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Evaluation of Density Separation for Defining Fruit Maturities and Maturation Rates of Once-over Harvested Muscadine Grapes[1]

M. R. Lanier and J. R. Morris[2]
University of Arkansas, Department of Horticultural Food Science, Fayetteville, AR 72701

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Abstract. **'Carlos' muscadine grapes (*Vitis rotundifolia* Michx.) were sorted into 5 density grades using 4 brine solutions of 8, 9, 10 and 11% NaCl. Soluble solids and berry weight increased, color improved, and acidity decreased with grape maturity and brine concentration. Panelist's sensory preference increased with increasing density (maturity). Berries that floated and sank in 11% NaCl (density grades 4 and 5) had acceptable ratings for flavor, aroma, and color. Density separation was used to monitor the rates of maturation of the cultivars 'Carlos' and 'Noble'. The technique was useful in characterizing the changes in berry population during the last month of ripening.**

Muscadines have traditionally been hand harvested, but large commercial operations require a once-over mechanical harvest. A major problem with once-over mechanical harvesting is that muscadines ripen unevenly. This problem can be reduced to some extent by selecting cultivars that are more suited to mechanical harvesting (2). However, cultivar selection alone will not always solve the problem of uneven ripening and it may become necessary to sort out the immature fruit prior to processing. Low frequency vibrations (5) and color (14) have been studied as a means of sorting muscadines for fruit ripeness.

Berries of *V. vinifera* have been shown to increase in density with maturation (4, 16, 17, 18), but little attention has been given to these changes in muscadine grapes (1, 6, 15). As a result of the formation of a dry stem scar on many muscadine cultivars, solute leakage during density sorting would be minimized which would make this species more readily adaptable to a commercial density sorting operation. Preliminary investigations indicated that muscadines could be sorted according to density. Therefore, a study was designed to determine the effectiveness of utilizing brine solutions for sorting muscadine grapes for maturity, and to investigate density sorting as a method of monitoring maturation rates of muscadine grapes.

Materials and Methods

Density separation study. The study was conducted during 1976 and 1977 using fruit from a 'Carlos' (bronze fruit) vineyard established in 1972 in Forrest City, Arkansas. Vines were trained to a modified Geneva Double Curtain system in which 46 cm separated the horizontal wires and 4 cordons extended 3 m in opposite directions along each of the 2 wires. Distance between vines in a row was 6 m and there were 3.5 m between rows. Vines were harvested by hand shaking until all fruit were removed. This once-over harvest was about 1 week prior to commercial machine harvest to allow for a large range of fruit maturities. Three replications of about 10 kg were collected and allowed to reach 25°C overnight in the laboratory. Solutions of 8, 9, 10, and 11% NaCl in water were allowed to equilibrate overnight at 25°. NaCl concentration was determined by salometer.

The separation procedure yielded 5 density grades. Fruit was poured into the 8% brine and the fruit that floated was removed, rinsed twice with fresh water and air dried. This fruit was designated density grade 1. This procedure was repeated for 9, 10, and 11% brine and the fruit that failed to float in the 11% was designated density grade 5. All 5 density grades were weighed and a composite sample was made on a % weight basis. Samples were placed in nonvented polyethylene bags and frozen until analyzed.

In 1977, an additional set of samples was made into juice and subjected to sensory evaluation. A sample of 2.5 kg of grapes was crushed, heated to 75°C, allowed to cool to 60°, and Pectinol CG added to achieve a concentration of 100 ppm. After 4 hr the pulp was removed by pressing through nylon cloth. The juice was placed in 120 ml bottles and pasteurized at 85° for 30 min and stored for 1 week at 0°. Sensory attributes of flavor, aroma, and color were scored 1-10 by 4 trained taste panelists with 10 being excellent, 5 acceptable and scores below 5 being unacceptable.

Maturity study. In 1976 and 1977, grapes for the maturity study were harvested from the same 'Carlos' vineyard used in the previous experiment and from a 'Noble' (black fruit) vineyard which was established in 1973. All fruit from 1 cordon from each of 4 representative vines were once-over harvested on 5 sampling dates, beginning 3 weeks prior to the estimated time of commercial harvest. Commercial harvest for both years was 1 week prior to the last sampling date.

Berries were separated by the method previously described with the exception that brine solutions of only 9 and 10% were used which resulted in 3 density grades: berries that floated in 9%, those that floated in 10%, and those that sank in 10% brine solution.

Fruit weight was determined and a composite sample was prepared on a % weight basis to reflect the average maturity of fruit harvested from each vine. Samples were bagged in nonvented polyethylene bags, frozen, and stored until analyzed.

Quality analysis. Samples were thawed overnight at 2°C and berry weight was determined. Samples were then blended for about 20 sec, poured into 250 ml beakers, warmed to 20° and % soluble solids determined by refractometer.

Samples were covered with watchglasses, and cooked at 85°C in a water bath for 1 hr. Samples were cooled 30 min and strained through 2 layers of 12 × 30 mesh cheesecloth. Color values of "a" and "b" were determined for the juice samples of 'Carlos' using a Gardner Color Difference Meter (model XL10) and reported, as discussed by Little (6), as the $\tan^{-1}$ of the hue angle b/a. The standard plate had values of "L"=23.1, "a"=22.0, and "b"=7.1. Five ml of the juice from 'Noble' were diluted to 100 ml with distilled water, centrifuged and absorbance at

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[2]Graduate Assistant and Professor, respectively.

520 nm determined. Titratable acidity was determined by titrating 5 ml of juice diluted to 125 ml with distilled water to pH 7 with 0.1N NaOH.

Results and Discussion

Density separation study. As density of 'Carlos' berries increased, there was a corresponding increase in % soluble solids and a decrease in titratable acidity (Table 1). For both years, % soluble solids of the composite samples fell between density grades 3 and 4 with an approximate value of 13.0%. Titratable acidity (Table 1) declined as fruit density increased for both years. However, titratable acidity values were lower in 1977 and appeared to level off after density grade 3. Elevated temperatures during ripening result in a reduction in the acidity of grapes (10). Grapes harvested in 1977 had accumulated 1,769 degree-days (°C) from peak bloom to harvest as opposed to 1,561 for the previous year (Fig. 1). High temperatures during the 1977 growing season could have resulted in a rapid decline of acidity early in the season. Increasing fruit maturity with increasing density was also indicated by the disappearance of green color of the expressed juice as evidenced by a decrease in the $\tan^{-1}$ b/a (Table 1). As the density of the berries increased, berry weight increased to a maximum in density grade 4 and then decreased in density grade 5 (Table 1). Visual observation of density grades 4 and 5 indicated that density grade 5 berries were over-ripe to the point that they were starting to dehydrate and shrivel while the berries in density grade 4 were still turgid.

All 3 sensory attributes increased in acceptance with each increase in density grade (Table 2). However, it was not until density grade 4 that a juice was acceptable in all quality attributes.

In summary, results indicated that muscadine berries within a cultivar may be effectively sorted based upon their density since the immature fruit could be removed by flotation in brine solutions. Commercial sorting of muscadines could probably be best accomplished by a single brine system such as that of the mass flow density sorter (8). The spherical shape of the muscadine berry, absence of stems, and the relatively small size variation characterize it as an ideal fruit for mass density sorting.

Maturity study. Fig. 2 shows the percentages of fruit of the 'Carlos' and 'Noble' cultivar separated into the 3 density grades on each harvest date during the 1976 and 1977 season. As each season progressed there was a reduction in the amount of fruit floating in the 9% brine and an increase in the amount of fruit sinking in 10%. By the last 2 harvest dates of 'Carlos' and the last 4 of 'Noble', the majority of the fruit had advanced into the most dense category. Distribution of the density categories indicated that 'Noble' ripened about 2 weeks earlier than 'Carlos'.

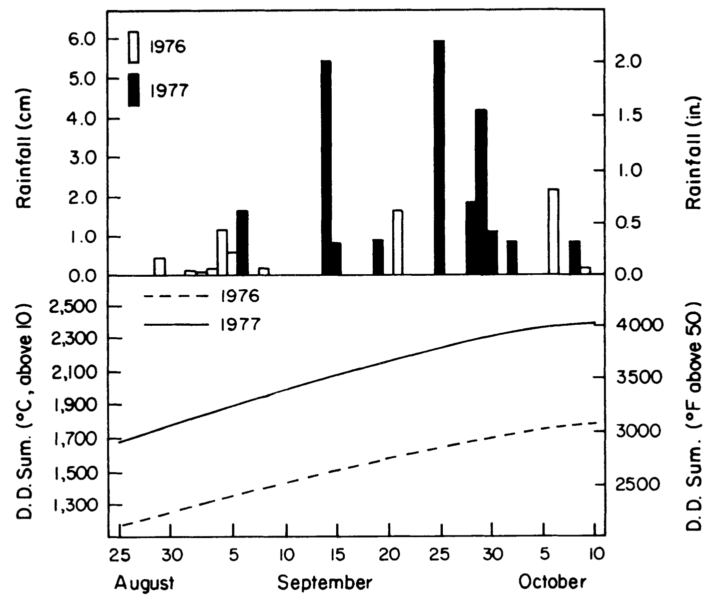

Fig. 1. Degree-day summation from peak bloom (June 12, 1976 and May 23, 1977) and rainfall accumulation during the seasons of 1976 and 1977.

As the sampling period progressed, % soluble solids and color improved while titratable acidity decreased for both cultivars (Fig. 3 and 4). These trends have been well documented for other species of *Vitis* (3, 7, 9, 10, 11, 13, 16, 17, 18). Research by Murphy et al. (15), Armstrong et al. (1), and Johnson and Carroll (6) on other muscadine cultivars indicated similar results. Soluble solids for 'Carolos' in 1977 showed an unexpected decline on the September 15 sampling date. Also, soluble solids for 'Noble' during this period did not increase as expected. Immediately prior to the September 15 harvest there was about 6 cm of rain (Fig. 1). The behavior of soluble solids during this harvest period may have been due to a dilution effect brought about by the rainfall.

For both years 'Noble' reached a higher level of soluble solids than 'Carlos' by the final sampling date (Fig. 3 and 4). This difference in maturation potential may be due to the fact that 'Carlos' forms a dry stem scar and translocation into the berry is probably stopped at a certain point. 'Noble' does not form as distinct a scar and translocation into the berry might continue beyond that of 'Carlos'. Loss of ripe 'Carlos' fruit

Table 1. Quality factors of 'Carlos' muscadine grapes for the 5 density grades and composite samples for 1976 and 1977.

Density[z] grade	Soluble solids (%)		Titratable acidity (ml)[x]		$\tan^{-1}$ b/a (rad)		Berry weight (g)		% of total yield	
	1976	1977	1976	1977	1976	1977	1976	1977	1976	1977
1	6.9	8.0	15.0	12.5	1.49	1.56	2.50	2.69	2.3	2.9
2	9.9	10.1	11.0	9.4	1.42	1.37	3.47	3.58	5.1	5.0
3	11.6	12.0	8.9	6.4	1.41	1.36	4.17	4.41	41.4	55.6
4	13.6	12.9	7.5	6.4	1.34	1.28	4.79	4.67	31.6	31.5
5	16.3	15.0	6.4	6.1	1.30	1.14	4.41	4.18	19.6	5.0
Composite	12.9	12.7	8.5	6.5	1.32	1.37	4.50	4.45	--[y]	--
LSD 5%	0.5	0.3	0.5	0.6	0.06	0.06	0.34	0.22	--	--

[z]1, 2, 3, 4, float in 8, 9, 10, and 11% brine, respectively; 5, sink in 11% brine.

[y]Data do not apply.

[x]ml 0.1 N NaOH to neutralize 5 ml juice.

Table 2. Sensory evaluations of 'Carlos' muscadine juice made from the 5 density grades and composite samples for 1977.

Density grade	Sensory score[z]		
	Flavor	Aroma	Color
1	1.0	1.9	1.7
2	2.1	2.8	3.2
3	4.3	5.1	5.7
4	6.2	6.7	7.0
5	7.8	9.0	8.7
Composite	4.7	6.4	6.1
LSD 5%	0.6	0.9	0.7

[z]10 = Excellent, 5 = Acceptable.

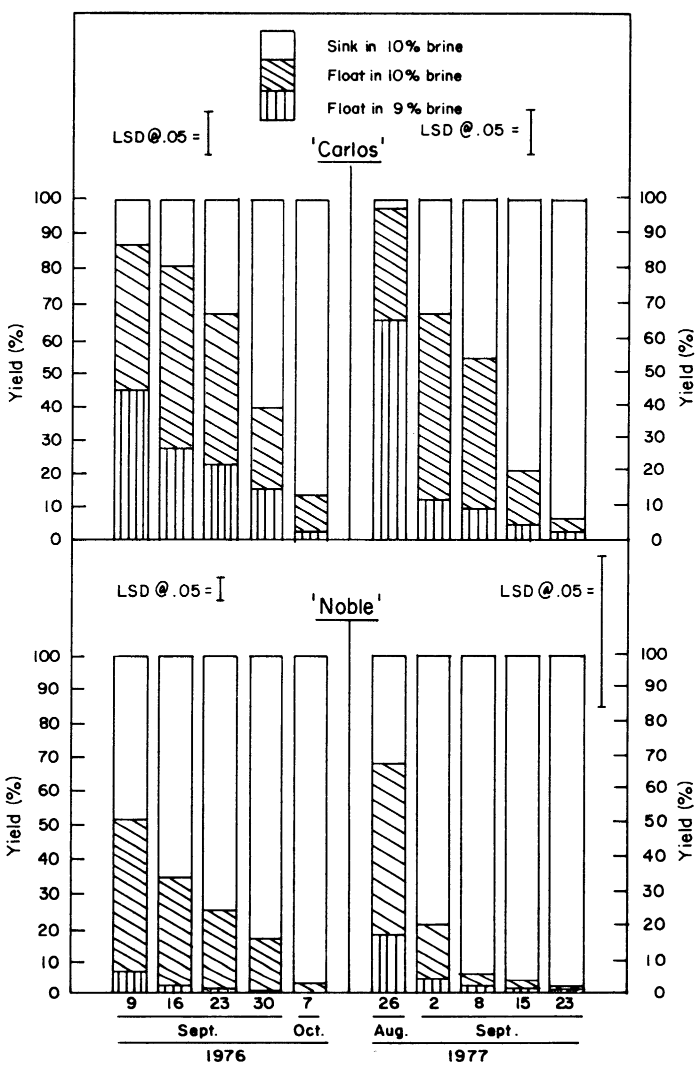

Fig. 2. Percentage of each density class for 'Carlos' and 'Noble' during the sampling periods of 1976 and 1977.

to berry abscission prevents the delaying of harvest until higher soluble solids are reached. However, once-over harvest can be delayed on 'Noble' until the majority of the berries have reached an acceptable soluble solids level.

The growing season of 1977 was much warmer than that of 1976 (Fig. 1). Because of the unusually warm weather, ripening during 1977, as evidenced by % soluble solids, was about 2 weeks earlier than the previous year (Fig. 3 and 4). Titratable acidity for both cultivars was lower in 1977, probably due to the effect of high temperatures on acid metabolism.

Average berry weight did not change drastically over the sampling periods for the 2 years (Fig. 3 and 4). This was expected since sampling was begun only 4 weeks prior to commercial harvest and berry growth was almost completed. Johnson and Carroll (6) reported that berry growth of 'Scuppernong' fruit occurred principally during July and August and leveled off during the final 5 weeks of sampling which roughtly coincides with our sampling period. Berry size was slightly larger in 1977 than in 1976 (Fig. 3 and 4). This difference may have been due to the greater rainfall during the 1977 growing season (Fig. 1).

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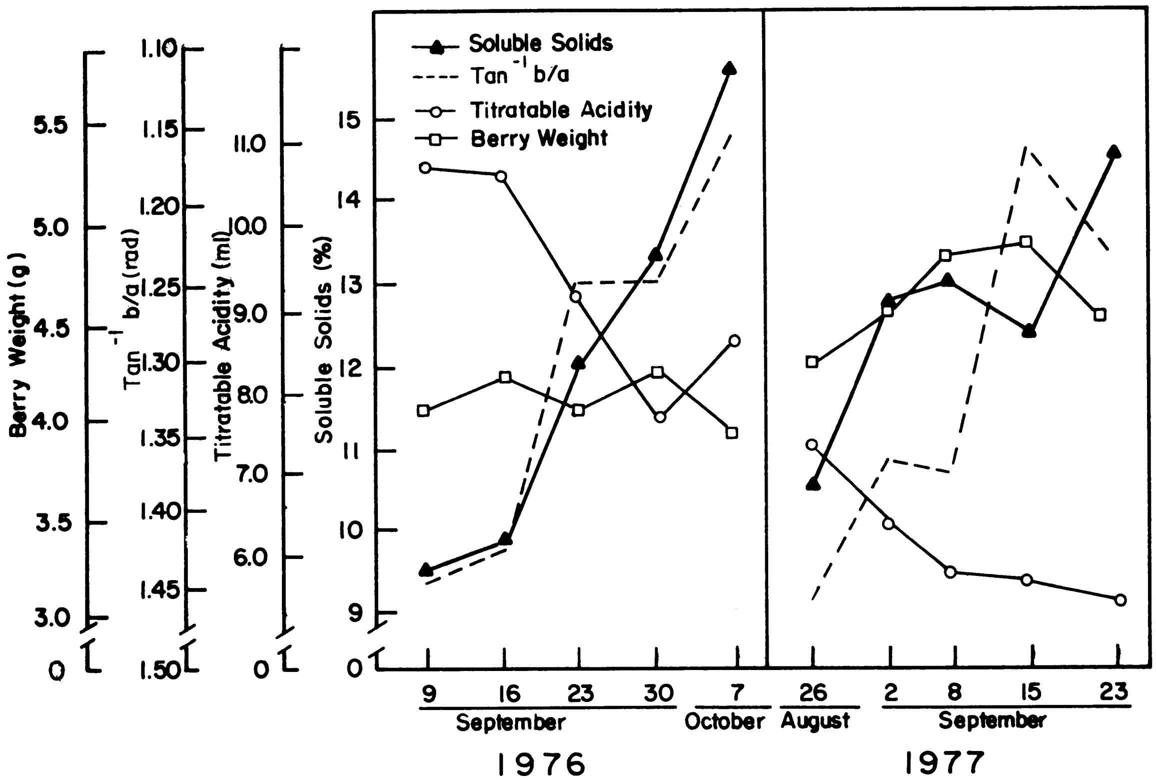

Fig. 3. Changes in % soluble solids, titratable acidity, color (expressed as tan^{-1} b/a) and berry weight for 'Carlos' composite samples during the 1976 and 1977 sampling periods.

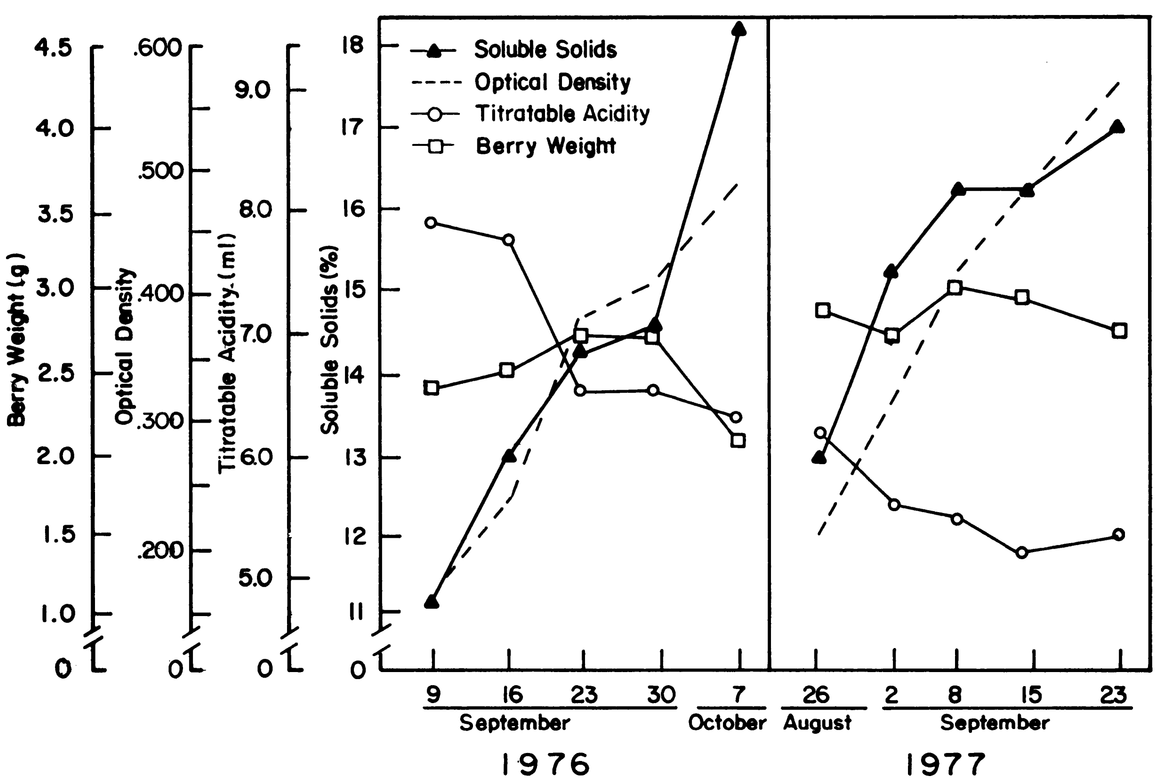

Fig. 4. Changes in % soluble solids, titratable acidity, color (expressed as optical density) and berry weight for 'Noble' composite samples during the 1976 and 1977 sampling periods.