QUALITY RELATIONS IN MUSKMELONS
(CUCUMIS MELO VAR. RETICULATUS NAUD.)

Thesis for the Degree of M. S.

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David Allan Gilbart

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By

DAVID ALLAN GILBART

AN ABSTRACT OF A THESIS

Submitted to

Michigan State University

in partial fulfillment of the requirements

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ABSTRACT

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Quality of the muskmelon fruit was studied on the basis of important criteria and the factors affecting these.

Consumer acceptance was used as the basis for quality comparison. Experiments were arranged in the field to study the relation of variety, potash and minor element fertilizer, and time of harvest to quality. Post-harvest studies were made of deterioration of quality in relation to heat unit accumulation.

Quality was found to be related to percent soluble solids, ratio of sugars to acids, and fruit firmness.

Variety and time of harvest were found to influence quality in the field; mineral nutrition was not. Variety and time of harvest acted through an influence on the condition of the plant as indexed by leaf area. Soluble solids among varieties was related to leaf area index and among varieties and dates of harvest to leaf/fruit ratio. Size of fruit among varieties and dates of harvest was related to leaf area index. Firmness was related to variety.

Varietal expression of firmness was a valid basis for estimation of storage longevity. Across temperatures from 32° to 70°F softening was related to degree days above the freezing point of the melon flesh. Soluble solids increased slightly in initial storage and decreased as the fruit became unmarketable.

Muskmelon quality was concluded to be dependent on leaf area and post-harvest handling as they affect the quality constituents.

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INTRODUCTION

Quality in muskmelons is an enigma. It is the condition and constituents of the fruit which, in the end, define quality. These factors are probably entirely the result of plant growth and development and the subsequent post-harvest handling as limited by genetic expression. Variable climatic conditions in Michigan dictate variable quality.

It is the purpose of this thesis to consider quality factors in muskmelons. Within this broad generality an attempt will be made to quantitatively define some of the major quality constituents and elucidate some of the field and storage factors which govern them.

REVIEW OF LITERATURE

Estimation of Quality by Fruit Constituents

Several workers have analyzed the fruit of the muskmelon and determined its organic and inorganic constituents. Others have taken these and the physical features of the fruit and developed, from quantitative comparisons to taste, equations for measuring quality.

Money (18) in a compilation of analyses of many fruits found the following average values for muskmelons: total solids, 9.1%; total sugars, 6.8%; refractometer reading, 8.9%; acidity, 50 ml. .1 N base/ 100 gms.; and pectins, 0.20%. Chace, Church and Denny (3) studied the relationship between composition and maturity and found sucrose and refractive index increasing to a stable value at maturity. Starch, which they found to occur only in the seeds, decreased to a trace or none by edible maturity of the fruit.

Wagner, Hoffman and Brown (32) measured vitamin C content in muskmelons and found that it was directly correlated with the refractive index. Hoffman (10) in another study found the refractive index directly correlated with cut slice density in some lines and fruit weight correlated with total fruit density. Huffman, Scott and Lime (13) analyzed Rio sweet variety of muskmelons and found that sucrose, d-glucose and d-fructose were present in the sugar portion.

Currence and Larson (5) found the blossom end of melon fruit higher in soluble solids and quality as measured by taste appeal. Those fruits higher in refractive index were likewise higher in quality. A positive correlation between fruit size and quality was found, but this was of minor import and for most purposes refractive index sufficed for quality estimation.

Jacob and White-Stevens (14) found direct correlation of an artificial flavour index with soluble solids, hexose, sucrose and total sugar. Others (3, 9) also found direct correlation between taste and soluble solids.

Influence of Growth Conditions on Yield and Quality

Edmond and McNall (7) found seasonal climatic differences more important than mineral nutritional differences in affecting quality.

Mineral nutrition

Cooper and Watts (4) found no yield response to adding 18 pounds of potash per acre, but did note that no potash resulted in poor netting. Brantley (1) and Sharples and Foster (26) found no response to increasing potassium above the commercial recommendation. Rahn (22) found a yield response to increased potassium up to 165 pounds per acre in a wet year, but not in a dry one.

Thompson and Nettle (31) found no yield response to potassium or nitrogen singly. However, increased yield attributable to potash was apparent when the nitrogen level was sufficiently high. No effect was noticed on fruit size, netting, flesh colour, texture or flavour.

A beneficial response in yield to levels up to 200 pounds per acre K_2O on soils low in this element was reported by Carolus and Lorenz (2). Application was less effective when used in conjunction with 15 to 30 tons of manure. High levels of potassium tended to delay maturity of the fruit.

Jacob and White-Stevens (14) showed that increasing potassium from 75 to 150 pounds per acre and adding 15 pounds of borax decreased sugar levels in the fruit. Addition of 60 pounds of magnesium had a beneficial effect approximately equal to the deleterious effect of boron. The effect of potash was decreased by high levels of boron.

Stark and Haut (30) studied the interrelationships of nitrogen, potassium, calcium, magnesium and boron on the growth and quality of muskmelons. Using nutrient solutions in sand culture they found that potassium at low levels inhibited fruit set. Increasing the potassium level to 4 meq. per liter increased the fruit set and the percent soluble solids of the fruit. However, when the substrate potassium level was adequate, the foliar potassium level was inversely correlated with the level of fruit soluble solids. Boron had no effect on growth and fruiting but at increased substrate levels did increase soluble solids in the fruit. In the field Stark (29) found foliar applications of 2 pounds of boron as borax and 4 pounds of $MgSO_4$ resulted in an increase in the percent soluble solids.

Plant Growth and Leaf Area

Hartman and Gaylord (9) measured the total leaf area and the number of diseased leaves. From these they developed a multiple linear regression relating soluble solids to photosynthetically active leaf area per unit total fruit weight, percentage leaves showing disease symptoms and varietal type. Nylund (19) related leaf area and defoliation through pruning to quality and yield of muskmelons. Plants were pruned on the basis of leaf number. Twenty-five percent pruning at any time did not reduce quality or yield, but 50 percent pruning late in the season resulted in a decrease in both yield and quality. Seventy-five percent pruning, especially late in the season, reduced yield and quality as indexed by percent soluble solids.

Experiments indicate that sugars accumulate most rapidly the two weeks prior to harvest (17) and increase until full slip maturity (11). Lapeer (15) found that the fruit increases in size until the half slip stage. These studies show the importance of leaf area in the time immediately prior to harvest.

The effect of nutrition on fruit yield and quality may, by and large, be explained indirectly through its effect on vegetative growth. Other environmental factors may be explained on the same basis. Generally as the leaf area per unit fruit weight increases the quality of the fruit increases (8).

Post-Harvest Factors in Quality

High quality fruit in the field is no assurance of an acceptable consumer product. Storage and handling are also important considerations.

Chace, Church and Denny (3) found little change in fruit stored for a short time. They noted an increase in flavour, but not in sweetness. Sugar levels noticeably decreased as the fruit softened. Rosa (24) found immature fruit could be ripened in storage effectively. He showed that total pectic substances decrease during storage, soluble pectins increase, and sugars remain relatively constant decreasing, however, toward the end of the storage period. This latter observation was also made by Showalter and Thompson (27), Hoover (11), and Ogle and Christopher (20).

Optimal temperature for muskmelon storage is uncertain. The United States Department of Agriculture Handbook for Commercial Storage (34) lists 40 to 50° for full slip melons and 45 to 50°F for half slip. Wiant (33), Ogle and Christopher (20) and Platenius, Jamison and Thompson (21) suggest that melons can be stored for longer periods at temperatures down to 32°F. Hoover (12) found storage at temperatures up to 90°F did not damage the fruit.

Christopher and Ogle (20) found maturity to be the most important factor in post-harvest quality. Flavour was best with full slip maturity

but deteriorated rapidly. At half slip it was initially low but increased during storage, however never equaling the initial full slip rating. Firmness, as measured with a pressure tester, was found to be correlated with keeping quality and flavour; varietal differences in keeping quality were related to firmness.

Several studies have resulted in recommendations concerning the time-temperature relationship in storage. Chace, Church and Denny (3) found melons held essentially without change for 10 days at 35 to 40° F storage. Rosa (24) stored melons for 10 days at 38° F and found they ripened normally on removal to room temperature, Platenius, Jamison and Thompson (21) successfully held melons for a month at 32° F. Wiant (33) recommended storage for only a week and a half at 32° F to obviate the danger of pathogenic invasion. However, he found that melons would ripen normally after being in storage up to 2 weeks. Ogle and Christopher (20) related storage time to maturity. They found that full slip green melons could be stored up to 10 days and half slip melons up to 15 days at 32° F.

No single factor or simple combination of factors was found to be an unequivocal estimate of melon quality. Field predisposition coupled with storage and handling materially influence acceptability through a direct or indirect effect on the fruit constituents.

GENERAL MATERIALS AND METHODS

During the 1961 and 1962 seasons muskmelons (Cucumis melo var. reticulatus Naud.) were grown at East Lansing, Michigan. Plants were started in bands in a coldframe and transplanted through black plastic mulch in two plant hills spaced four feet by seven feet. Lime and fertilizers were broadcast before planting.

The varieties grown in 1961 were Burpee Hybrid, Harvest Queen and Honey Rock. The nutritional treatments were 0, 150 pounds/acre added K_2O and 150 pounds K_2O plus foliar application at weekly intervals of a complete minor element spray (Table 1). All plots were fertilized with 250 pounds/acre 21-53-0.

TABLE 1. --Minor Element Spray Material

Nutrient	Source	Ppm Element in Final Solution
Fe	Fe-EDTA chelate	1.0
B	H_3BO_4	0.5
Mn	$MnSO_4 \cdot 4H_2O$	0.5
Zn	$ZnSO_4 \cdot 7H_2O$	0.05
Cu	$CuSO_4 \cdot 5H_2O$	0.02
Mo	$H_2MoO_4 \cdot 7H_2O$	0.05
Spreader-sticker	Tween 20	100.0

Fruits were harvested and yield measured at the full slip yellow stage of maturity. Estimates were made of fruit size, degree of netting, firmness, and percent soluble solids. Samples of the fruit were brought into the laboratory where they were evaluated for quality by an acceptance panel.

In 1962 seven varieties and three fertilizer treatments were used. Two varieties, Burpee Hybrid and Harvest Queen, were fertilized with two levels of potassium: low - 75 pounds K_2O/acre, and high - 200 pounds. Seven varieties, Burpee Hybrid, Harpers Hybrid, Harvest Queen, Hearts of Gold, Honey Rock, Spartan Rock, and Super Market were grown at the high potassium level with and without a minor element spray (Table 1). Five hundred pounds/acre 10-20-0 was applied to all plots. Fruit picked at the field ripe or full slip yellow maturity were indexed for soluble solids, firmness, size and panel acceptance rating. Fruits for storage studies were picked at the full slip green and half slip stages of maturity. Yield was totaled over all maturities.

All data were summarized by appropriate methods of statistical analyses (28).

Methods and materials germane to individual experiments have been incorporated into the relevant sections in the interest of simplicity.

FRUIT QUALITY EVALUATION

In order to evaluate factors affecting quality, a definition of what constitutes quality in muskmelons became necessary.

Materials and Methods

The quality aspects selected for study were soluble solids, the sugar/acid ratio, and firmness. Soluble solids were measured with a hand refractometer on a longitudinal slice, as recommended by Scott and MacGillivray (25). Total sugars for 40 individual fruits were analyzed by the Anthrone reaction (6) based on quantitative colorimetric comparison. The relationship between soluble solids and sugars was established and used as a basis for further samples. Titratable acidity was determined electrometrically for all samples by titrating a 30 gm. sample with 0.01 N. NaOH to pH 7.0. Results were expressed as meq. acid/100 gms. fresh tissue. Firmness was measured with a modified Magness Taylor puncture pressure tester. The plunger was directed from the cavity toward the rind.

Quality was estimated subjectively by an untrained panel of men and women. Panel tests were repeated eight times; four in each year. The panel was composed of seven to eight people, most of whom served through the entire season. The test for acceptance was a simple hedonic rating scale from 1 representing unacceptable to 5 representing excellent. Each judge rated each fruit independently. A total of 124 fruits were rated for quality.

Results and Discussion

Results of the taste panel showed that the fruit used was generally low in quality. Gross variation in all three quality aspects was found. To assess the role of each factor the regressions of mean quality rating on soluble solids, sugar/acid ratio, and firmness were determined.

Soluble solids

A positive linear regression was found for quality on percent soluble solids (Fig. 1). Although the levels of soluble solids tended to be low, the judges differentiated among them and within the range covered by the test preferred those with the higher levels. The results were in keeping with those of other workers (3, 5, 9, 14, 20).

Sugar/acid ratio

Total sugars and soluble solids showed a curvilinear relationship (Fig. 2). This relationship was used in further sampling. In the range of soluble solids above 10 percent an increase in soluble solids was compensated for by an equivalent increase in sugars, but below 10 percent the relationship indicated that some integral part of the soluble solids pool, other than sugars, was limiting.

The organic acid pool varied considerably between fruit. Values ranged from .01 to 1.5 meq./100 gms. fresh tissue. The wide range of acid levels resulted in a wide range of ratio values and a skewed distribution. To simplify the relationship logarithms of the ratio values were used in determining the regression of quality acceptance on sugar/acid ratio.

Figure 1

The relationship between quality as mean acceptance rating and the fruit condition as percent soluble solids, ratio of sugars to acids, and firmness.

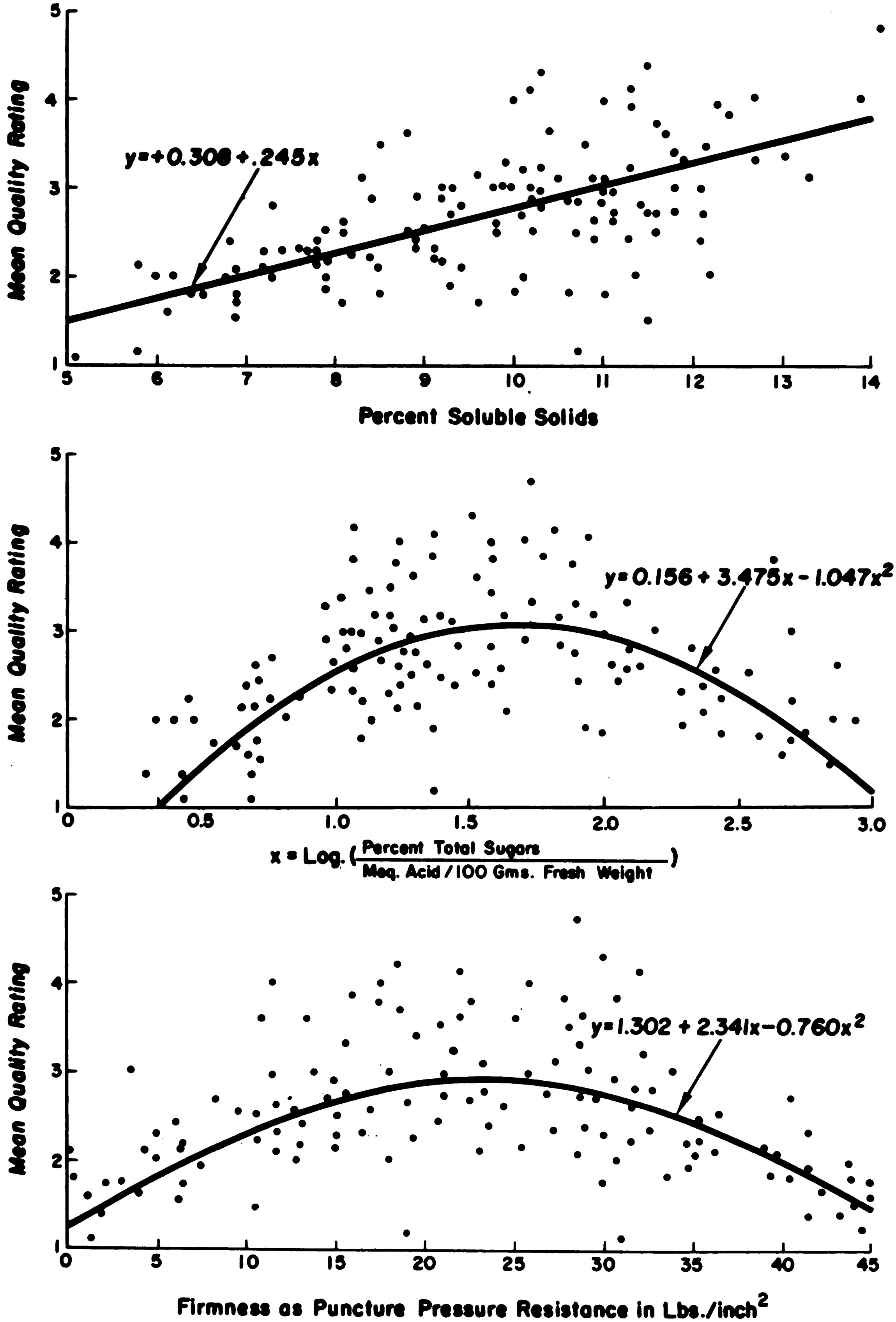
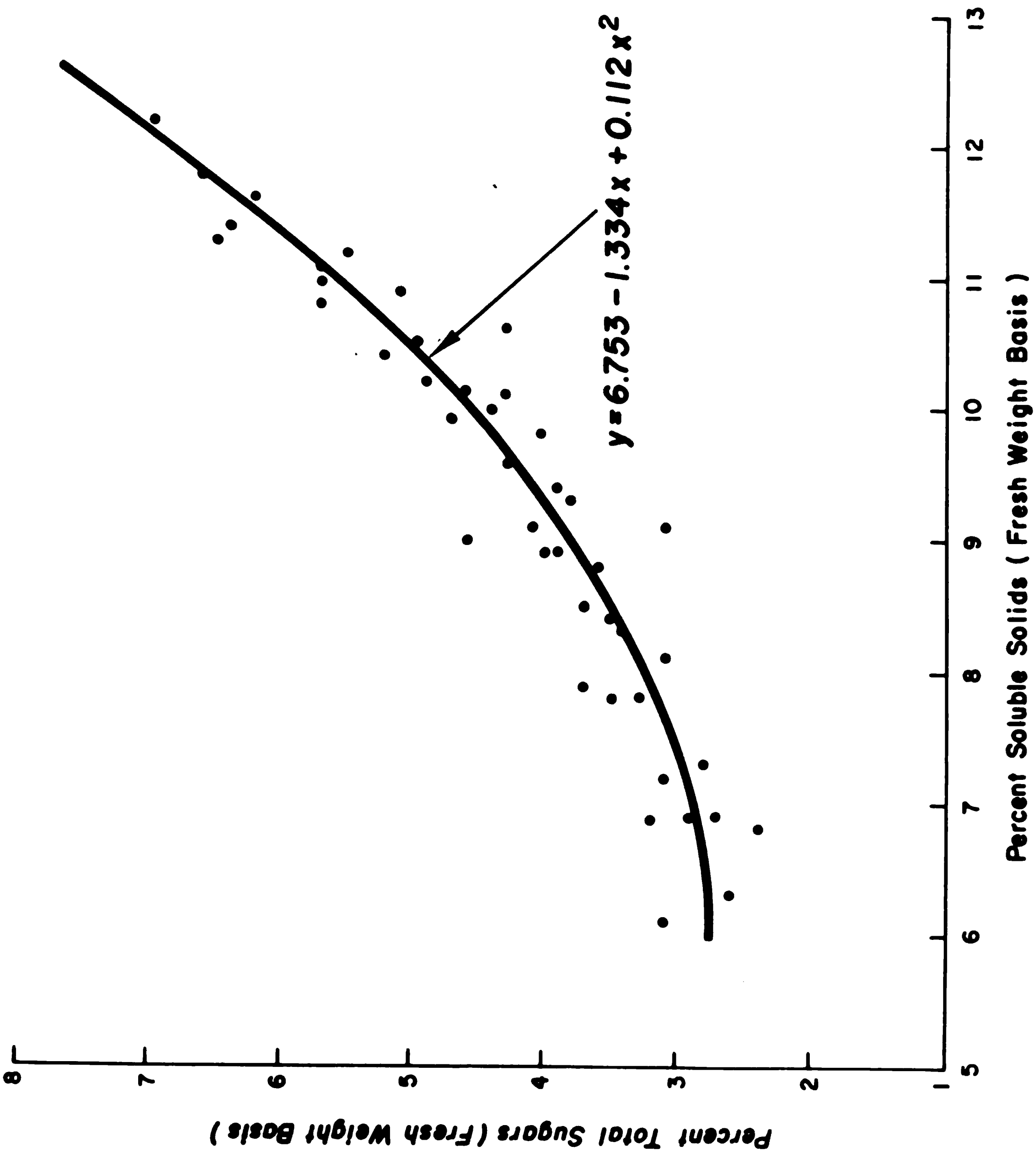

Mean Quality Rating
y=+0.308+.245x
Percent Soluble Solids
Mean Quality Rating
y=0.156+3.475x-1.047x²
x = Log. (Percent Total Sugars / Meq. Acid/100 Gms. Fresh Weight)
Mean Quality Rating
y=1.302+2.341x-0.760x²
Firmness as Puncture Pressure Resistance in Lbs./inch²

Figure 1

Figure 2

The relationship between total sugars expressed as percent sucrose and percent soluble solids.



y=6.753 − 1.334x + 0.112x²
Percent Total Sugars (Fresh Weight Basis)
Percent Soluble Solids (Fresh Weight Basis)
1
2
3
4
5
6
7
8
5
6
7
8
9
10
11
12
13

Figure 2

Figure 2

The relationship between total sugars expressed as percent sucrose and percent soluble solids.

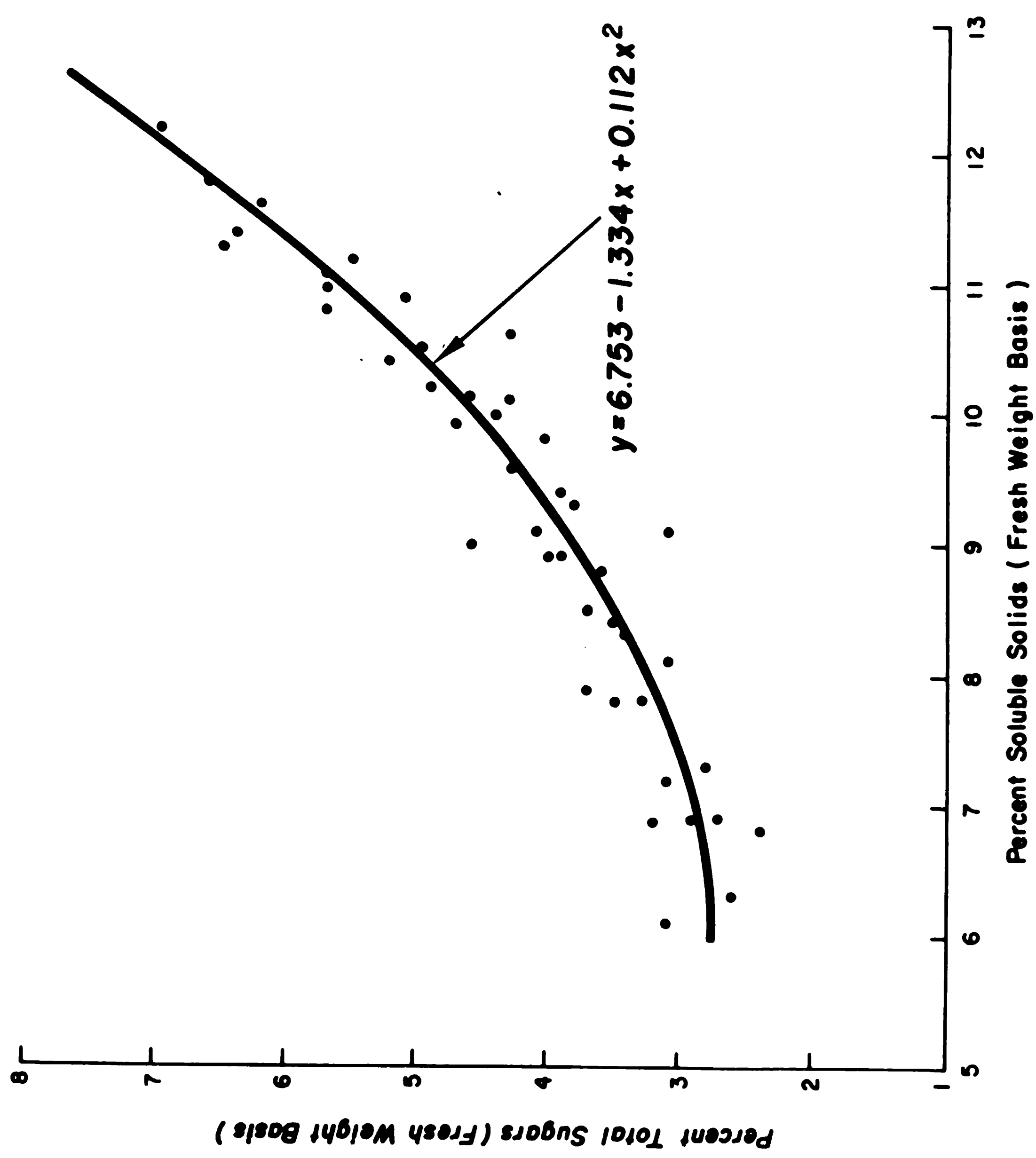

$y = 6.753 - 1.334x + 0.112x^2$
Percent Soluble Solids (Fresh Weight Basis)
Percent Total Sugars (Fresh Weight Basis)
5
6
7
8
9
10
11
12
13
1
2
3
4
5
6
7
8

Figure 2

Optimal acceptance by the panel was at the ratio value of 50 (Fig. 1). This relationship indicated that people have a definite preference for a balance of sugars and acids; however, they are tolerant of a reasonably wide range, but definitely dislike extremes. Judges gave comments on the fruit in the upper range, describing them as "flat" or "insipid", and in the lower part of the range as "sour" or "off flavour". This clearly demonstrates that it is not only the quantitative levels, but also the balance of sugars and acids that contribute to the taste appeal and therefore to fruit quality.

Firmness

The regression of quality acceptance on the firmness value of the fruit is curvilinear (Fig. 1). Optimal acceptance was 24 pounds per square inch. As with the sugar/acid ratio, the judges were tolerant of a certain range of values, but definitely disapproved of either extreme.

All three variables measured had an influence on quality. In each of the three factors there is appreciable deviation about the fitted regression. Much of this variability may be due to extreme variability in all three facets. A fruit may be optimal in one aspect and low in another, rendering the resultant compromise a poor description of either. Close scrutiny of the graphs reveals that the greatest deviation is in the range where each factor is associated with the highest quality, and therefore, is less likely to be limiting. For example, a fruit with good texture would be more likely to be downgraded or upgraded as a result of high or low soluble solids or sugar/acid ratio. This extreme variability may also explain the generally low quality acceptance found in this study.

Admittedly soluble solids, sugar/acid ratio, and firmness are not the only factors associated with quality in muskmelons. However, these three factors are important, and should not be overlooked in future studies.

FIELD FACTORS ASSOCIATED WITH QUALITY

Quality evaluation must include a study of the factors connected with growth and development of the plant which may influence fruit quality. Field studies were conducted for two years measuring the effect of variety and nutrition. During 1962 the study was expanded to include the effect of time of harvest.

Materials and Methods

Varieties, fertilizers, quality factors studied, and experimental designs are described under general methods. During the 1962 growing season added care was taken to ensure sampling for the entire harvest season. Sampling was not orthogonal for each variety and nutrient level as a result of harvest fluctuations.

Variety and time of harvest were related to quality through their effect on the condition of the plant. Leaf area as an index of the condition of plants was measured objectively once and thereafter estimated throughout the harvest season. The leaves from three one-square-foot sections in each plot were removed and taken to the laboratory where their areas were measured with a calibrated optical integrator. Correlations were found between number of leaves and leaf area for each variety and nutrient treatment. Further measures were made by counting the number of healthy leaves in three one-square-foot sections of each plot.

The first measure was made one week before the first harvest and subsequent measures were made at weekly intervals until the end of the harvest.

Results and Discussion

Nutrition and Variety

No quality response to nutrition was found in either year. Nor was there any influence of nutrition on leaf area.

Unlike nutrition variety showed an effect on quality (Table 2). Over both years varieties retained their relative positions. Varieties showed differences for yield. As the aim of the study was quality evaluation, no interpretation of yield was undertaken. Degree of netting, scored by visual rating, showed no difference among varieties as the variability within a group was considerable. The percent soluble solids, firmness, and size of the fruit was influenced by variety. Differences were found in both years.

Differences within quality factors were found between years. Percent soluble solids and size of fruit were lower in the 1962 season than in the previous one. Neither year was favorable for quality muskmelon production but, of the two, the latter season was the worse. Variable temperatures and droughty conditions were the rule during the latter part of both growing seasons. Severe infections of powdery mildew and spotty occurrences of fusarium wilt were present both years. During the 1962 growing season an

TABLE 2. -- The Influence of Variety of Michigan-Grown Muskmelons on Yield and Quality During Two Growing Seasons.[1]

Variety	Yield[2]		Percent Soluble Solids		Firmness		Fruit Size		Netting[3]	
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
Burpee Hybrid	13.1	10.6	12.0	9.6	33.4	34.6	2.69	2.50	3.0	-
Harvest Queen	9.2	8.4	11.4	10.0	32.8	31.2	2.79	2.51	3.5	-
Honey Rock	11.1	8.8	11.3	9.7	18.7	18.9	2.43	2.18	3.2	-
Harpers Hybrid	-	12.4	-	9.0	-	13.8	-	2.25	-	-
Hearts of Gold	-	8.0	-	10.3	-	35.0	-	2.19	-	-
Super Market	-	8.1	-	10.6	-	42.9	-	2.45	-	-
Spartan Rock	-	7.8	-	8.6	-	20.8	-	1.18	-	-

[1] Significant differences among varietal means in each season in all parameters excepting netting at odds of 19:1.

[2] Yield expressed as tons per acre.

[3] Netting as visually evaluated (0 = no netting, 5 = solid netting).

unidentified disease attacked the major muskmelon plantings in Michigan as well as the experimental plots. The general result was cessation of growth and hastened defoliation beginning at about the time of first harvest.

This factor may be responsible for the lower levels of soluble solids and smaller fruit during the second season. However, fruit firmness remained constant for any one variety over the two years. This suggests that fruit firmness was independent of climatic variance and controlled through genetic expression.

Variety, Time of Harvest and Condition of Plants

An attempt was made to associate two factors affecting quality; namely, variety and the time of harvest. Size, percent soluble solids and firmness of the fruit were studied for each variety as related to date of harvest.

To develop a dynamic estimate of the condition of the plants throughout harvest, the two weeks previous to the harvest of each lot was selected as the critical period as most sugar accumulation occurs during this time (16, 17). Thus, the average leaf area at the midpoint one week before a given harvest was used to estimate the condition of the plant.

Leaf area decreased in a linear fashion for each variety as the harvest advanced. Fitted regression values were calculated and used for leaf area estimations with respect to time. The condition of the plants was expressed in three ways. One was leaf area index calculated as the area index calculated as the area in square feet of healthy leaves per square foot of ground covered. The second was the ratio of leaf area one week before harvest to the number of fruits picked over the subsequent two-week period. The third was the ratio of leaf area to the weight of fruit picked over the following two weeks. The latter two included an estimate of the distribution of sugars as well as the synthesizing potential.

Both fruit size and soluble solids showed significant variation with respect to time of harvest. Fruit firmness was independent of time of harvest remaining constant for each variety and thus emphasizing its genetic control. Fruit size in all varieties showed a consistent decrease with the advancing season. The change in the level of soluble solids varied among varieties. Mid-season and late varieties tended toward a steady decrease, but early maturing varieties were characterized by an initial drop and then a rise in the level of soluble solids toward the end of the harvest season.

The simple correlations of soluble solids and fruit size on leaf area index, leaf/fruit number ratio, and leaf/fruit weight ratio were determined for all varieties and harvest dates. Soluble solids were correlated with all three estimates (Figs. 3 and 4). Fruit size was correlated with the leaf area index, but not correlated with the other two estimates of plant condition (Fig. 3).

All general correlations of soluble solids were highly significant. On the basis of these data it appears that soluble solids of the fruit is dependent on the leaf area of the plant shortly before harvest irrespective of variety. Much better agreement to the general relationship is obtained when the relative reproductivity of each variety is incorporated as a factor.

Within each variety the same relationship is not apparent to all three expressions of plant condition. Generally, soluble solids was related with leaf area index, but the same relationship did not hold within some varieties. As the leaf area consistently dropped as the harvest season progressed, the level of soluble solids assumed abberant patterns. When the leaf/fruit number ratio was used then there was correlation within each variety as the trend in soluble solids was partially compensated for by a fluctuating ratio. It was the poorness of association among varieties that lowered the degree of correlation. This was due to the difference in the size of the fruits among varieties. When soluble solids was compared to the leaf/fruit weight ratio, then a close fit was found within each variety and among all varieties.

Fruit size was correlated with the leaf area index. The correlation is apparently valid both within and among all varieties studied excepting the Spartan Rock variety. This variety, a small-fruited one, is of a type different from the other varieties tested. The slope of the fitted line for Spartan Rock is similar to that for all other varieties, indicating that it responds to the same influences. The correlation of fruit size with either one of the leaf/fruit ratios was not significant.

Fruit size was correlated with leaf area index, but not with either of the leaf/fruit ratios as soluble solids was correlated with all three. The data infer that soluble solids and fruit size are governed by different systems. The bulk of the sugar accumulates during the last two weeks and the leaf area index and leaf/fruit ratios used validly estimate the photosynthetic potential during this period. Conversely, size increase in fruit does not occur primarily during this period (15). As leaf area index is highly correlated with fruit size this parameter validly estimates fruit growth potential as well as sugar production.

Figure 3

The relationship within and between seven varieties of soluble solids and fruit size to the leaf area index as a factor of time of harvest.

General correlations:

soluble solids r = .65 (r reqd. = .30)

fruit size except Spartan Rock r = .91 (r reqd. = .31)

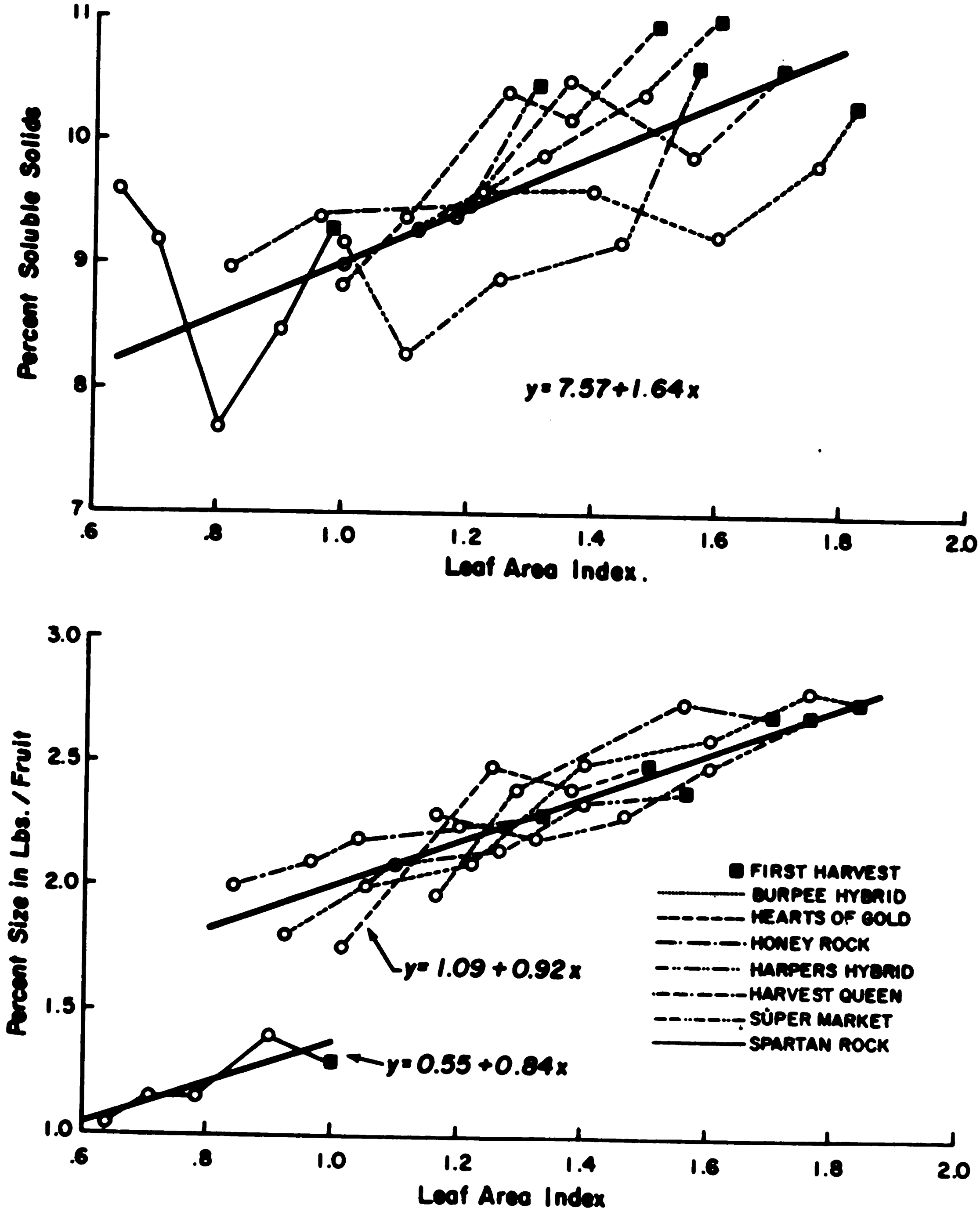

Percent Soluble Solids
11
10
9
8
7
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
y= 7.57+1.64x
Leaf Area Index.
Percent Size in Lbs./Fruit
3.0
2.5
2.0
1.5
1.0
y= 1.09 + 0.92x
y= 0.55 +0.84x
FIRST HARVEST
BURPEE HYBRID
HEARTS OF GOLD
HONEY ROCK
HARPERS HYBRID
HARVEST QUEEN
SUPER MARKET
SPARTAN ROCK
Leaf Area Index

Figure 3

Figure 4

The relationship within and between seven varieties of soluble solids to the leaf/fruit number ratio and the leaf/fruit weight ratio as a factor of time of harvest.

General correlations:

leaf/fruit number r = .74 (r reqd. = .30)

leaf/fruit weight r = .89 (r reqd. = .30)

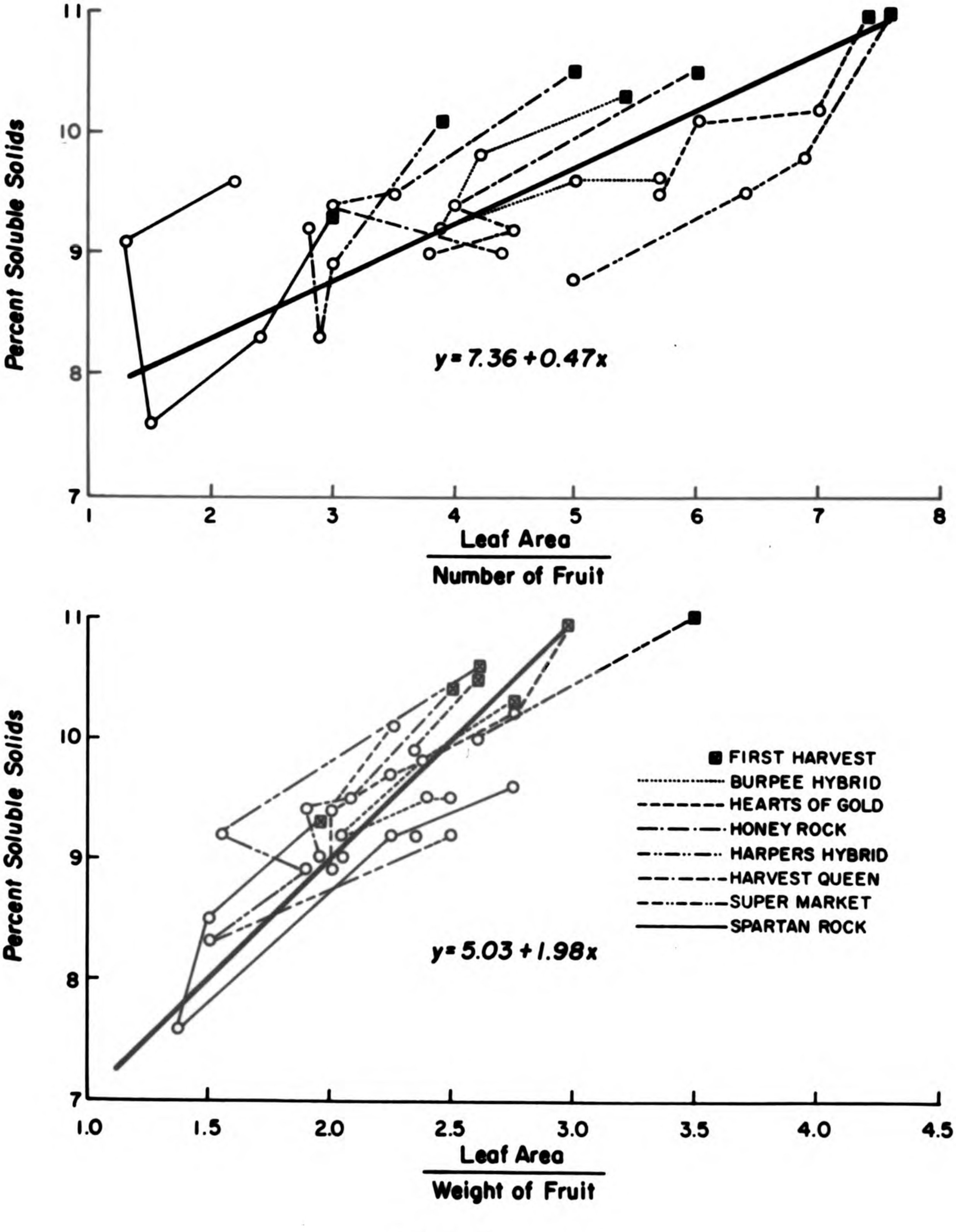

Percent Soluble Solids
y= 7.36 +0.47x
Leaf Area
Number of Fruit
Percent Soluble Solids
y= 5.03 + 1.98x
FIRST HARVEST
BURPEE HYBRID
HEARTS OF GOLD
HONEY ROCK
HARPERS HYBRID
HARVEST QUEEN
SUPER MARKET
SPARTAN ROCK
Leaf Area
Weight of Fruit

Figure 4

OBJECTIVE INDICES OF STORAGE AND KEEPING QUALITY

Studies previously undertaken in the storage of muskmelons have determined the range of acceptable storage temperature, approximate holding times and common storage diseases. However, recommendations regarding optimal and maximal storage times have been vague, contradictory, and subjective in nature. To develop a consistent, simple objective measure for storage time, a study was undertaken relating storage not to sidereal time but rather to degree days based on post-harvest heat unit accumulation.

Heat unit accumulation has been widely studied, in relation to growing crops, as an index of maturity. In many cases it has proven invalid due to progressive physiological development requiring ever changing base temperatures. The possibility also exists of a factor affecting growth other than temperature becoming limiting. These criticisms assume insignificant proportion in relation to post-harvest life.

Materials and Methods

Degree days were calculated as the mean daily temperature above the freezing point of the flesh (29° F) (34).

Storage temperatures used were: 32° F, 40° F and room temperature (70 to 75° F). Fruits stored at 32° F were left for from 9 to 15 days; and at 40° F for from 6 to 10 days, after which they were removed to room temperature. Parallel samples were kept at room temperature and observations were continued until the fruit became unmarketable. Samples of from two to three melons were taken daily at room temperature, every two days at 40° F, and every three days at 32° F, and analyzed for soluble solids and firmness.

Only the 1962 crop was used in the storage study. In all, seven varieties picked at two maturities were used. Burpee Hybrid, Harvest Queen, Hearts of Gold, Harpers Hybrid, Honey Rock, Spartan Rock and Super Market varieties were picked at full slip green and half slip stages of maturity.

Results and Discussion

Fruit Firmness

Fruit firmness was the most important factor contributing to keeping quality. To develop an objective index for fruit softening the regressions of firmness on cumulated degree days for each lot were determined. The results showed that fruit firmness decreased as a linear function of degree days.

The relationship between degree days and firmness was not affected by holding temperatures nor time of harvest. Variety and maturity did influence keeping quality as measured by firmness (Table 3). When the firmness was above the range of the instrument the value was derived by extrapolation of the fitted line.

Firmness at pick for full slip green and half slip maturities indicates

TABLE 3.--The Relationship of Variety, Maturity and Degree Days in Storage to Optimal Consumer Acceptance Based on Fruit Firmness.

Variety Maturity	Firmness at Pick	Degree Days to Optimal Firmness	95% Confidence Intervals
Burpee Hybrid			
Full slip	41.2	125.8	42.3 - 209.3
Half slip	61.9	233.3	167.2 - 299.4
Harpers Hybrid			
Full slip	30.3	46.5	0 - 122.7
Half slip	49.4	147.4	71.2 - 223.6
Harvest Queen			
Full slip	44.9	133.1	66.3 - 200.4
Half slip	62.4	230.1	159.4 - 300.8
Hearts of Gold			
Full slip	42.3	124.9	40.6 - 205.2
Half slip	60.3	225.6	94.7 - 356.5
Honey Rock			
Full slip	36.6	91.8	21.5 - 162.1
Half slip	55.6	195.8	102.5 - 288.1
Spartan Rock			
Full slip	36.7	102.2	53.3 - 151.7
Half slip	57.9	191.3	98.9 - 243.7
Super Market			
Full slip	59.8	176.7	75.3 - 278.1
Half slip	76.9	282.5	228.6 - 335.4

that varieties maintain relative firmness differences (Tables 2 and 3). Varieties may be grouped into four classes. Harpers Hybrid was the least firm, Honey Rock and Spartan Rock were second, followed by Burpee Hybrid, Harvest Queen, and Hearts of Gold. Super Market was the firmest. Within each variety half slip melons were consistently firmer than those of full slip green maturity.

A value in degree days to optimum keeping quality was derived from the regressions. The firmness value of 24 pounds/inch^2 was defined as optimal (Fig. 1). The 95 percent confidence bands were calculated on the degree day value corresponding to this firmness and might be used for predictive purposes (Table 3).

No difference in slopes due to variety or maturity was evidenced. This indicates that the rate of softening is not influenced by maturity at pick or by variety among the seven varieties measured. Softening is an enzymatic reaction which is present in all varieties, works independent of maturity past the half slip stage, but is dependent on temperature.

Since the rate of softening is constant the time in degree days to optimal firmness is correlated with the firmness at pick. In all cases melons at half slip maturity and also those of initially firmer varieties reached maximum quality later.

The range of degree days to optimal firmness is very broad. There is a great deal of overlapping between varieties and maturities. This is not to be taken, however, as an indication that the heat unit theory is not practical as here applied, but rather is a further indication of the inherent variability of muskmelon fruit. Acceptability studies showed no definite peak with firmness, but rather a range of equal acceptability (Fig. 2). Therefore, melons marketed according to this scheme would result in the bulk of the fruit lying within the acceptable range.

Soluble Solids

Coincident with firmness readings, measurements were made of soluble solids to determine their role in post-harvest quality of melons. Levels of soluble solids are shown as averages over 50 degree day intervals (Fig. 5).

The results show that soluble solids are not static after harvest. The trend is an initial rise in the soluble solids level followed by a short plateau which, in turn, is followed by a decline. This is in partial disagreement with the findings of others (3, 11, 20, 27) who reported the eventual decrease in soluble solids and sugars toward the termination of storage, but noted no initial increase.

The work of Rosa (24) who found that soluble pectins increased after picking by conversion from insoluble pectinaceous material may explain that rise. The contribution of soluble pectins to soluble solids could account for it. The ultimate decrease in soluble solids is explicable through the loss of sugars due to respiration.

The original plan was to note any disease growth and take it into account should it prove important. However, there was no appreciable invasion by pathogenic organisms except for extremely sporadic instances of fungus growth in the stem scar on unmarketable fruit. This freedom from disease may be related to the very intensive field spray program to control powdery mildew.

Figure 5

The relationship of soluble solids for seven varieties and the average of all varieties to storage time expressed as degree days.

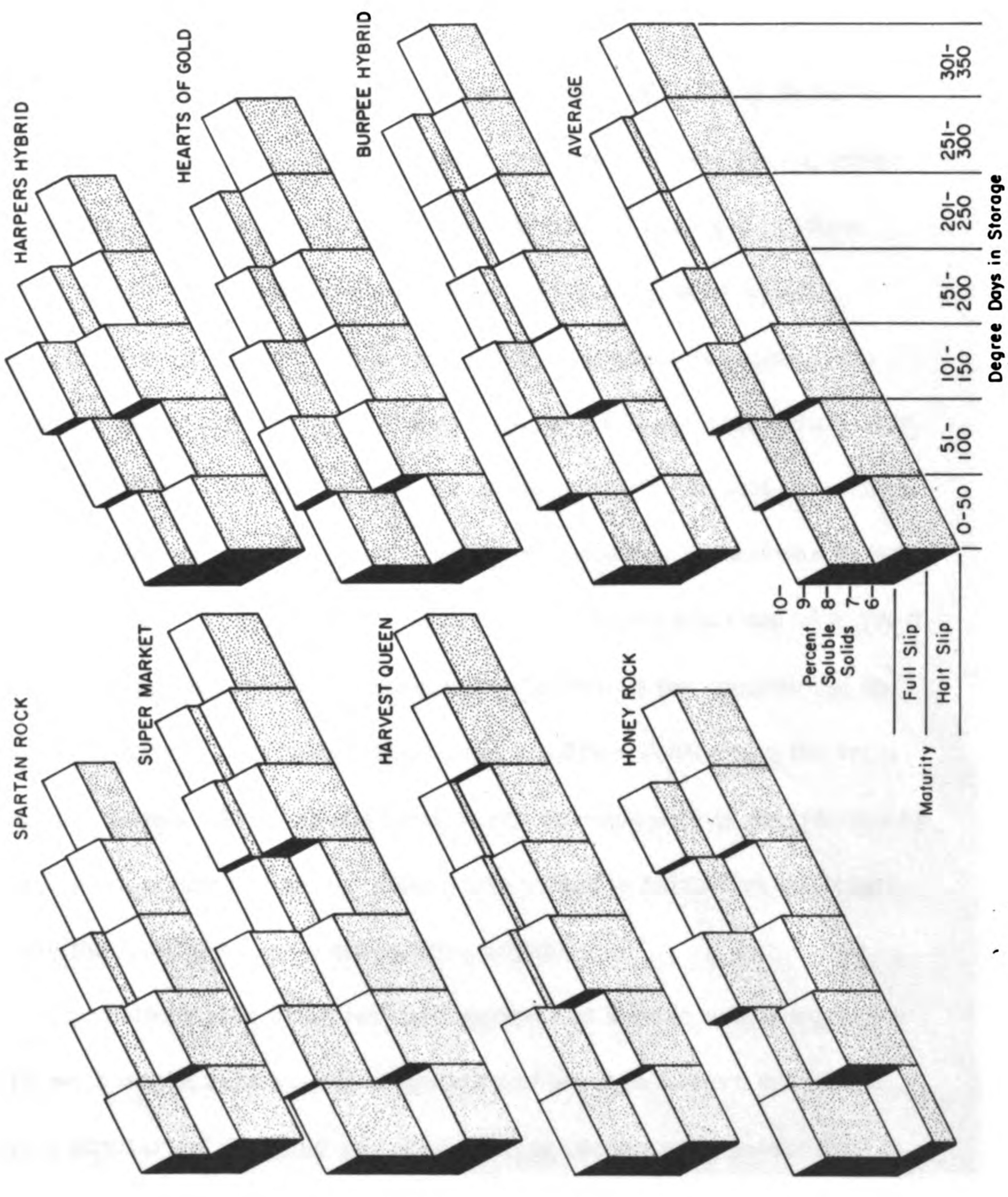

SPARTAN ROCK
SUPER MARKET
HARVEST QUEEN
HONEY ROCK
HARPERS HYBRID
HEARTS OF GOLD
BURPEE HYBRID
AVERAGE
10–
9–
8–
7–
6–
Percent
Soluble
Solids
Full Slip
Half Slip
Maturity
0–50
51–
100
101–
150
151–
200
201–
250
251–
300
301–
350
Degree Days in Storage

Figure 5

GENERAL DISCUSSION

To determine ultimate consumer acceptance by criteria definition and investigation of associated factors both in the field and during subsequent storage and handling was the objective of this series of studies. Several significant and interrelated aspects of quality were found.

The level of soluble solids, which was important in quality, was influenced by variety and harvest maturity but not mineral nutrition over the range studied. Soluble solids was correlated with the leaf area index, the leaf/fruit number ratio and the leaf/fruit weight ratio and was found to vary slightly during storage. The effect of variety and time of harvest could be adequately explained through their effect on the condition of the plant. Maturity at pick acts beyond plant condition in affecting the level of soluble solids. Although the level at any one maturity is determined by plant condition, the difference among maturities is related to the length of time the fruit has been accumulating sugars.

The relationship found between sugars and soluble solids warrants more work on the relationship of growth and storage factors to sugars. Since a similar relationship was found during two growing seasons a conversion factor could likely be implemented to convert all field data from soluble solids to sugars. This, however, may not be true in storage.

Slight early increases noted in soluble solids were likely not due to increased sugar, but rather to increased soluble pectins. If soluble pectins were still increasing toward the end of storage then the decrease in sugars would be greater than that in soluble solids.

In view of the very wide range of levels found and the importance of the sugar/acid ratio in taste appeal, it is recommended that further work be undertaken to study the effects of field and storage conditions on acids. Coupled with studies showing the trend of sugars in storage, factors affecting the sugar/acid ratio could be determined.

Size of fruit, found by other workers to be associated with quality, was related to variety and time of harvest through the leaf area index. The relationships showed that fruit size was related to palnt condition over a longer period of time than was soluble solids.

Fruit firmness was related to quality. Variety and maturity at pick were the primary influences found on firmness in the field. Time and temperature expressed in degree days was the controlling factor in storage. The linear relationshp to post-harvest heat accumulation indicates that softening is governed by an enzyme system similar in all varieties measured. Therefore, varietal firmness and holding differences may be due to genetic control of abscission layer formation at different physiological ages of the fruit.

Variety, or the genetic makeup of the plant affects quality in two ways. Genetic control directly influences firmness, and major fruit size differences and indirectly governs quality through an influence on the relative development of leaf area and fruit production. This, in turn, directly influences the level of soluble solids and within broad population groups influences the size of the fruit.

Nutritional status played no role in quality fruit production within the range investigated. Neither did it influence the condition of the plants or their relative reproductiveness. Perhaps the indigenous nutrient content of the soil was of sufficient magnitude to supply all the required elements or the added fertilizer was not made available or taken up by the plant.

Post-harvest quality is a distinct problem as the plant effect is negated and environment is constant. Trends were found in soluble solids over storage time. Firmness, related to time and temperature of storage, was the main physiological factor governing storage quality. The probable validity of heat unit summation as a storage index of other crops is inferred by the consistent results obtained with muskmelons.

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