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Increased bud load of the 'Cabernet Franc' grapevine influences the physical-chemical composition of the wine

Aumento da carga de gemas da videira 'Cabernet Franc' e sua influência sobre a composição físico-química do vinho

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RESUMO

O objetivo deste trabalho foi avaliar o efeito do aumento da carga de gemas sobre a qualidade físico-química dos vinhos elaborados com uvas 'Cabernet Franc' cultivadas em região de altitude de Santa Catarina. O presente trabalho foi conduzido durante a safra 2016/2017, em um vinhedo comercial, localizado no munícipio de São Joaquim. Os tratamentos consistiram em quatros níveis de poda: 15, 30, 50 e 75 gemas planta. Após seis meses do processo de elaboração, as amostras de vinho foram analisadas em triplicata quanto a acidez total (g L^{-1}), açúcares redutores (g L^{-1}), teor alcoólico (%), densidade relativa, extrato seco (g L^{-1}), cinzas (g L^{-1}), pH, glicerol (g L^{-1}), índice de polifenóis totais (IPT), antocianinas (mg L^{-1}), intensidade de cor (420 + 520 + 620 nm) e tonalidade de cor (420/520nm). O aumento da carga de gemas resultou em vinhos com maiores teores de glicerol, acidez total, e pH. As cargas de 30 e 50 gemas planta resultaram em valores superiores de cinzas e extrato seco. O aumento da carga de gemas, acima de 50 gemas planta, resultou em redução do índice de polifenóis totais dos vinhos. Os maiores valores de intensidade de cor e tonalidade de cor foram observados em cargas de 30 e 50 gemas planta.

PALAVRAS-CHAVE: *Vitis vinifera L.;* composição fenólica; glicerol; equilíbrio vegeto-produtivo.

ABSTRACT

The objective of this work is to evaluate the effect of increased bud load on the physicochemical quality of wines made from 'Cabernet Franc' grapes grown in the highland region of Santa Catarina. The present work was treated during the 2016/2017 harvest, in a commercial vineyard, located in the municipality of São Joaquim. The treatments consisted of four levels of pruning: 15, 30, 50 and 75 buds $plant^{-1}$. After six months of the elaboration process, the wine samples were obtained in triplicate regarding total acidity, reducing sugars, alcohol content, relative density, dry extract, ash, pH, glycerol, total polyphenol index (TPI), anthocyanins, color intensity and color tone. The increase in bud load results in wines with higher glycerol, total acidity, and pH contents. Loads of 30 and 50 buds $plant^{-1}$ resulted in higher ash and dry extract values. The increase in the bud load, above 50 buds $plant^{-1}$, resulted in a reduction in the total polyphenol index of the wines. The highest values of color intensity and color tone were observed in loads of 30 and 50 buds $plant^{-1}$.

KEYWORDS: *Vitis vinifera L.;* phenolic composition; glycerol; vegetative-productive balance.

The high-altitude region of Santa Catarina stands out for producing quality wines, as the area experiences a longer vegetative cycle, resulting in slower ripening and grapes with high oenological potential (BRIGHENTI et al. 2014, MALINOVSKI et al. 2016), and the Cabernet Franc variety demonstrates great potential in fine wine production (MARCON FILHO et al. 2015)

However, it is noteworthy that this region exhibits high levels of organic matter (MAFRA et al. 2011), high water availability (BEM et al. 2016), the predominance of the back support system associated with the graft port 'Paulsen 1103' (VIANNA et al. 2016), which can lead to excessive vegetative growth, reduction of gem fertility and productivity, as well as compromise the ripening of grapes (WÜRZ et al. 2017, WÜRZ et al. 2018).

To mitigate excessive vegetative growth and enhance productivity indices, as noted by WÜRZ et al. (2020) that increasing bud load is a viable management strategy, promoting greater branch and cluster development, leading to improved vegetative-productive balance, and is recommended as a practice to enhance productivity. According to MARCON FILHO et al. (2015) Understanding the vineyard's characteristics that favor wine quality is fundamental to proposing appropriate management techniques, and for RAJ KUMAR et al. (2017) to achieve vegetative-productive balance, it is essential to determine the optimal bud load per plant for each variety.

The number of gems that remain in the seedlings or spores after pruning will determine the size of the foliar area and the number of grape buds (WÜRZ et al. 2019), affecting the vegetative vigour and final composition of the grape for vinification (BINDON et al. 2008, O'DANIEL et al. 2012).

The literature provides information on the impact of increased bud load on grapevine agronomic performance; however, data on its effect on wine chemical and phenolic composition are scarce. This study aims to evaluate the influence of increased bud load on the physicochemical quality of wines produced from 'Cabernet Franc' grapes cultivated in São Joaquim, Santa Catarina.

This study was conducted during the 2016/2017 growing season in a commercial vineyard located in São Joaquim municipality (28°17'39" S, 49°55'56" W) at an elevation of 1,230 meters above sea level. The experimental design employed was a randomized block design with four blocks and five plants per block.

'Cabernet Franc' vines grafted onto 'Paulsen 1103' rootstock were used. The vineyard, established in 2004, features vines planted in north-south oriented rows with 3.0 x 1.5m spacing. The vines are trained on a vertical shoot positioning system, pruned to a double cordon at 1.2m height, and protected by anti-hail netting. Historically, the vineyard has experienced low yields (< 5 tons ha^{-1}).

The soils in the region are classified as Humic Cambisols, Lithic Neosols, and Haplic Nitosols, derived from rhyodacite and basalt bedrock (SANTOS et al. 2018). The region's climate is categorized as 'Cool, Cool Night, and Humid', with a Heliothermal Index of 1,714, an average annual rainfall of 1,621 mm, and an average annual relative humidity of 80% (TONIETTO & CARBONNEAU 2004).

The treatments comprised four distinct bud load levels. 15, 30, 50 e 75 gemas planta. At pruning time, 8, 15, and 25 spurs with two buds each were retained for the 15, 30, and 50 buds per plant treatments, respectively. For the 75 buds per plant treatment, 30 spurs with two buds each were retained, along with two canes containing 8 buds each. This latter treatment thus employed a mixed pruning system, incorporating both spurs and canes on the same plant.

The harvest was conducted on March 12, 2017, with 50 kg of grapes collected from each treatment for wine production. The microvinifications were carried out at the Enology Laboratory of the State University of Santa Catarina, in the municipality of Lages/SC and followed the adapted protocol of PSZCZOLKOWSKI & LECCO (2011) and MAKHOTKINA et al. (2013), described by WÜRZ et al. 2018

Following vinification, the wines were bottled in 375 ml containers and stored in a temperature-controlled room at 15°C. Six months after the winemaking process, the wine samples were analyzed in triplicate for total acidity ($g.L^{-1}$), reducing sugars ($g.L^{-1}$), alcohol content (%), relative density, dry extract ($g.L^{-1}$), ash ($g.L^{-1}$), pH, glycerol ($g.L^{-1}$), total polyphenol index (TPI) ($mg.L^{-1}$), anthocyanins ($mg.L^{-1}$), color intensity and color tone.

Total titratable acidity, pH, relative density, and alcohol content were determined according to the methodology proposed by the *Office International de la Vigne et du Vin* (OIV 2016). The anthocyanin content was quantified using spectrophotometric analysis as outlined by RIZZON (2010).

Color analysis was performed using spectrophotometry as outlined by RIZZON (2010). The extract was diluted 1:10 and analyzed spectrophotometrically at wavelengths of 420 nm, 520 nm, and 620 nm. The color was measured by the intensity and color tone parameters, obtained through the formulas: *Intensity = 420 nm + 520 nm + 620 nm and Tonality = 420/520 nm.*

The alcohol content was measured using an immersion refractometer, while reducing sugars were quantified following the method described by MEYER & LEYGUE-ALBA (1991). Dry extract was determined according to RIBÉREAU-GAYON & STONESTREET (1965), and ash content was obtained by incinerating 20 mL of wine in platinum crucibles at 530-550 °C (AMERINE & OUGH 1976). The total polyphenol index was determined using a method based on the wine's ultraviolet (UV) radiation absorption capacity at 280 nm (HARBERTSON & SPAYD 2006).

The data was submitted to analysis of variance (ANOVA) and compared using the Tukey test at a 5% probability of error.

Table 1 presents the impact of bud load on the chemical composition of wines produced from 'Cabernet Franc' grapevines. Regarding the chemical composition of wines, greater variability was observed in response to bud load per plant, highlighting that its effect on light, temperature, soil, water supply, nutrition, pathogens, growth regulators, and other factors are crucial for producing high-quality wine (DOWNEY et al. 2006).

It was observed that varying bud loads did not affect relative density, which remained constant at 0.990 across all four load intensities. Similarly, reducing sugar content ranged from 1.75 to 1.86 g L^{-1}, falling within the limits set by Brazilian legislation for dry wines (< 5 g L^{-1}). The alcohol content of wines produced from grapes harvested from vines pruned to 15 buds per plant was 12.0%, while other treatments yielded 12.4%, with no statistically significant differences among them. These values comply with Brazilian legislation, which stipulates a minimum of 8.6% v/v and a maximum of 14% v/v for table wines (BRASIL 2018).

According to GIOVANNINI & MANFROI (2009), when fermentation is complete, the density of the wines can vary between 0.993 and 0.996, with reducing sugars below 5g/L, thus indicating that the wines have completed their fermentation, thus indicating that the difference observed in alcohol content was influenced by the ripeness of the grapes subjected to different bud loads $plant^{-1}$.

Total acidity was affected by the different treatments, with an increase in bud load per plant resulting in higher acidity values. The lowest total acidity was observed in wines from the 15 buds per plant treatment, at 5.71 g L^{-1}, while plants subjected to a load of 75 buds per plant yielded wines with a total acidity of 5.94 g L^{-1}. It is noteworthy that the cold climate in these regions results in slower acid degradation, consequently leading to higher titratable acidity levels at harvest time (BRIGHENTI et al 2013). Para BONILLA et al. (2015) factors associated with excessive vigor influence high acidity levels and low concentrations of soluble solids and phenolic compounds.

For the dry extract variable, the lowest value (22.9 g L^{-1}) was observed in the treatment with 75 buds per plant, while higher values were recorded for intermediate treatments of 30 and 50 buds per plant, with 23.8 and 23.6 g L^{-1}, respectively.

Regarding ash content, the highest values were observed in the intermediate treatments of 30 and 50 buds per plant, with 1.78 and 1.81 g L^{-1}, respectively. The lowest value was found in the 15 buds per plant treatment, with 1.59 g L^{-1} of ash in the wine samples. According to Brazilian regulations (2018), the minimum ash content for red wines is set at 1.5 g/L^{-1}, indicating that the wine under study complies with the legally established quantity. According to BENDER et al. (2017), the ash content represents the inorganic matter present in wines.

Similar behavior was observed for the variable potassium content in the wines, with the lowest values for the 15 buds per plant treatment, with a value of 0.54 g L^{-1}, followed by the 75 buds per plant treatment, with a value of 0.63 g L^{-1}, and the highest values for the intermediate bud loads, with values of 0.68 and 0.69 g L^{-1}, for the 30 and 50 buds $plant^{-1}$ treatments, respectively.

Regarding the pH variable, the load of 15 buds showed the lowest value, at 3.27, while the other treatments did not differ, showing values of 3.35, 3.35 and 3.34 for the loads of 30, 50 and 75 buds $plant^{-1}$, respectively. According to BENDER et al. (2017) although pH is not regulated by Brazilian legislation, it plays a crucial role in determining flavor profiles and influencing the balance between free and combined SO_2. For optimal wine quality, the pH should be maintained between 3.10 and 3.60 (AMERINE & OUGH 1976).

Higher bud loads per vine were found to increase glycerol content in wines. While the treatment with 75 buds per plant resulted in a glycerol content of 9.00 g L^{-1}, treatments with 15, 30, and 50 buds per plant yielded glycerol values of 8.56, 8.66, and 8.88 g L^{-1}, respectively. This compound positively influences wine quality when present in concentrations exceeding the gustatory threshold of 5.2 g/L, contributing to the perception of sweetness (PERPETUINI et al. 2023). It is also believed that glycerol improves the overall balance between alcohol content, acidity, astringence and sweetness, thereby conferring a degree of softness and softness (GOOLD et al. 2017).

Table 1. Effect of bud load on the chemical composition of wines made with Cabernet Franc vine (*Vitis vinifera* L.) in a high altitude region of Santa Catarina. São Joaquim – SC, harvest 2017.

	Bud Load				CV
	15	30	50	75	(%)
Titulable Total Acidity (g L^{-1})	5.71 d	5.76 c	5,82 b	5,94 a	0,3
Residual Reducer Sugar (g L^{-1})	1,78 ns	1,76	1,86	1,75	8,7
Alcoholic content (%)	12,0 b	12.4 a	12.4 a	12.4 a	0,2
Density (g L^{-1})	0.990 ns	0.990	0.990	0.990	0,5
Dry Extract (g L^{-1})	23.4 b	23.8a	23.6 ab	22.9 c	0,6
Ash (g L^{-1})	1.59 c	1,78 a	1,81 a	1,65 b	1,4
pH	3,27 b	3,35a	3,35a	3,34 a	0,2
Glycerol (g L^{-1})	8.56 c	8.66 BC	8.88 ab	9,00 a	1,2

*Averages followed by the same letter, in the line, do not differ by Tukey test at 5% error probability. ns = not significant by variance analysis (ANOVA) at 5% error probability.

The total polyphenol index, expressed in mg L^{-1}, was higher in wines from grapes subjected to lower bud loads per plant during fruiting pruning. Values of 36.2 and 37.41 mg L^{-1} were observed for treatments with 15 and 30 buds per plant, respectively. In contrast, treatments with 50 and 75 buds per plant yielded lower total polyphenol indices of 34.95 mg L^{-1} and 32.80 mg L^{-1}, respectively (Table 2). Phenolic compounds are negatively correlated with vigor, according to CORTELL et al. (2005), due to the reduction of phenolic synthesis. In general, low yields are responsible for the higher accumulation of total polyphenols (CANON et al. 2014), which was observed in the present study, in which the increased load of plant gems, which enabled greater productivity, and denser vegetative sediment (WÜRZ et al. 2020), resulted in a lower index of total polyphenols in wines.

Regarding anthocyanin content, no statistically significant differences were observed among the various treatments evaluated. As far as anthocyanin content is concerned, reducing vigor tends to produce fruit with the highest anthocyanin content in grapevine berries (FILIPPETTI et al. 2013), however, modifying the canopy of Cabernet Franc vines did not affect this variable in the resulting wines.

Color intensity was highest in the 30 buds per plant treatment, with a value of 10.03, while the lowest value of 8.94 was observed in the 15 buds per plant treatment. Similar trends were observed for color hue, with the highest value (0.59) corresponding to 30 buds per plant and the lowest value (0.57) associated with 15 buds per plant.

Although Brazilian legislation does not mandate color parameters, this attribute remains one of the most crucial aspects of wine quality, as it directly influences the product's visual appeal. The color allows for speculation about the wine's age and potential flaws, and is typically the first aspect evaluated by wine consumers (OLIVEIRA et al. 2011).

When determining bud load per plant during fruiting pruning, prioritizing the plant's vegetative-productive balance is crucial, as this study's findings demonstrate that excessive bud loads (75 buds) or reduced bud loads (15 buds) per plant can negatively impact wine quality. Balancing optimal yield and quality is challenging, particularly in high-altitude regions where humid climates and fertile soils complicate growth management. However, unbalanced vines produce imbalanced musts, resulting in low-quality wine (JACKSON & LOMBARD 1993).

Based on the obtained results, it can be concluded that increasing bud load leads to wines with higher levels of glycerol, total acidity, and pH. As cargas de 30 e 50 gemas planta resultaram em valores superiores de cinzas e extrato seco. O aumento da carga de gemas, acima de 50 gemas planta, resultou em redução do índice de polifenóis totais dos vinhos. The highest values for color intensity, hue, and absorbance at 420, 520, and 620 nm were observed in plants with 30 and 50 buds.

Table 2. Effect of bud load on the content of total polyphenols, anthocyanins and chromatic variables of wines made with Cabernet Franc vine (Vitis vinifera L.) in a high altitude region of Santa Catarina. São Joaquim – SC, harvest 2017.

	Bud Load				CV
	15	30	50	75	(%)
IPT (mg L^{-1})	36,20 ab	37,41 a	34,95 b	32,80 c	2,6
Antocianins (mg L^{-1})	180,5 ns	175,5	179,9	181,2	6,9
Color intensity	8.94 c	10,03 a	9.16 BC	9.25 b	1,1
Tonality of Color	0.57 c	0,59 a	0,58 b	0,58 b	0,7

*Averages followed by the same letter, in the line, do not differ by Tukey test at 5% error probability. ns = not significant by variance analysis (ANOVA) at 5% error probability.

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