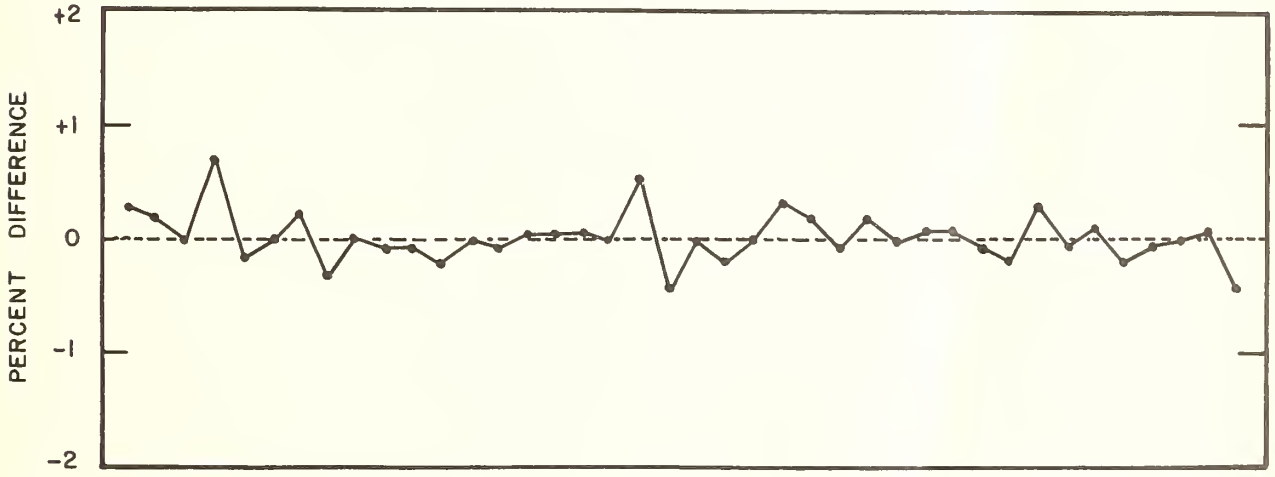

Figure 4.--Reproducibility of sorting results of identical raisin samples by the same machine and the same operator (first result set at zero, straight line).

Some artificial "raisins" were made from balsa wood pellets for use in checking performance. Some of the pellets were made heavier by inserting pieces of solder into the wood, causing them to be separated like heavy raisins. They helped in setting and adjusting the machines.

No significant differences in results were found between the two trained operators.

Comparison of Hand Sorting With Machine Sorting

The agreement in results between two airstream sorters and that found between two hand-sorting technicians confirmed the previous year's conclusion that the machines

would be a worthwhile improvement. The standard deviation between findings of the two hand-sorting technicians, calculated from a series of 106 duplicate determinations, was approximately 0.67 percent, after correction for difference in sample size, and only 0.20 percent between machines (figs. 3 and 6). This second year's tests of the reproducibility of results in hand-sorting by the same technician indicated that the error was approximately equal to that between two hand-sorting technicians (figs. 5 and 6).

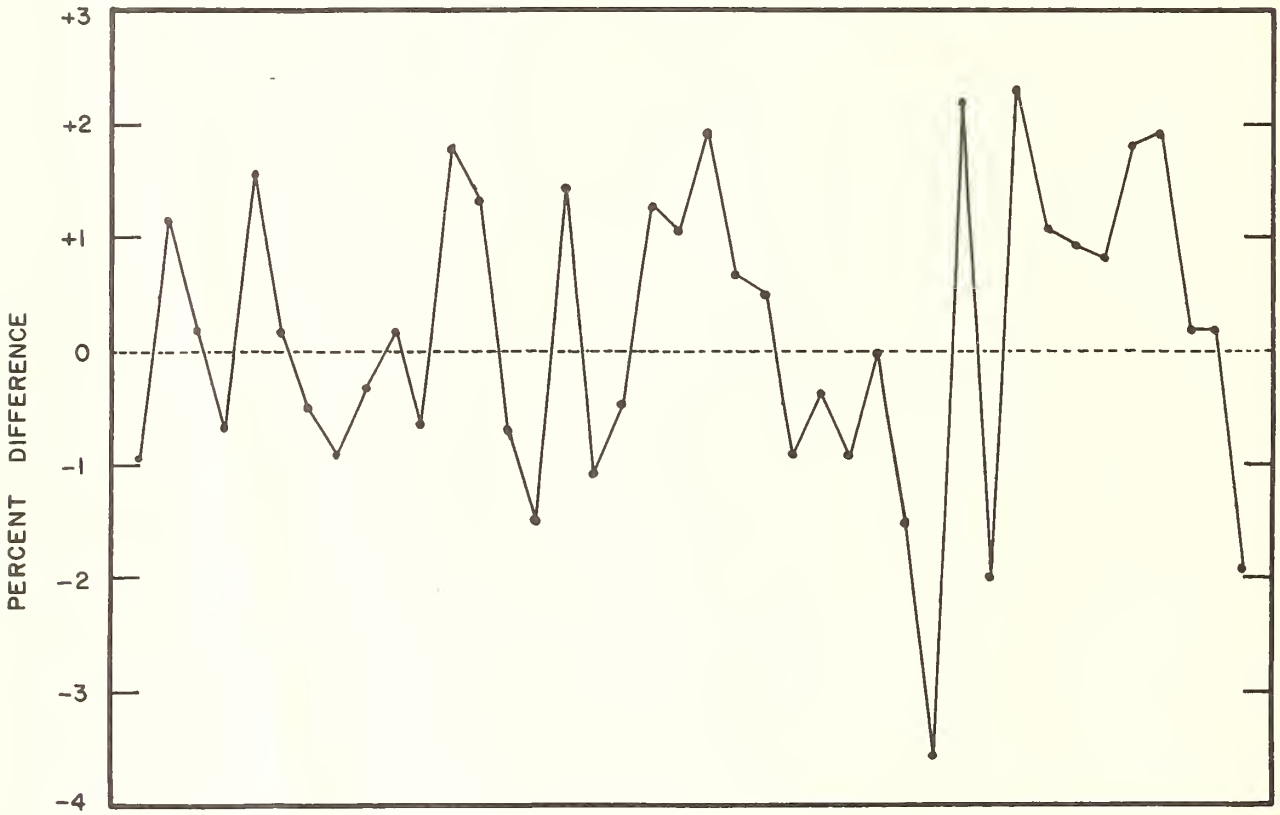

Figure 5. --Reproducibility of sorting results of identical raisin samples by the same hand-sorting technician (first sorting results set at zero, straight line).

The averages of results on the "meeting" portions of 53 loads sorted for maturity quality by the two methods were closely similar; 4.59 percent (immature and vine trash) for hand-sorting and 4.53 percent for the airstream method.

The machine-separated portions from 24 of these samples were examined by 2 hand-sorting technicians from the Processed Products Inspection Branch. They inspected the high-maturity and low-maturity quality portions and "adjusted" each on the basis of hand sorting. Usually the technician found a few raisins in each machine classification which she judged to be classified incorrectly. However, the net change in results was minor. The two technicians varied in adjustments of airstream-sorted samples. This was interpreted to mean that there were occasional raisin berries which were borderline and might be classified one way or the other. They appeared to be evenly divided between the two classifications made by the airstream-sorting equipment. The 1958 results thus showed that the two methods classified raisins at the same levels of maturity quality, but that the airstream method is more precise. The fact that larger samples can be run on the airstream sorter is an added advantage, because this reduces sampling error.

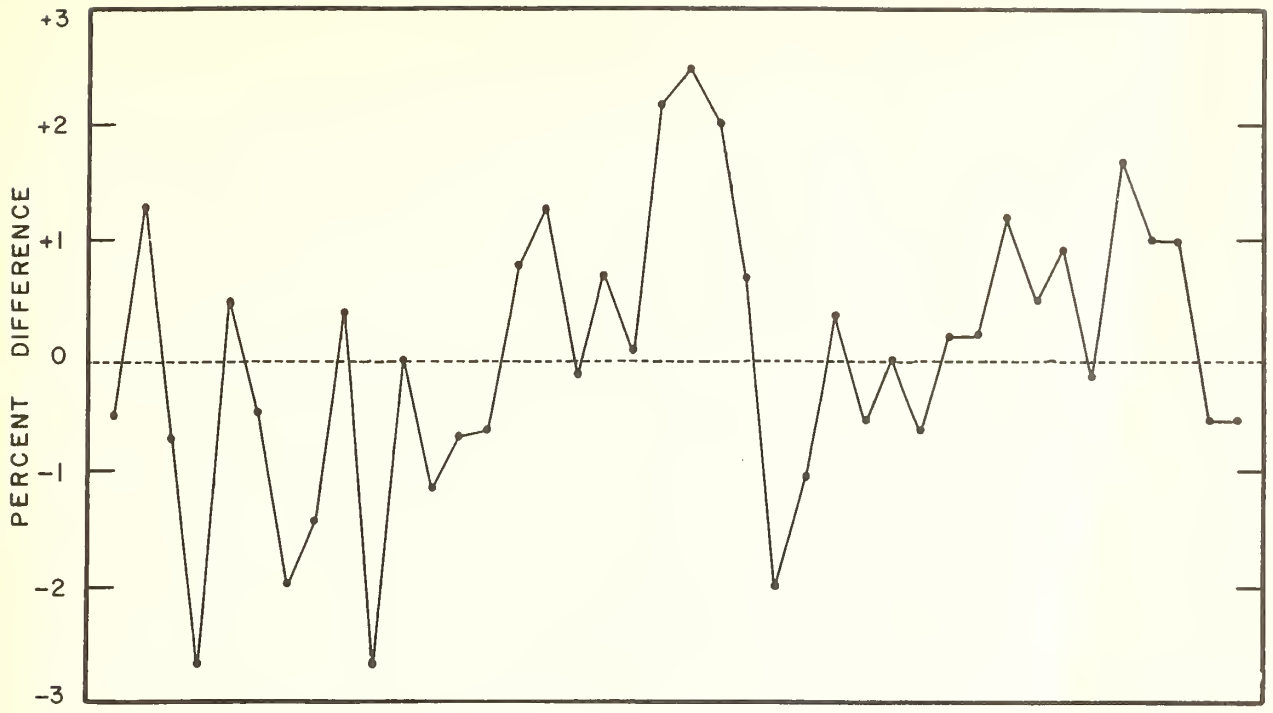

Figure 6. --Agreement of sorting results of two hand-sorting technicians on identical raisin samples (results from first technician set at zero, straight line).

Possibilities of Airstream Sorting at Minimum B Grade Level

The research up to this point concerned the separation of immature raisins (and vine trash) from the acceptable portion at the Standard or minimum C level as required by specifications pursuant to the Federal Raisin Marketing Order. Separations were attempted also at the minimum grade B level as described in the U. S. Grade Standards for Raisins, to see if Grade B, or better, raisins could be separated from Standard raisins by the machines. The machines were adjusted to separate at this level by setting up the air velocity to approximate the separations made by hand-sorting technicians at the minimum B level. Many preliminary settings and gradings were made before this setting was determined. After this preliminary work, 30 samples were sorted by machine and by hand-sorting. Both types of sorting were done in duplicate. The averages of the two methods agreed within 1 percent; the average of the airstream-sorting results was 25.2 percent below minimum B grade, while the average of the hand-sorting results was 26.0 percent. This agreement between averages was considered satisfactory; however, the agreement between duplicate runs by both methods was not as precise in this separation as in separation of mature from immature raisins. Likewise, differences between hand-sorting results and airstream-sorting results on individual samples were greater.

The greater variation between duplicate determinations indicates that there are many borderline raisin berries between minimum B and top C grades.

Variations in Maturity Quality Among Growers' Loads

The study on sampling of growers' loads during the second season's work was conducted to furnish basic data necessary to design an accurate method of sampling for application of the airstream-sorting method. Data were accumulated on the variations found between sweatboxes taken from the "Meeting" portions of growers' loads, and between samples taken from the same sweatbox. These data are not presented here, since

they should be collected for several years and at several locations before a reliable recommendation can be made.

However, these data did contribute an immediate practical observation. Since each load was rather thoroughly sampled, it was possible to calculate a reliable estimate of the percentage of immature raisins (and vine trash) in the "Meeting" portion of each load (fig. 7).

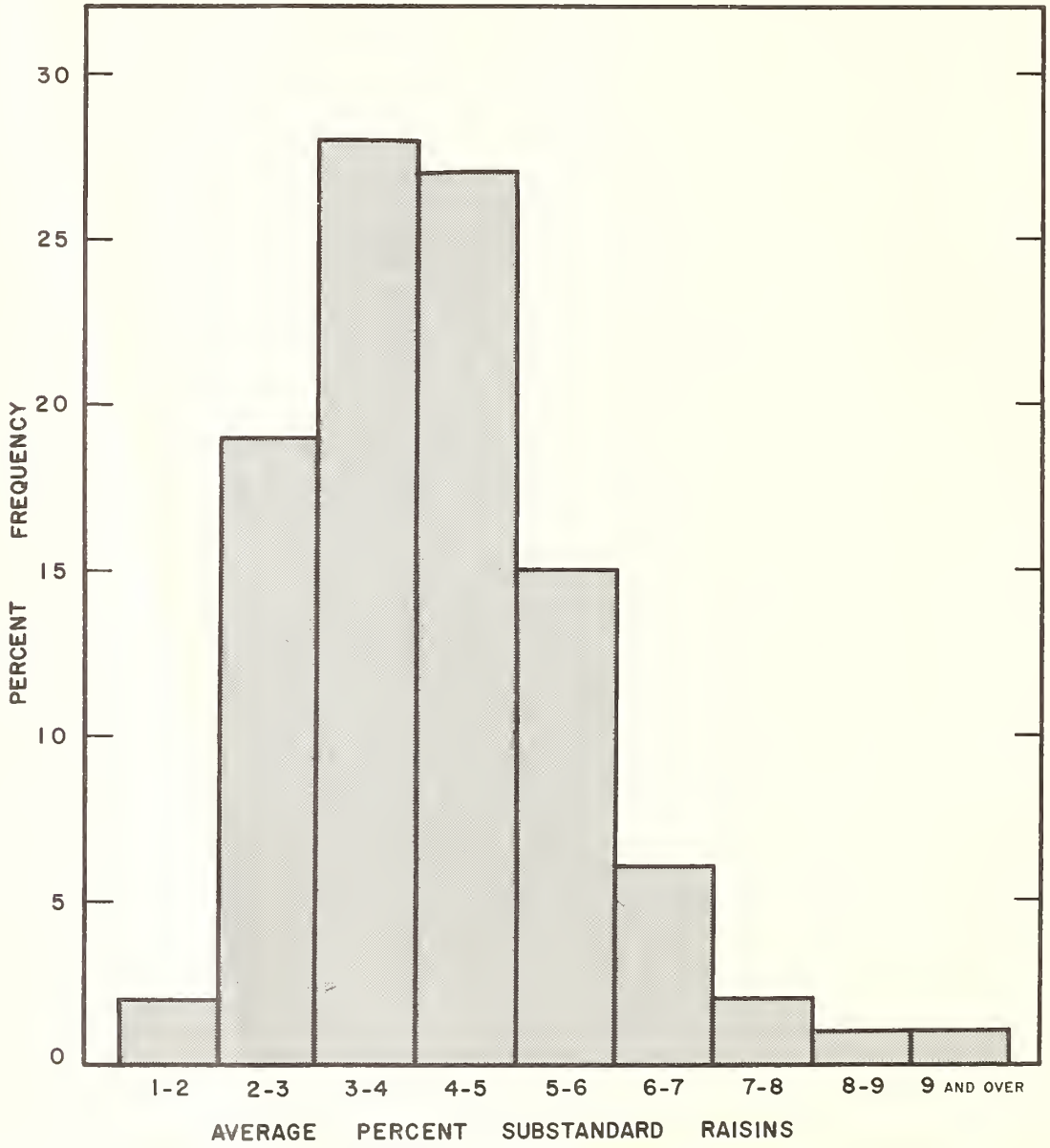

Figure 7.--Distribution of percentages of immature raisins (and vine trash) for 101 loads of raisins, 1958 season.

The quality differences apparent in figure 7 are not considered under the marketing order, which requires only that the loads be "fairly free" from "immature (skinny) raisins." The term "fairly free" is interpreted as less than 10 percent.

Determination of maturity quality to a more accurate degree by hand-sorting of inspection samples would increase inspection cost greatly. However, it might be done economically and accurately by the airstream sorter described in this report.

Exhibit A.--Abridged Table for Correction of Airstream Sorting Results to a Standard Percentage Moisture[1] [2]

Percentage moisture	Percentage rejected raisins blowing over in the airstream sorter																		
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
16.0%	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0
15.0%	0.1	1.1	2.1	3.1	4.3	5.2	6.2	7.3	8.3	9.3	10.3	11.3	12.3	13.3	14.3	15.2	16.2	17.2	18.3
14.0%	0.2	1.2	2.2	3.2	4.3	5.4	6.5	7.6	8.6	9.6	10.6	11.6	12.6	13.6	14.6	15.6	16.6	17.6	18.7
13.0%	0.4	1.4	2.4	3.4	4.5	5.6	6.7	7.8	8.8	9.8	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0
12.0%	0.5	1.5	2.5	3.5	4.7	5.8	6.9	8.1	9.1	10.1	11.2	12.2	13.3	14.4	15.4	16.4	17.4	18.4	19.4
11.0%	0.6	1.6	2.6	3.6	4.8	6.0	7.2	8.3	9.3	10.3	11.4	12.4	13.5	14.6	15.7	16.8	17.8	18.8	19.8
10.0%	0.8	1.8	2.8	3.8	5.0	6.2	7.4	8.5	9.5	10.5	11.6	12.6	13.7	14.8	15.9	17.0	18.0	19.0	20.1
9.0%	0.9	1.9	2.9	3.9	5.2	6.4	7.6	8.7	9.7	10.7	11.7	12.7	13.9	15.0	16.0	17.2	18.1	19.1	20.3

[1] For illustrative purposes only. The unabridged table can be obtained from Coast Laboratories, Fresno, Calif., or Market Quality Research Division, AMS, U. S. Department of Agriculture, Washington 25, D. C.

[2] A determination of moisture content of the sample is made at the same time that the sample is sorted. If the moisture content is less than 16 percent, then the percent "rejects" is adjusted to that corresponding to the 16 percent level.

Exhibit B.--Procedure, First Season (1957)

1.--Sample Collection

Large samples (about 8 to 10 pounds) were collected in paper bags by personnel of the Processed Products Inspection Branch. The bags were slipped into polyethylene bags to avoid moisture changes during temporary storage in a cool room.

2.--Sample Preparation

Each sample was run through a laboratory-size stemmer to loosen the raisin berries from vine stems. It was then blended by splitting it through a Denver splitter and recombining twice. After the third split, the two halves of the sample were placed in separate polyethylene bags and labeled as the A and B portions of the original sample number.

3.--Airstream and Hand-Sorting Procedures

a. The "A" portion of each sample was split mechanically and 227 grams weighed for hand-sorting. Another portion of the sample was tested for moisture.

b. After hand-sorting, the separated portions were recombined and replaced in the original sample bag.

c. The sample was then submitted to the airstream sorter operator (in another location), who mechanically split the sample to get the 1,000-gram machine-test sample.

d. Following the machine run, the operator recombined and blended the entire sample.

e. Each day a few A samples which had been sorted previously on the machine were coded and resubmitted to the entire process starting with "c" above. About 50 percent of the coded samples were resubmitted to the same hand-sorting technician.

f. Each day, a few B portions (sec. 2, Sample Preparation) of the original samples also were submitted to the entire process starting with "c" above. These were B portions of samples previously graded on the machine.

Exhibit C.--Procedure, Second Season (1958)

1.--Sample Collection

As each load entered the delivery area, 4 sweatboxes were marked, one from each quarter of the load. Selection within each quarter area was at random. As the electric hoists removed boxes from the load, the marked boxes were set aside, provided the inspector judged them to pass requirements for moisture content and freedom from damage and contamination. Boxes which failed to pass these requirements were set aside, and a second box which met the requirements was taken. Thus only the "Meeting" portions of the loads were sampled; however, the percentage of boxes failing the above requirements was usually low. Boxes were sampled by digging into the end area of the box. An effort was made to get a cross section of the box depth by prying up the raisins in the area approximately 6 inches from the box end and midway between the sides. Approximately 1,500 grams of raisins were taken for each of two samples from each of four sweatboxes of each load sampled.

2.--Sample Preparation

Each sample was run through a sample stemmer, individually. This stemmer separated the berries from the stems without loss of stems or other plant debris. Next, each sample was put through a splitter three times and recombined to insure thorough blending. Each sample was then poured into three-ply protective bags (two polyethylene bags inside a paper bag) for temporary storage at ambient room temperature.

3.--Moisture Testing

Each sample was tested for moisture with the Dried Fruit Association moisture tester. Periodic checks showed that moisture changes between October 15, 1958, and January 1, 1959, were neglible. Samples tested in March showed slight moisture gains, and therefore were retested for moisture before being used.

4.--Airstream and Hand-Sorting Procedures to Determine Reproducibility

a. Single airstream sorter, same operator, identical samples.--Samples were submitted to machine operators R and H. The report form instructed operator R to run the sample on machine A and operator H to run the sample on machine B, after recombination of the separated portions. At a later time the same sample was returned to the same operator with a new report form and instructions. The instructions again required operator R to run the sample on machine A and operator H to run the sample on machine B, again after recombination of the separated portions.

b. Two airstream sorters, same operator, identical samples.--A sample was submitted to one operator with instructions to run the sample on machine A. At a later time the same sample was submitted to the same operator with instructions to run the test on machine B.

c. Two trained operators, same airstream sorters, identical samples.--A sample was given to operator R with instructions to run the test on machine A or B. Later, the same sample was given to operator H with instructions to run this test on the machine used by operator R.

d. One hand-sorting technician, identical samples.--A sample was given to a hand-sorting technician who was instructed to sort 1 pound of the sample and report the result on the form provided. She then reblended the parts of the 1-pound sample with the original sample (totaling about 1,500 grams) by splitting and recombining three times. Later, the same sample was returned to the same technician with a new report form for re-sorting.

e. Two hand-sorting technicians, identical samples.--A sample was submitted to one technician and the results were recorded. Later, the same sample was submitted to the other technician for sorting.

Note: Raisin samples weighed out from the original 1,500-gram samples for individual tests of the airstream sorters and hand-sorting technicians weighed 1,000 grams and 1 pound (454 grams), respectively. After individual tests were completed, the separated portions were blended back into the remaining unused portion to re-create the original 1,500-gram samples.

5.--Higher Quality Separation Procedures

This separation was attempted at the "minimum B" level as defined in the U. S. Standards for Dried Raisins. The immature portion was first removed and discarded, then the air velocity of the sorters was adjusted to make a separation at a higher specific gravity level. The separations were then compared to those made by hand-sorting technicians and the air velocity of the machines was further adjusted. After suitable agreement had been reached, 30 samples were tested, and reproducibility of the machines was compared to that of hand-sorting technicians.

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