Effect of certain bentonite products on the temporal variation of elemental content in white wine

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Summary: The 'terroir' character of wines can be shaped with certain technological elements such as bentonite fining. Bentonite is an agent used for the removal of thermolabile proteins in wines. However, during fining, the quantity of certain wine components can change, including the elemental composition of the wine. According to the recommendations of bentonite suppliers, wines should be racked off the bentonite fining sediment within 2-3 weeks. However, in winemaking practice, wines can remain on bentonite fining sediment for up to 1-4 months. One reason for this is that racking wines off the sediment has a negative impact on wine quality. Thus, it is a question of how much the later or earlier racking time can alter the elemental content of the wine. Our study aimed to examine the elemental content of wines treated with three different bentonite products sampled from over the bentonite fining sediment at various time points. Our investigation was conducted with the 2019 vintage white wine of the University of Debrecen. Fining was performed with three bentonite products: Nucleobent, BW200, and Granubent Poretec. The sampling schedule following fining was: 0 days - unfined control, 7th, 14th, 27th, 56th, and 85th days. The macro-, meso-, and microelement contents (P, K, Ca, Mg, S, Al, Na, B, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba, and Pb) of the wines were determined using ICP OES and ICP MS devices. Our results showed significant changes in the Al, Na, Cr, Fe, Co, Ni, Sr, Ba, Cu, and Pb contents of the wines depending on the sampling time. It is noteworthy that all three bentonite products increased the Al and Pb contents of the wines. For Fe, dynamic increases were observed over time with the BW200 product, reaching the threshold value of susceptibility to brakeage. However, from a winemaking technology perspective, it was favorable for the Cu content of the wines to decrease with both earlier and later racking times, for all bentonite products examined. Based on the elemental analyzes of the white wines studied, it can be concluded that racking of wines should be timed according to the recommendations of suppliers.

Key words: white wine, bentonite, elemental content, wine fining timing

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Introduction

A key concept in the quality assessment of wines is 'terroir', the complex meaning of which is captured in the definition of the International Directorate of Viticulture and Enology, as follows: 'The concept of viticultural 'terroir' refers to an area where the collective knowledge of the interactions between the identifiable physical and biological environment and the applied viticultural practices confer unique characteristics on the products originating from this area. 'Terroir' includes specific soil, topographic, climatic and site characteristics, as well as biodiversity characteristics (Castellucci, 2010).

Most often, 'terroir' is associated with the verification of the place of origin of wines and is mainly discussed in relation to the agrogeological origin of the area (Erdei et al., 1985; Ozden et al., 2010). The 'minerality' of wines and 'terroir' are strongly linked, which is why the verification of the origin of wines is often determined in terms of elemental content profiles, which is supported by the fact that the roots of the grape can penetrate up to 15-20 m deep (Kozma, 2000; Keller, 2020), and the crop does indeed carry the characteristics of nutrient uptake. However, it cannot be ignored that numerous environmental, cultivation (Erdei et al., 1985; Ozden et al., 2010) and oenological technological factors (Kment et al., 2005; Lara et al., 2005) influence the elemental composition of wines (Díaz et al., 2003; Eschnauer, 1982; Lara et al., 2005; McKinnon, 1997; Pohl, 2007; Sauvage, Frank et al., 2002). According to

this simplified approximation, the 'terroir' character of wines can be shaped by numerous technological elements, oenological treatments and agent materials. This means that we would have tools to control and adjust the style of wines to a certain extent. One such oenological technological element is the bentonite fining of wines.

Bentonite is an agent material used to remove thermolabile proteins from wines, which allows the safe distribution and storage of wines without precipitation (Saywell, 1934). Most of these proteins have a positive charge in the pH range of wine (2.8-3.5), so these proteins form a precipitate with the negatively charged particles of the hydrated bentonite composition (predominantly montmorillonite: Al_2O_3-$4SiO_2$-H_2O) during clarification (Horvat et al., 2019). The composition is hydrated before use, during which the silicate layers open and the binding sites are activated. During activation, cations are exchanged: typically Na, Ca, Mg and other metal ions are exchanged. During the process, the negative surface charge binds positively charged particles and metal ions (Horvat et al., 2019; Reynolds, 2010). Some previous studies report that phenolic components and indirectly aroma components may also undergo changes during clarification (Miller, et al., 1985; Moio et al., 2004; Lambri et al., 2010; Voilley et al., 1990). The measured effects indicate that the origin and 'terroir' character of wines may undergo

wine component changes due to bentonite treatment. Several sources also highlight that bentonite treatment changes the elemental composition of wines, such as Na, Al and Ca content (Díaz et al., 2003; Lara et al., 2005; McKinnon, 1997; Pohl, 2007; Sauvage et al., 2002) as well as Fe, Sr and Ba content (Rakonczás et al., 2020, 2023). However, studies also point out that since bentonite is a mining product, its characteristics largely depend on the location, depth and time of extraction (Catarino et al., 2008; Dordoni et al., 2015; Reynolds, 2010), which can of course result in product-specific changes in wines during clarification.

Benonite distributors recommend that the wine be racked off the sediment within 2-3 weeks of bentonite fining. However, many winemakers assume that the presence of bentonite in the wine is indifferent – as stated by distributors - so the wine remains on the bentonite fining sediment for 1-4 months. This is supported by the fact that racking itself has a negative impact on the quality of the wine, as racking exposes it to great physical stress. The complexity of this question also encompass factors of sharing capacities, cost of labour work, energy and water loss.

The question arises as to what extent the racking the wine from over the sediment earlier or later can change the elemental content of the wine.

In connection with the above, the aim of our present trial was to examine the macro-, meso-, and microelement content of wine treated with three bentonite products - samples taken from over the bentonite sediment - at five different times.

Materials and methods

The raw material for the wine used in the experiment was provided by the regional historical grape gene bank located at the Pallagi Horticultural Experimental Farm of the University of Debrecen, Institute of Agricultural Economics and Landscape Research.(47°35'20" / 21°38'23"; altitude: 128m) in 2019. Grape varieties and their proportions: 'Vállas erdei' (50%); 'Piros gohér' (30%), 'Kübeli' (10%) and 'Szlankamenka' (10%). We did not use cooling or sulphurisation prior to grape processing. The crushing and destemming were not followed by soaking. Afterwards, the juice was extracted using a traditional vertical basket press, during which we performed only one pomace loosening, thus the juice extraction was carried out with low pressure. Stabile fermentation of the must started within 2 days in an environment of 15-20 °C without any inoculation. At this phase the must in fermentation was placed into a cooling chamber at 10-12 °C. The fermentation took place without any disturbances within a month, and then we racked it with open racking under 50 mg/l sulphurisation. The resulting 2019 vintage dry white wine was neutral in terms of aromas, had a medium alcohol content (10% v/v), and a pH of 3.2. Similar to the wine in our previous experiment (Rakonczás et al., 2023).

The bentonite clarification was set up on July 14, 2020 at 12 °C. The clarification was performed with 3 bentonite products (Nucleobent, BW200, and Granubent Poretec) taking into account the recommended dosage values, using a medium dose (*Table 1*). The applied products were the same lots as in our previous trial (Rakonczás et al., 2023).

To carry out the treatments, 25 litres of the starting wine were poured into a 30-liter plastic barrel. The prepared bentonite preparations added to it were intensively mixed with a mixing rod drill for 30 seconds. After the foam formed

collapsed, the treated wines were poured into a 15-liter glass flask with the addition of 10 mg/l SO_2 solution (InterkerWein). The treated wines were then stored in a 12 °C chamber for three months.

Timing of elemental sampling of the treated wine: 0) unclarified control (day 0); 1) 1 week (day 7); 2) 2 weeks (day 14); 3) 1 month (day 27); 4) 2 months (day 56); 5) 3 months (day 85) (*Table 2*).

Table 1. Characteristics of the bentonite preparations tested in the experiment.

Product name	Composition	Dosage (g/hl)		Manufacturer
		applied	recommended*	
Granubent Poretec	Na-bentonite	60	20-150	ERBSLÖH, D
BW 200	Na-bentonite	80	40-120	Sud-Chemie, D
Nucleobent	Na-bentonite	30	20-40	Ever, Italy

* as defined by the distributor

Table 2. Timing of sampling of the examined white wine from over the bentonite sediment at five different times with a control sampling on day zero.

Sampling dates (day)	Sampling date
Control (day 0)	July 14, 2020
1 week later (day 7)	July 22, 2020
2 weeks later (day 14)	July 29, 2020
1 month later (day 27)	August 11, 2020
2 months later (day 56)	September 10, 2020
3 months later (day 85)	October 10, 2020

The elemental content of the wine treated with the three bentonite products was expressed in mg/L for macro- and meso-elements (P, K, Ca, Mg, S, Al, Na and B), while for microelements (Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba and Pb) in µg/L. The elemental content was determined using ICP OES and ICP MS in the same way as described in our previous publications (Rakonczás et al., 2020, 2023). The elemental content determination method was briefly as follows. Before analysis, the wine samples were diluted tenfold with 5 (m/V) % nitric acid (VWR International Ltd., Debrecen, Hungary) in Milli-Q® type-1 quality deionized water. Three replicates of each sample were analyzed. Analyses were performed using an iCAP 6300 ICP-OES instrument equipped with a CETAC ASX-520 autosampler and a Meinhard-type concentric nebulizer (Thermo Fischer Scientific, Cambridge, UK). External calibration was used to determine elemental quantities.

During the statistical evaluation of the data, significant differences between the 5 sampling times for each bentonite preparation and element were determined at a SZD 5% probability level using the SPSS statistical program (SPSS Inc., Chicago, IL, USA).

Results and discussion

Among the elements tested, there was no significant difference between the 5 sampling times for K, P, S, Mg, Ca and Na in any of the preparations at the 5% probability level (*Table 3*). Although no significant difference was detected at the 5% probability level, the K content showed a decreasing trend as the sampling time progressed compared to the control. It can be highlighted that in the case of Ca, the BW200 product showed an increase of over 10% compared to the control, although this was also not significant at the 5% probability level.

Na showed constant values in the individual bentonite treatments, however, compared to the control, Nucleobent showed an increase of 15%, Granubent Poretec showed an increase of 27%, while BW200 showed an increase of 62%, and the latter represented a significant difference compared to the control.

In the case of Fe, all three products showed significant differences depending on the sampling time (**Table 4**). The most significant increase in Fe levels was observed in the BW200 product in the wine samples over time (range 3.59-5.07 mg l^{-1}). Fe is an important microelement in winemaking technology: a level of 2-3 mg l^{-1} is still considered safe, however, above 4-5 mg l^{-1}, black or gray braking may appear due to ferri-tannate and ferric phosphate precipitation (Kállay, 2010). Our data confirm that keeping the wine ower the BW200 clarification sediment for a longer period of time can lead to breakage of the wine.

The Al content of the wine showed a 50% increase in the first week after all three bentonite treatments and a further dynamic increase was observed as time progressed (**Table 4**). These increases were statistically verifiable at the 5% probability level for most sampling times.

The Mn content of the tested wine showed significant differences at certain sampling times for all three preparations (range: 1.03-1.40 mg l^{-1}, **Table 4**). The typical level of Mn in wines is 1-2 mg l^{-1}, but can vary between 0.5-4 mg l^{-1} (Kállai, 2010). It is a significant element from the point of view of the life processes of wine, as it plays a significant role in both protein and carbohydrate metabolism, so its level is not limited by the food industry (Kállai, 2010).

The Sr content of the wine showed significant differences at some sampling times for all three products (range: 234-295 mg l^{-1}, **Table 4**). A significant increase was observed for all three preparations compared to the control values.

The Zn content in wines varies from 0.1 to 5 mg l^{-1}, and values above 5 mg l^{-1} appear as toxic heavy metals in wines (Kállay, 2010). In our results, the Zn content varied in a wide range (80-672 µg l^{-1}) and the Zn content of the tested wine showed significant differences at certain sampling times in respect to the products. The outlier (672 µg l^{-1}) was shown by the 2-month sample of the BW200, which can be considered as contamination.

The Ba content of the tested wine showed a significant difference between the individual sampling times only in the case of the BW 200 product. Ba showed constant values in the individual bentonite treatments, however, compared to the control, BW200 showed a 27% increase, Nucleobent: 90% and Granubent Poretec: 125% increase, i.e. all three products showed a significant increase compared to the control regardless of the test times. It should be noted that the values measured in our sample are below the health limit value (1ppm), i.e. they can still be considered safe (Anon, 2024).

The Pb content of the tested wine showed significant differences at some sampling times for all three products (range: 12-21 µg l^{-1}, **Table 5**). The Pb concentration increased in the first week compared to the control treatment (12 µg l^{-1}) for all three bentonites (BW200 – by 42%, Nucleobent – by 52%, Granubent Poretec – by 25%). The maximum Pb values exceeded the control treatment value by 77.5%, 68% and 31% for BW200, Nucleobent and Granubent Poretec respectively. The corresponding Pb values were significantly higher compared to the control treatment values.

The Ni content of the tested wine showed a significant difference between the individual sampling times only in the case of the BW 200 product. The Ni concentration can be considered neutral in the case of the Nucleobent and Granubent Poretec products with regard to clarifications. In the case of BW200, the values at months 1, 2 and 3 are significantly higher than the value of the control treatment.

The Cu concentration of the tested wine decreased by almost 80% in the first week compared to the control treatment (9.42 µg l^{-1}) as a result of bentonite treatments and remained at a low level until the end of 3 months (**Table 5**). This is favourable from an oenological point of view, due to the reduction of the tendency of wine breakage. Due to the use of copper-containing agents used in the grapevine, the grapevine can contribute up to 20-30 µg l^{-1} of copper to the winemaking technology. After reduction and sedimentation during fermentation, its typical level is below 1 µg l^{-1} (Kállay, 2010).

The Cr concentration of the tested wine did not show a significant increase compared to the control values for any of the products. However, the BW200 and Nucleobent showed a significant difference between the individual sampling times (**Table 5**).

The amount of Co in the tested wine shows a 39.5% increase in the case of the BW200 product in the first week after treatment compared to the untreated control, and this increase is noticeable until the end of the second month (**Table 5**). The other two fining agents do not show a significant increase in Co.

In the tested wine, the B and Cd content did not show a significant difference in the case of any of the products at the individual sampling times (**Tables 4-5**). The B content does not differ significantly compared to the values of the control treatment (2.96 µg l^{-1}). In the case of Cd content, Granubent Poretec showed a 100% increase in the 3rd month sampling compared to the value of the control treatment (0.32 µg l^{-1}), with a significant standard deviation.

Conclusions

The aim of this work was to demonstrate the macro-, meso-, and microelement content of three bentonite-treated wines left over the bentonite fining sediment sampled at five different times. From an elemental content perspective, we examined whether it is worth following the technological recommendation and racking the wine from over the bentonite fining sediment within two weeks, or whether it can be left on until the next reasonable finishing treatment operation.

The following should be noted regarding the three bentonite products in this trial:

1. All three bentonite products increased the Al content of wines. The most prominent was the BW200 product, but a linear increase was observed with all three products as a function of time.

2. In the case of Fe, we observed a dynamic increase in the BW200 product over time, at which point the wine reached the limit of its tendency to break. This means that leaving the wine over the bentonite fining sediment can be a source of this technological error. From this point, earlier racking is recommended. However, this scenario seems to be product specific. Nucleobent and Granubent products eventuated time neutral character.

3. The increase in Pb in the tested wine sample was also significant compared to the control in all three products. In the case of leaving the wine over the bentonite sediment, an unfavourable increase in Pb levels is to be expected (from about +25-40% to +30-60%). Thus, from

Table 3. Changes in the K, P, S, Mg, Ca, and Na content of white wine fined with three bentonite products (BW 200, Nucleobent, Granubent Poretec) as a function of six sampling times (days 0, 7, 14, 27, 56, and 85) (mg l^{-1}, Debrecen, 2020).

	K	P	S	Mg	Ca	Na
Day 0	**931.80**	**155.43**	**157.70**	**66.76**	**56.07**	**26.14**
	±37.55	*±1.41*	*±44.12*	*±13.02*	*±7.76*	*±0.54*
BW 200						
Day 7	**908.40**	**150.03**	**106.30**	**66.72**	**62.57**	**42.05**
	±28.07	*±0.42*	*±23.48*	*±13.23*	*±9.56*	*±0.86*
Day 14	**918.25**	**152.43**	**109.78**	**67.36**	**62.91**	**42.73**
	±13.58	*±0.00*	*±26.33*	*±14.26*	*±9.81*	*±1.10*
Day 27	**927.20**	**151.58**	**109.88**	**67.49**	**63.46**	**42.93**
	±44.76	*±5.16*	*±28.88*	*±14.62*	*±10.40*	*±2.27*
Day 56	**904.00**	**151.68**	**111.56**	**66.97**	**62.63**	**42.75**
	±17.18	*±0.92*	*±27.63*	*±13.37*	*±9.35*	*±0.38*
Day 85	**895.15**	**151.83**	**111.73**	**67.25**	**62.25**	**42.43**
	±32.95	*±2.97*	*±30.79*	*±14.65*	*±10.71*	*±1.57*
Nucleobent						
Day 7	**902.75**	**151.68**	**110.92**	**65.18**	**56.98**	**30.64**
	±13.86	*±1.63*	*±28.82*	*±14.19*	*±7.74*	*±0.64*
Day 14	**905.55**	**153.38**	**112.70**	**65.51**	**56.43**	**30.73**
	±50.63	*±6.01*	*±31.11*	*±16.91*	*±10.35*	*±2.14*
Day 27	**879.75**	**148.68**	**110.52**	**64.00**	**55.35**	**30.00**
	±56.00	*±5.59*	*±32.22*	*±16.54*	*±10.61*	*±2.08*
Day 56	**890.65**	**151.83**	**114.11**	**64.60**	**55.48**	**30.35**
	±24.18	*±3.11*	*±32.38*	*±15.08*	*±9.97*	*±0.81*
Day 85	**888.70**	**152.83**	**114.84**	**66.03**	**55.77**	**30.42**
	±46.03	*±3.96*	*±33.88*	*±16.02*	*±10.03*	*±1.50*
Granubent Poretec						
Day 7	**880.85**	**153.03**	**114.30**	**66.37**	**58.99**	**33.00**
	±16.69	*±3.39*	*±31.83*	*±16.38*	*±10.00*	*±1.71*
Day 14	**877.45**	**152.93**	**115.25**	**66.18**	**58.22**	**33.24**
	±41.01	*±2.97*	*±32.03*	*±15.39*	*±9.87*	*±1.24*
Day 27	**873.65**	**151.08**	**113.70**	**66.17**	**57.96**	**32.91**
	±27.15	*±2.62*	*±31.68*	*±16.33*	*±10.08*	*±1.08*
Day 56	**869.65**	**152.68**	**116.27**	**65.06**	**57.52**	**33.01**
	±21.78	*±2.19*	*±33.56*	*±14.11*	*±9.81*	*±1.17*
Day 85	**868.45**	**152.13**	**116.32**	**64.68**	**57.79**	**33.10**
	±39.32	*±3.82*	*±34.34*	*±16.22*	*±10.15*	*±1.65*

Note: For the elements K, P, S, Mg, Ca and Na, there was no significant difference between the 5 sampling times (days 7, 14, 27, 56 and 85) at the 5% SZD level for the given bentonite product and the given element.

Table 4. White wine clarified with three bentonite products (BW 200, Nucleobent, Granubent Poretec) Changes in Fe (mg l^{-1}), B, (mg l^{-1}), Al, (mg l^{-1}), Mn, (mg l^{-1}), Sr (µg l^{-1}), Zn (µg l^{-1}) and Ba content (µg l^{-1}) depending on six sampling dates (days 0, 7, 14, 27, 56, and 85) (Debrecen, 2020).

	Fe	B	Al	Mn	Sr	Zn	Ba
Day 0	**3.02**	**2.96**	**0.85**	**1.03**	**233.92**	**171.05**	**59.17**
	±0.04	*±0.25*	*±0.04*	*±0.01*	*±6.58*	*±8.34*	*±1.10*
BW 200							
Day 7	**3.59 a**	**2.87**	**1.26 a**	**1.22 a**	**257.77 a**	**119.50 a**	**76.94 a**
	±0.18	*±0.23*	*±0.07*	*±0.07*	*±9.76*	*±1.06*	*±1.75*
Day 14	**3.65 a**	**2.90**	**1.32 ab**	**1.26 a**	**261.52 a**	**288.70 b**	**76.61 a**
	±0.04	*±0.22*	*±0.08*	*±0.02*	*±5.02*	*±2.62*	*±0.11*
Day 27	**4.21 b**	**2.90**	**1.41 b**	**1.31 ab**	**276.77 ab**	**132.55 a**	**82.97 b**
	±0.13	*±0.31*	*±0.11*	*±0.05*	*±2.40*	*±0.85*	*±2.90*
Day 56	**5.07 c**	**2.86**	**1.61 c**	**1.40 b**	**294.12 b**	**671.75 c**	**87.47 c**
	±0.40	*±0.19*	*±0.09*	*±0.10*	*±20.58*	*±36.91*	*±4.94*
Day 85	**4.71 c**	**2.86**	**1.75 c**	**1.24 a**	**258.62 a**	**149.30 a**	**77.38 ab**
	±0.02	*±0.26*	*±0.14*	*±0.02*	*±5.59*	*±1.63*	*±1.10*
Nucleobent							
Day 7	**3.07 ab**	**2.87**	**1.29 a**	**1.07 ab**	**256.62 a**	**255.70 d**	**113.45**
	±0.03	*±0.23*	*±0.04*	*±0.00*	*±0.49*	*±0.78*	*±0.07*
Day 14	**3.00 a**	**2.88**	**1.28 a**	**1.05 a**	**250.87 a**	**115.10 b**	**110.95**
	±0.12	*±0.32*	*0.13*	*±0.01*	*±7.35*	*±0.35*	*±1.77*
Day 27	**3.09 ab**	**2.82**	**1.30 a**	**1.04 a**	**252.17 ab**	**104.45 a**	**111.45**
	±0.03	*±0.31*	*0.11*	*±0.01*	*±4.53*	*±1.70*	*±3.75*
Day 56	**3.18 ab**	**2.84**	**1.38 ab**	**1.10 ab**	**263.82 bc**	**120.30 b**	**115.20**
	±0.19	*±0.26*	*0.12*	*±0.06*	*±11.38*	*±7.28*	*±7.78*
Day 85	**3.23 b**	**2.85**	**1.44 b**	**1.12 b**	**266.52 c**	**150.60 c**	**115.45**
	±0.05	*±0.28*	*0.11*	*±0.01*	*±2.62*	*±0.78*	*±2.76*
Granubent Poretec							
Day 7	**3.10 ab**	**2.85**	**1.33 a**	**1.12**	**283.12 ab**	**164.30 ab**	**135.70**
	±0.11	*±0.25*	*±0.10*	*±0.00*	*±1.34*	*±1.63*	*±1.27*
Day 14	**2.99 a**	**2.84**	**1.39 a**	**1.09**	**280.57 ab**	**79.62 a**	**132.40**
	±0.08	*±0.23*	*±0.11*	*±0.05*	*±14.99*	*±3.96*	*±4.53*
Day 27	**3.13 ab**	**2.81**	**1.45 ab**	**1.15**	**294.77 b**	**86.11 a**	**140.05**
	±0.08	*±0.24*	*±0.11*	*±±0.03*	*9.48*	*±2.40*	*±6.01*
Day 56	**3.23 b**	**2.81**	**1.55 bc**	**1.13**	**287.37 ab**	**117.75 ab**	**135.65**
	±0.13	*±0.23*	*±0.12*	*±0.02*	*±15.84*	*±5.09*	*±6.72*
Day 85	**2.93 a**	**2.80**	**1.63 c**	**1.12**	**271.87 a**	**182.05 b**	**136.00**
	±0.17	*±0.25*	*±0.15*	*±0.03*	*±19.37*	*±84.00*	*±2.69*

The different letters next to the numbers indicate the significant difference between the 5 sampling dates (days 7, 14, 27, 56 and 85) of the given element after fining with the given bentonite product at the SZD5% probability level. The absence of letters next to the numbers means that there is no significant difference between the sampling days following clarification of the given element with the given bentonite product.

Table 5. White wine clarified with three bentonite products (BW 200, Nucleobent, Granubent Poretec) Pb, Ni, Cu, Cr, Co and Cd content changes as a function of six sampling times (days 0, 7, 14, 27, 56, and 85) (μg l^{-1}, Debrecen, 2020).

	Pb	Ni	Cu	Cr	Co	Cd
Day 0	**12.05**	**15.66**	**9.42**	**5.14**	**2.79**	**0.32**
	±0.42	*±0.86*	*±0.69*	*±0.06*	*±0.01*	*±0.08*
BW 200						
Day 7	**16.94 a**	**16.48 a**	**2.06**	**5.15 a**	**3.89 a**	**0.36**
	±0.11	*±1.51*	*±0.06*	*±0.21*	*±0.19*	*±0.01*
Day 14	**17.24 a**	**17.15**	**2.46**	**5.30 ab**	**4.07 a**	**0.65**
	±0.64	*±0.00*	*±0.83*	*±0.39*	*±0.19*	*±0.40*
Day 27	**19.30 b**	**18.15 ab**	**2.31**	**5.68 b**	**4.20 a**	**0.37**
	±1.27	*±0.83*	*±0.12*	*±0.11*	*±0.19*	*±0.04*
Day 56	**21.32 c**	**19.75 b**	**2.00**	**6.33 c**	**4.73 b**	**0.46**
	±0.33	*±1.68*	*±0.37*	*±0.49*	*±0.40*	*±0.01*
Day 85	**19.00 b**	**17.59 a**	**1.60**	**5.61 ab**	**4.21 a**	**0.35**
	±0.42	*±0.40*	*±0.01*	*±0.11*	*±0.12*	*±0.00*
Nucleobent						
Day 7	**18.21 ab**	**15.22**	**1.96 a**	**5.03 a**	**2.86**	**0.25**
	±0.74	*±1.27*	*±0.09*	*±0.09*	*±0.06*	*±0.02*
Day 14	**17.90 ab**	**13.93**	**2.29 b**	**4.94 a**	**2.91**	**0.31**
	±0.57	*±0.17*	*±0.21*	*±0.08*	*±0.01*	*±0.04*
Day 27	**17.32 a**	**14.13**	**2.00 ab**	**5.02 a**	**2.90**	**0.27**
	±1.71	*±0.54*	*±0.22*	*±0.14*	*±0.07*	*±0.01*
Day 56	**20.22 c**	**15.94**	**1.87 a**	**5.32 b**	**2.98**	**0.28**
	±0.11	*±1.32*	*±0.13*	*±0.17*	*±0.17*	*±0.06*
Day 85	**19.50 bc**	**15.37**	**1.73 a**	**5.41 b**	**3.04**	**0.26**
	±1.23	*±0.61*	*±0.03*	*±0.01*	*±0.05*	*±0.02*
Granubent Poretec						
Day 7	**15.00 ab**	**15.18**	**5.77**	**5.39**	**2.98**	**0.30**
	±0.99	*±0.52*	*±0.21*	*±0.11*	*±0.06*	*±0.05*
Day 14	**14.54 a**	**15.11**	**1.35**	**5.12**	**2.89**	**0.24**
	±0.05	*±0.45*	*±0.17*	*±0.37*	*±0.21*	*±0.04*
Day 27	**14.43 a**	**15.05**	**1.61**	**5.36**	**3.05**	**0.29**
	±0.81	*±0.16*	*±0.01*	*±0.26*	*±0.13*	*±0.01*
Day 56	**15.69 ab**	**15.93**	**1.38**	**5.25**	**2.88**	**0.28**
	±0.19	*±1.46*	*±0.05*	*±0.14*	*±0.13*	*±0.01*
Day 85	**16.19 b**	**17.22**	**2.89**	**6.27**	**3.63**	**0.68**
	±1.35	*±2.62*	*±2.43*	*±1.32*	*±1.01*	*±0.55*

The different letters next to the numbers indicate the significant difference between the 5 sampling dates (days 7, 14, 27, 56 and 85) of the given element after clarification with the given bentonite product at the SZD5% probability level. The absence of letters next to the numbers means that there is no significant difference between the sampling days following clarification of the given element with the given bentonite product.

the point of Pb content it is recommended to perform earlier racking. This phenomenon is less product specific. In our earlier study only two products remained about 100% of the control, most products eventuated +50-150% increase compared to the control.

However, from the perspective of winemaking technology, the reduction of Cu content in wine is favourable for both shorter and longer clarification periods for all bentonite products. After the first week time copper content of wine seems to be indifferent to the time of racking.

Acknowledgements

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