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VARIATION IN SOLIDS OF THE JUICE FROM DIFFERENT REGIONS IN MELON FRUITS[1]

G. W. SCOTT[2] AND JOHN H. MACGILLIVRAY[3]

THE IMPORTANCE of quality in melons (*Cucumis melo* L.) has prompted research to compare existing varieties in attempts to improve their flavor and palatability through selection and breeding; and incidental to this is the need for a basis upon which to formulate a state standard to regulate or prevent the shipment of melons low in soluble solids. These considerations make it desirable to have adequate methods for obtaining and analyzing samples, and to have a clear conception of the possible variability in different regions of the cantaloupe fruit. This paper presents data on the variability of solids in melons and discusses methods of testing and sampling.

Palatability of melons has usually been associated with sugar content and other water-soluble solids. The soluble solids consist largely of sugars together with minor amounts of dissolved compounds of nitrogen, minerals, and other constituents. It is generally accepted that there is a correlation between sugar content and palatability or quality of melons (*3*)[4]; this seems true even though the flavor factor has not been measured. As a cantaloupe ripens there is an increase in total solids, and a decrease in reducing sugars, as well as a softening of the flesh and a development of color (*9*).

REVIEW OF LITERATURE

Chace, Church, and Denny (*3*) were among the first to make use of the immersion refractometer in determining the relative concentrations of cantaloupe juice. Their samples consisted of the juice from the entire edible flesh and they were able to show a positive correlation between the density of the juice, or percentage of sucrose, and the eating quality of melons. The density of the juice was determined at different stages of maturity. A few years later Rosa (*9*) reported a study upon the effect of stage of maturity on the composition of melons. Longitudinal segments were preserved in alcohol for chemical analysis. Juice was also

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[4] Italic numbers in parentheses refer to "Literature Cited," at the end of this paper.

expressed and the density determined by means of a Brix spindle. Rosa expressed the relation between the solids soluble in 55 per cent alcohol and the total solids. The alcohol-soluble solids may differ in amount from the water-soluble solids. He found that 94 per cent of the total solids were soluble in the case of Golden Beauty Casabas, 87 per cent in Honeydews, and 93 per cent in black-seeded Angeleno watermelons.

Tucker (*13*), although his data were limited to one fruit, has pointed out the variations in the soluble-solids content in different regions of the watermelon. There was also some indication that the stem end was lower in hand-refractometer reading (soluble solids) than the blossom end. Lloyd[5] observed that there was considerable difference in the quality of different parts of the same cantaloupe. The stem end and the undersides of the fruits were usually of poorer quality than the blossom end and the top. The underside of a melon, especially at the point of contact with the ground, was usually of poorer quality than the upper portion of the same melon. All quality tests were made by tasting and extended through two seasons. Scott (*11*) published an abstract of the results obtained with *Cucumis melo* L. in 1935 and these data are included in this paper.

METHODS AND RESULTS

There are several methods available for determining the concentration of solids in the juice of melons. Various workers have used the Brix hydrometer or spindle, and the Abbé, immersion, and hand refractometers. Since there are three different scales represented by these instruments, it seems desirable to explain the relation between them. The scale readings of each of these instruments give an indication of the relative concentrations of similar solutions when tested. The Brix hydrometer scale is calibrated by means of solutions of pure sucrose in water and the scale is expressed in per cent sucrose. Juice from mature cantaloupes contains over 50 per cent sucrose and the Brix hydrometer has therefore been used to indicate the per cent soluble solids, although obviously the results are not so accurate as with pure sucrose solutions. The scale readings of refractometers are based on the refractive index of the liquid being tested; in some instruments the scale reading is established arbitrarily, while in others (Abbé) the scale readings indicate directly the refractive index. The arbitrary scale reading of the immersion refractometer may be expressed in terms of refractive indices by calibration. From a table of refractive indices of sucrose-water solutions the percentage composition of an unknown sucrose-water solution may

[5] Lloyd, J. W. Studies of variation in the quality of melons. p. 213–14. Unpublished thesis, filed in Cornell University Library, Ithaca, New York.

therefore be obtained. The hand refractometer has been in use for only a few years. The manufacturer has expressed the scale in percentage of "dry substance" and has indicated that the scale was determined about the year 1910 by means of pure sucrose solutions. Thus, the scale readings express the percentage of both the soluble solids and total solids for standard sucrose solutions, while if plant juices containing other dissolved substances are tested, the scale readings give only approximate percentages of soluble solids. In the early work with cantaloupes, the Brix reading was referred to as the "soluble solids" (*3*). In more recent

TABLE 1

THE RELATION BETWEEN THE REFRACTIVE INDEX AND THE PER CENT SOLUBLE SOLIDS OF SUGARS AND OTHER SOLUTIONS*

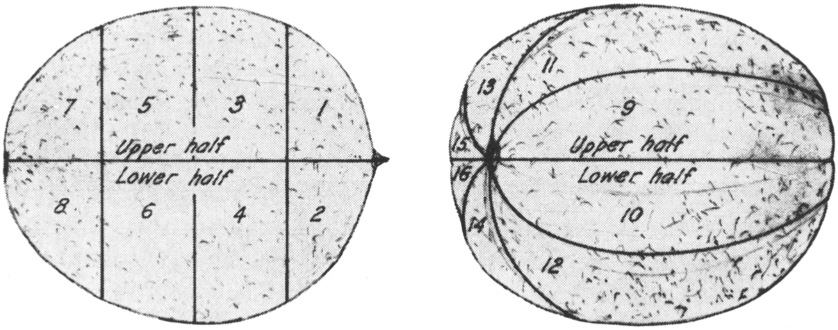
Refractive index, 20° C	Sucrose	Maltose	Commercial glucose	Lactose	Dextrin	Soluble solids in tomato pulp
1.3402................	5.00	5.07	5.00	5.13	4.87	4.60
1.3477................	10.00	10.07	10.07	10.13	9.60	9.45
1.3555................	15.00	15.12	15.06	15.13	14.13	....
1.3637................	20.00	20.17	20.06	.....	18.94	....

* Data in columns for sucrose, maltose, commercial glucose, lactose, and dextrin are from table XV of bibliography citation *2*; data for the column of soluble solids in tomato pulp, are from citation *1*.

work with watermelons the hand-refractometer reading has also been referred to either as "soluble solids" or "total soluble solids" (*6, 7, 8*). The California Standardization Act is enforced for cantaloupes on the basis of minimum per cent of soluble solids in the edible portion, and consequently this term is in common use by growers and shippers.

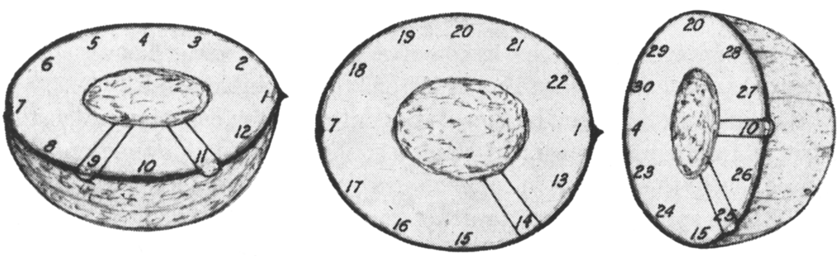
The Brix spindle and hand refractometer indicate the relative concentration of melon juice on the basis of comparative sucrose solutions. It seems possible that the fruit juices containing other soluble material than sucrose may be subject to a corrective factor before readings will accurately express soluble solids. Browne (*2*) and Bigelow and Fitzgerald (*1*) have made such comparisons between refractive index and soluble solids. Some of these data are found in table 1. There are still wider variations where the solids of inorganic salts are compared as to their refractive index and soluble solids. A silver nitrate solution (*4*) with a refractive index of 1.33484 at 20° C contains 1.7 per cent solids. An ammonium sulfocyanate solution with a refractive index of 1.33499 at 20° C contains 0.8 per cent solids. Both of these solutions are tenth molar. With these facts in mind, it seemed desirable to give the data as hand-refractometer readings in the tables, and to use the term "soluble solids" in the text, because of its common use in the melon industry.

Method of Sampling Fruits.—The melons were cut into cross and longitudinal sections to determine their possible variability. These procedures are described in succeeding paragraphs, and are illustrated by figures 1, 2, and 3. The edible flesh was removed from the rind, cut into small pieces, and the juice from the whole section was obtained by press-



A *B*

Fig. 1.—The melons used for data presented in table 2 were first cut along their polar diameters through the stem and blossom ends parallel to the ground. In *A*, subsequent vertical cuts were made so that there were 8 equal sections. In *B*, 8 longitudinal sections were cut.



A *B* *C*

Fig. 2.—Location of taking sample cores for data found in table 3: *A*, a longitudinal section cut parallel to the ground; *B*, a longitudinal section cut vertical to the ground; and *C*, a cross section made midway between the stem and blossom ends. Cores were taken at all locations indicated by the numbers except in the case of cantaloupe where the samples were taken only from locations shown in *A* and *C*.

ing it through fine cheesecloth. The hand or field refractometer was adjusted for laboratory temperatures.

In the twenty fruits for the data in table 2 (fig. 1) the first cut was made through their blossom and stem ends parallel to the ground. In ten of these, subsequent vertical cuts were made so that there were 8 equal halves of cross sections (fig. 1, *A*), while the other ten fruits were cut along the sutures of their polar (*10*) diameters to obtain 8 equal longitudinal sections (fig. 1, *B*). The samples for the determinations presented in table 3 were obtained by means of a cork borer from a single fruit each of cantaloupe and Honeydew; the cores were $\frac{9}{16}$ inch in diameter and were taken at the locations indicated in figure 2.

The melons for the data in table 4 (fig. 3) were first cut through their blossom and stem ends (and ground spot), vertical to the ground (fig. 3, *A* and *B*). One half (fig. 3, *A*) was cut into longitudinal sections as shown in figure 1, *B*. One longitudinal section was cut from the other half

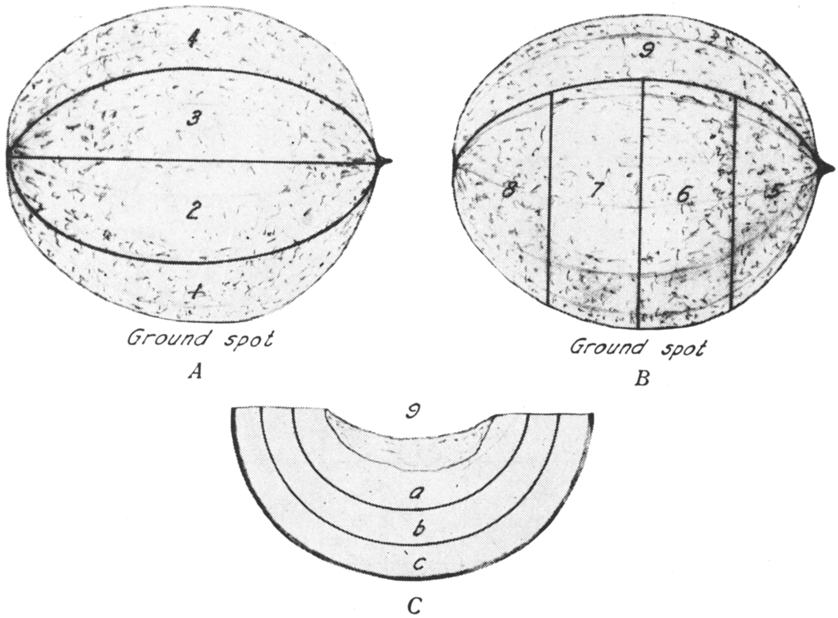


Fig. 3.—For data presented in table 4, each melon was cut in half along the polar diameter, vertical to the ground, the cut passing through the middle of the ground spot. *A*, longitudinal sections from half the melon; *B*, the other half of the melon from which one longitudinal section was cut, and four cross sections; and *C*, the last longitudinal section separated into three sections from the seed cavity to the rind.

for section 9, and the remainder was cut into cross sections as shown in figure 3, *B*. Determinations were made on regions 9*a*, *b*, and *c*, as shown in figure 3, *C*. In tables 2 and 4, the juice was obtained from large sections, and consequently was a composite sample for the section. Samples obtained by means of the cork borer were from a much smaller area than the other samples.

In 1935 and 1937, there was little difference between the soluble-solids (refractometer reading or dry substance) content of the different longitudinal sections. None of the sections were consistently lower or higher in soluble solids, and in 60 per cent of the comparisons the differ-

TABLE 2

HAND-REFRACTOMETER READINGS (PER CENT SOLUBLE SOLIDS) FROM DIFFERENT REGIONS OF THE EDIBLE PORTION OF MELONS; 1935

Regions of fruit sampled	Sample section (fig. 1)	Upper half				Sample section (fig. 1)	Lower half			
		Cantaloupe	Honeydew	Casaba	Average		Cantaloupe	Honeydew	Casaba	Average
Cross sections of 10 fruits										
Stem end	1	8.6	9.6	8.7	8.9	2	9.6	10.0	9.3	9.6
Middle (stem end)	3	10.9	10.5	9.9	10.4	4	10.7	11.2	10.2	10.7
Middle (blossom end)	5	11.1	10.9	10.1	10.7	6	10.7	11.2	10.3	10.7
Blossom end	7	10.4	10.7	10.0	10.4	8	10.4	10.6	9.9	10.3
Longitudinal sections of 10 fruits										
First segment	9	9.4	10.9	9.5	9.9	10	9.1	10.8	9.4	9.8
Second segment	11	9.6	10.9	9.6	10.0	12	8.9	10.4	9.4	9.6
Third segment	13	9.5	10.8	9.7	10.0	14	8.9	10.6	9.0	9.5
Fourth segment	15	9.2	10.8	9.7	9.9	16	9.0	10.3	9.4	9.5
Coefficient of variability of cross sections*	..	12.5	17.4	15.1	....	..	13.5	15.3	16.7	....
Coefficient of variability of longitudinal sections*	..	7.3	11.4	11.1	....	..	8.1	16.2	13.6	....

* The standard error of the coefficient of variability was calculated according to the following formula (see bibliography citation *12*): $\frac{v}{\sqrt{2n}}\sqrt{1+2\left(\frac{v}{100}\right)^2}$. The standard error of the difference between the coefficients of variability was determined and the difference considered significant when greater than twice the standard error. All differences between coefficients of variability of cross and longitudinal sections of the same variety and melon half are significant.

ence was equal to the accuracy of the hand refractometer. The data in table 3, as well as the cross-section results indicate that different areas in these longitudinal sections are variable in soluble solids. As the juice was taken from the entire segment, these differences were neutralized.

The stem end quarter of the cross sections (tables 2 and 4) was always lowest in soluble solids, with either the middle blossom quarter or the blossom quarter highest in percentage of soluble solids. When the sample was obtained by means of a small plug at the blossom end (table 3), this area was definitely highest in soluble solids. The longitudinal sections show less variability between the different sections than do the four cross sections.

Regions of Flesh.—In eating cantaloupes it has been a common observation that the inner flesh next to the cavity was more desirable than the flesh next to the rind. It seemed desirable to measure the variability of these regions. In 1937 a longitudinal section was obtained from each melon and divided into (1) one-third of the inner flesh next to the placental cavity, (2) the next third of the flesh which was firmer in consistency, and (3) the last third which was next to, but did not include, the rind (table 4, figure 3, *C*).

The inner flesh was always greatest in soluble solids, and there was a consistent decrease as the samples were obtained closer to the rind. In taking samples of a portion of the fruit or the whole fruit great care should be used to sample a uniform distance from the rind.

Placenta.—This region although never eaten is the first portion of the fruit to disintegrate upon ripening. A full-slip melon contains a large number of fibrous strands and seeds imbedded in gelatinous material. Readings were made on the region in order that there would be a complete analysis of the different regions of the fruit.

The placenta, blossom quarter, and inner flesh of the longitudinal section, are all high in percentage of soluble solids. The placental tissue was higher in percentage of soluble solids than the blossom-end quarter in five out of eight determinations, found in table 4. In some preliminary results where the sections were fewer and larger, the placental tissue was always highest in soluble solids. In all cases the regions of high soluble solids were associated with greater ripeness and softness of the flesh.

Storage.—Duplicate melons were stored at room temperature for about 6½ days, in 1937 (table 4), and the soluble solids were determined from the different regions. Fruits tested immediately and those stored were as nearly identical as was possible to obtain. After storage the cantaloupes were lower in soluble solids, the Persian melons changed slightly, while the Honeydews were slightly higher in solids. Storage did

TABLE 3

HAND-REFRACTOMETER READINGS (PER CENT SOLUBLE SOLIDS) FROM CORES OF DIFFERENT REGIONS OF THE EDIBLE PORTION OF ONE FRUIT EACH OF CANTALOUPE AND HONEYDEW; 1935

Cantaloupe				Honeydew					
Longitudinal section parallel to ground		Cross section at equatorial diameter		Longitudinal section parallel to ground		Longitudinal section at a right angle to ground		Cross section at equatorial diameter	
Sample no. (fig. 2, *A*)	Reading	Sample no. (fig. 2, *C*)	Reading	Sample no. (fig. 2, *A*)	Reading	Sample no. (fig. 2, *B*)	Reading	Sample no. (fig. 2, *C*)	Reading
1	9.8	4	11.6	1	13.0	1	13.0	4	14.8
2	10.8	23	11.8	2	15.0	13	13.4	23	14.2
3	11.2	24	11.4	3	14.4	14	14.2	24	14.0
4	11.6	15	11.6	4	15.0	15	14.6	15	14.6
5	12.0	25	11.6	5	15.4	16	15.0	25	14.4
6	12.8	26	11.4	6	15.6	17	15.0	26	14.4
7	13.0	10	11.6	7	16.0	7	16.0	10	14.4
8	12.4	27	11.6	8	15.4	18	15.4	27	13.0
9	11.4	28	12.2	9	15.4	19	14.2	28	13.8
10	11.6	20	12.2	10	14.8	20	14.2	20	14.2
11	10.8	29	12.0	11	14.2	21	13.4	29	14.8
12	10.2	30	11.4	12	14.6	22	13.6	30	15.4

TABLE 4

HAND-REFRACTOMETER READINGS (PER CENT SOLUBLE SOLIDS) FROM DIFFERENT REGIONS OF THE EDIBLE PORTION OF FRESH AND STORED MELON FRUITS, 1937

Fruit sample	Sample section (fig. 3)	Fresh				Stored for 6½ days			
		Cantaloupe full slip	Cantaloupe, half slip	Honeydew	Persian	Cantaloupe, full slip	Cantaloupe, half slip	Honeydew	Persian
Placenta	..	13.0	10.2	11.8	10.9	12.0	10.2	12.9	11.1
Longitudinal sections of 10 halves									
Ground spot	1	12.2	10.3	11.7	10.6	11.2	10.0	12.0	10.5
Next to ground spot	2	12.2	10.3	11.8	10.5	11.2	10.1	12.0	10.6
Next to top	3	12.0	10.1	11.6	10.4	11.2	10.1	12.1	10.7
Top	4	12.2	10.3	11.5	10.1	11.2	10.0	12.0	10.5
Cross sections of 10 three-eighths melon									
Stem quarter	5	11.1	9.4	10.3	9.5	10.1	9.3	10.6	9.4
Middle stem quarter	6	11.9	10.4	11.5	10.2	11.0	9.8	12.0	10.3
Middle blossom quarter	7	12.6	10.6	12.2	10.5	11.8	10.0	12.5	10.6
Blossom quarter	8	12.8	10.6	12.2	10.3	11.9	10.5	12.5	10.4
Longitudinal section									
Inner flesh	9a	13.1	10.9	12.8	11.0	12.1	10.6	13.1	11.2
Middle flesh	9b	11.5	9.3	10.4	9.4	10.7	9.5	10.8	9.1
Rind flesh	9c	9.5	7.3	7.7	7.4	9.8	8.5	8.3	6.8
Coefficient of variability* of longitudinal sections (1–4)	..	5.3	14.0	16.6	15.5	14.2	19.9	14.5	14.9†
Coefficient of variability* of cross sections (5–8)	..	8.8	15.6	19.4	17.2	16.0	16.2	16.4	15.5†
Coefficient of variability*‡ of longitudinal sections (9, *a*, *b*, *c*)	..	15.9	21.4	27.6	21.6	21.0	22.2	23.3	25.9

* The standard error of the coefficient of variability was calculated by the following formula (see bibliography citation *12*): $\frac{v}{\sqrt{2n}}\sqrt{1+2\left(\frac{v}{100}\right)^2}$. The standard error of the difference between the coefficients of variability was determined, and the difference considered significant when greater than twice the standard error.

† All comparisons between longitudinal and cross sections are significant except in the case of the Persian variety.

‡ The samples from the longitudinal sections (9*a*, *b*, *c*) are significantly more variable than the cross sections (5-8).

not make an appreciable change in the relative variability of the cross and longitudinal sections.

Statistical Analysis.—A comparison of the coefficients of variability of the longitudinal and cross sections indicate that the longitudinal sections are the least variable. In both tables 2 and 4 there is one case each where the longitudinal sections are the most variable, and the difference between the methods of sampling is not significant for the stored Persian melons. The three regions of the longitudinal section marked as 9*a*, *b*, and *c* are more variable than either the cross sections (5–8) or the longitudinal sections (1–4). It is evident that sampling by longitudinal sections is the most desirable.

In order to determine whether there was any significant difference between the longitudinal sections, they were compared in the following manner by the use of "Student's" method (*5*). The *Z* value was obtained by comparing each longitudinal section with every other longitudinal section. In 76 out of the possible 84 comparisons, it made no difference as to which one of the longitudinal sections was used. In the comparisons between the longitudinal sections of the lower half of Honeydews, there were found three comparisons where the differences were significant; in the fresh Honeydews there were two comparisons that were significant. The statistical data seem to support an observational analysis of the data when recognition is taken of the fact that melons are variable in composition, there is no exact method of removing the same proportional amount of flesh from each section, and the small number of fruits used.

SUMMARY

It is evident from these data that the different regions in the individual fruits of *Cucumis melo* L. are variable in composition and extreme care should be taken when either the entire edible flesh or any section of the melon is used for a composite sample.

The results indicate that the two most satisfactory methods of obtaining samples for soluble solids are as follows: (1) Pressing the juice from all of the edible flesh, using care to remove a uniform percentage of the flesh; and (2) pressing juice from a longitudinal segment and using care to remove a uniform percentage of the flesh.

The composition of melons is slightly changed by storage for 6½ days.

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