

Development of alternative bentonite treatments for heat-unstable white wine

by

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STATEMENT OF AUTHORSHIP

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ABSTRACT

Protein-induced wine haze is a major concern to the wine industry worldwide. While the presence of protein haze is unlikely to affect the sensory profile, consumers will generally reject wines containing hazes as they appear microbially spoiled. Consequently, an important step during commercial winemaking is to treat wines with bentonite, which removes heat unstable proteins by adsorption, and prevents haze formation. Whilst this process is effective, it is claimed to adversely affect the quality of the treated wine under certain conditions. Furthermore, 5-10% of the wine volume is typically occluded in bentonite lees. This wine is either lost or substantially diminished in quality and value during recovery. Therefore the development of alternative and economically viable process technologies that maintain wine quality and reduce costs would be highly desirable.

This thesis is concerned with the development of alternative and innovative approaches to bentonite treatment of wine. Particular emphasis was placed on developing practical research outcomes that could be readily commercially adopted. Pursuant to this, fundamental research regarding the mechanics of protein adsorption onto bentonite was undertaken to gain an understanding of how bentonite properties relate to adsorption and settling behaviour in wine. The effect of bentonite heat treatment on protein adsorption performance and settling behaviour in a model wine was also investigated. In general, heating was found to increase the initial hindered settling velocity and reduce both protein adsorption capacity and the final volume of lees. Particle size, pH and cation exchangeability of bentonites and the changes that occur to these properties on heating are related to the nature of bonding between cations and the clay surface, as are protein adsorption performance and settling behaviour. Partial Least Squares (PLS) Analysis showed that the variance in individual cation exchangeability and the total cation exchange capacity was primarily responsible for the observed variance in protein adsorption performance and settling behaviour. PLS analysis was also used to develop correlations for the prediction of adsorption and settling behaviour, based on the physical and chemical properties of the bentonites tested. Qualitative comparison of the volume fraction of model wine occluded by each of the bentonites indicated that certain heat treatments may result in a combination of protein adsorption performance and settling behaviour which would produce a significant reduction in wine loss.

The effect of different factors on adsorption of a purified grape protein (VVTL1) in a model wine was investigated using a factorial design approach with surface response analysis. Adsorption of VVTL1 by sodium bentonite was well characterised by the Langmuir adsorption isotherm. pH, temperature, potassium concentration ($[K]$), and the $pH^*[K]$

interaction were all found to have a significant effect ($p < 0.05$) on the adsorption capacity. Block effects appeared to correctly correlate with bentonite slurry age, suggesting that increasing slurry age may have a positive effect on adsorption capacity. Ethanol concentration, phenolic (caffeic acid and catechin) concentration, sugar (glucose and fructose) concentration, as well as the pH*temperature and temperature*[K] interactions did not have a significant effect. The equilibrium constant was found to be independent of the factors studied. This may be explained by changes in protein structure and charge with pH, which affect electrostatic interaction with the bentonite surface. Variation in potassium concentration can cause similar effects and may also influence adsorption capacity by affecting bentonite swelling and zeta potential.

This knowledge was applied to the development of in-line dosing of bentonite as an alternative process strategy for commercial use. Field tests of in-line dosing at a commercial winery were conducted on a Sultana wine and Gordo (*Muscat of Alexandria*) juice with Vitiben and SIHA-Aktiv-Bentonit G bentonites. Fining performance was monitored by heat testing and quantification of heat unstable protein by HPLC. Heat test turbidity and heat unstable protein concentration were reduced in a similar manner upon fining. These reductions were achieved with a contact time of less than two minutes. Sensory evaluation of Sultana wine fined with Vitiben by balanced reference duo-trio difference tests did not detect any difference between untreated, in-line dosed and batch fined wine. A dynamic simulation model of in-line dosing was developed and compared with field trial results, marking the first quantitative study of the dynamic adsorption kinetics of wine protein adsorption onto bentonite. The simulation results confirmed the rapid adsorption behaviour observed during field testing, and provided strong evidence that protein adsorption occurs predominantly on the external particle surface only, with adsorption kinetics being limited by external-film mass transfer. Incomplete separation of bentonite from wine/juice during centrifugation produced a carryover of up to 30% of the added bentonite into the clarified wine. If this problem can be overcome, use of in-line dosing instead of batch fining could eliminate significant value losses presently arising from quality downgrades of wine recovered from bentonite lees by rotary drum vacuum filtration. Moreover, in-line dosing of selected *heat-treated* bentonites under optimal wine or juice conditions may provide even further costs savings whilst maintaining wine quality.

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