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Evolution of the Maturation Point of Wine Grapes Intended for Juice Processing

Angelica Bender[1], Vagner Brasil Costa[2], Marcelo Barbosa Malgarim[1], Valmor Guadagnin[3], Vinícius Caliari[4] and Suélen Braga de Andrade[1]

1. Federal University of Pelotas (UFPel), Capão do Leão University Campus, Capão do Leão, RS, CEP 96900-010, Brazil

2. Federal University of Pampa (UNIPAMPA), Dom Pedrito, CEP 96450000, RS, Brazil

3. Instituto Federal Sul-rio-grandense (IFSul), Education Science and Technology, Campus Pelotas Visconde da Graça, Av. Engenheiro Ildefonso Simões Lopes, 21-Três Vendas, Pelotas, RS, CEP 96060-290, Brazil

4. University of Western Santa Catarina (UNOESC), Brazilian Agricultural Research Company-Epagri, R. Paese, 198-Bairro Universitário, Videira, SC, CEP 89560-000, Brazil

Abstract: Rainy years especially in the ripening period end up weakening grape quality, thus making it unsatisfactory for winemaking. The possibility of using wine grape varieties in the preparation of juices presents an alternative to the grapes that do not reach ideal harvest for winemaking. Assuming that the preparation of juice from wine grapes can be an alternative to these grapes which in harvests are considered poor for winemaking and can be harvested in advance, thus preventing losses from late cycle disease and excessive spending on phytosanitary treatments, the present study aimed to evaluate the juices made from "Cabernet Sauvignon", "Merlot" and "Chardonnay" grapes harvested at different points of maturation, and subsequently compare with current legislation. Physicochemical analysis of titratable acidity (TA), soluble solids (SS), relative density, total sugar, alcohol, volatile acidity and SS/TA ratio was carried out on the juices produced at three sampling points (15, 17 and 19 °Brix). The results showed variability between treatment factors (cultivars and points of maturation). Analyses of titratable acidity, soluble solids, SS/TA ratio, relative density, total sugars and volatile acidity showed significance for the interaction between the tested treatment factors. For the variable alcohol, there was no significance for the effect of variety, maturation stage or the interaction between the factors of treatment. It was concluded that Cabernet Sauvignon juice met the parameters set by law at 17 °Brix, while Chardonnay and Merlot juices showed consistent results only at harvest point 19 °Brix.

Key words: *Vitis vinifera*, maturation point, grape juice, physicochemical quality.

1. Introduction

Grapes stand out as one of the most consumed fruits in the world, not only in the consumption of the fruit *in natura*, but as processed production as well. Among the products derived from this crop, grape juice is considered to be one of the main ones and has been presenting perspectives of increase in the market [1]. Grape juice may be prepared with any variety that reaches suitable maturation and is in a good state of health. In general, the more mature grapes favor the better juice quality, because besides having higher sugar content, they have lower acidity, and consequently, higher sugar/acidity ratio [2].

Grape is a non-climacteric fruit, therefore, it is of fundamental importance that the harvest takes place at the maximum moment of expression of its quality potential in a particular crop or region. The ideal maturation for harvesting is evidenced by the appearance, consistency and mainly the sugar content in the must. Thus, it is necessary to monitor the maturation by means of sensorial and chemical analyses every two or three days of representative samples of the vineyard [2, 3].

The ideal is to harvest the grapes by the degree of maturation and not due to phytosanitary problems

Corresponding author: Angelica Bender, M.Sc., research field: temperate climate fruit culture.

caused especially by bunch rot [4]. Rainy years, especially in the maturation period, end up weakening the quality of the grape, thus making it unsatisfactory for winemaking. The possibility of the use of grape varieties in the elaboration of juices presents itself as an alternative for harvests, in which the grapes do not reach ideal point of harvest for the elaboration of wines.

Based on the premise that the production of juices from grapes can be an alternative for the use of crops which are considered bad for vinification and can be harvested in advance, thus avoiding losses with end-of cycle diseases and excessive expenditures with phytosanitary treatments, the present study mainly aimed to evaluate the juices elaborated from the grape varieties Cabernet Sauvignon, Merlot and Chardonnay harvested at different maturation points.

2. Materials and Methods

2.1 Experiment Area

The grapes used as raw material for the elaboration of the juices were the European varieties (*Vitis vinifera*): Cabernet Sauvignon, Merlot and Chardonnay from the 2015 crops grown in a commercial orchard located in the municipality of São Lourenço do Sul (31°21′54″ S, 51°58′40″ W, 26 m altitude). The climate of the region is of the type subtropical, temperate with hot and humid summers and quite cold winters [5]. The soil is classified as Bruno-grayish argisols, red-yellow argisols and litolics and Regolithic neosols, and composed of plateaus and plains [6]. The municipality of São Lourenço has no meteorological station, thus data from the municipality of Pelotas were used since it belongs to the same micro-region of this municipality. The data on the minimum and maximum temperature and rainfall of the municipality of Pelotas, related to the duration of the experiments were obtained from the meteorology laboratory of Embrapa Clima Temperado [7]. The mean minimum temperature was 20.2 °C, the mean maximum temperature was 27.4 °C and the total precipitation was 168.8 mm for the month of January, 2015. For February, 2015, the average minimum temperature was 20.8 °C, the mean maximum was 25.6 °C and the total precipitation was 407.4 mm.

2.2 Identification of Plants

Ninety plants were selected from each cultivar, arranged in three distinct rows for the experiment. The plants were harvested under a Paulsen 1103 grating system and pruned in spore cord. The space between plants was 2 m, and the space between rows was 3 m. The management and cultural treatment were carried out following the technical recommendations of the culture. The harvest was conducted manually, differing the dates between the varieties and harvesting points, during the months of January and February 2015 (Fig. 1). About 20 kg were set aside to elaborate the juice of each cultivar in each point of harvest. The collection points were previously determined according to the soluble solids content, being 15, 17 and 19 °Brix for all cultivars.

2.3 Phenological Monitoring

Monitoring of the phenological behavior of the grapevine production cycle during the pruning period was carried out by means of visual observations by visits to the vineyard, carried out every 5 d until the beginning of maturation, and subsequently intensified visits to 3 d intervals.

Phenological characterization was performed in 20 randomly selected plants, which were used for the phenological scale evaluations [8]. The durations of the different stages observed are shown in Fig. 2.

2.4 Juice Production

The juices were elaborated in the Postharvest Laboratory of the Federal University of Pelotas (Pelotas, RS/Brazil). The extraction of the must occurred via a steam extractor with capacity for 20 kg of the fruit. Initially, the berries were destalked and

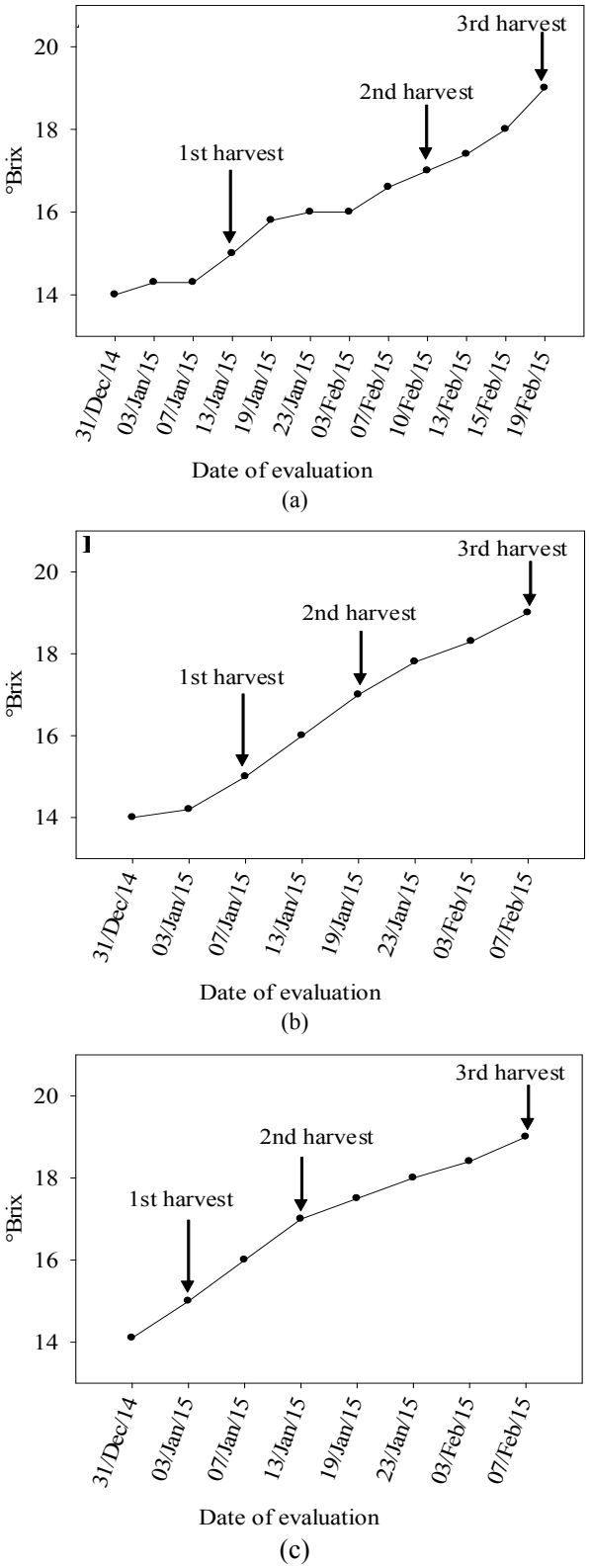

Fig. 1 Harvest points of Cabernet Sauvignon (a), Merlot (b) and Chardonnay (c) for the preparation of juices.
1st harvest: 15 °Brix; 2nd harvest: 17 °Brix; 3rd harvest: 19 °Brix.

selected manually, excluding the damaged ones and incomplete maturation. Afterwards, they were placed in the perforated container, fitted in the external container, and both coupled on the water tank that was accommodated on a gas cooker, for the generation of heat. After approximately 20 min, the must began to flow through the outlet tube, being put back on the grapes until the temperature of 85 °C was reached.

Bottling of the samples lasted for about 1 h and 30 min, controlling the temperature inside the bottle with the aid of a thermometer (Incoterm, -10 °C to 100 °C), discarding the first and the last extracted portion of juice. Glass bottles of 1.5 L were used. They were previously sanitized with chlorinated water and later kept in boiling water until the bottling. Immediately after bottling, the bottles were closed with a plastic screw cap and kept with the bottleneck down. The samples were kept under refrigeration until analysis.

The experimental design was completely randomized, with three replications. The treatments were arranged in a two-factorial scheme, including the varieties (Cabernet Sauvignon, Merlot and Chardonnay) and the maturation stages (15, 17 and 19 °Brix). Three bottles were used for each variety at each collection point, where each bottle represented a repetition, totaling nine bottles per variety for physicochemical analyses.

2.5 Physicochemical Analysis

The physicochemical analyses of titratable acidity (TA), soluble solids (SS), relative density, total sugars, alcohol, volatile acidity and SS/TA ratio were performed at the Epagri Station, Agricultural Research and Extension Company of Santa Catarina, Estação Experimental de Videira (Videira, SC/Brazil). The analyses were carried out according to the methodologies of the Ministry of Agriculture [9].

To determine the titratable acidity, 10 mL of juice was homogenized in 100 mL of distilled water, added with 2-3 drops of phenolphthalein, and this dilution was titrated with NaOH solution (0.1 N) until pink

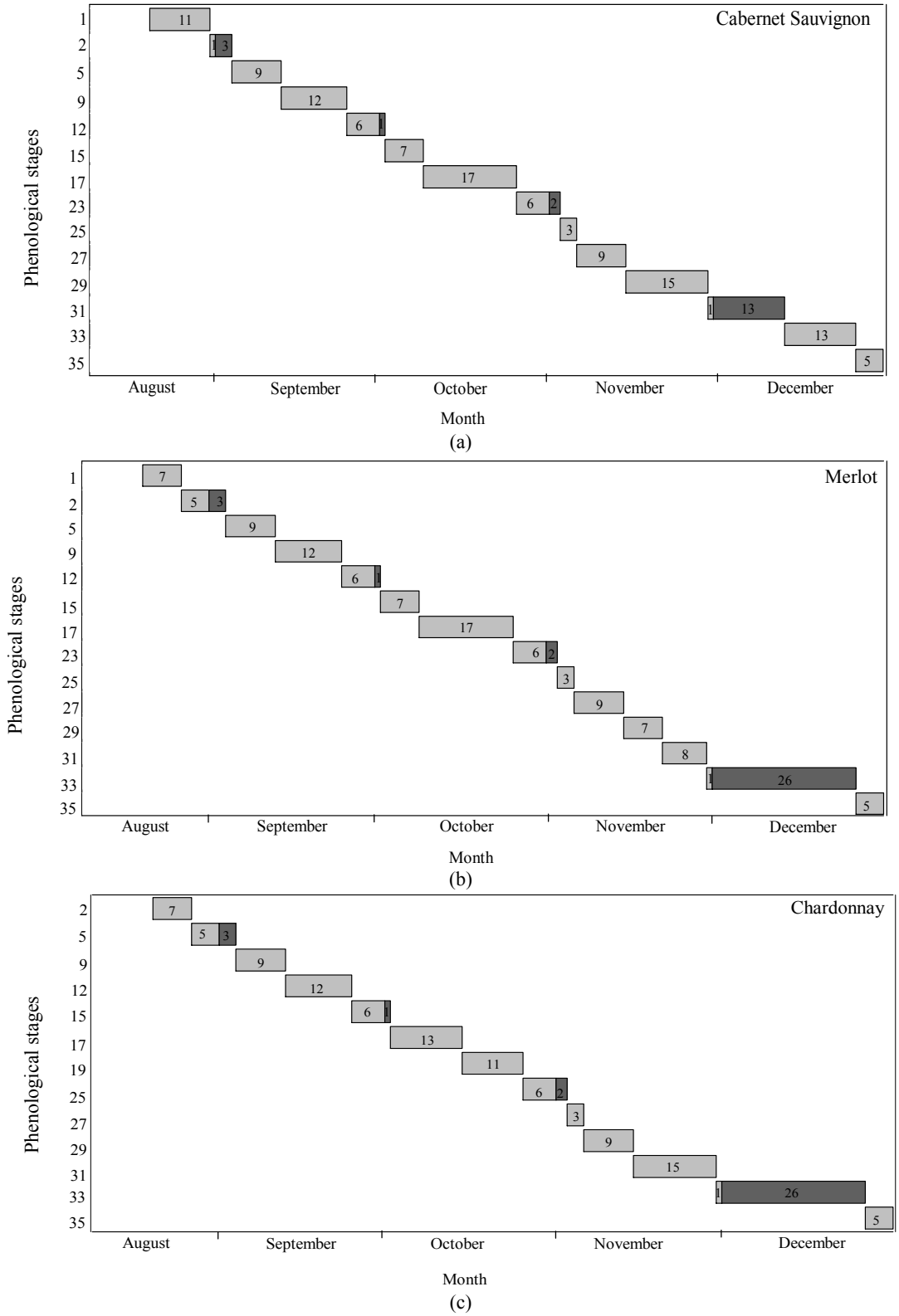

Fig. 2 Phenological monitoring of the varieties Cabernet Sauvignon (a), Merlot (b) and Chardonnay (c) to define the maturation stages.

1st harvest: 15 °Brix; 2nd harvest: 17 °Brix; 3rd harvest: 19 °Brix.

The phenological stages were determined according to the phenological scale system of Eichhorn and Lorenz [8].

(turning point). The results were expressed as g/100 g of tartaric acid.

The results of soluble solids were expressed in °Brix, the relative density expressed in cm^3, total sugars expressed in g/100 g, alcoholic content expressed in v/v and volatile acidity in g 100/g of acetic acid were determined by an electronic enologic distiller (Gibertini®), which was calibrated with distilled water, and then placed on the samples, thus obtaining the readings. The SS/TA ratio was obtained through the quotient between soluble solids and titratable acidity.

2.6 Statistical Analysis

The data obtained were analyzed for normality by the Shapiro Wilk test, homoscedasticity by Hartley test and the independence of residues by graphic analysis. Subsequently, the data were submitted to analysis of variance through the F test ($P \leq 0.05$). Being statistically significant, the effects of the varieties were compared by the Duncan test ($P \leq 0.05$) and maturation stages by linear regression models ($P \leq 0.05$) as Eq. (1):

$$y = y_o + ax \quad (1)$$

where, y = response variable; y_o = response variable corresponding to the minimum or maximum point of the curve; a = slope of the line or curve; x = degrees in °Brix.

The selection of the model was based on low residue, low P value, and high R^2 and R^2_{adj} (the adequacy of determination coefficient R^2). The presence of correlations between the dependent variables of the study was analyzed through the Pearson correlation coefficient in general for the whole experiment, as well as individualized for the varieties at each stage of maturation.

3. Results

3.1 Physicochemical Analyses

The assumptions of the mathematical model were all met and data transformation was not necessary for all variables. The titratable acidity analyses ($F = 12.41$, $P < 0.0001$), soluble solids ($F = 6.52$, $P = 0.0020$), SS/TA ratio ($F = 15.18$, $P < 0.0001$), relative density ($F = 7.04$, $P = 0.0014$), total sugars ($F = 10.37$, $P = 0.0002$) and volatile acidity ($F = 5.55$, $P = 0.0048$) showed significance in the interaction between the treatment factors tested. For the alcohol variable, there was neither significance for the variety effect ($F = 1.88$, $P = 0.1883$), maturation stage ($F = 0.49$, $P = 0.6204$) nor for the interaction between the treatment factors ($F = 0.09$, $P = 0.9834$) (Table 1).

3.1.1 Titratable Acidity

For titratable acidity, at the maturation stage of 15 °Brix, significant differences were observed between the juices from the Chardonnay variety, which obtained the highest values, in relation to the other juices. For 17 °Brix, Cabernet Sauvignon differed from the others with the lowest values. Whereas at 19 °Brix, the behavior was the same as that at 15 °Brix (Table 1). The titratable acidity content is regulated by law with a minimum value of 0.41 g/100 g in tartaric acid, so all juices met the requirement at different maturation points [10].

The titratable acidity data were adjusted to the linear regression model for Cabernet sauvignon ($F = 21.2138$, $P = 0.0025$), Merlot ($F = 43.9187$, $P = 0.0003$) and Chardonnay ($F = 253.2303$, $P < 0.0001$), respectively (Fig. 3a). Decreases in titratable acidity values of 21.6% and 43.1% were observed for Cabernet Sauvignon for 17 °Brix and 19 °Brix, respectively, when compared to 15 °Brix. For the juices obtained from the Merlot variety, the percentages decreases were similar to Cabernet Sauvignon, being 23.4% and 46.8% for the same comparisons. The highest percentages decreases were observed for Chardonnay, 29.7% and 59.5% for 17 °Brix and 19 °Brix, respectively, when compared to 15 °Brix.

3.1.2 Soluble Solids

The juice of the Merlot variety presented a

significant difference for the soluble solids content at the 15 °Brix maturation point, presenting the highest average in relation to the other processed juices. At the 17 °Brix maturation point, there was a significant difference between the variety, with the highest mean being Cabernet Sauvignon, followed by Chardonnay and Merlot. However, at 19 °Brix, there was no significant difference between the different processed juices (Table 1). According to legal standards, the soluble solids content of whole grape juice must be at least 14.0 °Brix [10]. At the 15 °Brix point, none of the analyzed juices met the specification of the legislation, and at point 17 °Brix, only the Cabernet Sauvignon juice was in line with the recommended value. At 19 °Brix, all the juices presented similar behavior, according to the identity and quality standards for the soluble solids variable. The data for this variable were adjusted appropriately to the linear regression model for Cabernet Sauvignon (F = 15.3412, P = 0.0058), Merlot (F = 19.0876, P = 0.0033) and Chardonnay (F = 31.2046, P = 0.0008) (Fig. 3b). Increases were observed in the soluble solids content in Cabernet Sauvignon of 7.8% for 17 °Brix and 15.5% for 19 °Brix when confronted with the initial maturation point of 15 °Brix. For the Merlot juice, in the same comparison, increases were lower than

Table 1 Physicochemical variables of grape juice of the varieties Cabernet Sauvignon, Merlot and Chardonnay over three maturity stages.

Variety	Maturation stage (°Brix)		
	15	17	19
	Titratable acidity (g/100 g tartaric acid)		
Cabernet Sauvignon	1.04 ± 0.00[b]	0.59 ± 0.01[b]	0.58 ± 0.01[a]
Merlot	1.01 ± 0.06[b]	0.71 ± 0.03[a]	0.58 ± 0.01[a]
Chardonnay	1.24 ± 0.01[a]	0.79 ± 0.02[a]	0.52 ± 0.01[b]
	Soluble solids (°Brix)		
Cabernet Sauvignon	12.40 ± 0.10[b]	14.37 ± 0.09[a]	14.37 ± 0.32[a]
Merlot	13.20 ± 0.06[a]	13.27 ± 0.13[c]	14.73 ± 0.18[a]
Chardonnay	12.17 ± 0.20[b]	13.73 ± 0.09[b]	14.40 ± 0.40[a]
	SS/TA ratio		
Cabernet Sauvignon	11.95 ± 0.11[a]	24.50 ± 0.43[a]	24.64 ± 0.66[a]
Merlot	13.17 ± 0.82[a]	18.69 ± 1.01[b]	25.43 ± 0.80[a]
Chardonnay	9.79 ± 0.16[b]	17.41 ± 0.57[b]	27.56 ± 1.21[a]
	Relative density (g/cm^3)		
Cabernet Sauvignon	1.050 ± 0.00[b]	1.060 ± 0.00[a]	1.060 ± 0.00[a]
Merlot	1.060 ± 0.00[a]	1.046 ± 0.00[c]	1.060 ± 0.00[a]
Chardonnay	1.049 ± 0.00[b]	1.059 ± 0.00[b]	1.060 ± 0.00[a]
	Total sugars (g/100 g)		
Cabernet Sauvignon	10.63 ± 0.09[b]	12.30 ± 0.07[a]	12.33 ± 0.25[a]
Merlot	11.33 ± 0.03[a]	11.40 ± 0.10[c]	12.57 ± 0.18[a]
Chardonnay	10.43 ± 0.18[b]	11.77 ± 0.07[b]	13.00 ± 0.30[a]
	Volatile acidity (g/100 g acetic acid)		
Cabernet Sauvignon	0.009 ± 0.00[a]	0.01 ± 0.00[a]	0.01 ± 0.00[a]
Merlot	0.01 ± 0.00[a]	0.009 ± 0.00[b]	0.01 ± 0.00[a]
Chardonnay	0.01 ± 0.00[a]	0.01 ± 0.00[a]	0.009 ± 0.00[b]
	Alcohol content (%)[NS]		
Cabernet Sauvignon	0.10 ± 0.10	0.23 ± 0.12	0.17 ± 0.09
Merlot	0.00 ± 0.00	0.05 ± 0.05	0.00 ± 0.00
Chardonnay	0.10 ± 0.10	0.13 ± 0.09	0.10 ± 006

[a-c] Mean ± standard error accompanied by the same lowercase letter in the column did not differ by Duncan test ($P \leq 0.05$) comparing the varieties at each maturation stage; [NS]: not significantly different by the F test ($P \leq 0.05$).

Cabernet Sauvignon, being 5.9% and 11.8% for 17 °Brix and 19 °Brix, respectively. In relation to the Chardonnay juice, the increases were higher than the others mentioned above, being 9% and 18.2% for 17 °Brix and 19 °Brix, respectively, when compared to 15 °Brix.

3.1.3 SS/TA

For the variable SS/TA, the Chardonnay juice presented significant difference at 15 °Brix maturation point, due to the lower average obtained. Cabernet Sauvignon obtained a difference from the others, presenting the highest average in the maturation point 17 °Brix, followed by Merlot and Chardonnay. However, at 19 °Brix, there were no significant differences between the varieties tested (Table 1).

The values obtained for the 15 °Brix harvest point were below the limits established by the legislation, which is between 15 and 45. At the 17 °Brix harvesting point, all the juices met the legislation requirements, while Chardonnay and Merlot were very close to the minimum, showing that these juices have considerable acidity. In the grapes at 19 °Brix, the values remained similar among the varieties tested, being in agreement with Choudhury [11], who considered the value to be equal to or greater than 20. Rizzon and Link [12] found a value of 18 for SS/TA in Cabernet Sauvignon grape juice, below that of the same variety at harvesting points 17 °Brix and 19 °Brix.

The SS/TA ratio data were appropriately fit to the linear regression model for Cabernet Sauvignon (F = 20.9122, P = 0.0026), Merlot (F = 106.6346, P = 0.0001) and Chardonnay (F = 236.3966, $P < 0.0001$) (Fig. 3c). Increases were observed when comparing the maturation points of 17 °Brix and 19 °Brix in relation to 15 °Brix. The values of the percentages were 45.4% for 17 °Brix and 90.7% for 19 °Brix. Merlot and Chardonnay presented greater increases for this same comparison. 47.2% and 94.2% was obtained for Merlot, and 95.2% and 190.4% for Chardonnay, for 17°Brix and 19 °Brix, respectively. The analyzed juices presented increasing percentages when comparing the 17 °Brix and 19 °Brix points with 15 °Brix, however, it is possible to verify that for the variety Cabernet Sauvignon; the difference between 17 °Brix and 19 °Brix is relatively small, the others presented opposite behavior.

3.1.4 Relative Density

For the relative density at the 15 °Brix maturation point, the juice of the Merlot variety showed significant differences obtaining the highest average, in relation to the other juices. For 17 °Brix, there was a difference between the three analyzed juices, with Cabernet Sauvignon holding the highest average, followed by Chardonnay and Merlot. At 19 °Brix, there was no significant difference between grape types (Table 1).

The density of the grape juice should be at least 1.057 g/cm^3 [10]. At 15 °Brix, Cabernet Sauvignon and Chardonnay values were lower than those defined by law, at 17 °Brix the behavior was the reverse of the previous harvest point, and at 19 °Brix, all juices remained above the minimum required.

The relative density data were appropriately fit to the linear regression model for Cabernet Sauvignon (F = 17.6937, P = 0.0040), Merlot (F = 13.4919, P = 0.0079) and Chardonnay (F = 96.1785, $P < 0.0001$) (Fig. 3d). When comparing the maturation points 17 °Brix and 19 °Brix with 15 °Brix, increases of 0.4% and 0.8%, respectively, were observed for Cabernet Sauvignon. These values were repeated for Merlot, for the same comparison. In the case of the Chardonnay variety, the increases were slightly higher, being 0.6% for 17 °Brix and 1.2% for 19 °Brix. In the same way as the soluble solids content, the density had a significant linear increase, since it has direct relation with the sugar concentration in the must and can be diluted by the water vapor used in the extraction method.

3.1.5 Total Sugars

The total sugars showed a significant difference for the Merlot variety with the highest average at the

15 °Brix harvest point. At 17 °Brix, there was a significant difference for all varieties tested, the highest average being Cabernet Sauvignon, followed by Chardonnay and Merlot. At 19 °Brix, there was no significant difference between grape types (Table 1). The Brazilian legislation establishes a maximum value for total sugars of 20 g/L [10], so all processed juices, regardless of the maturation point, met the defined limit.

The total sugar content data were appropriately fit to the linear regression model for Cabernet Sauvignon (F = 14.9148, P = 0.0062), Merlot (F = 18.6078, P = 0.0035) and Chardonnay (F = 88.8715, P < 0.0001) (Fig. 3e). Increases were observed in the values of total sugars, where Cabernet Sauvignon presented 7.7% and 15.4% for 17 °Brix and 19 °Brix, respectively, when compared with the 15 °Brix harvest point. For the juice obtained from the Merlot variety, the percentage increases were 5.5% and 11.1% for the same comparisons. For Chardonnay, the highest percentage increases of 12.3% and 24.6% were observed for 17 °Brix and 19 °Brix, respectively, when compared to 15 °Brix.

3.1.6 Volatile Acidity

For the volatile acidity variable, there was no statistical difference between the varieties at the 15 °Brix harvest point. At 17 °Brix, the Merlot variety differed from the others, presenting a lower mean. At 19 °Brix, the Chardonnay variety showed the same behavior as the Merlot variety at the stated harvesting point, differing from the others (Table 1). The volatile acidity data were appropriately fit to the linear regression model only for Cabernet Sauvignon (F = 17.6842, P = 0.0040). For Merlot and Chardonnay, no equation adjustments were observed (Fig. 3f), with increases of 13.9% and 27.7% being observed for 17 °Brix and 19 °Brix, respectively, when compared to 15 °Brix.

3.2 Correlations

The correlations (Table 2), which were generally verified for the whole experiment, between the dependent variables were positive or negative. There were negative correlations between titratable acidity and soluble solids (r = -0.89, P < 0.0001), SS/TA ratio (r = -0.97, P < 0.0001), relative density (r = -0.88, P < 0.0001) and total sugars (r = -0.90, P < 0.0001), showing that the increase in titratable acidity resulted in decreases in soluble solids values, and consequently in the SS/TA ratio, relative density and total sugars.

Positive correlations occurred between soluble solids with SS/TA ratio (r = 0.93, P < 0.0001), density (r = 0.90, P < 0.0001) and total sugars (r = 0.90, P < 0.0001). Correlations between SS/TA ratio with relative density (r = 0.92, P < 0.0001) and total sugars (r = 0.93, P < 0.0001) also occurred, as well as positive correlations between relative density with total sugars (r = 0.97, P < 0.0001) (Table 2). These correlations showed that as the soluble solids content and SS/TA ratio were higher, the other abovementioned variables obtained were proportional increase.

In the Cabernet Sauvignon variety for the maturation stage of 15 °Brix, there was a positive correlation of relative density with total sugars (r = 0.99, P = 0.05). For the maturation stage of 17 °Brix, titratable acidity with volatile acidity (r = 0.99, P < 0.0001) obtained a positive correlation. In the 19 °Brix maturation stage, correlation only occurred between soluble solids and total sugars (r = 0.99, P = 0.01).

In the Merlot variety at the 15 °Brix maturation stage, negative correlations were observed between titratable acidity with SS/TA ratio (r = -0.99, P = 0.004) and positive correlations between soluble solids and relative density (r = 0.99, P < 0.0001). In the maturation stage of 17 °Brix, a negative correlation of titratable acidity with soluble solids (r = -0.99, P < 0.0001) was also observed. While positive correlation of soluble solids with SS/TA ratio (r = 0.99, P < 0.0001) and total sugars (r = 0.99, P < 0.0001), and SS/TA ratio with total sugars (r = 0.99, P < 0.0001) were observed. At the 19 °Brix maturation

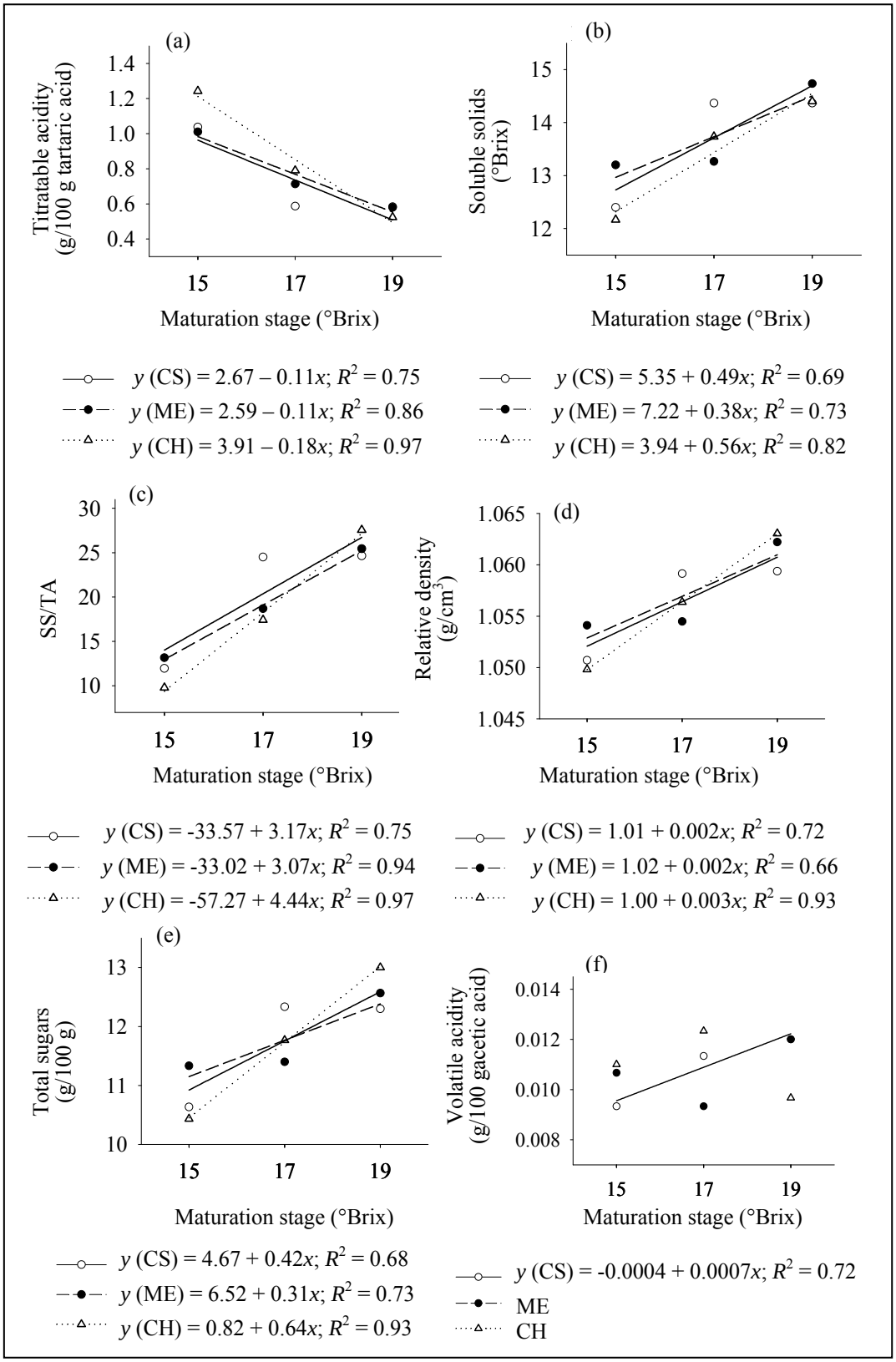

Fig. 3 Titratable acidity (a), soluble solids (b), SS/TA ratio (c), relative density (d), total sugars (e) and volatile acidity (f) of grape juice of Cabernet Sauvignon (CS), Merlot (ME) and Chardonnay (CH) over three stages of maturation.

Table 2 Pearson correlation coefficients and *P* values of the dependent variables of different varieties of grape juice over three maturity stages.

Dependent Variables	Titratable acidity (1)	Soluble solids (2)	SS/TA ratio (3)	Relative density (4)	Total sugars (5)	Volatile acidity (6)	Alcohol (7)
1	1.000	-0.889*; < 0.0001**	-0.968; < 0.0001	-0.878; < 0.0001	-0.896; < 0.0001	-0.207; 0.309	-0.136; 0.535
2		1.000	0.926; < 0.0001	0.900; < 0.0001	0.902; < 0.0001	0.374; 0.060	0.099; 0.650
3			1.000	0.918; < 0.0001	0.926; < 0.0001	0.208; 0.307	0.137; 0.533
4				1.000	0.973; < 0.0001	0.237; 0.244	0.048; 0.828
5					1.000	0.213; 0.296	0.100; 0.649
6						1.000	0.173; 0.441
7							1.000

* Pearson correlation coefficient; ** *P* values.

stage, the negative correlation occurred between SS/TA ratio and titratable acidity (r = -0.99, P = 0.03). The SS/TA ratio is given by the value of soluble solids divided by the value of titratable acidity. Higher values of titratable acidity result in smaller values for the SS/TA ratio, characterizing more acidic juices. The more pronounced acidity at the 19 °Brix harvest point for the Merlot variety can be explained by the fact that the transformations occurring in the grapes during maturation do not occur simultaneously, and concentration of sugar may occur without decreasing the acid concentration [13].

Considering the Chardonnay variety at the 15 °Brix maturation stage, only correlation between relative density and total sugars (r = 0.99, P = 0.008) was observed. In this same variety, the correlation was verified between relative density and soluble solids (r = 0.99, P = 0.04) at maturation stage of 17 °Brix. At the maturation stage of 19 °Brix, no significant correlations were found between the dependent variables studied.

The correlation of the dependent variables observed in all juices under study along the maturation points shows that there is an increase in the content of soluble solids, also an increase in total sugars, relative density and SS/TA ratio. As for titratable acidity, it can be observed that as higher values presented, the correlations with the aforementioned variables are negative, showing that their evolution occurs in the opposite way.

4. Discussion

The titratable acidity decreased significantly over the different maturation points. The three varieties tested had similar behavior during maturation, differing only in the observed percentages. The decrease in the concentration of the organic acids during the evolution of the maturation is due to the dilution of the must by the entrance of water in the fruit, transported in the xylem by the mobilization of bases that neutralize the organic acids and by the respiratory process [14]. The phenomenon of respiration suffers influence with temperature and rainfall, so years of hot and dry summers characterize less acidic grapes [13]. The highest averages obtained by Chardonnay, followed by Merlot, may be related to the higher temperature and lower rainfall levels during the month of January (Figs. 1b and 1c), which coincided with most of the harvests for these varieties, while Cabernet Sauvignon had its last two harvests in February (Fig. 1a), which was characterized as a rainy month in the municipality of São Lourenço do Sul in 2015.

Similar to the titratable acidity, the soluble solids content is influenced by climatic factors. When high temperatures and sunshine prevail, vine metabolism

favors a greater accumulation of soluble solids in the grape berry [15]. The method of juice preparation may influence the difference observed in the value of soluble solids of the grape in relation to the juice. These variations may be due to the dilution caused by the incorporation of water generated by the steam used in the heating to extract the coloring matter from the berries [12]. Dutra et al. [16] found higher values of 15.4 °Brix and 16.4 °Brix for juices made from Cabernet Sauvignon and Tempranillo, but in the same study, Syrah juice had a lower value of 13 °Brix. The authors also associated their results with the possible dilution caused by the preparation method.

The total sugars of the whole juice originate exclusively from the grape that gave rise to it. In general, *Vitis vinifera* cultivars have a higher sugar production potential than American *Vitis labrusca* grapes [17, 18]. The sugars produced in the grape vary between cultivars and environmental conditions [19]. The health status of the grapevine, mainly diseases that attack the leaves, causing early defoliation influence in a lower accumulation of sugars in the berries, since most of them come from the leaves in the form of sucrose and later it is transformed into fructose and glucose in the berries [19]. Increases were observed in the total sugar content at harvest points 17 °Brix and 19 °Brix in relation to the 15 °Brix harvest point. When comparing the averages of the three harvest points, it is possible to verify that this increase was relatively small, especially for Cabernet Sauvignon between 17 °Brix and 19 °Brix. These results may be reflective of the severe attack of downy mildew that led to the loss of leaves in advance. This fact occurred between the end of January and beginning of February, coinciding with the maturation period of the grapes, which reflected in a low sugar content accumulated in the berries. It was more severe for Cabernet Sauvignon, since it had its last two harvests in the second half of February (Fig. 1a).

A linear increase in volatile acidity was observed only in the grape juice of Cabernet Sauvignon, probably due to the sanitary state of the grape by the attack of mildew, evidenced in the last harvests. However, the values are low, but are within the limits established by Brazilian legislation, which is 0.50 g/100 g [10]. Dutra et al. [16] found values of 0.15 g/100 g in acetic acid for Cabernet Sauvignon and Syrah and 0.12 g/100 g in acetic acid for Tempranillo, arguing that the low values show good sanitary status of the grapes used in the experiment. Rizzon and Link [12] observed higher values for volatile acidity in juices from Cabernet Sauvignon, when compared to American varieties, reaching 0.2 g/100 g in acetic acid, the authors also associated the highest value to the sanitary state of the grape.

5. Conclusions

Three *Vitis vinifera* varieties (Cabernet Sauvignon Merlot and Chardonnay) were tested for juice at different ripening stages 15, 17 and 19 °Brix. The juices showed a decrease in the titratable acidity and increase in the other physicochemical variables tested along the different harvest points. All tested varieties were suitable for juice production, and the harvest point of 19 °Brix received the best sensorial acceptance by the evaluators.

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