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Effects of pre- and post-veraison cluster thinning on Montepulciano and Cabernet Franc grape varieties in southern Brazil highlands

Raleio de cachos próximo ao 'véraison' nas variedades 'Montepulciano' e 'Cabernet Franc' em região de elevada altitude do sul do Brasil

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ABSTRACT

The objective of this study was to evaluate the effects of pre- and post-veraison cluster thinning on the physicochemical characteristics of Montepulciano and Cabernet Franc grape varieties grown in regions 900 m above sea level (ASL) in Santa Catarina, southern region of Brazil. The experiment was conducted in two commercial vineyards, Montepulciano vineyard located at 28º12'58"S, 50º06'45"W, 1,185 m ASL during the 2007, 2008 and 2009 vintages; and Cabernet Franc vineyard located at 28°15'20"S, 49°56'60"W, 1,284 m ASL, during the 2010 and 2011 vintages. Treatments consisted on cluster thinning at three distinct moments for both varieties: during veraison, about 15 days pre-veraison and 15 days post-veraison. For Montepulciano, when cluster thinning is performed post-veraison, there is a reduction in cluster mass and a slight reduction on the acidity of grapes. For Cabernet Franc, when cluster thinning is performed during veraison, there is an increase in total soluble solids of grapes. In general, cluster thinning is recommended two weeks pre- or post-veraison for Montepulciano and Cabernet Franc wine grapes produced in southern Brazilian highlands.

KEYWORDS: *Vitis vinifera* L., management, ripening, total polyphenols, altitude wines.

RESUMO

O presente trabalho teve como objetivo avaliar o efeito do raleio de cachos próximo ao 'véraison' sobre as características físico-químicas das variedades 'Montepulciano' e 'Cabernet Franc' cultivadas em regiões acima de 900m de altitude no estado de Santa Catarina, Sul do Brasil. Os ensaios foram conduzidos em vinhedos comerciais da variedade 'Montepulciano' coordenadas 28º12'58"S, 50º06'45"W, 1,185 m de altitude durante as safras 2007, 2008 e 2009; e da variedade 'Cabernet Franc' coordenadas 28°15'20"S, 49°56'60"W, 1,284 m de altitude durante as safras 2010 e 2011. Os tratamentos consistiram no raleio de cachos realizado em três momentos para ambas as variedades: Na 'véraison'', cerca de 15 dias antes da 'véraison' e 15 dias após 'véraison'. Para 'Montepulciano', quando o raleio de cachos é realizado após a 'véraison' há uma redução da massa do cacho, bem como uma redução na acidez das uvas. Para 'Cabernet Franc' quando o raleio de cachos é realizado durante a 'véraison' há um aumento no teor de sólidos solúveis. Em geral, o raleio de cachos pode ser indicado durante as duas semanas que antecedem ou sucedem a virada de cor das bagas para as variedades 'Montepulciano' e 'Cabernet Franc' produzidos nas regiões de altitude do sul do Brasil.

PALAVRAS-CHAVE: *Vitis vinifera* L.*,* manejo da planta, maturação da uva, polifenois totais, viticultura de altitude.

Regions located between latitudes 26º and 28ºS and altitudes between 950 m and 1,400 m above sea level (ASL) in southern Brazil have been acquiring great importance due to the high potential for wine production from *Vitis vinifera* L. varieties (GRIS et al. 2010, BRIGHENTI et al. 2013, MALINOVSKI et al. 2016). The knowledge and characterization of this region shows potential to produce high-quality wines,

however, considering that southern Brazilian highlands are an emerging wine-growing region, fundamental research on vineyard practices are needed.

Cluster thinning is the removal of a portion of the fruit cluster after fruit set (JACKSON 2008). This process aims to adjust the fruit load to the plant's productive capacity to establish a balance between the vegetative and reproductive parts of the vine (DAMI et al. 2006, FREDES et al. 2010). Trials conducted in Santa Catarina highlands, southern Brazil, with Malbec (SILVA et al. 2008) and Syrah (SILVA et al. 2009) wine grapes reported that reductions of crop load during veraison by cluster thinning resulted in the highest levels of anthocyanin in berries. Due to the great economic importance of phenolic compounds, which are an integral part of red wines, it is important to understand the interactions and variations of these compounds resulting from the management techniques applied to vineyards, fruit maturation and characteristics inherent to each grape wine variety (KENNEDY 2003).

The timing of cluster thinning can be important to modify grape composition (FANZONE et al. 2011). The period most commonly used to perform cluster thinning in wine grapes is during veraison (TARDÁGUILA & BERTAMINI 1993), which corresponds the beginning of the last growth phase of grapes, when the green color starts to fade and the pulp starts to soften (JACKSON 2008). However, this practice becomes onerous in large vineyards due to requiring a high concentration of workers in a short period.

In addition, the effect of level and time of cluster thinning must be studied in each wine-growing region, since literature reports contrasting results about cluster thinning leading to better grape quality in some cases (PALLIOTTI & CARTECHINI 2000, PRAJITNA et al. 2007) but with no clear effect in others (MOTA et al. 2010, FANZONE et al. 2011).

To improve scientific understanding about vineyard practices, this study aims to investigate the effect of different timing of cluster thinning, during, pre- and post-veraison, on the physicochemical characteristics of Montepulciano and Cabernet Franc grapes to guide appropriate management for red winemaking in southern Brazil highlands.

The experiment was conducted in two commercial *Vitis vinifera* L. vineyards located in Santa Catarina highlands, southern Brazil. First, the experiment was conducted in a commercial Montepulciano vineyard located at 28º12'58"S, 50º06'45"W, 1,185 m ASL during the 2007, 2008 and 2009 vintages. Montepulciano vines (grafted on Kobber 5BB) were planted in 2001, with 3.0 m (row) x 1.5 m (vine) spacing. Following, the experiment was conducted in a Cabernet Franc vineyard located at 28°15'20"S, 49°56'60"W, 1,284 m ASL, during the 2010 and 2011 vintages. Cabernet Franc vines (grafted on 1103 Paulsen) were planted in 2006 in a northwest to southeast row orientation, with 3.0 m (row) x 1.2 m (vine) spacing. Both varieties were trained in vertical shoot position using trellis system on a double cordon with spur pruning. For both varieties, spur pruning was conducted in the first week of August in all vintages. For Montepulciano grapevine, the harvest started according to the winery standards, on April 1, 2007; on March 28, 2008 and March 27, 2009; for Cabernet Franc grapevine, the harvest started on March 15, 2010 and March 20, 2011.

Treatments consisted on cluster thinning into three distinct times for both varieties: during veraison (V), about 15 days pre-veraison (Pre-V) and 15 days post-veraison (Post-V). Montepulciano crop load was standardized in 4.0 kg plant^{-1} or 9 t ha^{-1}; Cabernet Franc crop load was standardized in 3.0 kg plant^{-1} or 8 t ha^{-1}. Clusters were removed uniformly and at the end of the operation about one cluster per shoot remained. Crop reduction by cluster thinning was roughly 28% in yield per grapevine.

At harvest, five clusters and 100 berries were randomly collected per plot/treatment from different portions of the vine and both sides of the rows. The samples were immediately submitted to the following analysis: a) cluster mass (g); b) mass of 50 berries (g) c) berry size (mm), d) soluble solids (°Brix); e) titratable acidity (meq L^{-1}); f) pH. These analyses were determined by protocols of the International Organisation of Vine and Wine (OIV 2009).

For polyphenol and anthocyanin extraction of Montepulciano grapes, 50 berries without seeds were crushed, homogenized in ethanol (1:1; pH 2) and macerated for 10 min at 70 ºC. Extract were separated, homogenized and filtered using a Whatman Grade one filter paper (ILAND et al. 2004). Polyphenol index concentration was determined by spectrophotometry with absorbance at 280 nm wavelength (RIZZON 2010).

For polyphenol and anthocyanin extraction of Cabernet Franc grapes, 40 g of skins were weighed, homogenized in 16 ml of methanol (1:1), macerated for 24 hours at 30±0.5 °C and then washed with 4 ml methanol (1:1). A second extraction with the remains of the skins was made using the same methanol volume and time, at 0±0.5 °C. Both extracts were separated, homogenized and filtered using a Whatman Grade one filter paper. Total polyphenol concentration was determined by the spectrophotometry method described by SINGLETON & ROSSI (1965), using the Folin-Ciocalteu reagent, with absorbance at 760 nm

wavelength. Phenolic content was determined using a gallic acid calibration curve; results are expressed in mg L^{-1} gallic acid equivalents.

Quantification of total monomeric anthocyanin in both varieties was conducted by spectrophotometry, applying the pH-differential method (LEE et al. 2005), and results are expressed in mg L^{-1}.

The experimental design used were randomized blocks, with four blocks and ten plants per plot. Data was analyzed by the F test and Tukey's multiple range tests. Statistical significance was considered as $p< 0.05$.

Table 1 shows the results for physicochemical characteristics of Montepulciano grapes, considering the different timing of cluster thinning. Some parameters were affected by time of cluster thinning but with no clear effect in others.

Table 1. Physicochemical characteristics of Montepulciano grapes considering the different timing of cluster thinning: 15 days pre-veraison (Pre-V), during veraison (V) and 15 days post-veraison (Post-V) in southern Brazilian highlands. Vintages: 2007, 2008 and 2009.

Parameter	Vintage	Thinning timing			CV
		BV	V	AV	(%)
50 Berries mass (g)	2007	157.87 b	182.87 a	153.22 c	1.9
	2008	155.59 a	146.87 b	153.83 ab	4.2
	2009	155.58 ab	145.36 b	161.48 a	6.0
	Avg.	156.35 a	158.37 a	156.18 a	10.1
Cluster mass (g)	2007	310.64 a	309.13 a	249.89 b	8.2
	2008	266.93 a	219.12 b	226.71 b	10.5
	2009	171.53 b	280.35 a	171.01 b	9.8
	Avg.	249.71 a	269.53 a	215.87 b	10.5
Berry size (mm)	2007	16.46 b	17.21 a	16.44 b	3.5
	2008	15.73 a	15.76 a	15.73 a	3.0
	2009	16.18 b	17.06 a	16.22 b	3.7
	Avg.	16.12 a	16.68 a	16.13 a	5.9
Soluble solids (ºBrix)	2007	20.43 b	20.23 b	21.03 a	0.8
	2008	22.90 a	22.51 a	22.83 a	3.6
	2009	24.27 a	23.24 b	22.80 b	2.8
	Avg.	22.53 a	21.99 a	22.22 a	6.8
Acidity (meq L^{-1})	2007	92.23 a	88.40 b	91.12 a	2.5
	2008	86.36 a	93.37 a	74.8 b	7.4
	2009	88.47 b	93.23 a	89.84 b	4.2
	Avg.	89.02 ab	91.67 a	85.25 b	7.7
pH	2007	3.28 ab	3.32 a	3.21 b	2.5
	2008	3.57 a	3.56 a	3.62 a	2.7
	2009	3.63 a	3.62 a	3.60 a	2.7
	Avg.	3.49 a	3.50 a	3.48 a	14.3
Polyphenol index	2007	76.57 a	75.00 a	74.00 a	5.1
	2008	76.77 a	68.23 a	74.67 a	10.9
	2009	65.77 a	78.34 a	68.17 a	15.7
	Avg.	73.04 a	73.86 a	72.28 a	18.3
Anthocyanin (mg L^{-1})	2007	747.97 b	780.14 a	710.46 c	2.3
	2008	812.65 a	815.64 a	787.65 a	10.1
	2009	909.42 a	893.88 a	874.14 a	3.8
	Avg.	823.35 a	829.89 a	790.75 a	10.4

Different small letters in line show statistical differences by Tukey test ($p<0.05$).

No differences were observed for berry mass and size between treatments, considering the mean values of years. Post-veraison cluster thinning showed a reduction in cluster mass, and a slight reduction on the acidity of grapes. In general, the recommendation to produce high-quality red wines considers a total acidity value lower than 135 meq L^{-1} and pH lower than 3.5 (JACKSON 2014), and the recommended values were observed in both treatments. In red winemaking, the higher the skin/berry ratio, caused by lower values

of berry mass, berry size and cluster mass, the higher will be the grape potential to provide enological quality to the wines, because according to CONDE et al. (2007), desirable compounds, such as as anthocyanins and phenols, are located on the skin.

Commercial maturity (soluble solids, pH, polyphenol index and anthocyanin) were not affected by pre- or post-veraison cluster thinning on Montepulciano grapes. Differences observed for soluble solids at 2007 and 2009 vintages would not have a major impact on wine production from a practical view point. Similar results were found in a study with Sauvignon Blanc grapes, which found that grape composition was not influenced by pre- and post-veraison cluster thinning (KOK 2011). Furthermore, for Chardonnay and Vidal Blanc varieties, total soluble solids in juice did not differ due to time of cluster thinning, regardless of being right after bloom or immediately before veraison (FERREE et al. 2003).

For Montepulciano grapes, pre- or post-veraison cluster thinning hardly affects the chemical characteristics of berries. This can allow winemakers to enlarge the time to perform cluster thinning, since the veraison corresponds to a short time of change in the maturation of berries (JACKSON 2008); thus. Improving the management of labor in vineyards and reducing costs.

Table 2 shows the effect of different timing of cluster thinning on physicochemical characteristics of Cabernet Franc.

Table 2**.** Physicochemical characteristics of 'Cabernet Franc' grapes considering the different timing of cluster thinning: 15 days pre-veraison (Pre-V)', during veraison (V) and 15 days post-veraison (Post-V) in southern Brazilian highlands. Vintages: 2010 and 2011.

Parameter	Vintage	Thinning timing			CV
		BV	V	AV	(%)
50 Berries mass (g)	2010	87.16 a	81.24 b	86.61 a	1.9
	2011	62.80 b	65.80 a	67.80 a	1.7
Cluster mass (g)	2010	145.38 a	119.45 a	126.60 a	11.4
	2011	202.18 a	147.33 b	152.53 b	2.4
Berry size (mm)	2010	13.09 a	12.96 a	13.15 a	3.0
	2011	13.00 a	13.10 a	13.50 a	2.0
Soluble Solids (ºBrix)	2010	19.10 b	21.00 a	18.00 b	4.8
	2011	20.40 c	21.60 a	20.80 b	0.8
Acidity (meq L^{-1})	2010	75.00 b	84.10 a	68.90 c	7.0
	2011	93.60 a	99.00 a	90.60 a	4.5
pH	2010	3.84 a	3.72 a	3.79 a	1.8
	2011	3.30 a	3.25 a	3.30 a	1.0
Polyphenol (mg L^{-1})	2010	4780.10 a	4740.60 a	5263.50 a	4.5
	2011	3953.30 a	4130.30 a	4314.00 a	10.9
Anthocyanin (mg L^{-1})	2010	432.70 a	533.50 a	546.70 a	11.7
	2011	741.30 b	816.50 a	735.20 b	2.7

Different small letters in line show statistical differences by Tukey test ($p<0.05$).

For Cabernet Franc, an increase in cluster mass was found for pre-veraison cluster thinning. Berry size, pH and total polyphenol parameters were not influenced by cluster thinning for both vintages. The same was observed for cluster mass and anthocyanin for the 2010 vintage, and for acidity for the 2011 vintage. Berry size, pH, acidity and polyphenols are important to evaluate the production of grapes into high-quality wine. Therefore, no differences observed on these parameters would suggest that the window to accomplish cluster thinning might be wider than previously investigated (TARDÁGUILA & BERTAMINI 1993).

When cluster thinning is performed during veraison, there is an increase in total soluble solids in grapes. Considering this parameter, pre- and post-veraison cluster thinning are not indicated for Cabernet Franc grapes produced in southern Brazilian highlands. Cluster thinning influences the source/sink ratio, by having fewer sinks (fruits), the photosynthetic assimilation may improve, increasing soluble solids (REYNOLDS et al. 1994). A report comparing cluster thinning time on Vidal Blanc grapes found positive effects on fruit quality when cluster thinning was performed over the growing season, i.e., pre-veraison (FERREE et al. 2010).

The results from this study show that post-veraison cluster thinning reduces cluster mass of both grape varieties, suggesting compensation with increase in cluster weight in plants subjected to early cluster removal.

When performing pre-veraison cluster thinning, it was reported that the vines compensated by increasing the number of berries set, as well as increases in berry and bunch mass, resulting in a smaller reduction in yields (KLIEWER et al. 1983, FERREE et al. 2003). Maximum crop reduction is obtained when performing post-veraison, since berry set has been completed by this stage and cell division and growth have ended (VAN SCHALKWYK et al. 1995).

Post-veraison cluster thinning reduces cluster the mass of Montepulciano and Cabernet Franc grapes.

In general, cluster thinning can be performed over the two weeks that precede or succeed veraison without significant losses to the commercial maturity of Montepulciano and Cabernet Franc grapes in southern Brazilian highlands; therefore, vineyards have an extended period to perform cluster thinning, optimizing the use of the labor force.

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