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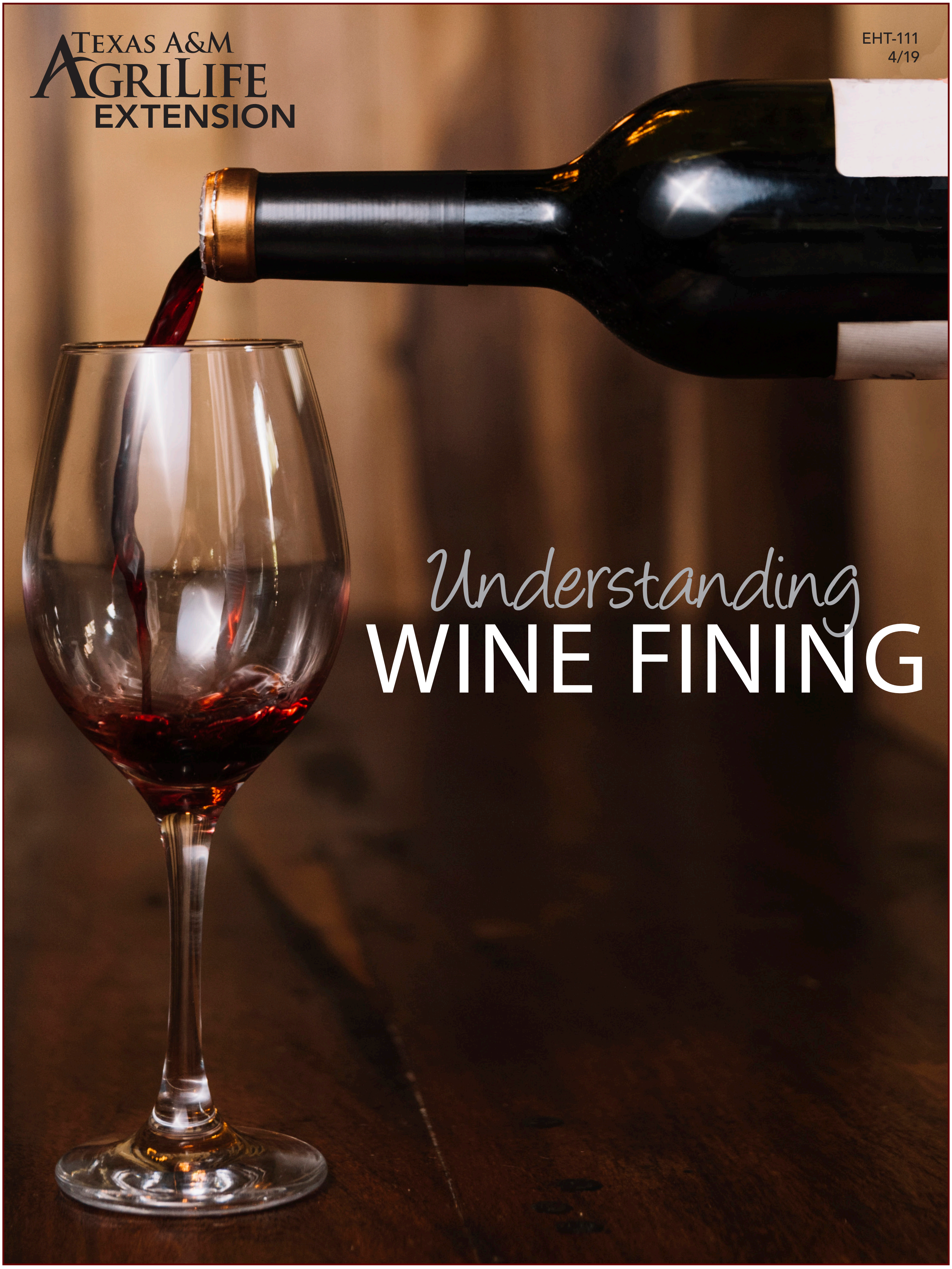

Understanding WINE FINING

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Wine quality is a complex concept that includes visual cues, aroma profile, taste and mouthfeel characteristics, and overall balance. Lack of clarity (haziness), off-colors (browning, pinking), unpleasant aromas, bitterness, and harsh tannins can all decrease wine quality in both white and red wines.

*Fining** is a technique that mitigates many of these issues. This guide will help you navigate the various problems that can arise during winemaking and find the optimum fining approach for each of them (Table 1).

Remediating Color

Reducing browning through fining

Excessive oxygen exposure, enzymatic browning activity, heat damage, and lack of *tannins* (in red wines) can all lead to browning. Generally, brown hues—a negative characteristic in both white and red wines—indicate either a mishandling of the wine or premature aging. Several fining agents can decrease browning intensity and restore the wines to their original color.

**See glossary on page 11 for italicized terms.*

Activated carbon is purified charcoal that has been physically and/or chemically treated to generate microfissures that exponentially increase its adsorptive surface area. As such, it can adsorb a wide range of compounds, particularly *phenols* and their derivatives without great specificity. Carbon can help wines with color problems such as excessive browning or pinking because it is effective at removing nonpolar substances, but weak at removing water-soluble components such as sugar and amino acids. Activated carbon comes in two forms: one used for stripping color (decolorizing) and one used for removing unwanted aromas (deodorizing). Regardless of form, carbon efficiency is increased when used in conjunction with PVPP. Use the decolorizing form when tackling browning issues. Typical ranges to evaluate are 100 to 2,000 milligrams per liter (mg/L) for removing color (0.4–8 g/gal).

Casein (a protein found in milk) is also available in several forms such as casein, potassium caseinate (the most widely used), mixtures of potassium caseinate with bentonite/silica, and skim milk. Casein is mainly

Table 1. Common wine problems that can be remedied through fining and recommended fining agents

Problem	Cause	Recommended Fining Agent
Browning, pinking, excess color	Oxidation, enzymatic browning, excess anthocyanins	PVPP, activated charcoal, casein
Bitterness	Cathechin and epicatechin (flavonoids)	PVPP, Kieselsol
Harsh astringency	High tannins	Protein-based agents
Haze	Proteins	Bentonite
	Polysaccharides	Enzymatic treatment
Stinky wines (rotten eggs, garlicky, onion)	H_2S, mercaptans, disulfides	Copper sulfate
Oxidative aromas (brown apple, baked apple)	Acetaldehyde	Casein, activated charcoal, gelatin
Phenolic aromas (barnyard, horse, leather, Band-Aid®)	4-ethyl phenol, 4-ethyl guaiacol	Activated charcoal, albumin, isinglass, chitosan

PVPP stands for *polyvinylpolypyrrolidone*. Source: Andreea Botezatu, Texas A&M University.

used for removing unwanted color in white wines, but it also has some deodorizing properties. Typical ranges for adding casein are 50 to 250 mg/L (0.2–1 g/gal). Dissolve casein in a small volume of wine or distilled water before adding it to the wine.

PVPP (*polyvinylpolypyrolidone*) can also prevent oxidative browning and remove brown (or pink) by-products after they form in wine. PVPP works best if added early in the maturation stages of the wine. This fining agent functions well at low temperatures and settles relatively quickly (2 to 3 hours after adding it). PVPP needs to be removed from the treated wine, most commonly through filtration. The typical addition range is between 4 to 10 pounds for 1,000 gallons.

Reducing Bitterness and Astringency

Reducing bitterness through fining

Bitterness in wines is often caused by cathechin and epicatechin, although other compounds contribute to a lesser degree. The most effective fining agents for reducing bitterness are PVPP, Kieselsol, and casein.

PVPP is a resinous *polymer* particularly well-suited for removing flavans (such as catechin) as well as mono and dimeric phenols (these small-chain polymeric phenols have a higher ratio of bitterness to astringency than higher-chain ones). Use the same rates of addition previously mentioned. (See **Reducing browning through fining.**)

Another fining agent used for reducing bitterness is **Kieselsol.** This product is an aqueous suspension of silicon dioxide and is available in both positively and negatively charged forms. It is commonly used to remove bitter polyphenolic compounds from white wines but can also be used in reds since it tends to remove very little color and does not add any unwanted taste characteristics. Add Kieselsol at a rate of 25 to 50 milliliter (mL) per hectoliter (hL) of wine, stirring gently while adding it (1–2 mL/gal).

Casein also decreases bitterness in wines. (See above for more detailed information on casein.)

Reducing excessive astringency through fining

Astringency is not a taste but rather a variety of tactile (touch) sensations such as puckering, drying, roughness, dust-in-the mouth. It is included in the description of "mouthfeel" together with "body," "volume," and "heat." Astringency is often confused with bitterness (a taste), but they are distinct phenomena. Many wines can be bitter without being astringent or be very astringent but have low or no perceivable bitterness.

The interaction of phenolic compounds with saliva can create these types of sensations. Various classes of phenolics generate different characteristics in wines; tannins (polymeric flavan-3ols) cause astringency as they interact with the proteins in saliva, binding them so the mouth is no longer lubricated, causing dry and rough sensations.

Because evaluating astringency can be subjective, consider several factors such as the age of the wine, its aging potential, the varietal, and even the style of wine you wish to produce. Consumer preference also influences the desired levels of astringency in a given wine. With all that taken into account, once a wine is deemed to be excessively astringent, winemakers have a few fining options to help remedy this problem.

Because tannins bind with proteins in human saliva and separate (precipitate) the proteins out of the solution, it is intuitive to use proteins to help bind and precipitate tannins in wine. Just like salivary protein, the proteins added to wine coagulate with tannins to form an insoluble complex which, in time, settles to the bottom of the barrel or tank as a precipitant.

Proteins used for fining astringency

Most proteins used in the winemaking industry for fining are relatively cheap and readily available, being generated as by-products by the food industry. Proteins tend to bind to bigger tannins (the ones mainly responsible for astringency) more readily, and larger tannins usually precipitate faster than smaller ones. Based on their origin, it appears that seed tannins tend to react more easily with proteins than skin or stem tannins. The most effective proteins for astringency fining are the proline-rich ones. This type of protein is abundant in human saliva as well as in the connective tissue of different mammals (gelatin is produced from this type of tissue).

Protein charge

Understanding protein charge is essential because it affects the capacity of proteins to bind with tannins. Proteins are less soluble and more likely to co-precipitate tannins at their *isoelectric point.* The isoelectric point of a protein is the pH of a solution at which their net charge is 0. Generally, wine pH broadly ranges between 3 and 4, and casein has the closest isoelectric point to wine pH (Table 2). However, even though more soluble than casein, gelatin is the most aggressive and can easily result in overfining and color removal.

Selecting proteins for fining

Gelatin, used mainly to remove excess tannins from wines, is usually added early during maturation. Removing tannins early in the aging process prevents color loss (otherwise tannins would continue polymerizing with *anthocyanins*—color compounds—and potentially precipitate out of the solution).

Table 2. Proteins commonly used for astringency reduction, listed in order of effectiveness.

Type of product	Typical addition rates (mg /L)	Characteristics	Isoelectric point	Efficiency
Gelatin	15–120 (whites) 30–240 (reds)	Good clarity. Also effective in reducing bitter aftertaste.	4.80–04.85	Decreasing Efficiency ↓
Egg whites (albumin)	30–150	Very good fining agent for tannic wines with some age. Tends not to remove protective colloids.	4.5–4.9	
Isinglass	10–100	Good clarity. Intensifies yellow color (whites). Light flakes, bulky, settles slowly.	NA	
Casein	50–250	Good clarification. Also treats and prevents oxidation. No overfining.	3.7–6.0	

Source: Modified table reproduced from *Handbook of Enology Volume 2: The Chemistry of Wine Stabilisation and Treatments.*

Also, as gelatin preferentially binds with larger molecules, it dramatically affects color and tannin reduction in older wines since they contain more large *polyphenols*.

Gelatin added to white juice, particularly press fractions, can reduce the level of phenolic compounds associated with astringency. Fining white wines with gelatin as well as overfining with it can lead to the formation of a protein haze and, in red wines, to color loss. This may be mitigated through adding flavorless tannins, Kieselsol, or other protein-binding agents.

Gelatin is available in two forms: powder and liquid. The most commonly used is a commercially available liquid form. When using gelatin, note the percentage of gelatin activity (normally around 30%) recommended on the manufacturer's instructions. With the temperature of the wine at about 10°C, the liquid form of gelatin should be added directly to the wine. The solid form needs to be solubilized in a solution of water and ethanol before use.

Although **egg whites** have long been used in fining wines, this practice may be slightly confusing (Fig. 1). Egg whites contain *polysaccharides* and proteins (albumin) and are used because they are readily available and easy to use. However, achieving consistent results when using egg whites can be difficult as eggs vary in volume and consistency.

Purified forms of egg white proteins (ovalbumin and conalbumin) are also commercially available. Fining with egg whites or albumin leads to a softening and improved suppleness in the wine. This type of fining is often done when the wine is in the barrel or before bottling it.

An egg white in a medium-sized egg weighs approximately 30 grams (g), and about 12 g of it is protein. Usually, 2 to 8 egg whites are added to 225 liters (L) of wine.

When preparing the egg whites, add table salt (sodium chloride) and a few milliliters of water to make the albumin more soluble

Figure 1. Egg whites are an effective and easy-to-use fining agent.

Source: Egg whites used in the fining of wine. Photo by Agne27 by Wikimedia Commons is licensed under CC BY-SA 3.0

and easier to disperse. For optimal results, the temperature of the wine during treatment should be around 10°C.

Isinglass is made from proteins extracted from the air bladder of fish, particularly sturgeons. It is used to remove tannins and also to clarify white wines (Fig. 2). It produces brilliantly clear wines, can bring out or unmask fruit character without substantial changes in phenolic levels, and has a less dramatic effect than gelatin on the astringency and body of the wine. Because *monomers* and smaller polyphenolic compounds react easily with isinglass, it is a top choice as an aid in removing harsh taste sensations.

Another benefit of isinglass is that it does not need extra counter-fining that other protein-based fining agents do. Over-addition of isinglass can give wine a fishy odor, so bench-top trials are highly recommended. Isinglass lees are light and fluffy and can easily clog filters. The wine should be racked carefully so as not to distrub the lees. Similar to gelatin,

Figure 2. Isinglass helps reduce astringency and improve clarity.

Source: Isinglass fining agent being added to a tank of Semillion to aid in the clarity and stability of the wine. Photo by Agne27 by Wikimedia Commons is licensed under CC BY-SA 3.0.

using too much isinglass can produce residual protein in the wine, causing a greater incidence of protein haze.

Flocculated isinglass is the form most widely used as it does not require rinsing to eliminate fishy odors (as sheet-isinglass does) and so it is perceived as most convenient to work with.

Casein (See above – **Reducing browning through fining.**)

Addition amounts

Typical addition rates for each protein are shown in Table 2. Keep in mind that federal regulations limit the amount of egg whites to 3 pounds per 1,000 gallons of wine.

Look for information about recommended addition rates on the packaging of the fining agents; formulations tend to differ somewhat from manufacturer to manufacturer. It is essential that you perform laboratory trials before treatment to establish the optimal rate for your particular wine or application. The bench-top trial additions should cover a range of concentrations from low to high and test a number of fining products. The relationship between how much tannin a specific amount of protein removes will vary based on the individual characteristics of both the tannins and proteins involved as well as how they interact.

Timing and duration

Always conduct fining with protein earlier rather than later to avoid losing *polymeric pigments* through coprecipitation with proteins. Distribute the fining protein uniformly through the wine or juice being treated. Thoroughly mix the wine or pump over it while adding the fining agent. Using dosing valves on the line between the pump and the tank gives control over how much fining solution gets added.

Once the fining agent is added, the reaction time is usually quite short—anywhere from 15 minutes to 1 hour. Precipitation (settling) time, however, is longer, sometimes taking up to a few days to complete. Settling time can vary based on the density of the wine, the total volume, the height of the tank to be treated, temperature, and the amount of protein added. Once settling is complete, rack the treated wine and filter it to remove any remaining proteins to avoid possible protein instability in the future. Protein stability tests are recommended after fining. (See **Fining proteins** for more information on heat stability tests.)

Clarifying

Fining for clarification

Clarification fining usually occurs during white wine processing. It removes haze by precipitating the soluble compounds that contribute to it. If done immediately after fermentation, clarification fining also helps speed up the settling process. Generally, two distinct classes of compounds cause haze: **proteins** and **polysaccharides.**

Fining proteins

The most commonly used fining agent for removing protein is ***bentonite.*** It is a type of montmorillonite clay used for clarifying juice and wine and removing heat-unstable proteins. Two main types of bentonite are available: sodium bentonite (from the US) and calcium bentonite (from Africa and Europe). Sodium bentonite has a higher swelling capacity and better separation in sheets of aluminum silicate, which leads to a higher surface area and better adsorptive capacity. Swelling bentonite in water (a few hours to up to 2 to 3 days, depending on the manufacturer's recommendations) before adding it to wine significantly increases its efficacy.

Bentonite itself has no charge due to the presence of either the sodium or calcium cations (positively charged ions), but during fining, it acts similar to an ion-exchange system where positively charged proteins exchange with the metal cations. The resulting protein complex settles to the bottom of the tank.

Bentonite is more effective in wines with lower pH values, where proteins carry a greater positive charge. If you plan to adjust the pH and titratable acidity (approximate total acidity of a solution) of the wine, do it before bentonite fining since stability might be different under the new pH conditions.

Limit the use of bentonite, particularly in red wines, not only because of its ability to reduce color by adsorption of anthocyanins (red color compounds) but also for waste disposal issues and product loss.

Bench-top trials are strongly recommended for bentonite fining. These tests involve adding increasing amounts of bentonite slurry (a 5% solution of bentonite hydrated in water) to several wine samples of constant volume. Once the bentonite has settled, evaluate the wine clarity visually to establish the best addition rate. If you are fining to accomplish heat-protein stability, conduct a protein-stability test with the

treated wine. (To learn more about protein-stability testing, see https://www.awri.com.au/industry_support/winemaking_resources/laboratory_methods/chemical/heat_stab/#heat.)

Fining polysaccharides

All wines contain polysaccharides which, based on their origin, can be classified as grape-, fungus-, or yeast-derived.

- **Grape-derived polysaccharides** such as pectins, arabinanes, galactanes, and arabino-galactanes can impart viscosity to wine, but they sometimes require using pectolitic enzymes to clarify the wine and make filtration easier.
- The most common **fungi-derived polysaccharides** are beta-glucans produced by *Botrytis cinerea* which are known to cause problems in wine filtration.
- **Yeast polysaccharides** include glucanes and mannoproteins. These types of molecules do not usually pose any problems with filtration.

While some polysaccharides (mannoproteins) can definitely make a positive contribution to the overall quality of wines (including a better mouthfeel as well as better overall stability), in excess, they can create hazing and filterability issues, occasionally making fining necessary (Jackson, 2008). This is common in *Botryitis*-infected grapes where beta-glucans can cause serious clarification issues.

Remove polysaccharides by using enzymes that have unique chemical reactivity to particular compounds. The best strategy is to use a mixture of enzymes (containing cellulase, hemi-cellulase, protease, pectinase, or beta-glycosidase) to target all the different types of polysaccharides that may be causing the hazing issue.

One issue with enzymes is that they are only effective under specific pH, temperature, and ethanol conditions. Keep in mind that the quantity and composition of grape polysaccharides change from year to year.

Each season, winemakers should observe and document the characteristics of the grapes to determine the most effective way to remove excess polysaccharides. Changing the amounts of enzyme(s) is usually an effective strategy.

Improving Off-Aromas

Fining for off-aromas

Some of the most common off-aromas corrected through fining are those associated with **sulfur compounds** such as *hydrogen sulfide* (H_2S) or mercaptans, phenolic aromas, and oxidative aromas.

During fermentation, yeasts can produce unwanted sulfur compounds such as H_2S. Yeast naturally metabolizes various amino acids necessary for their survival, but lack of sufficient nutrients can disturb the metabolic processes and create these undesirable compounds. Reducing sulfates and sulfites during fermentation can also produce H_2S.

Reduction and the presence of H_2S, mercaptans, and other sulfur-related compounds in wines can create aromas such as rotten eggs (H_2S), burnt rubber, garlic, onion, stagnant water (mercaptans), mushrooms, and quince (dimethyl sulfide). (See Table 3 for a list of unwanted sulfur compounds found in wine, their human detection thresholds, and a description of the aromas).

Some winemakers may consider even traces of reduction as flaws, while others approach them as contributors to aroma complexity and sometimes wine typicity (the taste

Table 3. Wine sulfur compounds, thresholds, and descriptions.

Compound	Sensory Threshold (micrograms per liter)	Sensory Descriptor	Non-tainted wines (micrograms per liter)	Tainted wines (stinky) (micrograms per liter)	Removable by copper fining?
Hydrogen Sulfide H_2S	0.8 µg/L	Rotten eggs	0.3 µg/L	16.3 µg/L	Yes
Methyl Mercaptan CH_3SH	0.3 µg/L	Stagnant water	0.7 µg/L	5.1 µg/L	Yes
Ethyl Mercaptan CH_3CH_2SH	0.1 µg/L	Onion	< 0.1 µg/L	10.8 µg/L	Yes
Methyl Sulfide CH_3SCH_3	5.0 µg/L	Mushroom	1.4 µg/L	2.0 µg/L	No
Dimethyl Disulfide CH_3SSCH_3	2.5 µg/L	Quince	< 2.5 µg/L	5.0 µg/L	No

Source: *A Guide to the Fining of Wine* by James F. Harbertson, Washington State University reflects the characteristics of the grape variety from which it is produced). As winemaker, one should carefully distinguish between desirable aroma contributions and off-odors. If these types of aromas linger after fermentation and are deemed unpleasant, removal of the sulfur compounds should be addressed.

The most effective fining agent for sulfur-related off-aromas is *copper sulfate* ($CuSO_4$). The best approach to this type of fining is to conduct a copper-addition trial to determine if you can remove the off-odor. If the odor is diminished or removed after the initial test, conduct bench-top trials to find the optimum amount to add. These trials are usually performed using a 0.004% $CuSO_4$ solution added in increasing amounts to a number of wine beakers that hold a constant volume of wine. Additions should be less than 0.5 mg/L, which is the maximum $CuSO_4$ federal laws allow. The reaction between copper and H_2S is usually fairly quick, with changes evident as soon as 1 to 2 hours.

Remove copper from wine after fining. The legal limit for residual $CuSO_4$ in wines is 0.2 mg/L. Use yeast hulls, bentonite, or potassium caseinate to fine excess copper. After treatment and fining, analyze the wines at a commercial lab to check the levels of residual $CuSO_4$ and make sure they are under the legal requirements.

Yeast lees and hulls are a promising alternative technique for removing sulfur aromas—including dimethyl sulfide—but there is limited published evidence to support their use (Palacios et al., 1997). Aerating wine can reduce excessive hydrogen sulfide, but this approach can carry a number of risks such as oxidative browning (white wines), acetic acid formation (reds), and the conversion of mercaptans to disulfides (stagnant water, rotten cabbage, mushrooms). These are volatile aroma compounds that have a greater sensory threshold concentration and are harder to perceive; however, the formation of too many disulfides during aeration may lead to a worsening of the problem, as disulfides are not treatable either by aeration or copper treatments (Jackson, 2008).

Phenol-related aromas. Phenol-related aromas (barnyard, horse, leather, Band-Aid®, chemical) are usually associated with *Brettanomyces* sp. (Brett) yeast infestations and can negatively affect the perceived quality of the wines. Fining agents that are effective in reducing these compounds are, in order of efficiency, **activated carbon** (up to 57% reduction in wine, 75% in headspace—air between the wine and the top of the container holding it), **egg albumin** (19% in wine, 30% in headspace), **isinglass** (27% in headspace), and **chitosan** (27% in headspace).

Chitosan is a chitin-derived polysaccharide extracted from crustaceans or from the *Aspergillus niger* fungus. Its use in the food industry is increasing. In 2011, the European Union authorized the use of chitosan to remove heavy metals and contaminants, prevent cloudiness, and reduce undesirable *Brettanomyces* sp. populations in various foods and beverages. Fungoid chitosan from *Aspergillus niger* is the only type of chitosan accepted in winemaking, and its addition to wines helps control *Brettanomyces* sp populations; remove ochratoxin A, iron, lead, cadmium, and copper; and, more recently, phenols. The limit for adding chitosan ranges from 10 grams per hectoliter (g/hL) to 500 g/hL (0.4 g/gal–20 g/gal). For fining purposes, this limit is set at 100 g/hL (4 g/gal).

Casein, activated carbon, and yeast hulls have been used with varied success to reduce **oxidative aromas**.

Conclusion

A variety of tools and products allow winemakers to correct and refine their wines, increasing product quality. However, all of these products may have unwanted side effects or require extra labor and energy consumption, which can increase overall costs. As in many situations, an ounce of prevention is worth a gallon of (wine) health. If, however, treatment is the only option, understand the specifics of each fining option, its potential performance, dosing, and removal requirements, as well as potential legal limitations.

Best of luck and may Texas wines be always clear and bright!

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Glossary

Anthocyanin: A group of naturally occurring phenolic compounds that are responsible for the red, purple, and blue colors found in many fruits, vegetables, and wine grapes.

Astringency: A tactile sensation that arises from reducing the lubrication of the tissues in the mouth.

Bentonite: An impure clay formed by the weathering of volcanic ash. It is an absorbent material that is able to bond with the floating particles that cause cloudiness in wine. The main types used to fine wine are sodium and calcium bentonite.

Copper sulfate: A copper salt used to remove sulfur aromas.

Fining: A winemaking technique that removes certain unwanted wine components.

Hydrogen sulfide: A sulfur compound that has an odor reminiscent of rotten eggs.

Isoelectric point: The pH at which the net charge of the protein is zero and usually results in reduced solubility for the protein.

Monomer: A molecule that can be bonded to other identical molecules to form a polymer.

Phenols: Any compound with a hydroxyl group linked directly to a benzene ring.

Polyphenols: A large group of compounds that use a chemical structure called phenol as the basic building block; in wine they include tannins and anthocyanins.

Polymer: A substance that has a molecular structure consisting chiefly or entirely of a large number of similar units bonded together.

Polymeric pigments: For an in-depth understanding of this term, see https://psuwineandgrapes.wordpress.com/tag/polymeric-pigment/.

Polysaccharides: A heterogeneous (diverse) group of complex sugar polymers that are generally derived from grapes.

Polyvinylpolypyrolidone: An insoluble fining agent that removes low molecular-weight phenolics such as catechins from wine.

Tannins: A heterogeneous class of polymeric phenolics that are capable of binding proteins, a major source of astringency in wine.

Sources: *A Guide to the Fining of Wine* and *Wine Science. Principles and Applications*

The author would like to thank Mengmeng Gu,
Associate Professor and Extension Ornamental Horticulturist;
Justin Scheiner, Assistant Professor and Extension Viticulture Specialist;
and Larry Stein, Professor and Extension Horticulturist
for their review of this publication.

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