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(54) Title: USE OF ABSCISIC ACID TO ALTER SENSORY CHARACTERISTICS OF RED GRAPES AND WINE

(57) Abstract: This invention describes the use of S-abscisic acid (S-ABA) to modify sensory characteristics such as aroma, bouquet, flavor, mouthfeel, astringency, balance, complexity or finish of red grapes and red wine.

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USE OF ABSCISIC ACID TO ALTER SENSORY CHARACTERISTICS OF RED GRAPES AND WINE

FIELD OF THE INVENTION

The present invention is directed to the use of S-abscisic acid and its salts to
5 modify the development of the sensory characteristics of red grapes and red wine,
such as aroma, bouquet, flavor, mouthfeel, astringency, balance, complexity or
finish.

BACKGROUND OF THE INVENTION

Abscisic acid (S-Absciscic acid, S-ABA, ABA) is a natural occurring plant
10 hormone found in all higher plants (Cutler and Krochko. 1999. Trends in Plant
Science. 4: 472-478; Finkelstein and Rock. 2002. The Arabidopsis Book. ASPB,
Monona, MD, 1-52). S-ABA is involved in many major processes during plant
growth and development including dormancy, germination, bud break, flowering,
fruit set, general growth and development, stress tolerance, ripening, maturation,
15 organ abscission, and senescence. S-ABA also plays an important role in plant
tolerance to environmental stresses, such as drought, cold, and excessive salinity.

One key role of S-ABA in regulating physiological responses of plants is to
act as a signal of reduced water availability to reduce water loss, inhibit growth and
induce adaptive responses. All these functions are related to stomatal closure of
20 plant leaves (Raschke and Hedrich, 1985, Planta, 163: 105-118). When stomata
close, plants conserve water to survive in environmental stresses. However,
stomatal closure also can result in the reduction of photosynthesis, and respiration
and thus growth. Stomatal closure is a rapid response of plants to S-ABA. The
mechanism of action of S-ABA-induced stomatal closure has been studied, and the
25 effect has been shown to be due primarily to S-ABA's effect on guard cell ion
channels. Specifically, S-ABA blocks H^+ extrusion and K^+ influx from guard cells
and promotes K^+ , Cl^- , and malate extrusion and Ca^{2+} influx. The net effect of S-
ABA is to reduce the total osmotica in the guard cells, which in turn decreases the

water content in the cell. This causes the guard cells to lose their turgor and thus close the stomata (Assmann 2004 In: *Plant Hormones Biosynthesis, Signal Transduction, Action!* ed. Davies, p 391-412). The closing of stomata results in reduced transpiration of the plant leaf. In grapes, application of S-ABA has been reported to increase stomatal resistance in grapevines, thereby reducing the gas exchange and stomatal transpiration of the leaves (Düring and Broquedis, 1980, Sci. Hort., 13: 253-260).

The exogenous application of S-ABA to red grapes prior to harvest has been shown to increase the accumulation of anthocyanins and increase the red color of the grape berry skins (e.g. Han, D. H, S.M. Lee, and S.B. Kim. 1996, J. Kor. Soc. Hort. Sci. 37: 416-420; Lee, K.S., J.C. Less, Y.S. Hwang, and I.B. Hur, 1997, J. Kor. Soc. Hort. Sci. 38: 717-721; Kondo, S., Masuda, E. and Inoue, K., 1998, Acta Hort., 464: 35-40; Pepe, M.C., Fidelibus, M.W., Dokoozlian, N. 2006, HortScience, 41:1440-1445).

The sensory characteristics of wine such as aroma and flavor are complex and there is interest in altering wine grape berry and/or wine characteristics to produce more diverse or better wine, or wines with different balances of sensory characteristics. A patent application has been filed (Quaghebeur, K., 2005, US 2005/0198896 A1) claiming that ABA application enhances wine quality as a consequence of simulating drought in the grapevine leading to reduction in grape berry size in conjunction with increased sugar content. However, no mention is made of ABA application affecting sensory characteristics such as aroma, bouquet, flavor, mouthfeel, astringency, balance, complexity or finish. The literature reports that the effect of S-ABA application on grapes is to increase berry and cluster weight (Han, D. H, S.M. Lee, and S.B. Kim. 1996. J. Kor. Soc. Hort. Sci. 37: 416-420). While the effect of S-ABA to increase red color of red grapes has been studied and reported, there are no previous reports on the effect of and the use of S-ABA on red grapes to affect the various sensory characteristics of red grapes and/or the resulting wine.

SUMMARY OF THE INVENTION

The present invention is directed to the preharvest treatment of red wine grapes with S-ABA or its salts after fruit set. This treatment alters the development of red grape berry and wine flavor characteristics, allowing the berry and wine
5 sensory characteristics, such as aroma, bouquet, flavor, mouthfeel, astringency, balance, complexity or finish to be manipulated to help achieve the wine style desired by the viticulturist and winemaker.

DETAILED DESCRIPTION OF THE INVENTION

The present invention comprises the application of S-ABA or its salts to red
10 grape grapevines to modify development of grape berry and wine sensory characteristics. S-ABA or a salt of S-ABA is applied to the grapevines as a foliar spray to the grape berries and leaves, by application to the roots of the grapevine through irrigation or fertigation methods, or by injection into the grapevine.

Abscisic acid (S-ABA; ABA; S-(+)-abscisic acid; +-ABA, (+)-(S)-cis,trans-
15 abscisic acid, (+)-(S)-cis,trans-ABA; S-ABA; (S)-5-(1-hydroxy-2,6,6-trimethyl-4-oxo-2-cyclohexen-1-yl)-3-methyl-(2Z,4E)-pentadienoic acid; CAS registry no. [21293-29-8]) is available from Lomon BioTechnology Co., Ltd. (Shichuan, China).

Suitable salts of S-ABA include, but are not limited to sodium, potassium, calcium, ammonium, magnesium and amine salts.

20 S-ABA or its salts is applied to the grapevines after berry set to achieve the desired effect on the sensory characteristics of the grape berries and wine. The presently preferred timing of the S-ABA application is during the period of pre-veraison (approximately 3 weeks before veraison, where veraison is defined as berry softening) through the post-veraison period (when sugar levels in berries measure
25 approximately 18-20° brix (10-11 Baume)).

Water is used as the carrier solvent for the applications. In the present invention, surfactants can be added to the chemical solution to improve the

performance of the S-ABA or its salts, particularly for the foliar application. The water solution may contain between 0.01% to 0.5% v/v of a surfactant, such as Tween 20 (available from Sigma-Aldrich, St. Louis, MO).

The presently preferred surfactant for S-ABA or S-ABA salt performance is Brij 98 (polyoxyethylene (20) oleyl ether) available from Uniqema (Castle, DE). Other surfactants are also useful in the present invention, including but not limited to, other surfactants in the Brij family (polyoxyethylene fatty alcohol ether) available from Uniqema (Castle, DE), surfactants in the Tween family (Polyoxyethylene sorbitan ester) available from Uniqema (Castle, DE), the Silwet family (Organosilicone) available from Momentive Performance Materials (Wilton, CT), the Triton family (Octylphenol ethoxylate) available from The Dow Chemical Company (Midland, MI), the Tomadol family (ethoxylated linear alcohol) available from Tomah3 Products, Inc. (Milton, WI), the Myrj family (Polyoxyethylene (POE) fatty acid ester) available from Uniqema (Castle, DE), the Span family (Sorbitan ester) available from Uniqema (Castle, DE), and the Trylox family (Ethoxylated Sorbitol and Ethoxylated Sorbitol Ester) available from Cognis Corporation (Cincinnati, OH) as well as commercial surfactants such as Latron B-1956 (77.0% modified phthalic/glycerol alkyl resin and 23.0% Butyl alcohol) available from Dow AgroSciences LLC (Indianapolis, IN), Capsil (Blend of Polyether-polymethylsiloxanecopolymer and nonionic surfactant) available from Aquatrols (Paulsboro, NJ), Agral 90 (Nonyl phenol ethoxylate) available from Norac Concept, Inc. (Orleans, Ontario, Canada), Kinetic (99.00% proprietary blend of polyalkyleneoxide modified polydimethylsiloxane and nonionic surfactants) available from Setre Chemical Company (Memphis, TN), and Regulaid (90.6% 2-butoxyethanol, poloxalene, monopropylene glycol) available from KALO, Inc. (Overland Park, KS).

Other additives are also useful in the present invention including, but not limited to, urea, nitrate salts such as ammonium nitrate, salts such as calcium chloride, humectants such as poly(ethylene glycol), and vegetable oils such as soybean oil, corn oil, cotton oil, and palm oil.

The effective concentration range of the active ingredient S-ABA varies depending on the water volume applied as well as other factors such as the plant variety, height, age, desired duration of effect and application method. The S-ABA concentration range is from about 1 – about 10,000 ppm S-ABA. The preferred S-ABA concentration range for foliar applications is about 50 – about 500 ppm. The preferred application volume for foliar applications is about 25 – about 300 gallons/A. Foliar spray applications are directed at the grape bunches to achieve complete coverage of the grapes bunches and to maximize the effect of the S-ABA application. Soil applications are directed towards the rooting zone. Application methods include, but are not limited to application through irrigation/fertigation dripper line or application of S-ABA formulations or solutions to the soil at the base of the vine, followed by application of water to the soil to transport the S-ABA to the roots of the vine.

EXAMPLES

The following examples illustrate that application of S-ABA to red grapes alters wine sensory characteristics.

EXAMPLE 1

S-ABA (200 ppm) was applied by foliar spray using a standard vineyard airblast sprayer at 2000 L/ha to commercially grown Shiraz grapes approximately 3 weeks prior to initiation of veraison. The spray mix contained the surfactant/wetter Agral at 10 ml/100 L. Results reported are means of 4 replicates (grapes) and 3 replicates (wines) per treatment. Winemaking followed a standard small lot fermentation protocol with each replicate wine being made from 50 kg of harvested grapes.

Table 1 shows that S-ABA does not affect at-harvest grape sugar, pH, or total acidity or wine pH. However, at-harvest grape anthocyanin and wine color density and total phenolics are increased by S-ABA.

Table 1. Effect of abscisic acid (S-ABA) on Shiraz grape quality at harvest and wine quality.		
	Untreated	S-ABA treated
Grapes at harvest		
Sugar (Be)	13.6	13.8
pH	4.1	4.1
Total acidity	4.3	4.2
Anthocyanins (mg/g)	0.92	1.02
Wine		
pH	3.75	3.76
Wine color density (a.u.)	5.52	7.23
Wine hue	0.58	0.56
Total phenolics	23.84	29.94

Table 2 shows the sensory profile as determined by 10 experienced sensory assessors. Shiraz wine made from S-ABA-treated fruit were described as have a more intense berry aroma and a more fruity, more acidic taste. Using a nine-point hedonic scale rating (dislike = 1 to like = 9) the sensors judged wine from the S-ABA treatment higher than the untreated (6.2 vs. 5.0, respectively) and thus a technically better wine.

Table 2. Effect of abscisic acid (S-ABA) on Shiraz wine sensory profile.		
Character	Untreated	S-ABA treated
Aroma	Berry, vegetal	More intense berry
Taste	Dark fruit, soft tannins	More fruity, more acidic
Color	Red, purple hues	Increased intensity
Hedonic scale (1 – dislike, 9 like)	5.0	6.2

EXAMPLE 2

- S-ABA (200 ppm) was applied by foliar spray to Cabernet Sauvignon grapes when sugar levels were approximately 11Be using a standard vineyard airblast sprayer at approximately 2000 L/ha. The spray mix contained the surfactant/wetter
- 5 Agral at 10 ml/100 L. Wine was prepared from the treated and untreated grapes. Table 3 shows that S-ABA did not affect sugar, pH, total acidity, and anthocyanins of grapes at harvest and did not affect the alcohol, pH, wine color density, wine hue, and total phenolics of the wine.

Table 3. Effect of abscisic acid (S-ABA) on Cabernet Sauvignon grape quality at harvest and wine quality.		
	Untreated	S-ABA treated
Grapes at harvest		
Sugar (Be)	12.9	13.1
pH	3.94	3.97
Total acidity	4.9	4.9
Anthocyanins (mg/g)	0.91	0.93
Wine		
Alcohol (%)	13.3	13.2
pH	3.49	3.52
Wine color density (a.u.)	7.0	7.1
Wine hue	0.6	0.6
Total phenolics	26.3	25.7

- 10 Although S-ABA did not affect sugar, total acidity, and anthocyanin/color of grapes at harvest or wine, an experienced sensory panel judged Cabernet Sauvignon wine from the S-ABA treatment as having a longer finish, increased aroma, and greater color intensity than the untreated wine (Table 4).

Table 4. Effect of abscisic acid (S-ABA) on Cabernet Sauvignon wine quality (1-5 scale; 1= low/short; 5=high/long).		
	Untreated	S-ABA treated
Finish	1.70	2.3
Flavor intensity	3.0	2.7
Body/fullness	2.0	1.7
Aroma intensity	2.3	3.7
Color intensity	3.0	4.0

EXAMPLE 3

S-ABA (0.4 grams per vine) was applied to commercially grown Shiraz grapes through the drip irrigation system at approximately 3 weeks prior to initiation of veraison. No surfactant was added to the irrigation water. Results reported are means of 3 replicates. Winemaking followed a standard small lot fermentation protocol with each replicate wine being made from 50 kg of harvested grapes.

Table 5 illustrates that S-ABA increased anthocyanin and phenolics of grape/juice at crush and wine color density and total phenolics and reduced wine hue. S-ABA had no effect on sugar, pH, or total acidity of grapes/juice at crush or on alcohol or pH of wine. Wine made from S-ABA treated Shiraz berries produced a wine that had more intense fruit and was less acidic based on the judging of 6 experienced wine sensory assessors.

Table 5. Effect of abscisic acid (S-ABA) on Shiraz grape quality at harvest and wine quality.		
	Untreated	S-ABA treated
Grapes/Juice at crush		
Sugar (Be)	13.7	13.6
pH	3.78	3.75
Total acidity	4.3	4.3

Anthocyanins (mg/g)	0.88	1.06
Phenolics (mg/g)	0.99	1.06
Wine		
Alcohol (%)	13.7	13.9
pH	3.66	3.65
Wine color density (a.u.)	6.66	7.87
Wine hue	0.73	0.68
Total phenolics	34.33	37.41
Sensory panel of 6 assessors	-	More intense fruit and less acidic

EXAMPLE 4

- S-ABA (200 ppm) was applied by foliar spray at veraison to commercially grown Shiraz grapes through standard agricultural spray equipment on 12 January 2007. Kendeen 20 (Tween 20) was added to the spray mix at 50 ml/100 L.
- 5 Reported results are means of 3 replicates. Winemaking followed a standard small lot fermentation protocol with each replicate wine being made from 50 kg of harvested grapes.

- Table 6 shows that S-ABA did not affect sugar, pH, total acidity, anthocyanins, or phenolics of grapes/juice at crush. S-ABA increased color density and total phenolics, but did not affect alcohol, pH, or wine hue. However, wine
- 10 made from S-ABA treated Shiraz berries produced a wine that had more intense fruit, spice and herbaceous flavors and more tannin based on the judging of 6 experienced wine sensory assessors.

Table 6. Effect of abscisic acid (S-ABA) on Shiraz grape quality at harvest and wine quality.		
	Untreated	S-ABA treated
Grapes/Juice at crush		
Sugar (Be)	13.9	13.5
pH	3.84	3.85

Total acidity	3.8	3.5
Anthocyanins (mg/g)	0.93	0.92
Phenolics (mg/g)	1.04	1.04
Wine		
Alcohol (%)	13.7	13.8
pH	3.71	3.72
Wine color density (a.u.)	9.37	10.63
Wine hue	0.55	0.53
Total phenolics	40.1	43.4
Sensory panel of 6 assessors	-	More intense fruit, spice and herbaceous. More tannin

Thus, regardless of the effect of S-ABA on sugar, acidity, anthocyanin/color or phenolics of red grapes at harvest or the subsequent wine made from these berries, these examples illustrate that S-ABA consistently alters the sensory characteristics of the wine such as aroma and flavor.

CLAIMS

1. A method of modifying red grape berry and wine sensory characteristics, such as aroma, bouquet, flavor, mouthfeel, astringency, balance, complexity or finish by application of S-abscisic acid or its salts to red grapes or grapevines after fruit set.
2. The method of claim 1 wherein the red grapes are used to prepare Shiraz wine.
3. The method of claim 1 wherein the red grapes are used to prepare Cabernet Sauvignon wine.
4. A method of intensifying fruit flavor and aroma characteristics of red grape berries and wine by application of S-abscisic acid or its salts to red grapes or grapevines after fruit set.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/01216

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A01G 17/02 (2008.04)

USPC - 47/58.1FV

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A01G 17/02 (2008.04)

USPC - 47/58.1FV

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 424/451; 514/557 504/348; 504/193 560/126 562/508 568/343 568/378 568/447

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST(USPT,PGPB,EPAB,JPAB); Google Scholar: abscisic acid, grape, wine, quality, water, stress or drought or deficit or availability, shiraz, cabernet sauvignon, stomata, aroma or bouquet or flavor or mouth-feel or balance or complexity or finish

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0198896 A1 (QUAGHEBEUR) 15 Sep 2005 (15.09.2005); para [0035], [0054] and [0061]	1-4
Y	ROSSOUW et al. The phenolic composition of South African Pinotage, Shiraz and Cabernet Sauvignon Wines. South African Journal of Enology and Viticulture 2004, 25(2):94-104; pg 94, abstract and para 1; pg 103, para 4. Retrieved from the Internet on Apr 24, 2008: < http://www.sasev.org/journal/sajev-articles/volume-25-2/Vol%2025%20(2)%20Paper%208.pdf >	1-4

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