

REGULAR ARTICLE

'Niágara Rosada' and 'Isabel' grapes quality cultivated in different altitudes in the state of Espírito Santo, Brazil

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ABSTRACT

Altitude and climate and its microclimatic characteristics influence the grapes and wines quality. The objective of this study was to evaluate 'Niagara Rosada' and 'Isabel' grapes quality at three different altitudes in the highlands of the state of Espírito Santo. The experiment was a randomized complete block design in subdivided plots (3x2). The plots were in different altitudes and, in the subplots, the two cultivars. Also, five replicates were done in each treatment. The grapes quality were evaluated in the laboratory from total soluble solids (TSS), total titratable acidity (TTA), pH and the relationship between TSS/TTA. The cultivar 'Niágara Rosada' showed higher values than the 'Isabel' cultivar in relation to the evaluated parameters. The altitude of 650 m favored to obtain higher values of total titratable acidity and lower values of pH. The excess of leaf nitrogen in environment 1 contributed to the higher values of TTA and lower pH for the cultivars 'Niágara Rosada' and 'Isabel'. The quality of the 'Niágara Rosada' and 'Isabel' grapes produced in the state of Espírito Santo were influenced by altitude, and the altitude of 650 m favored to obtain higher values of total titratable acidity and lower values of pH.

Keywords: Climate; Composition; Viticulture; *Vitis labrusca* L.

INTRODUCTION

Currently occupying an area of 77,786 hectares and with a production of 984,244 tons in 2016, vine is one of the main fruit trees cultivated in Brazil (Mello, 2017). Analyzing the Brazilian market for fruits, it is possible to observe an increasing demand of consumers for better quality grapes, not only in relation to the visual aspect, but also in flavor, aroma and consistency (Lulu et al., 2005).

The grape quality involves a set of peculiar properties or characteristics. It has sensory properties (appearance, firmness, aroma and flavor), nutritive and multifunctional value, due to chemical components, mechanical properties and the absence or presence of defects (Chitarra & Chitarra, 2005).

Environmental factors, such as soil and climate, together with varietal and crop characteristics, define the "terroir"

of a region, which has a marked influence on the grapes and wine quality (Brighenti et al., 2014). The climate and its microclimatic characteristics are especially important, since they have a strong influence on the grapevine, determining the grape and wine quality (Orduña, 2010). Among the environmental factors that have a strong relationship with grapevine phenology are: air temperature and humidity, rainfall and solar radiation (Brighenti et al., 2015).

The interactions of environmental factors with the environment, as well as the variety and cultivation techniques are responsible for the potential of each region, as well as for the grapes productivity and quality (Bock et al., 2011).

Recently few studies on the effect altitude has on physical-chemical components of the grape (Alessandrini et al., 2017) have been carried out. Therefore, 'Niágara Rosada' and 'Isabel' grapes produced at three different altitudes were

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Received: 29 March 2018; Accepted: 20 November 2018

studied in the state of Espírito Santo considering the total soluble solids (TSS), total titratable acidity (TTA), pH and the TSS/TTA ratio.

MATERIALS AND METHODS

The research was carried out in the municipality of Santa Teresa, northwest region of the state of Espírito Santo. The climate of the region, according to the classification of Köppen, is in the type Cwb (temperate oceanic climate/tropical highland climate), with an average annual temperature of 24.6 °C and annual precipitation ranging between 700 and 1,200 mm.

The evaluated cultivars were 'Niágara Rosada' and 'Isabel' in vineyards located at three different altitudes named environment A1 (250 m), A2 (500 m) and A3 (650 m), with coordinates 19° 52' 34" South and 40° 36' 42" West; 19° 54' 50" South and 40° 41' 38" West; 19° 56' 41" South and 40° 34' 40" West, respectively. In the three vineyards, the grapes are grown in area of 3.0 m x 2.0 m, in grape vines, covered with 18% of shading and drip irrigation.

During the production cycle, phytosanitary treatments, fertilization, weed management and practices such as mooring, branching, removal of double sprouts and tendrils, inbreeding, and floral buds, berries and bunches were performed. The nutritional status of the 'Niágara Rosada' and 'Isabel' vines in all three environments was performed by harvesting leaves at full bloom time (when most of the vines are in stage I - open flowers, ready to be fertilized) (Terra, 2003) and the results are shown in Table 1.

For the analysis and evaluation on the effect the environment has on the grapes quality, an experiment was considered with 6 treatments: T1: Cultivate 'Niágara Rosada' at 250 meters altitude; T2: Cultivar 'Isabel' at 250 meters altitude; T3: Cultivate 'Niágara Rosada' at 500 meters of altitude; T4: Cultivate 'Isabel' at 500 meters of altitude; T5: Cultivate 'Niágara Rosada' at 650 meters altitude and T6: Cultivate 'Isabel' at 650 meters of altitude. A randomized complete block design (RCBD) was used with subdivided plots. The plots were in three different altitudes and in two cultivars in the subplots. Each of the treatments had five replicates, each repetition consisting of 2 bunches of grapes. The bunches were collected at the moment when the farmers harvested in January and February, 2016, and the grapes were harvested when they reached the physiological maturation. However, due to the market demand, many times the 'Isabel' grape was harvested in the same period as the 'Niágara Rosada' grape. The collected grapes were stored at -80°C until ready for laboratory analysis.

Table 1: Nutritional status of 'Niágara Rosada' and 'Isabel' grapes in three different environments in the state of Espírito Santo

Attribute (g kg ⁻¹)	Niágara rosada			Isabel		
	A1	A2	A3	A1	A2	A3
N (g kg ⁻¹)	41.2	38.9	31.2	39.7	35.9	31.2
P (g kg ⁻¹)	3.7	3.6	3.2	3.4	3.6	3.6
K (g kg ⁻¹)	20.1	17.9	10.7	16.9	17.4	13.4
Ca (g kg ⁻¹)	15.1	16.4	11.6	16.3	16.7	11.0
Mg (g kg ⁻¹)	4.2	3.4	2.7	4.01	2.9	2.3
S (g kg ⁻¹)	2.8	2.7	2.2	2.6	2.9	2.2
B (mg kg ⁻¹)	96	45.4	43.3	83.5	53.1	41.7
Zn (mg kg ⁻¹)	29.1	33.7	35.9	26.6	43.8	30.5
Mn (mg kg ⁻¹)	157	142.5	128.5	176.5	238.5	96
Fe (mg kg ⁻¹)	202.5	170.5	228.9	239.5	204.5	228.1
Cu (mg kg ⁻¹)	10.8	9.6	8.9	9.1	6.6	9.0

A¹: environment 1 (altitude 250 m); A²: environment 2 (altitude 500 m) and A³: environment 3 (altitude 650 m)

The wort of each replicate was extracted by manual pressing, homogenized and evaluated for total soluble solids (TSS) (°Brix) in an ATAGO portable digital refractometer; pH in a pHmeter calibrated with standards 4.0 and 7.0; Titratable total acidity (TTA) (g tartaric acid/100 mL pulp) by titration with 0.1 N sodium hydroxide using phenolphthalein as an indicator and the ratio of total soluble solids to total titratable acidity (TSS/TTA).

In order to compare the 'Niágara Rosada' and 'Isabel' grapes quality in the three environments, the data for the evaluated variables were submitted to normality tests (Lilliefors) and homoscedasticity (Bartlett), hypothesis for the validation of variance analysis (THE NEW). All variables obeyed the hypothesis and therefore were subjected to analysis of variance, considering the main effects and their interaction in the plot and subplot. Statistical analysis was performed using the Tukey test ($p \leq 0.05$).

RESULTS AND DISCUSSION

By means of ANOVA, no significant differences were observed for the total soluble solids (TSS) variable for the two cultivars in the three environments. For the titratable total acidity (TTA) variable, all factors and interactions analyzed were significant by the F test ($p \leq 0.05$). Table 2 presents the results of the interaction between the environments versus cultivars for the TTA variable, using the Tukey test.

When analyzing the cultivars individually, it was verified that the 'Niágara Rosada' cultivar in environment 3 (650 m) did not differ significantly in environment 1. Similarly, in environment 1 (250 m) did not differ from environment 2 (500 m). The highest acidity was obtained when 'Niágara Rosada' was grown in environment 3 (0.78 g of tartaric

Table 2: Titratable total acidity (TFA), expressed as g tartaric acid/100 mL of pulp, in grapes berries of 'Niágara Rosada' and 'Isabel' cultivars in three environments

TFA (g tartaric acid/100 mL of pulp)		
	N. rosada	Isabel
A1	0,66abB	1,32aA
A2	0,50bB	0,87bA
A3	0,78aB	1,36aA

The averages followed by the same letter, uppercase and lowercase in the column do not differ by Tukey test ($p \leq 0.05$)

acid/100 mL of pulp), followed by environment 1 (0.66 g of tartaric acid/100 mL of pulp) and environment 2 (0.50 g of tartaric acid/100 mL of pulp), respectively (Table 02). There was no significant difference between environments 1 and 3.

For the 'Isabel' cultivar, TTA in environment 1 (1.32 g of tartaric acid/100 mL of pulp) and 3 (1.36 g of tartaric acid/100 mL of pulp) showed no significant difference between them. Both environments produced grapes with higher acidity than environment 2 (0.87 g of tartaric acid/100 mL of pulp) (Table 02).

Acidity values close to this study for 'Isabel' and 'Niágara Rosada' cultivars were found by other authors. Oliveira (2014) studied the 'Isabel' Precoce grape quality in Mossoró-RS and TTA had a value of 1.33 g of tartaric acid/100 mL of pulp in the spring-summer period. Assis et al. (2011) studied the maturation evolution and physicochemical and productive characteristics of 'Isabel' grapevine and obtained TTA of 0.80 g of tartaric acid/100 mL of pulp in Rolândia-PR. Abreu et al. (2017) evaluating the productivity and fruit quality of the 'Isabel' grapevine obtained TTA values ranging from 0.83 to 0.99 g of tartaric acid/100 mL of pulp in the winter. Sanchez-Rodriguez et al. (2016) when analyzing the physiology and production of 'Niágara Rosada' grapevine in the region of Piracicaba-SP obtained TTA values of 0.50 g of tartaric acid/100 mL of pulp.

Table 2 shows that the highest TTA values were obtained in 'Isabel' cultivar. It is believed that this result may be associated with the characteristics of the cultivar itself and the harvest season in the region. It was observed during the study, that 'Isabel' grape has a maturation time greater than the 'Niágara Rosada', probably due to having greater vegetative and reproductive cycle. However, due to market demand, producers often harvest 'Isabel' grapes at the same time as 'Niágara Rosada', which has a slightly shorter life cycle compared to 'Isabel' grapes. Therefore, knowing that as the grape matures, there is a tendency to increase soluble solids content and acidity decrease (Rombaldi et al., 2004), and most likely 'Isabel' grape will have a lower TSS value and higher value of TTA compared to 'Niágara Rosada'.

It can be seen in Table 02 that for both 'Niágara Rosada' and 'Isabel', the highest TTA values were found in environments 1 and 3.

The altitude is also well considered when choosing an area for grape production, since this factor directly influences the characteristics of grapes and wines (Falcão et al., 2007). According to Rizzon & Miele (2003) the climate influenced the sugar/acid, TTA and phenolic compound contents of grapes, among other factors, noted haversted.

It is noteworthy that the highest temperature is responsible for the attenuation of malic acid and the acidity of the wort (Brighenti et al., 2015). Thus, it was expected that the lowest TTA values would be found in environment 1, since it is located at the lowest altitude. The highest values of acidity in environment 1 can be related to the excess of leaf N, verified through Table 01, where the values of leaf N in environment 1 for both cultivars are in excess and slight excess, respectively (Terra, 2003). The excess of leaf N makes the vine very vigorous, prolonging the period of vegetative growth and delaying the fruit ripening (HILBERT et al., 2003). Bunches that are exposed to the sun has a decisive influence on the composition and maturation of the grape (Almeida & Ono, 2017) and it anticipates the maturation process as a whole, especially the accumulation of sugars (Jackson, 2000) and consequently a decrease in TTA, shading caused by the high vegetative vigor resulting from the excess of N in environment 1 was probably responsible for the highest TTA values found. In this study, the results of the experiments were carried out in several wine growing regions, showing that slightly deflating the bunches at different phenological stages (Hunter et al., 1995) increases the TSS content and decreases TTA, pH and potassium. This is due to eliminating old and shaded leaves, which contribute little or nothing to the sugar synthesis (Poni et al., 2005). In addition, vegetative canopy management allows greater sunshine and aeration of the vineyard, favoring the microclimate close to the leaves and fruits and increasing their quality (Manfroi et al., 1997).

It is believed that the climatic conditions of environment 2 favored the decrease in TTA in the two cultivars compared to environment 3 (650 m), probably due to the higher temperatures during the cycle. Since, environment 2 is located at a lower altitude (500 m), it presents maximum and minimum temperatures slightly higher than the environment 3. These higher temperatures contribute decisively to greater degradation of the malic acid of the berries (Conde et al., 2007), contributing in the decrease of the acidity.

However, the higher acidity in environment 3 may be related to lower mean temperatures at this altitude.

Probably, the lower average temperature in the maturation period did not favor in the decrease of TTA of the wort, by the combustion of malic acid, through cellular respiration, causing greater acid accumulations in the berry. Regina et al. (2010) studying the influence of altitude on the quality of 'Chardonnay' and 'Pinot Noir' grapes in Minas Gerais, found lower TTA values in grapes cultivated at a lower altitude. Brighenti et al. (2015) while comparing between two wine-growing regions at different altitudes obtained higher TTA levels when vines were cultivated at a higher altitude.

Regarding the pH variable and TSS/TTA ratio, it was verified by ANOVA that there was no significance for the interactions analyzed by the F test ($p \leq 0.05$). Thus, the independent factors were analyzed, where the results of the cultivars and environments are presented in Tables 3 and 4, respectively.

In Table 3, it is observed that the 'Niágara Rosada' cultivar presented higher pH than the 'Isabel' cultivar. The pH value obtained was dependent on the TTA concentration. The 'Isabel' cultivar reached higher TTA values, as discussed above, and consequently lower pH values, since TTA and pH are inversely related. Thus, as for the TTA variable, this result may be due to the cultivar characteristics and the harvest season in the region. According to Magalhães (2008), the values obtained for the pH in the final phase of maturation are between 3 and 4. In this study, the two cultivars presented values within this range.

According to the results of Table 4, for the pH variable in the three environments, environment 2 differed statistically from the others, reaching the highest pH values. This result is again lead to a lower TTA of the wort obtained in this environment.

In the TTA variable, the lower pH value obtained in the environment 3 may be associated with the lower average temperatures in the environment. The pH is directly related

Table 3: pH and TSS/TTA ratio obtained in 'Niágara Rosada' and 'Isabel' in the state of Espírito Santo

Variable	N. rosada	Isabel
pH	3,97a	3,49b
TSS/TTA	20,83a	11,24b

The averages followed by the same lowercase letter in the row do not differ by Tukey test ($p \leq 0.05$)

Table 4: pH and ratio of TSS/TTA obtained in grapes in three environments in the state of Espírito Santo

Variable	A1	A2	A3
pH	3,73b	3,86a	3,60c
TSS/TTA	14,00b	20,62a	13,48b

Means followed by the same lowercase letter in the line do not differ by Tukey test ($p \leq 0.05$)

to TTA and the lower mean temperature did not favor in decrease of TTA of the wort, by the combustion of malic acid, through cellular respiration which caused greater acid accumulations in the berry and, consequently, caused lower pH values in the grapes cultivated in lower altitude regions. Brighenti et al. (2015) found lower pH values in grapes grown in higher altitude regions. Regina et al. (2010) obtained lower pH values in the higher altitude region for 'Chardonnay' and 'Pinot Noir' cultivars in Minas Gerais.

It is observed in Table 4 that in environment 2 the value of the STT/TTA ratio was significantly higher than those observed in environments 1 and 3 (these did not differ from each other). This result was already expected, since in environment 2 the lowest values of TTA were found.

The relationship between TSS/TTA in 'Niágara Rosada' cultivar differed statistically from 'Isabel' cultivar (Table 3). The lowest relation between TSS and TTA found for 'Isabel' cultivar is related to the higher TTA values, since the TSS content was not significant by the F test. Brazilian legislation establishes the limits of the TSS/TTA ratio between 15 and 45 which would be the maturation index (Brasil, 2000). Thus, it is observed that only 'Niágara Rosada' presents STT/TTA ratio within the ranges established as adequate.

Ratio values of STT/TTA higher than this study for 'Isabel' cultivar were found by Assis et al. (2011) and by Abreu et al. (2017), with mean values of 19.20 and 16.27, respectively. However, for 'Niágara Rosada', values of TSS/TTA ratio higher than this study were found in literature. Vedoato (2016) studied the production, physicochemical quality and antioxidant activity of 'Niágara Rosada' grapes in different rootstocks obtained values of TSS/TTA ratio of 34.50 in 2014.

CONCLUSION

The quality of the 'Niágara Rosada' and 'Isabel' grapes produced in the state of Espírito Santo were influenced by altitude, and the altitude of 650 m favored to obtain higher values of total titratable acidity and lower values of pH. The excess of leaf nitrogen in environment 1 contributed to the higher values of ATT and lower pH for the cultivars Niagara Rosada and Isabel.

Authors' Contributions

Authors 1 and 2 designed the study, managed the writing of the manuscript and performed the statistical analysis. Authors 3, 4 and 6 performed the evaluations of the parameters analyzed in the study. The author 5 managed the bibliographic searches. All authors read and approved the final manuscript.

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