Sensory Evaluation of Spoiled Wines

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Learning sensory evaluation skills is important to all the people who produce, market and enjoy wines. When consumers acquire these skills, they become discriminating wine drinkers, buying good quality wines. This in turn forces wine producers to make better products.

To a wine producer, developing good sensory evaluation skills is indispensable. It is an important tool for controlling wine quality. A winemaker with well developed sensory skills is more likely to make better wines. Thus, production and consumption of quality wines is encouraged when both the consumer and producer acquire sound sensory evaluation skills.

One of the more important aspects of learning to evaluate wine is to learn to recognize wine faults. So let's focus our attention on the attributes of faulty wine, the causes of the defects, and how to prevent them.

Several factors contribute to wine spoilage. The major ones include:

1. Yeast spoilage
2. Acetic spoilage
3. Lactic spoilage
4. Development of sulfide aroma,
5. Oxidation and browning

Yeast Spoilage

Yeast spoilage can lead to turbidity, deposition of precipitate, and formation of off-odors. The yeasts used to ferment the must can also cause a refermentation in a bottled wine containing residual sugar. Refermentation causes the wine to become cloudy and gassy, but the flavor is usually not adversely affected. Ways to prevent a refermentation in the bottle include: addition of sorbate, sterile filtration and bottling.

Wine flavor is adversely affected when a wine is contaminated by film-forming yeasts. These yeasts require air for their growth and often develop on the surface in wines exposed to air. They usually belong to the genera *Pichia*, *Hansenula* and *Candida*. Their activity leads to the formation of several compounds such as acetaldehyde, acetic acid and ethyl acetate. These compounds impart an oxidized and/or vinegar-like aroma to the spoiled wine. To prevent wine spoilage by these yeasts, the wine should be protected from air and adequately sulfited.

Another serious wine spoilage yeast is known as *Brettanomyces/Dekkera* and often found in spoiled red wines. The spoiled wine acquires very unpleasant tastes and odors. The off-odors are often described as burnt beans, sweaty horse blanket, band-aid, metallic and mousy. The development of a "mousy" odor has been attributed to the formation of the compound 2-acetyltetrahydropyridine. It is important to note here that this compound has also been found to be produced by certain lactic acid bacteria. Contrary to film yeasts, *Brettanomyces* grow throughout the wine. The contaminated wine becomes turbid, gassy, and develops off-odors. To prevent spoilage by this yeast, a winemaker needs to follow very stringent sanitation measures, maintain 0.8 ppm molecular SO_2, and sterile filter the wine at bottling.

Acetic Spoilage

Acetic spoilage is a serious defect in wine. The spoiled wine acquires a sour, pungent and sometimes burning aroma and can have a sour, acrid and bitter aftertaste. Such a wine is often referred to as "vinegar-like." This typical odor occurs due to the formation of acetic acid and ethyl acetate. Of the two compounds, ethyl acetate has lower taste and odor threshold values (160-180 mg/L) and is largely responsible for the spoiled taste and unpleasant aroma.

It should be noted that acetic acid is also produced by commercial wine yeasts, but the amount formed is usually very small. When the wine is spoiled by acetic acid bacteria the concentration of acetic acid can be significantly higher. There is a legal limit on the amount of volatile acidity (expressed as acetic acid) that can be present in wine; however, the spoilage can be noticeable well below the legal limit.

The bacteria responsible for causing acetic spoilage belong to two genera: 1) *Acetobacter* and 2) *Gluconobacter*. They are aerobic (they need air to grow), they have respiratory metabolisms, and oxidize ethanol to acetic acid. Species of *Gluconobacter* oxidize ethanol to acetic acid only; whereas species of *Acetobacter* oxidize ethanol to acetic acid and can finally degrade it to CO_2 and water. For this ability they are also called over-oxidizers. It should be noted that the reaction involving conversion of acetic acid to CO_2 and water is inhibited by the presence of ethanol. The mechanism of acetic acid formation is a two-step process. In the first step, ethanol is oxidized to acetaldehyde (which becomes hydrated) and in the second step the hydrated acetaldehyde is converted to acetic acid and water by the enzyme aldehyde dehydrogenase.

What is the source of acetic acid bacteria in wine? And how does it exist during the various stages of vinification? There are two main sources of acetic acid bacteria in wine: 1) grapes (sound or diseased) and 2) contaminated winery equipment and storage containers. The bacteria are naturally present on grapes. In the case of healthy grapes, the population is small, eg. 10^2 cells/g. At harvest the bacteria gain entry into the winery on the fruit. During alcoholic fermentation the bacterial population declines. If rotten fruit with a large bacterial population is used, significant acetification (increase in VA) of the must can occur during the fermentation. Dirty cellar equipment such as hoses, pumps and contaminated wooden barrels are probably the most important sources of acetic acid bacteria in wine. For this reason, great care should be taken in cleaning and sanitizing equipment and containers before they are used for either wine processing or storage.

Growth of the bacteria surviving after the alcoholic fermentation will depend on how the wine is handled. Aeration of wine during transfer, storage in partially filled containers, high pH, warm storage temperature, and

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...inadequate levels of free SO_2 offer favorable conditions for bacteria growth and spoilage.

To prevent acetic spoilage a winemaker should use clean fruit, protect the wine from air, maintain adequate levels (0.8 ppm molecular) of free SO_2 and follow sound sanitary procedures.

Lactic Spoilage

Other wine spoilage organisms that merit attention are lactic acid bacteria (LAB). These organisms are involved in the production of many fermented foods such as sausage, pickles, sauerkraut, olives and yogurt. They also occur in wine. In wine they are responsible for malolactic fermentation (which may or may not be desirable) and, in certain situations, wine spoilage.

The LAB belong to the genera *Leuconostoc, Pediococcus* and *Lactobacillus*. These organisms are gram positive, catalase negative, cocci, coccobacilli or rods. They are microaerophilic and grow best under reduced oxygen conditions. They grow throughout the wine as opposed to acetic acid bacteria which grow on the wine surface.

Based on their metabolic activity, LAB bacteria can be divided into two groups:

Group 1

Bacteria capable of decomposing malic acid, sugars, and citric acid, but not tartaric acid and glycerol. These are the bacteria normally involved in malolactic fermentation. In a must with high residual sugar and high pH these organisms can also metabolize sugar and produce several compounds detrimental to wine quality.

Group 2

These organisms can utilize tartaric acid and glycerol *in addition to malic acid, citric acid and sugars* and cause serious spoilage.

The nature and type of spoilage caused by LAB largely depends on wine composition and the strains of bacteria present. The wine composition determines the various constituents available to bacteria as substrates and the type of bacteria influences the kind of by-products formed from a given substance.

The spoilage caused by lactic acid bacteria is complex and varies considerably. A variety of off-odors are formed and they have been characterized as mousy, geranium-like, butyric or rancid butter, sauerkraut-like, pickle aroma and cheesy.

What is the source of these bacteria? The bacteria are naturally present on grapes and when the grapes are processed they get into the wine. They are also present in the winery and especially in contaminated wooden barrels.

At crush, their population in the must is small. The population declines during the alcoholic fermentation. This may be due to competition by yeast and the formation of ethanol and SO_2 (by yeast). Following the fermentation the population can grow and cause malolactic fermentation.

Following a malolactic fermentation (MLF) the fate and activity of LAB depends on how the wine is handled and stored. It should be noted that MLF causes an increase in pH, and this makes a wine more prone to attack by undesirable types of lactic acid bacteria.

There are several factors that favor the growth of lactic-acid bacteria. Important factors include high pH in the wine, inadequate SO_2, and warm storage temperatures. To discourage the growth of undesirable lactic acid bacteria, it is important to work with relatively low must pH, adequate SO_2, cool storage temperatures and good sanitary practices.

Hydrogen Sulfide

Hydrogen sulfide (H_2S) has the unpleasant odor of rotten eggs. It is one of the most undesirable metabolites of the (yeast) alcoholic fermentation. Sulfur is an essential element for yeast growth and is present in grape juice as sulfate (SO_4). The sulfate is converted to H_2S before it is incorporated into other compounds such as proteins and vitamins. A simplified version of yeast sulfur metabolism was reported by Eschenbruch (1982) to be as follows:

SO_4 —	SO_3 —	H_2S —	Amino acids, proteins, vitamins, and other sulfur compounds
sulfate	sulfite	hydrogen sulfide	

It should be emphasized that H_2S is an intermediate by-product of yeast sulfur metabolism and thus, it is naturally formed during alcoholic fermentation. It is very volatile and can be detected when present in small quantities.

There are various sources of H_2S in wine. It is important to understand them in order to minimize its formation and consequently the spoilage of wine.

Organic Sulfur Compounds

Sulfur-containing organic compounds such as amino acids are synthesized as well as decomposed by yeast. H_2S is formed during the process of synthesis or breakdown. For example, H_2S is an intermediate by-product in the formation of cysteine and methionine. Decomposition of cysteine results in the production of H_2S, pyruvate and ammonia. Yeast metabolic activity is, therefore, an important source of H_2S formation.

Inorganic Sulfur Compounds

Sulfate (SO_4) is the inorganic form of sulfur present in juice. The oxidized forms of sulfur (SO_4 and SO_2) are reduced by the yeast and are used in the production of various cell constituents. These metabolic pathways involve H_2S production.

Elemental Sulfur

Elemental sulfur can be readily used by yeast to produce H_2S. In fact, this is probably one of the most important sources of H_2S in wines.

There are two important sources of elemental sulfur in wine. First, is the use of sulfur-containing fungicides such as lime sulfur. If residual sulfur is present on the grapes at the time of harvest, it can get into the must. For this reason, it is recommended to hold the last sulfur spray application no later than 35 days before harvest.

The second source of elemental sulfur is insufficiently burned sulfur strips or candles used to sterilize wooden cooperage. To avoid this problem, a small device called a sulfur candle holder should be used to burn the sulfur strips.

Yeast Strain

Yeast strains widely differ in their ability to produce H_2S. Therefore, a selected pure culture of a low-H_2S forming strain should be used for conducting the fermentation. Certain strains (including wild ones) can have a metabolic disorder which results in H_2S formation. These strains require vitamins

...as pantothenic acid and pyridoxine. In the absence of these compounds H_2S is produced. For this reason yeast having no metabolic disorders should be chosen for the fermentation. That means that the winemaker should not rely on natural wild yeast for the alcoholic fermentation. Supplementing a must with these vitamins can minimize H_2S problems.

Yeast autolysis occurs when the wine is left on lees following the alcoholic fermentation. During this process proteins decompose and certain sulfur-containing amino acids can be released. Degradation of these amino acids can produce H_2S. It is, therefore, advised that the wine be racked off the lees soon after the fermentation.

Juice Composition

Musts deficient in assimilable nitrogen have been found to produce H_2S. It is claimed that in these musts the extracellular proteases degrade juice proteins which result in H_2S formation. In the case of nitrogen-deficient musts, the addition of nitrogen such as diammonium phosphate can overcome the problem of H_2S production.

Metal Contamination

The presence of certain metals such as zinc and copper can cause H_2S formation. Since wineries are using equipment made of stainless steel and plastic, metal contamination does not seem to be a major cause. However, when certain copper-based fungicides are used and the copper residue gets into the must, then the changes of H_2S formation are greatly increased. Prevention of H_2S spoilage is easier than the cure.

WAYS TO PREVENT H_2S IN WINE

1. Select and use low H_2S producing yeast strains for the alcoholic fermentation.
2. Use a yeast nutrient. This should include assimilable nitrogen and several essential vitamins.
3. Rack promptly. Autolysis of yeast can lead to H_2S formation.
4. Avoid must contamination by elemental sulfur. Contamination of must by elemental sulfur, either from fungicide or dripping of molten sulfur from candles, will almost invariably cause H_2S formation.

Removal of H_2S

H_2S is very volatile and can be removed if the wine is treated soon after H_2S is detected. If H_2S is not quickly removed, it can form complex sulfur compounds which can be difficult to remove and can permanently impair wine quality. Some of the measures that can be used to remove H_2S are as follows:

- *Aeration:* Soon after H_2S is detected, the wine should be aerated. Carbon dioxide or nitrogen should be used if wine is sparged to avoid oxidation during aeration.
- *Added sulfur dioxide:* In some cases SO_2 addition can reduce H_2S aroma; however, it is important to treat wine soon after H_2S is detected.
- *Copper treatment:* When copper is added to the wine, the cupric ions combine with H_2S to form copper sulfide. The insoluble copper sulfide will settle to the bottom and can be removed by filtration. The BATF regulations require that the residual copper content of the wine does not exceed 0.2 ppm. Therefore, after the copper treatment, vintners must get the wine analyzed to assure compliance with this regulation. Usually copper sulfate is used for this treatment.

Oxidation and Browning

Oxidation of must and wine causes browning, loss of fruity and/or varietal character, and the development of oxidized or aldehydic odors.

Phenolic compounds are the primary substrate for oxidative reactions in wine. These reactions can be enzymic (catalyzed by an enzyme), or they can occur without the participation of an enzyme. In this case (without an enzyme), they are called chemical oxidation. Generally, must oxidation is enzymic, whereas, oxidation of wine is direct chemical or autoxidation.

Enzymic Oxidation

As the name implies, enzymes catalyze enzymic oxidation. Polyphenol or laccase (in the case of botrytis infection) oxidizes phenols in the presence of O_2; it oxidizes phenols into quinones. The O-quinone can polymerize and form dark-colored pigments. This second reaction (polymerization) does not involve enzyme participation. Sulfur dioxide inhibits the activity of these enzymes and thus, prevents oxidation.

It should be emphasized that the enzyme laccase is fairly resistant to SO_2 and is also capable of using a large number of phenolic compounds as a substrate for oxidation. It is also more stable in wine.

Chemical Oxidation

In the case of chemical oxidation, oxygen directly combines with a phenol and produces a quinone plus a strong oxidizing agent such as hydrogen peroxide. In a second (but coupled) reaction, the hydrogen peroxide oxidizes ethyl alcohol to acetaldehyde.

Sulfur dioxide can inhibit the formation of acetaldehyde by interacting with hydrogen peroxide, which oxidizes it (SO_2) to sulfate (SO_4).

Several measures can be employed to prevent oxidative spoilage of wine.

1. Use of sound and healthy grapes is important. Rotten grapes contain enzymes that make the must more prone to browning.
2. Adding moderate amounts of SO_2 to must as well as to wine is essential to prevent oxidation. The amount of added SO_2 should be based on pH. Another important aspect about SO_2 is that it declines with time. Therefore, it must be replenished periodically.
3. If the must pH is high (>3.5) it should be lowered by tartaric acid additions prior to the fermentation. High pH wines are more easily oxidized.
4. Minimize the aeration of wine during transfer and storage. Use inert gas to sparge the wine and also sparge the storage containers. The wine containers should always be kept full and if a headspace is allowed, then the oxygen content in the headspace should be reduced to less than 0.5%.

Undesirable microbial activity and oxidation can cause serious faults in wine. Adopting sound vinification techniques, such as using clean fruit, adjusting must pH, using adequate levels of SO_2, controlling the fermentation

-ate, minimizing air exposure to wine, ıd following stringent cleaning and sanitary procedures would help avoid ese problems. ☐

Literature Cited

1. Eschenbruch. 1982. H_2S formation – the continuing problem during winemaking. Fermentation Technology. Proceedings of a seminar held October 4, 1982, McLaren Vales, South Australia. p. 79.

WINE FAULT	SENSORY ATTRIBUTES	
	APPEARANCE	AROMA
Yeast Spoilage	Cloudy, gassy, may have sediment	Oxidized, aldehydic, ethyl acetate and acetic acid
Acetic Spoilage	Cloudy, gassy, may have sediment	Acetic acid, ethyl acetate, "vinegar-like" or VA odor
Lactic Spoilage	Cloudy, hazy, may have sediment	Diacetyl, sauerkraut-like, butyric, rancid butter, geranium-like, pickle aroma, mousy and other off-odors
Hydrogen sulfide		Rotten egg, garlic, skunky and other sulfide aromas
Oxidation	Browning	Aldehydic and oxidized aroma