WINE STORAGE AND BOTTLING QUALITY CONTROL

Learning Outcomes: ***This review covers practical and important issues regarding wine storage and bottling quality control. It outlines the importance of*** **a proactive management system that should be utilized by winemakers to help assure product quality control from the cellar thought bottling. It identifies a number of monitoring points during each step.**

Chapter Outline

Section 1.

Wine Storage and Bottling Quality Control

The principal quality control difficulties of the wine industry in include the following:

- lack of adequate recordkeeping
- fruit quality
- control of phenol extraction
- oxidative and microbiological degradation

The key to adequate quality control is to monitor how each production activity affects wine palatability and to make adjustments accordingly. Complete and accurate recordkeeping is the cornerstone of a successful quality control program. Only when proper up-to-date accounts of wine production activities are kept can a full understanding of the parameters affecting wine quality occur.

The development of a HACCP (Hazard Analysis and Critical Control Point) Plan is the key to consistently crafting fine wines. Such a system allows one to use his or her own philosophy to determine which steps in the kaleidoscope of winemaking choices should be monitored.

The following is an outline of some common issues . For the establishment of a detailed quality control or best-practices program, see *Enology Notes* index HACCP at www.vtwines.info.

Aging and Storage Quality Control

Sanitation

Each winery should have an established sanitation program, and periodically monitor the effectiveness of that program. Such simple procedures as tasting barrel and tank rinse water can be a significant step in ensuring quality. Alcohol is an excellent solvent. Therefore, any off-character in the rinse water may be picked up in the wine.

Chemical Analysis

A procedure should be established for running a specific set of analyses according to a specific timetable. The analysis performed depends somewhat upon the philosophy of the winemaker. Several analyses are essential on newly-fermented wines:

- pH
- free and total sulfur dioxide (by the aeration-oxidation method, see Zoecklein et al. 1999)
- titratable acidity
- reducing sugar

- alcohol
- protein stability (for whites and low-tannin reds)
- potassium bitartrate stability
- MLF status, biological stablity
- Proper and controlled sensory analysis

These are the very minimum analyses which the winery should be capable of performing or willing to contract.

It is important that the winemaker know how each processing step affects his product, both chemically and organoleptically. Formal or semi-formal sensory evaluations should be conducted regularly using reference samples. For example, wines should be evaluated for comparison of color and body stripping due to filtration, cold stabilization, etc., both before and after the procedure is conducted.

Oxygen Pickup

Most winemakers strive to retain as much of the “grape” as possible in their wines. The loss of aroma components between fermentation and bottle release is a significant problem in this state.

The colder the wine, the greater is the solubility of molecular oxygen in the wine. When the wine is then allowed to warm, oxidation can occur. This is a principal disadvantage of conventional cold stabilization for potassium bitartrate stability. Such procedures often result in prolonged refrigeration of wines, resulting in oxidative degradation and high energy demands.

Each winemaker must know how processing and equipment affect O_2 uptake. Free sulfur dioxide analysis is a good indication of O_2 uptake, since sulfurous acid is oxidized by the dissolved oxygen in wine. Therefore, a rapid decline in the free SO_2 level in a short period of time is indicative of O_2 pickup.

Such preventive steps as proper equipment, sulfur dioxide additions *during or just* prior to wine movements, nitrogen blanketing, CO_2 sparging, and flushing lines and receiving tanks, all have their place in reducing the likelihood of excessive oxidation. (The use of a "Y'" valve on the suction side of a positive-displacement pump is an easy way to introduce SO_2, gases, fining agents, etc., during racking). For a discussion on the use of displacement gases, see *Enology Notes*.

There is no substitute for storing wines in full containers, with the possible exception of barrels. A partial vacuums is formed in *properly sealed* barrels over time. Many assumed that barrels should be topped regularly to prevent oxidation and biological growth. The frequency of barrel topping should be part of the winery's HACCP program, and determined based on wine chemistry, style (secondary lees volume), and barrel sanitation program.

As stated, wine temperature is important because of its effect on oxygen solubility. Knowing storage temperatures and temperature fluctuations is a key to understanding the aging potential of a wine.

Pre-Bottling

A checklist should be established to ensure that important factors are not overlooked. These should include the following:

- free sulphur levels (FSO_2)
- dissolved carbon dioxide (DCO_2)
- dissolved oxygen (DO)
- turbidity
- residue sugar/density
- temperature
- stability: protein, color, bitartrate, and microbiological
- final sensory analysis or review, including screen for volatile sulfur-like off odors.

It should be noted that wines are generally stable with regard to MLF if the malic acid content is less than 30 mg/L. Paper chromatography is only semi-quantitative and will detect malic acid levels in the range of 100 mg/L or more.

Wines to be either bottled unfiltered would without absolute membrane porosity should be tested for viable yeast, acetic acid bacteria and lactic acid bacteria. includes *Brettanomyces* spp. Testing procedures include traditional bench top techniques such as plating or molecular methods such as Scorpion ™.

Dissolved oxygen meters must be calibrated regularly can capable of reading to the hundredths. Residue carbon dioxide may increase the risk of foaming, necessitating the use of anti-foam adjuncts.

Chemical Analysis

Has the wine met the proper analytical criteria for bottling? Do you know the accuracy and precision of your analysis?

Stability Analysis

Has the wine met such stability criteria including protein, color, and bitartrate and microbiological stability? Note that any blending, acid or sweetness source addition can change a wine from stable to unstable. If wine was produced from compromised fruit and the calcium level is greater than 40 mg/L there is a possibility of post-bottling calcium tartrate precipitation (See *Enology Notes* Index).

Sensory Analysis

All bottling lots should be reviewed by a panel, not solely by the winemaker. It is easy for those in the commercial wine industry to overestimate their own sensory abilities. The fact that winemakers can distinguish between ethyl acetate and ethyl mercaptans does not necessarily mean they are the best judge of what the buying public desires. It is recommended that the winemaker take a sample of the wine home and have it with several meals in a comfortable, relaxed atmosphere. Many contrast their wine with at least one other.

Materials and Quality Control Analysis

Are all materials needed for bottling present and in the proper condition? Clearly distinguish between critical (functional) and minor ("cosmetic") flaws.

- Acceptable Quality Levels (AQL): This is a satatistical measures of consistency or quality common to sampling programs. AQL refers to the maximum number of defects that are considered acceptable during inspection of a randomly selected sample.
- AQL sampling fixes the probability of lot acceptance at 95%. For example, establishing a AQL of 1.5% for cork equates to ≤15 defects per 1,000 cylinders. A restrictive AQL such as 0.010 (1/10,000) will require a much larger sample size than a higher AQL such as 1.0 (100/10,000).
- Selection of AQLs depend upon the nature of defect(s) to be detected:
    - Major defect (Critical) : 1%
    - Minor (Cosmetic) defect 2.5 - 4%
    - The set Acceptable Quality Levels (AQL) should be equal to (but not more restrictive) than your processing capabilities.

Bottling Quality Control

Sanitation Program

The winery should have a set bottling sanitation program and know its effectiveness. Sanitation in the absence of monitoring is faith-based.

Biological and Oxidative Quality Control

Based upon microbiology, is there a need to sterile package? Options include the following:

- sterile bottling (0.45 µm filtration)
- 0.80 µm filtration
- “sterile” pads
- chemicals (preservatives or sterilant)

Aside from packaging, the two most important considerations during bottling are biological and oxidative. Spoilage organisms which are present in the winery can easily find an adequate growth medium in spilled wine, particularly if the wine is not cleaned up properly. The major sources of contamination during bottling include the following:

- Filter pad drip trays. This is of increased importance due to the use of cellulosic pads, which drip heavily. Trays must be drained often during bottling runs if wine is being filtered during bottling.
- Fill bowls. Leaky spouts, wine blown from snifter valves, wine residue on bell rubbers, etc., can harbor wine contaminants. It may be desirable, particularly during long runs, to occasionally mist bell rubbers and filler stems with a 60-70% ethanol solution to inhibit microbial growth.
- Corking machines. Corkers are a significant source of potential sanitation difficulties, due to the likelihood of wine spillage, and are easily contaminated. These units should be completely dismantled and cleaned before and after each bottling. Ethanol misting of the corker jaws during bottling can be a significant asset in minimizing biological problems.
- Work activity. Increased worker activity in the bottling area increases the spread of airborne wine microbes. It is desirable to limit the number of employees around the filling and corking area to as few as possible.

Bottling line sanitation monitoring is essential for minimizing potential problems.

Optimally, sampling should occur at 1 hr intervals during operational run. Bottling line samples should be held 2-3 days before biological plating (if that is to occur) to allow sulfur dioxide and other preservatives to impact microbes.

If biological plating is to occur the universal question is how much wine needs to be plated to detect problems?

- Hypothetical Scenario: Assume that >10 cells/L constitutes microbiological instability.
- 100 mL and 750 mL membrane-filtered samples:

Case 1: $\frac{20 \text{ cells}}{1000 \text{ mL}} \times 100 \text{ mL} = 2.0 \text{ cells}$

Case 2: $\frac{20 \text{ cells}}{1000 \text{ mL}} \times 750 \text{ mL} = 15 \text{ cells}$

Wine Oxidation

Another potential problem during bottling is wine oxidation. It is not unusual for bottling to impart from 0.5 to greater than 2 mg of O_2/L into the wine. Such addition can have a profound effect on wine quality and shelf life. It is therefore essential to know your bottling equipment and how it affects wine oxidation. Such production practices as sulfur dioxide additions just prior to bottling, ascorbic acid additions, nitrogen sparging, carbon dioxide or nitrogen flushing of bottles prior to filling, vacuum corkers and fillers, etc., can be useful in limiting O_2 problems.

The loss of free sulfur dioxide in wine is proportional to the dissolved oxygen content. Producers not using vacuum fillers and corkers, or flushing bottles with gas, can have up to 5 mL of air in the headspace of their bottled wine (750 mL bottles). This amounts to approximately 1 mL (1.4 mg) of oxygen. Four mg of sulfur dioxide are needed to neutralize the effects of 1 mg of oxygen.

Using this relationship, an additional 5-6 mg of free sulfur dioxide is needed to reduce molecular oxygen in the headspace. This represents a rather significant loss of free sulfur dioxide which could otherwise be available as an antimicrobial agent. It should be noted that the reaction of sulfur dioxide with oxygen is not instantaneous. As such, oxidation of desirable aroma and flavor components can occur. An advantage of the use of ascorbic acid is that it reacts very rapidly. For a discussion on the advantages and disadvantages of ascorbic acid see *Enology Notes* # 133 and 144 at www.vtwines.info.

If the extent of potential oxidation is high, wines should not be bottled cold, due to the increased solubility of molecular oxygen. High levels of oxygen are particularly detrimental to wines which contain sorbic acid (potassium sorbate), due to the development of oxidative products which impart an unpleasant character to the wines.

There is a risk in the cellar operation of picking up oxygen during the mixing of wine. The risk of picking up dissolved oxygen can be reduced by ensuring that there is good cover of CO_2 gas on the top of the tank during the mixing process, and that all hose and fitting connections on the pump and tank, particularly on the suction side, are air tight.

There is a much greater risk in picking up oxygen in this cellar operation if wine is being recirculated and chilled through a heat exchanger. A good CO_2 gas cover on the top of the wine maybe helpful. The risk of picking up dissolved oxygen when using mixing tanks can be reduced by ensuring that there is a good cover of CO_2 gas on the top of the tank during the mixing process, and that all hose and fitting connections on the pump and tank are air tight.

In wines with dissolved carbon dioxide, the CO_2 level should be monitored prior to bottling to assure that proper concentration has been attained and that there are not foaming issues.

Wine Temperature

The TTB requires proprietors to test representative wines at intervals during the wine bottling operation for correct fill height. Fill height is highly dependent on wine temperature. Ideally, wine temperature should be between 60-70°F at bottling. Thermal expansion of wine between 20°C (68°F) and 40°C (104°F) is 0.08%. As a general rule, wine volume will increase 0.166 mL/1°F in the neck of most 750-mL bottles.

Thus, if a winery bottles at 58°F with 4.5 mL of headspace, that ullage will be reduced to under 3 ml at 68°F, and internal bottle pressure will have risen significantly. This generally is alcohol dependent. The higher the alcohol, the greater is the volume increase, resulting in decreased headspace and corresponding increases in pressure. If lower temperatures are used, the fill points should be adjusted down to compensate for expansion in the bottle when room temperature is reached. General tolerances for 750 mL bottles is 2.0 percent, for 350 mL bottles, 3.0 percent at 20° C/68° F.

Label Coding

Label coding is a means by which the winemaker can extend his quality control into the marketplace. By placing very small notches, one each for day, month, and year on the label, winery personnel can determine the bottling date and, from there, the complete history of the wine.

Label coding can be done by simply placing a stack of labels in a vise and using a saw to cut a small notch on each axis. Using a standard – usually a piece of plastic – the vintner can identify the bottling date. This can be highly important if the winery is forced to have several to many bottling runs of a particular wine lot.

We have had several cases where sheer biological or physical instability occurred with only one bottling date, of a wine with several bottlings. Had these wineries coded their bottles, they could have gone into the marketplace and simply removed only that particular bottling date affected. Instead, they were forced to recall all bottling dates of that particular wine, resulting in a major credibility problem – to say nothing of the direct economic loss.

Warehousing and Bottle Release

Wines bottled in synthetic closures should be stored upright. Cork-finished wines can be stored on their closures some time after bottling.

Bottle release dates are usually determined based on marketing decisions. However, bottled wines should be periodically tasted by a panel against reference samples (held at < 40°F) to determine how the wine is developing. Too early a release date results in a bottle bouquet that is less than fully developed, too late may mean a large segment of the consumers could receive the wine after its quality begins to diminish.

Bottle shock

Bottle shock is a rather strange phenomenon where a wines aromatic intensity is reduced after bottling only to return sometime later. The cause(s) of bottle shock are unknown, but widely debated and are likely the result oxidative effects. Generally, if wines are tasted immediately during or shortly after bottling, there is no noticeable effect. However, within the course of a few hours or days the oxygen present can react with wine components causing a reduction in the aromatic intensity. Traditionally this loss has been attributed to the production of aldehydes, a product of ethanol oxidation. Others suggest that bottle shock is the result of another oxidation product, hydrogen peroxide.

Bottle aging is dependent upon the wine chemistry and the warehousing conditions. It is essential that the winemaker understand how each processing step affects wine chemistry and, therefore, wine shelf life. Bottle storage temperature naturally impact wine longevity. For example, it is estimated that a white wine stored at 55 degrees F and expected to continue to improve for 5 years may have that time reduced by one half if stored at 70 degrees F.

Premium wine quality is the result of quality fruit and many processing steps. These steps, viewed individually, may be insignificant. However, collectively they make the difference between standard and outstanding wines. It is the responsibility of the winemaker to understand how production parameters affect wine quality, and to make adjustments accordingly.

For a more detailed discussion on quality parameters, see *Enology Notes* HACCP (Hazard Analysis and Critical Control Points) at www.vtwines.info.