Sorbic Acid*
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A. W. Van Hoffman was the first to isolate sorbic acid from the berries of the mountain ash tree in the year 1859. The antimicrobial (preservative) properties of sorbic acid were recognized in the 1940's. In the late 1940's and 1950's it became commercially available. Since then, sorbic acid has been extensively tested and used as a preservative in many foods. In wine, its use was legalized in France in 1959 and in Germany in 1971. Sorbic acid and its potassium salt are now used in many countries in the production of sweet white wines. In the United States, BATF permits the use of sorbic acid and potassium sorbate to preserve wine. The maximum concentration of sorbic acid allowed in finished wine is 300 mg/L, (300 ppm).

Sorbic acid (2,4-hexadienoic acid) is a straight chain unsaturated fatty acid with a molecular weight of 112.13 and the formula: CH_3 - CH = CH - CH = CH - COOH. Sorbic acid is commercially produced as a powder or granules, it has a characteristic acrid odor and acid taste. The carboxyl (COOH) group in sorbic acid is very reactive and can form salts with calcium, sodium, and potassium. The potassium salt of sorbic acid is commercially available as a powder or granules. Its molecular weight is 150.22 and it is very soluble in water. The solubilities of sorbic acid and potassium sorbate are given in Table 1.

Table 1. Sorbic acid and potassium sorbate solubilities

Solvent	% Solubility Sorbic Acid	% Solubility Potassium Sorbate
Water		
20ºC (68ºF)	0.16	58.20
50°C (112°F)	0.55	61.00
100°C (212°F)	4.00	64.00
Ethanol		
5%	0.16	57.40
100%	12.90	2.00
Sucrose		
10%	0.15	58.00
40%	0.10	45.00
60%	0.08	28.00

Source: Gooding et.al. (1955), Pfizer (1974), Monsanto (1978), and Sofos and Busta (1981), Cited by Sofos and Busta (1983).

As shown in Table 1, the solubility of sorbic acid in water is low (.16 g/100 ml) and it increases with temperature. The solubility is higher in ethanol, but decreases in the presence of other solutes such as sugar. Potassium sorbate (as compared to sorbic acid) is very soluble in water. The solubility decreases with an increase in ethanol, and/or sugar content in the solvent mixture. This point is important since sweet wines contain both sugar and alcohol.

Antimicrobial Activity
The antimicrobial action of sorbic acid is primarily against yeasts and molds. It's action against bacteria appears to be selective. At concentrations used in wine it does not seem to prevent spoilage from either acetic or lactic acid bacteria. Must and wine related yeasts inhibited by sorbic acid include species of genera *Brettanomyces, Candida, Hansenula, Pichia, Saccharomyces, Torulaspora,* and *Zygosaccharomyces.*

The inhibitory effect of sorbic acid on yeast strains is not uniform. Certain species are more tolerant than others. For example, according to Pitt (1974), *Zygosaccharomyces bailii* was not inhibited by sorbic acid at 0.06% in 10% glucose. It should be noted that the yeast *Zygosaccharomyces bailii* is also resistant to sulfur dioxide and diethyl pyrocarbonic acid (DEPC) and it can ferment high sugar musts such as grape juice concentrate containing 55 to 72 percent sugar. If contaminated concentrate is used for sweetening wine, it is likely to cause a refermentation even if a normal concentration of sorbic acid is present.

The minimum inhibitory concentration of sorbic acid for various strains of yeast is shown in Table 2.

Table 2. Inhibitory action of sorbic acid on yeasts

Name of test organism	**pH value**	**Minimum inhibitory concentration in ppm**
Saccharomyces cerevisiae	3.0	25
Saccharomyces ellipsoideus	3.5	50 - 200
Saccharomyces spec.	3.2 - 5.7	30 - 100
Hansenula anomala	5.0	500
Brettanomyces versatilis	4.6	200
Byssochlamys fulva	3.5	50 - 250
Rhodotorula spec.	4.0 - 5.0	100 - 200
Torulopsis holmii	4.6	400
Torula I lipolytica	5.0	100 - 200
Kloeckera apiculata	3.5 - 4.0	100 - 200
Candida krusei	3.4	100
Candida lipolytica	5.0	100

Source: Rehm (1961), Luck (1972), Cited by Erick Luck (1980).

The inhibitory influence of sorbic acid is greatest when it is in undissociated form. The pka of sorbic acid is 4.75. The antimicrobial action increases as the pH value decreases below 4.75. In other words, the proportion of undissociated form of sorbic acid increases (above 50%) as the pH drops below 4.75, this can lead to increased antimicrobial action. The effect of pH on the dissociation of sorbic acid is shown in Table 3.

Table 3. Sorbic acid dissociation at various pH values.

pH	**% undissociated acid**
7.00	0.6
6.00	6.0
5.80	7.0
5.00	37.0
4.75	50.0
4.40	70.0
4.00	86.0
3.70	93.0

3.00	98.0

Source: Sauer (1977), Sofos and Busta (1981).
Cited by Sofos and Busta (1983)

Sorbic acid also inhibits mold growth. Some of the important species that are suppressed by sorbic acid belong to the genera *Alternaria, Botrytis, Cladosporiwn, Fusariwn, Mucor, Penicilliwn, Rhizopus, Trichoderma.* Mold can be a problem in wine cellars. To control mold in the wine cellar, sorbic acid could be included in the antimicrobial compounds used for sanitizing.

Several microorganisms can metabolize sorbic acid particularly when it is present in small concentrations. For this reason, it is not a suitable preservative in foods with high microbial counts. To derive the maximum benefit from the antimicrobial action of sorbic acid, it is important to clean the wine well and keep the microbial count low in the bottled wine. It should be emphasized that sorbic acid inhibits yeast and mold, but not acetic and lactic acid bacteria. In fact, lactic acid bacteria can metabolize sorbic acid and produce off flavored compounds.

The antimicrobial action of sorbic acid is due to its inhibitory influence on various enzymes in the microbial cell. The enzymes inhibited by sorbic acid include the following:

1. Enzymes involved in carbohydrate metabolism such as enolase and lactate dehydrogenase.
2. Enzymes of citric acid cycles such as malate dehydrogenase, isocitrate dehydrogenase, ketoglutarate dehydrogenase, succinate dehydrogenase, and fumerase.
3. Several enzymes containing SH group, and other enzymes such as catalase and peroxidase.

Application in the Winery
Potassium sorbate is used in the production of sweet white table wines. Although BATF permits its use in wine, up to 300 ppm, it is important to remember that its taste threshold is well below the legal limit. The taste threshold for experienced tasters has been reported to be about 130 ppm. Addition of sorbic acid often results in the formation of ethyl sorbate, which is said to impart an unpleasant odor when present in a significant level.
As mentioned earlier, lactic acid bacteria can decompose sorbic acid and produce 2-ethoxyhexa-3, 5 diene, and other compounds which give a geranium like off odor. Crowell and Guyman (1975) explained the reaction as follows:

Sorbic acid ETOH, H+
(2, 4-hexadienoic acid) Ethyl sorbate

Lactic acid bacteria

Sorbyl alcohol
(2, 4 - hexadien - 1 - 01)

rearrangement, H+
ETOH

3,5- Hexadien -2-ol 2, ethoxyhexa -3,5 diene

They suggested that in addition to 2 ethoxyhexa - 3, 5 diene (main compound with geranium like odor) other compounds such as the two dienols and the other ether, (1 - ethoxyhexa 2,4 diene) also contribute to the overall off odors in wines containing sorbic acid and spoiled by lactic acid bacteria.

To prevent bacterial spoilage in sweet wines it is important to add a sufficient amount of sufur dioxide in addition to sorbic acid.

Besides pH, the ethanol content of a wine also influences the antimicrobial action of sorbic acid. For this reason, with a relatively high amount of alcohol in the wine, lower levels of sorbic acid would be needed. Peynaud (1980) recommended the following doses of sorbic acid in clarified wine based on alcohol content. This is shown in Table 4.

Table 4.

% Alcohol in wine	Sorbic acid mg/L
10	150
11	125
12	100
13	75
14	50

It should be emphasized that a wine must be clarified to reduce the yeast population below 100/ml for sorbic acid to be effective.

The key points in sorbic acid use are summarized below.

1. Potassium sorbate (most soluble form of sorbic acid) should be used. However, this can cause bitartrate precipition problems.
2. The solubility of potassium sorbate is influenced by temperature, therefore, it should not be added to a cold wine.
3. Wine should be mixed well after sorbate addition.
4. Sorbate should be used in conjunction with sulfur dioxide.
5. Certain yeast and bacteria are not inhibited by sorbic acid.
6. Properly clarified wine (low yeast count), low pH, and relatively high alcohol would help in reducing the amount of sorbic acid needed for effectively controlling yeast.
7. Sorbic acid addition should never be considered as a substitute for poor sanitation.

Calculating Potassium Sorbate Additions

Sorbic acid is added to a wine in the form of the potassium salt. Potassium sorbate contains 73.97% sorbic acid. In order to calculate the amount of potassium sorbate, the following formula should be used.

Formula: ppm = mg/liter
mg/liter of sorbic acid x 1.35 = mg/
liter of potassium sorbate

Example: To obtain 200 ppm sorbic acid in wine, the following steps may be used.

I. 200 ppm = 200 mg/liter
II. 200 mg/liter x 1.35 = 270 mg/liter of potassium sorbate
III. 270 mg/liter x 3.785 = 1021.95 mg/gallon or 1.022 gram/gallon

Table 5, given below shows the amount of potassium sorbate needed (1 to 1000 gallons) to obtain various levels of sorbic acid in wine.

*ppm of sorbic acid desired	Grams of Potassium Sorbate Required	Grams of Potassium Sorbate Required	Grams of Potassium Sorbate Required	Grams of Potassium Sorbate Required
	gm/gal	**gm/10 gal**	**gm/100 gal**	**gm/1000 gal**
50	0.225	2.55	25.5	255
75	0.383	3.83	38.3	383
100	0.511	5.11	51.1	511
125	0.639	6.39	63.9	639
150	0.767	7.67	76.7	767
175	0.894	8.94	89.4	894
200	1.022	10.22	102.2	1022
225	1.150	11.50	115.0	1150

250	1.278	12.78	127.8	1278
275	1.405	14.05	140.5	1405
300	1.533	15.33	153.3	1533
325	1.661	16.61	166.1	1661
350	1.789	17.89	178.9	1789

*Values given in the left column are for sorbic acid, while the values given in other columns are for potassium sorbate. For example, to obtain 150 ppm sorbic acid level, you need to add 150 x 1.35 = 202 mg/L of potassium sorbate and not 150 mg/L of potassium sorbate. This is due to the fact that potassium sorbate on a molecular weight basis contains about 74% sorbic acid.

References

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