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Effects of Fruit Maturity and Processing Method on the Quality of Juices from French-American Hybrid Wine Grape Cultivars

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This study was conducted to examine the effects of grape maturity and processing method on the quality of juices from four French-American hybrid wine grape cultivars (Seyval, Vidal, Aurore, and Chancellor). The flavor of juices from more mature grapes (soluble solids:acidity ratio of 20 - 30, pH 3.45 - 3.60) was rated higher than the flavor of less mature grapes (soluble solids:acidity ratio of 13 - 19, pH 3.25 - 3.40) initially and after five months storage at 37°C, but maturity had no significant effect on the color of the juices. Heating grapes to 60°C before pressing or leaving juice and skins in contact for 24 hours before pressing rather than pressing immediately produced juices with higher pH and superior color initially. The processing method had little effect on the flavor ratings of the white cultivars initially, but the Chancellor juices with 24 hours of skin contact had higher flavor ratings than the Chancellor juices that were pressed immediately. Heat extraction was detrimental to the flavor and color of juices from the three white cultivars after storage, but it improved color and flavor stability of the red cultivar, Chancellor.

Most grape juice available in retail markets today is produced from Concord and Niagara grapes. However, there has been interest recently in grape juices produced from traditional wine grape cultivars. Research has shown that acceptable juices can be produced from several of these cultivars (7,15) and from muscadine cultivars (2,3,4,23,24). According to Pederson (15), very few *Vitis* v*inifera* cultivars produce a desirable juice without blending due to a lack of a strong characteristic flavor, high sugar, and low acid. However, more recent research (7) indicates that some V. *vinifera* and French-American hybrid cultivars produce acceptable juices. Since production of French-American hybrid cultivars represents a significant portion of the wine grape production in the eastern US, there could be potential for juices from these cultivars.

There has been considerable research on factors affecting the quality of Concord and muscadine grape juices (2,4,6,10,11,17,20,21,22,23,27), but very little information is available on factors influencing juice from other cultivars (7,15). Grape maturity (10) and juice extraction temperature (2,4,6,10,20,23) are among the most important factors influencing the quality of Concord and muscadine grape juices. More mature Concord grapes produced a superior juice compared to less mature grapes (10). Higher extraction temperatures generally produce Concord and muscadine juices with more initial color (2,3,4,10,20,23), but muscadine juices extracted at higher temperatures often have poorer flavor (2,4,23). Extraction of juice from traditional wine grape cultivars without the use of heat also seems to produce juices with better flavor (7).

The mild flavors of many French-American hybrid cultivars may also be sensitive to high extraction temperatures. The extraction of adequate varietal character from the grapes must be balanced against destruction of these flavors. In addition, many wineries do not have the equipment necessary to heat extract or pasteurize juice. Thus, the purpose of this study was to examine the effects of grape maturity and processing methods utilizing little or no heat on the quality of juices from four commercially important French-American hybrid grape cultivars.

Materials and Methods

Grape juices were produced from four French-American hybrid cultivars (Seyval, Vidal, Aurore, and Chancellor) harvested at two maturities (pH 3.1 - 3.2 or pH 3.4 3.5) utilizing three processing methods (immediate press, 24-hr skin contact, or heat extraction). Seyval, Vidal, and Aurore are all white grapes; Chancellor is a red grape. All grapes were grown at the University of Arkansas experiment station in Fayetteville in 1985. Grapes from the two maturities of each cultivar were harvested 11 to 13 days apart. Treatments were arranged as a factorial in a randomized complete block (2 blocks) within each cultivar.

Approximately 14.5 kg of grapes per block from each maturity were crushed and destemmed within four hours after harvest, and 100 mg/kg sulfur dioxide (as potassium metabisulfite) was added immediately. The immediate press juices were obtained by adding 13 AL Pectinol 60G pectic enzymes (Genencor, Inc.) per kg crushed grapes, holding for one hour at ambient temperature (ca 25°C), and pressing in a hydraulic basket press. The 24-hour skin contact juices were obtained by adding the same amount of enzyme to the crushed grapes and pressing after a 24-hour holding period at approximately 25°C. Heat extraction juices were prepared by rapidly heating crushed grapes to 60°C in a stainless steel steam kettle, cooling to 45°C in a 0°C cold room, and adding the same amount of enzyme. The grapes were held at 40° to 45°C for three to four hours and then pressed. All juices were placed in 3.8-L glass jugs, sealed, and placed at 0°C for 24 hours to settle.

The juices were carefully racked after settling into 3.8L glass jugs, sealed, and put in a freezer at -23°C for cold stabilization. The juices were removed from the freezers when they became slushy and placed at 0°C for one week. The juices were subsequently racked, 25 g diatomaceous earth (grade 577) was added per 3.8 L juice, and the juices were filtered

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through a 2-Am "Pre-Kote" 10-inch cartridge filter (Membrana). The hot press juices were extremely difficult to filter in this manner due to the high level of suspended solids in these juices. The juices were then filtered though a 0.8-Am, 10-inch cartridge filter and a 0.45-A.m, 10-inch membrane cartridge filter. The filtered juices were collected in 3.8-L glass jugs, and 500 mg/L benzoic acid (as sodium benzoate) and 100 mg/L sorbic acid (as potassium sorbate) were added to the juices to prevent fermentation.

Each treatment yielded approximately 3.8 L of finished juice, which was bottled into 750-mL wine bottles and a 1.9-L glass jug. The wine bottles were corked and used for initial sensory and laboratory analysis, and the 1.9-L jugs were sealed with screw-on closures and placed in storage at 37°C for post-storage evaluation.

For sensory evaluation, 30 panelists (faculty and students of the Department of Food Science, University of Arkansas, Fayetteville) rated the juices within 10 days after bottling. All of the panelists had evaluated grape juice or wine previously. Juices from each cultivar were evaluated separately; thus, all six juices (2 maturities x 3 processing methods) of each cultivar were evaluated at one session. Each sample was assigned a random number, and 25 mL of juice was presented to panelists in random order in wine glasses. All juices were served at room temperature (ca 22°C) against a white background. Panelists were instructed to rate the flavor and color of samples from 1 to 9, with 1 = very poor, 5 = acceptable, and 9 = excellent. Panelists were requested to give the reasons for differences in ratings. This sensory evaluation was repeated in the same manner after five months storage at 37°C, but only 25 of the original panelists were available to rate the juices.

One-half of the panelists were given juices from one replicate, and the other one-half were given juices from the second replicate. Panelists were used as blocks or replications in the analysis of variance. The sensory data from each cultivar were subjected to factorial analysis of variance, with data from the two storages analyzed separately. Least significant difference (LSD) was used to separate means of the main effects within cultivar and storage.

For laboratory analysis, percent soluble solids was determined using a Reichert Abbe Mark II refractometer. The pH was determined with a combination electrode. Titratable acidity was determined by diluting 5 mL of juice to 125 mL with deionized water and titrating to pH 8.2 with 0.1 N NaOH. Titratable acidity is expressed as percent tartaric acid. The tristimulus color of the juices was determined with a Gardner color difference meter that had been standardized to a dark red plate (L = 23.1, a = 22.0, b = 7.1) for Chancellor and a white plate (L = 85.4, a = 83.2, b = 99.4) for the white cultivars. Only the a values (redness) are reported for Chancellor, and only the b values (yellowness, brownness) are reported for the white cultivars since these values best illustrate the color differences between the juices. The data were analyzed in the same manner as for the sensory data, except that there were only two blocks.

Results and Discussion

Due to the experimental design, each cultivar will be discussed separately, and no direct comparison of cultivars or storage dates will be made. The main effects of maturity and processing method explained nearly all of the variation. The interaction between these two factors was not significant for most variables, but the few significant interactions will be mentioned in the discussion.

Vidal: The levels of sorbate and benzoate added to the juices were considered adequate since none of the juices fermented during the rather harsh storage period. Lower levels of one or both preservatives may have also produced stable juices. Although most panelists did not seem to notice any undesirable flavors imparted by the preservatives, a few people were able to detect "foreign" flavors, presumably from the preservatives.

Juices from more mature Vidal grapes had higher soluble solids, higher pH, higher soluble solids:acidity ratios, and lower titratable acidity than juices from less mature grapes initially and after storage (Table 1). The sensory panel rated the flavor of juices from more mature grapes higher than the flavor of juices from less mature grapes initially and after storage, although no significant color differences (sensory or CDM b values) could be detected between juices from the two maturities.

A better sugar:acid balance (a higher soluble solids: acidity ratio) in juices from more mature grapes was the main reason for the higher rating according to written comments from the panel. Juices from less mature grapes were too acidic, and thus, the flavor of these juices was rated unacceptable initially and after storage. The flavor ratings in all of the evaluations were greatly influenced by the sugar:acid balance. In general, the optimum soluble solids:acidity ratio of these mild-flavored juices seems to be between 20 and 30, which agrees with research on the strong-flavored muscadine juice (3,24). Previous research (3) has shown that a soluble solids:acidity ratio of 25 to 35 is optimum for muscadine grape juice, and Sistrunk and Morris (24) reported that a soluble solids:acidity ratio of 25 to 30 resulted in grape juice blends with highly acceptable sugar:acid balance.

The 24-hour skin contact and heat extraction juices had higher pH values than the immediate press juices, but the processing method had no significant effect on soluble solids, titratable acidity, or soluble solids:acidity ratios initially or after storage (Table 1). Morris et al. (10) has reported that Concord grape juice extracted at 85° or 99°C had higher pH than juice extracted at 60°C. Other researchers have shown that skin contact generally increases the pH of wines (13,14,25).

There were no significant differences in flavor ratings between juices from any of the treatments initially, but heating the grapes to 60°C was very detrimental to the juice flavor after storage as shown by unacceptable flavor ratings. Thus, the skin contact treatment and heat treatment did not extract any desirable juice flavors from the skin, while heating created off-flavors. This is in agreement with other researchers (4,5,6,23), who have reported that heat extraction of muscadine grapes produced juice with poorer flavor than no-heat

Table 1. Effects of grape maturity and processing method on the quality of Vidal grape juice initially and after five months at 37°C.

Treatment	Soluble solids (%)	pH	Titratable acidity (as % tartaric)	SS:Acidity	Flavor accept. rating[y]	CDM b	Color accept. rating[y]
			Initial				
Maturity							
Less mature	13.5b[z]	3.25b	1.00a	13.5b	4.7b	-1.7a	6.2a
More mature	16.0a	3.47a	0.68b	23.7a	6.8a	-1.6a	6.3a
Processing method							
Imm. press	14.9a	3.22b	0.85a	18.7a	5.9a	-2.1 b	5.4b
24-hr skin	14.6a	3.42a	0.82a	18.8a	5.9a	-1.6ab	6.7a
Heat extraction	14.8a	3.44a	0.85a	18.3a	5.5a	-1.2a	6.6a
			5 months at 37°C				
Maturity							
Less mature	13.6b	3.20b	1.00a	13.7b	4.5b	1.3a	5.7a
More mature	16.1 a	3.42a	0.72b	22.4a	6.0a	1.7a	6.1 a
Processing method							
Imm. press	15.ia	3.17b	0.87a	18.2a	6.2a	0.1c	7.3a
24-hr skin	14.6a	3.37a	0.83a	18.3a	5.6a	1.4b	5.8b
Heat extraction	14.9a	3.38a	0.87a	17.6a	4.0b	2.9a	4.5c

[y] Rated on a scale of 1-9; 1 = very poor, 5 = acceptable, 9 = excellent.

[z] All means within each treatment and each storage time followed by the same letter are not significantly different at the 5% level (LSD).

Extraction. Recent research indicated that a 24-hour pomace treatment of Chardonnay did not increase the fruity aroma of the wine, although differences in wine flavor were detected between the 24-hour pomace wine and the control wine (25). Other research has shown that pomace contact can increase the fruity aroma of Chardonnay (1).

The immediate press juices had poorer sensory color than the other treatment juices initially (Table 1). Comments from the panel indicated that the intense yellow color of the 24-hour skin contact or heat extraction juices was more acceptable than the less intense color of the immediate press juice. The CDM b values also indicate that the immediate press juices were less yellow (lower b values) than the heat extraction juices. However, the immediate press juices had superior sensory color compared to the other treatment juices after storage because of less browning. The higher CDM b values in the 24hour skin contact and heat extraction juices also reflect this browning. The heat extraction juices had unacceptable color ratings after storage due to this browning. The heat treatment and 24-hour skin contact treatment probably accelerated browning by extracting readily oxidizable phenolics from the skins. Previous research has shown that skin contact generally increases phenolic extraction into wines (16,18,19) and that increased temperatures during pomace contact of Chardonnay results in increased extraction of phenolics into the wine, especially the flavonoid phenols (16). The heat treatment of these juices may have also resulted in some caramelization of the sugars and/or browning via the Maillard reaction.

Seyval: Juices from the more mature Seyval grapes also had higher soluble solids, higher pH, higher soluble solids:acidity ratios, and lower titratable acidity than the

Table 2. Effects of grape maturity and processing method on the quality of Seyval grape juice initially and after five months at 37°C.

Treatment	Soluble solids (%)	pH	Titratable acidity (as % tartaric)	SS:Acidity	Flavor accept. rating[y]	CDM b	Color accept. rating[y]
			Initial				
Maturity							
Less mature	16.3b[z]	3.40b	0.87a	18.9b	5.5b	-1.6a	6.4a
More mature	18.3a	3.64a	0.62b	29.6a	6.5a	-1.4a	6.6a
Processing method							
Imm. press	17.2a	3.34c	0.79a	23.0b	5.7a	-2.1 c	6.0b
24-hr skin	17.4a	3.57b	0.73ab	24.8ab	6.2a	-1.4b	6.7a
Heat extraction	17.4a	3.64a	0.71b	25.0a	6.1a	-1.1a	6.9a
			5 months at 37°C				
Maturity							
Less mature	16.3b	3.38b	0.86a	19.1b	5.2b	-0.2a	6.4a
More mature	18.7a	3.57a	0.63b	29.8a	5.9a	-0.1a	6.3a
Processing method							
Imm, press	17.4a	3.30c	0.79a	23.4a	6.1a	-0.8b	6.6a
24-hr skin	17.6a	3.54b	0.72a	25.3a	5.5ab	0.1a	6.4a
Heat extraction	17.6a	3.59a	0.72a	24.6a	5.1b	0.4a	6.2b

v Rated on a scale of 1-9; 1 = very poor, 5 = acceptable, 9 = excellent.

z All means within each treatment and each storage time followed by the same letter are not significantly different at the 5% level (LSD).

juices from less mature grapes both initially and after storage (Table 2). The juice flavor from more mature grapes was again rated higher than the juice flavor from less mature grapes, primarily due to a better sugar:acid balance. There were no significant differences in the sensory color ratings or CDM b values between juices from the two maturities.

The processing method had no effect on soluble solids initially or after storage, but the heat extraction juices had lower titratable acidity and higher soluble solids: acidity ratios than immediate press juices initially (Table 2). However, there were no differences in titratable acidity or soluble solids:acidity ratios between the processing methods after storage. The pH of the juices increased as the severity of the juice extraction increased both initially and after storage, as was the case with Vidal juices. There were no differences in flavor between juices from the different processing methods initially.

The immediate press juices had poorer sensory color initially than the other juices due to less intense yellow color (lower CDM b values) (Table 2). After storage, the heat extraction juices had poorer flavor and sensory color than the other juices due to the presence of off-flavors and some browning. The 24-hour skin contact and heat extraction juices had higher CDM b values than the immediate press juices, which also indicates less browning in the immediate press juices. Thus, Seyval juice responded to heat extraction in a manner similar to Vidal juice.

Aurore: As with the other two cultivars, juices from more mature Aurore grapes had higher soluble solids, higher pH, higher soluble solids:acidity ratios, and lower titratable acidity than juice from less mature grapes (Table 3). A significant maturity X processing method interaction for the soluble solids:acidity ratio indicated that heat extraction juices from the less mature grapes had a lower ratio than the other juices, but the heat extraction juices from more mature grapes had a higher ratio than the other juices (data not shown).

The juices from the less mature grapes were again rated lower for flavor than the juices from more mature grapes both initially and after storage, but no color differences between maturities were detected.

The immediate press juices had higher soluble solids and titratable acidity than the 24-hour skin contact juices initially (Table 3). After storage, the immediate press juices had higher soluble solids than the other two treatments and higher acidity than the 24-hour skin contact juices. There were no differences in the soluble solids:acidity ratios between the processing methods, but the pH increased as the severity of juice extraction increased. There were no differences in flavor or color between juices from the different processing methods initially, but after storage the heat extraction juices were rated lower for flavor than the immediate press juices. The heat extraction juices also had poorer color than the other juices after storage due to some browning according to the panel and higher CDM b values. The effect of heat extraction on this cultivar is similar to the effect on the other white cultivars.

Chancellor: The juices from the more mature Chancellor grapes had higher soluble solids, higher pH, higher soluble solids:acidity ratios, and lower titratable acidity than juices from the less mature grapes (Table 4). A significant maturity X processing method interaction for the soluble solids:acidity ratio indicated that the 24-hour skin contact juices had the lowest ratio of the processing methods with the less mature grapes, but this same treatment produced the highest ratio with more mature grapes. As with the white cultivars, the sensory panel rated the flavor of juice from more mature grapes higher than the flavor of juice from less mature grapes. There were no differences in color between the red juices from the two maturities initially or after storage. A light crop (5 t/ha) of this cultivar in this season allowed for early development of color and may help to explain this lack of color difference between maturities.

Table 3. Effects of grape maturity and processing method on the quality of Aurore grape juice initially and after five months at 37°C.

Treatment	Soluble solids (%)	pH	Titratable acidity (as % tartaric)	SS:Acidity	Flavor accept. rating[y]	CDM b	Color accept. rating[y]
Initial							
Maturity							
Less mature	12.8b[z]	3.22b	0.97a	13.2b	4.8b	-1.6a	6.6a
More mature	15.5a	3.51a	0.71b	20.0a	6.5a	-1.7a	6.6a
Processing method							
Imm. press	14.7a	3.28c	0.88a	17.4a	5.6a	-1.9a	6.5a
24-hr skin	13.7b	3.38b	0.80b	17.6a	5.9a	-1.7a	6.7a
Heat extraction	14.0ab	3.43a	0.83ab	17.7a	5.4a	-1.5a	6.6a
5 months at 37°C							
Maturity							
Less mature	13.0b	3.21b	0.97a	13.4b	4.5b	0.7a	6.3a
More mature	15.5a	3.48a	0.69b	20.6a	5.9a	0.8a	6.6a
Processing method							
Imm. press	14.7a	3.27c	0.87a	17.7a	5.7a	0.3b	6.6a
24-hr skin	13.9b	3.36b	0.79b	18.1a	5.1ab	0.5b	6.6a
Heat extraction	14.1b	3.41a	0.83ab	18.1a	4.8b	1.4a	6.1b

[y] Rated on a scale of 1-9; 1 = very poor, 5 = acceptable, 9 = excellent.
[z] All means within each treatment and each storage time followed by the same letter are not significantly different at the 5% level (LSD).

Table 4. Effects of grape maturity and processing method on the quality of Chancellor grape juice initially and after five months at 37°C.

Treatment	Soluble solids (%)	pH	Titratable acidity (as % tartaric)	SS:Acidity	Flavor accept. rating[y]	CDM a	Color accept. rating[y]
			Initial				
Maturity							
Less mature	15.3b[z]	3.23b	0.99a	15.5b	5.8b	10.1a	6.5a
More mature	16.2a	3.46a	0.78b	20.7a	6.6a	10.6a	6.3a
Processing method							
Imm. press	15.5a	3.23c	0.88a	17.8a	5.8b	-0.9c	4.9c
24-hr skin	15.8a	3.37b	0.89a	18.3a	6.6a	6.3b	6.7b
Heat extraction	16.0a	3.45a	0.89a	18.3a	6.2ab	25.7a	7.6a
			5 months at 37°C				
Maturity							
Less mature	15.3b	3.18b	0.98a	15.5b	4.8b	5.1b	5.0a
More mature	16.2a	3.39a	0.79b	20.5a	6.0a	6.1a	5.2a
Processing method							
Imm. press	15.5a	3.17c	0.89a	17.6a	4.8b	0.3c	3.4c
24-hr skin	15.7a	3.30b	0.88a	18.3a	4.9b	3.4b	4.4b
Heat extraction	15.9a	3.38a	0.89a	18.1a	6.4a	13.1a	7.6a

[y] Rated on a scale of 1-9; 1 = very poor, 5 = acceptable, 9 = excellent.
[z] All means within each treatment and each storage time followed by the same letter are not significantly different at the 5% level (LSD).

The processing method had no significant effect on soluble solids, titratable acidity, or the soluble solids: acidity ratio initially or after storage (Table 4). However, the pH increased as severity of the juice extraction increased, following the same trend as with the white cultivars. The 24-hour skin contact juices were rated higher for flavor initially than the immediate press juices, but after storage, the heat extraction juices had superior flavor compared to the immediate press and 24-hour skin contact juices. Only the heat extraction juices had acceptable flavor ratings after storage. The panel noted off flavors in the immediate press and 24-hour skin contact juices after storage. This is in contrast to the detrimental effects of heat extraction on the white cultivars.

The sensory panel rated the darker red color of the heat extraction juices higher than the lighter red color of the 24-hour skin contact juices and the light blush color of the immediate press juices (Table 4). In addition, the color of the 24-hour skin contact juices was rated higher than the color of the immediate press juices. The CDM a values also show that the heat extraction juices were darker red (higher a values) than the other juices, with the immediate press juices having the lightest red color. After storage, the immediate press juices and 24-hour skin contact juices had unacceptable color due to extensive browning, but the heat extraction juices did not brown to any extent during storage. This tends to indicate that a heat-labile enzyme was responsible for the browning and flavor deterioration of the red juices that had not received a heat treatment. Heating to 60°C and holding for several minutes should have inactivated any polyphenoloxidase (12,26) that had not been inactivated by SOS (8,26). Heating may have also inactivated peroxidase to the extent that it did not cause extensive browning and flavor loss, although peroxidase was probably not completely inactivated by heating to 60°C (9). Other researchers have observed that heat extraction resulted in superior color and color stability of red muscadine juices as compared to cold pressing (4,5).

Conclusions

Grape maturity had a tremendous impact on the juice flavor of all cultivars, with more mature grapes producing a superior-flavored juice with higher soluble solids, higher pH, lower acidity, and a higher soluble solids:acidity ratio. However, grape maturity had no major impact on juice color. Immediate press juices had lower pH than the 24-hour skin contact and heat extraction juices. Processing method had very little effect on the flavor of the white juices initially, but heat extraction resulted in poorer flavor and color of the juices after storage. In contrast, heat extraction of the red cultivar, Chancellor, resulted in juice with superior color initially and superior flavor and color after storage.

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