

Plant-Based Byproducts as Fining Agents for Winemaking

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Contributor: Arianna Ricci

An increasing number of consumers demand traceability along the entire food production chain for several reasons, including to avoid the use of animal proteins as adjuvants in plant-based products such as wine. To achieve sustainable, organic, and environmentally friendly wines, enologists are seeking plant-based and allergen-free alternatives to traditional fining agents.

wine tannins

wine polyphenols

wine fining

patatin

surface response methodology

Freundlich adsorption isotherm

1. Introduction

Fining improves wine stability and enhances its characteristics while respecting its structure. A fining agent removes unwanted wine components by creating an almost insoluble protein–polyphenolic complex that precipitates from the solution. Indeed, complex formation has received extensive attention and the polyphenolic compounds involved in this complex have become the target for red wine treatments. Traditional fining agents include proteinaceous compounds such as casein, isinglass, albumin, and gelatin, which remove tannins and/or brown polymeric phenols; and polyamide materials such as polyvinylpolypyrrolidone (PVPP), which remove monomeric and small polymeric phenols ^[1]. Considering the allergenic and environmental drawbacks of some of the traditional fining agents, the search for an alternative is currently in progress. Potential substitutes include yeast protein extracts ^{[2][3]}, grape pomace ^[4], cork powder ^[5], recycled PVPP ^[6], and vegetable proteins ^[7].

Unfortunately, fining agents are seldom perfectly selective. Valuable components may be partially removed from the wine, particularly when surplus fining agent is used (called overfining); its incomplete precipitation can not only cause wine instability (i.e., haze) but can also be a health concern if the agent has allergenic potential ^{[8][9]}. An in-depth evaluation of the effect of protein fining on the composition of wine shows that only a minor amount of the total phenolic content is removed, despite the lower astringency perception by sensory analysis ^[10]. According to Cheynier et al. ^[11], this apparent contradiction may be due to the combining of the remaining protein with the potentially astringent tannins to form a soluble or colloidal substance, so that the tannins are ‘unavailable’ to generate an astringent response. The evidence for the existence of soluble molecular assembly processes (“aggregates”), particularly involving tannins, proteins, and polysaccharides, has been thoroughly substantiated ^[12]. Ongoing concerns about residual proteins and related health issues have increased the use of fining agents made of plant proteins (e.g., cereals, grape seeds, potatoes, and legumes) as alternatives to potentially allergenic animal

proteins (e.g., casein, gelatin, egg, and fish proteins) [13]. In fact, a new allergen-free plant protein (known as patatin) made from potatoes, the second-most wasted food ingredient in the world [14], has been recently approved at the EU level (Reg. EU 2019/924). Patatin does not require labeling as a potential allergen (unlike casein and egg white, for example) and is suitable for vegetarians and vegans as well (unlike gelatin, for example). The ability of patatin to reduce the flavanol compounds responsible for astringency in red wines was uncertain [7][15], as was the effect of patatin dosage on the time course of tannin and phenolic removal in red wine [16][17].

With the growing interest in patatin as a fining agent, there is a need to ascertain its adsorption of the phenolic compounds of red wines. The capacity of fining agents is best evaluated with a thorough understanding of adsorption processes in winemaking. Data from adsorption isotherms provide information on the affinity and capacity of the tested adsorbent [18]. Further, the isotherm can be fitted to both model wine solutions and real wines. Spectrophotometric methods, often used for routine analysis by industry, are valuable to researchers as well. The chemical reactivity and protein-binding capacity of the tannins are of great interest for quality control in winemaking; selecting an appropriate method may seem overwhelming to the nonspecialist, as there is no perfect method so far. In general, chemical assays are most useful for determining the amount of tannin in a sample, whereas protein-binding assays can be useful for evaluating the potential interaction of tannins in wine.

2. Fining Trials and Adsorption Isotherms

Previous studies on the effect of fining agents on red wine have focused on the phenolic composition, instead of modeling the activity as a function of the type and concentration of fining agent. The present findings can be used to tailor winemaking practices and improve analytical quality control. The amount of solute removed by a fining agent depends on the solute/agent adsorption equilibrium, which approaches a steady state as the wine's solute concentration is reduced; therefore, the fining agent becomes increasingly less effective. From a practical point of view, the solute concentration is merely decreased to a point below a solubility condition (in a stability test) or a taste threshold (in a sensory test) [4]. Thus, the adsorption isotherms can help determine the most appropriate fining agent as well as predicting the performance of adsorption systems. According to Waterhouse et al. [8], tannin fining with gelatin follows the Freundlich model, where addition of tannin results in a decreasing fraction of tannin adsorbed, but without leveling off in the amount of tannin bound to the protein. Indeed, binding also depends on the isoelectric point (pI) of protein and is, thus, at a maximum (for most proteins) when the pH is at or near its pI value. Since patatin and BSA have similar isoelectric points of 4.6 and 4.7, respectively [19][20], this variable can be neglected in the present research.

In agreement with the findings, the adsorption isotherm of (–)-epigallocatechin gallate (EGCG) on BSA, which appears to be dominated by nonspecific hydrophobic interactions, is better described by the Freundlich model than the Langmuir model [21]. Further comparison on mass balance should consider the pH effect, as BSA undergoes conformational isomerization with decreasing pH, EGCG adsorption increases below pH 4.0 (fast “F” form: $40 \times 129 \text{ \AA}$) and increases even more for pH close to 3.0 (expanded “E” form: $21 \times 250 \text{ \AA}$) [22]. The Freundlich and Langmuir models are both suitable for modeling the adsorption of catechins onto PVPP at a neutral pH. The

reaction was driven by the PVPP and catechin concentrations, and favored by low temperature, i.e., 20 vs 40 °C [23].

In a preliminary study on distilled water, the Freundlich equation showed that the adsorption of the hydroxybenzoic acids by PVPP is not selective [24]. Further experiments on model beer solution (5.0% ethanol at pH 4.0) revealed that PVPP preferentially removed the more highly hydroxylated phenolic acids, but similar selectivity was not found for the adsorption of dimeric flavanols. The Freundlich constants (K_F , $1/n$) for the adsorption of phenolic acids and beer flavanols by PVPP ranged between 0.02 and 10 for K_F and between 0.60 and 0.91 for $1/n$ [25]. These values are consistent with the findings on PVPP (K_F 1.07; $1/n$ 0.96). Mitchell et al. [26] showed that the trend of beer proanthocyanidins to bind to PVPP increased with the degree of polymerization [$(n = 3) > (n = 2) > (n = 1)$] [26]. This trend was also confirmed in rosé wines, in which about 64% of the total flavanol content was removed by PVPP, with trimers slightly more adsorbed than dimers (79% vs. 72%) and much more adsorbed than monomers (43%) [27]. Interestingly, in model wine solution, the compounds having more affinity for PVPP were quercetin (100%) and catechin (67%) [28]; also, quercetin aglycone above 3 mg/L may also become insoluble [29]. On the contrary, BSA does not precipitate flavanol monomers and dimers, whereas the ability of BSA to precipitate condensed tannins increased with increased degree of polymerization from trimers (1000 µg) to octamers (50 µg) [30].

3. Practical Implication on Red Wine Properties

Wine stability represents one of the more debated topics in enology. Practically speaking, there is no ideal fining product, as all of them have specific selectivities that are more or less effective on each parameter, depending on the type of wine. It is thus essential to follow a sound scientific approach supported by an empirical model in order to select the most suitable product and the optimal dosage. For example, Aglianico red wine treated with patatin at 30 gr/HI showed a significant decrease in astringency, due to the removal of polyphenols reactive toward salivary proteins [15]. Although potato-derived proteins (max dosage 25 gr/HI) effectively reduced large proanthocyanidins in Montepulciano, Primitivo, and Nebbiolo red wines, the monomeric and oligomeric forms of flavanols, evaluated with vanillin assay, occasionally increased up to 4% compared with untreated wine [7]. This increase is consistent with the findings.

The occurrence of a soluble protein–tannin complex should be considered in winemaking—not just because of the technical interference among different analytical methods, but also because of the regulatory implications and the complex's effect on wine's sensory properties and stability. The International Organization of Vine and Wine [31] has recommended a limit of <0.25 mg/L for potentially allergenic residues of fining agent proteins in wine, above which a mention becomes compulsory on the wine label. Potato protein fining is significantly influenced by wine pH, ethanol concentration, and fining temperature [16]. The combined use of several fining agents is also a concern, since it can lead to synergistic or antagonistic effects. The complexity of the fining process and the large number of possible combinations make it difficult to predict the outcome [32].

4. Conclusions

Fining binds with targeted compounds and precipitates them, removing undesired components to improve wine quality (and conform to consumer preferences). Developing environmentally friendly fining agents is crucial for reducing wine loss and minimizing waste in the winemaking processes. Laboratory trials play a vital role in ensuring that the fining agent has the desired effect. Moreover, precision fining helps reduce the risk of wine oxidation by lowering the concentration of oxidized/oxidizable phenolic compounds.

References

1. Boulton, R.B.; Singleton, V.L.; Bisson, L.F.; Kunkee, R.E. The fining and clarification of wines. In *Principles and Practices of Winemaking*; Springer: Boston, MA, USA, 1999; pp. 279–315.
2. Fernandes, J.P.; Neto, R.; Centeno, F.; De Fátima Teixeira, M.; Gomes, A.C. Unveiling the potential of novel yeast protein extracts in white wines clarification and stabilization. *Front. Chem.* 2015, 3, 20.
3. Gaspar, L.M.; Machado, A.; Coutinho, R.; Sousa, S.; Santos, R.; Xavier, A.; Figueiredo, M.; Teixeira, M.d.F.; Centeno, F.; Simões, J. Development of potential yeast protein extracts for red wine clarification and stabilization. *Front. Microbiol.* 2019, 10, 2310.
4. Gil-Muñoz, R.; Jiménez-Martínez, M.D.; Bautista-Ortín, A.B.; Gómez-Plaza, E. Effect of the use of purified grape pomace as a fining agent on the volatile composition of Monastrell wines. *Molecules* 2019, 24, 2423.
5. Filipe-Ribeiro, L.; Cosme, F.; Nunes, F.M. A simple method to improve cork powder waste adsorption properties: Valorization as a new sustainable wine fining agent. *ACS Sustain. Chem. Eng.* 2019, 7, 1105–1112.
6. Ferreira, S.S.; Alves, A.J.; Filipe-Ribeiro, L.; Cosme, F.; Nunes, F.M. Holistic and sustainable approach for recycling and valorization of Polyvinylpolypyrrolidone used in wine fining. *ACS Sustain. Chem. Eng.* 2018, 6, 14599–14606.
7. Río Segade, S.; Paissoni, M.A.; Vilanova, M.; Gerbi, V.; Rolle, L.; Giacosa, S. Phenolic composition influences the effectiveness of fining agents in vegan-friendly red wine production. *Molecules* 2020, 25, 120.
8. Waterhouse, A.L.; Sacks, G.L.; Jeffery, D.W. Fining. In *Understanding Wine Chemistry*; Waterhouse, A.L., Sacks, G.L., Jeffery, D.W., Eds.; John Wiley & Sons, Ltd.: Chichester, UK, 2016; pp. 332–345.
9. Maury, C.; Sarni-Manchado, P.; Cheynier, V. Highlighting protein fining residues in a model red wine. *Food Chem.* 2019, 279, 272–278.

10. Maury, C.; Sarni-Manchado, P.; Lefebvre, S.; Cheynier, V.; Moutounet, M. Influence of fining with plant proteins on proanthocyanidin composition of red wines. *Am. J. Enol. Vitic.* 2003, 54, 105–111.
11. Cheynier, V.; Dueñas-Paton, M.; Salas, E.; Maury, C.; Souquet, J.-M.; Sarni-Manchado, P.; Fulcrand, H. Structure and properties of wine pigments and tannins. *Am. J. Enol. Vitic.* 2006, 57, 298–305.
12. Scollary, G.R.; Pásti, G.; Kállay, M.; Blackman, J.; Clark, A.C. Astringency response of red wines: Potential role of molecular assembly. *Trends Food Sci. Technol.* 2012, 27, 25–36.
13. Marangon, M.; Vincenzi, S.; Curioni, A. Wine fining with plant proteins. *Molecules* 2019, 24, 2186.
14. Jagtap, S.; Bhatt, C.; Thik, J.; Rahimifard, S. Monitoring potato waste in food manufacturing using image processing and internet of things approach. *Sustainability* 2019, 11, 3173.
15. Gambuti, A.; Rinaldi, A.; Moio, L. Use of patatin, a protein extracted from potato, as alternative to animal proteins in fining of red wine. *Eur. Food Res. Technol.* 2012, 235, 753–765.
16. Kang, W.; Muhlack, R.A.; Bindon, K.A.; Smith, P.A.; Niimi, J.; Bastian, S.E.P. Potato protein fining of phenolic compounds in red wine: A study of the kinetics and the impact of wine matrix components and physical factors. *Molecules* 2019, 24, 4578.
17. Rinaldi, A.; Errichiello, F.; Moio, L. Alternative fining of Sangiovese wine: Effect on phenolic substances and sensory characteristics. *Aust. J. Grape Wine Res.* 2021, 27, 128–137.
18. Sun, L.; Srinivas, A.; Runnebaum, R.C. Understanding the impact of key wine components on the use of a non-swelling Ion-Exchange resin for wine protein fining treatment. *Molecules* 2019, 26, 3905.
19. Adamczyk, B.; Salminen, J.-P.; Smolander, A.; Kitunen, V. Precipitation of proteins by tannins: Effects of concentration, protein/tannin ratio and pH. *Int. J. Food Sci.* 2012, 47, 875–878.
20. Løkra, S.; Helland, M.H.; Strætkvern, K.O.; Egelanddal, B. Chemical characterization and functional properties of a potato protein concentrate prepared by large scale expanded bed absorption chromatography. *LWT Food Sci. Technol.* 2008, 41, 1089–1099.
21. Wang, X.; Ho, C.-T.; Huang, Q. Investigation of adsorption behavior of (–)- epigallocatechin gallate on Bovine Serum Albumin surface using quartz crystal microbalance with dissipation monitoring. *J. Agric. Food Chem.* 2007, 55, 4987–4992.
22. Peters, T.J. *All about Albumin*; Academic Press: San Diego, CA, USA, 1996.
23. Dong, Z.-B.; Liang, Y.-R.; Fan, F.-Y.; Ye, J.-H.; Zheng, X.-Q.; Lu, J.-L. Adsorption behavior of the catechins and caffeine onto polyvinylpolypyrrolidone. *J. Agric. Food Chem.* 2011, 59, 4238–4247.

24. Mennett, R.H.; Nakayama, T.O.M. The adsorption of hydroxybenzoic acids by Poly-N-Vinyl Pyrrolidinone. *Am J. Enol. Vitic.* 1969, 20, 169–175.
25. McMurrough, I.; Madigan, D.; Smyth, M.R. Adsorption by Polyvinylpolypyrrolidone of catechins and proanthocyanidins from beer. *J. Agric. Food Chem.* 1995, 43, 2687–2691.
26. Mitchell, A.E.; Hong, Y.-J.; May, J.C.; Wright, C.A.; Bamforth, C.W. A comparison of Polyvinylpolypyrrolidone (PVPP), silica xerogel and a Polyvinylpyrrolidone (PVP)–Silica co-product for their ability to remove polyphenols from beer. *J. Inst. Brew.* 2005, 111, 20–25.
27. Gil, M.; Avila-Salas, F.; Santos, L.S.; Iturmendi, N.; Moine, V.; Cheynier, V.; Saucier, C. Rosé wine fining using Polyvinylpolypyrrolidone: Colorimetry, targeted polyphenomics, and molecular dynamics simulations. *J. Agric. Food Chem.* 2017, 65, 10591–10597.
28. Durán-Lara, E.F.; López-Cortés, X.A.; Castro, R.I.; Avila-Salas, F.; González-Nilo, F.D.; Laurie, V.F.; Santos, L.S. Experimental and theoretical binding affinity between polyvinylpolypyrrolidone and selected phenolic compounds from food matrices. *Food Chem.* 2015, 168, 464–470.
29. Gambuti, A.; Picariello, L.; Rinaldi, A.; Forino, M.; Blaiotta, G.; Moine, V.; Moio, L. New insights into the formation of precipitates of quercetin in Sangiovese wines. *J. Food Sci. Technol.* 2020, 57, 2602–2611.
30. Harbertson, J.F.; Kilmister, R.L.; Kelm, M.A.; Downey, M.O. Impact of condensed tannin size as individual and mixed polymers on bovine serum albumin precipitation. *Food Chem.* 2014, 160, 16–21.
31. OIV. Code of Good Fining Practices for Wine to Be Applied in the Use of Proteinaceous Wine Fining Agents with Allergenic Potential (Casein and Egg White); Resolution Oeno 5202014; International Organisation of Vine and Wine-OIV: Paris, France, 2014.
32. Ficagna, E.; Gava, A.; Rossato, S.B.; Rombaldi, C.V.; Borsato, D. Effect on Merlot red wine of fining agents mixture: Application of the simplex centroid design. *Food Sci. Technol.* 2020, 40, 1–7.

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