Ethanol vapours limit Botrytis development over the postharvest life of table grapes

Christian Chervin[1], Pascale Westercamp[2] and Ghislaine Monteils[2]

[1]UMR 990, INRA/INP-ENSAT, BP 107, 31326 Castanet, France

[2]CTIFL-CEFEL, 49 Chemin des Rives, 82000 Montauban, France

Corresponding author: chervin@ensat.fr

Abstract:

The application of ethanol vapours has been optimised over two seasons in order to prevent rot development, caused by Botrytis cinerea, and stem browning in 'Chasselas' table grapes. At a dose rate of 2 ml per kg of grapes, ethanol vapour was as effective as sulphur dioxide pads. Consumer panels detected no significant difference in sensory perception between controls and treated grapes. The ethanol vapour treatment could be easily implemented by the table grape industry since the technology is similar to sulphur dioxide treatment.

Introduction

Table grapes are routinely treated with sulphur dioxide (SO_2) to reduce the incidence of postharvest decay, largely caused by *Botrytis cinerea* (Lichter et al.,2002), during storage and transportation. By limiting rot development, the SO_2 treatments allow to keep the grapes at high humidity thus limiting stem browning, that is mainly due to desiccation. However SO_2 treatment may cause damage to the grape berries (discolouration, off-flavours), and sulphite residues are not acceptable to some consumers.

Ethanol is known to influence ripening and senescence in some fruit plant tissues (Podd and Staden, 1998), to reduce postharvest fungal decay (Gabler and Smilanick, 2001) and to kill insect pests (Dentener et al., 1998). Application of ethanol to table grapes by dipping has been shown to effectively improve storage life, mainly by limiting postharvest rot development (Lichter et al., 2002; Karabulut et al., 2003). We have already investigated the efficacy of ethanol vapours to control rots. Preliminary results indicated that the optimal ethanol dose for effective disease control was less than 5 $ml.kg^{-1}$ of fruit (Chervin et al., 2003). Since stem browning was higher at 5 ml $ethanol.kg^{-1}$ compared to SO_2 treatments, we conducted new experiments in order to find a lower dose of ethanol that would still control rot development without too high stem browning as in commercial SO_2 treatments,. In addition to the optimisation of the ethanol dose, we also report on the use of a simple system to generate ethanol vapours with pre-soaked paper pads.

Material and methods

'Chasselas' table grapes (*Vitis vinifera*, L.) were picked in a local vineyard (Montauban, France) the second fortnight of September in 2002 and 2003 (at 20% Brix and 3.5 $g.l^{-1}$ tartaric acid), and packed in wooden boxes (dimensions 40 x 28 x 12 cm) each containing 4 kg of fruit. In the first year of experimentation (2002) there were five treatments: an untreated control, one SO_2 pad per box (7 g $Na_2S_2O_5$), ethanol 1.25 $ml.kg^{-1}$, ethanol 3.75 $ml.kg^{-1}$ and ethanol 7.5 $ml.kg^{-1}$. Each box was a replicate and there were three replicates per treatment. All boxes were wrapped with individual polyethylene bags, then stored at 0°C for four weeks. In 2003 there were four treatments: an untreated control, one SO_2 pad per box, ethanol 2 $ml.kg^{-1}$ and ethanol 4 $ml.kg^{-1}$. All boxes were wrapped with individual polyethylene bags. The boxes were sealed and stored as described above then assessed after four and seven weeks.

The ethanol vapours were generated by pre-soaking newspaper sheets (40 x 28 cm) in various quantities of ethanol in order to reach the rate in $ml.kg^{-1}$. The sheets were left in contact with

ethanol in a sealed plastic bag for two hours to allow equilibrium of the ethanol into the paper sheet. During fruit packing operations, a macro-perforated plastic sheet was placed between the paper sheet and the grapes to prevent direct contact. Ethanol concentration in the box headspace was measured with a Dräger pump (Dräger Sicherheitstechnik, Lübeck, Germany) fitted with specific glass tubes (Chip Dräger Ethanol 100 - 2500 ppm ref. 6406370).

At the end of each storage period, the bags were removed and boxes were left at 8°C for half an hour to limit condensation on the fruit, then transferred to ambient temperature (20°C) for three days. Botrytis incidence was visually assessed by counting the number of affected berries per bunch on all the bunches in each box. In the first experiment, when the average number of rotten berries per bunch exceeded 5, the bunch was considered as "rejected", i.e. not suitable for sale. During the second year experiment, the rotten berries of each box were weighed and the result expressed as a percentage of the grape total weight in the box.

The assessment of stem browning was performed visually using the following 0 to 5 scale: the scores were 0, 1, 2, 3, 4, and 5 for stem browning being <10%, 10 to 30 %, 30 to 50 %, 50 to 70%, 70 to 90% and > 90%, respectively.

Sensory analyses were performed with consumer-type panellists, using a hedonic scale derived from Poste et al. (1991). The scale for sensory appreciation was a continuous line of 10 cm and the extremities at each end of the scale were: "I dislike extremely" (equivalent to 0) and "I like extremely" (equivalent to 10). The 20 to 25 panellists in each session were asked to mark the scale line with a pencil tick to give an indication of their appreciation. The advantage of the continuous scoring system is that it suits most of the parametric statistical tests. The samples were presented to them in a given order and were coded with five digit numbers. There were as many different tasting orders as possible, as we appreciate food as a function of what we ate before. The tasting sessions were performed after lunch.

The differences between treatments were analysed by ANOVA and LSD using SigmaStat 3.0.1 (SPSS, Chicago, IL, USA).

Results and Discussion

Ethanol vapour at doses equal or higher than 3.75 $ml.kg^{-1}$ resulted in grapes to a similar commercial standard as SO_2 treatment after the four week storage (Table 1). However rots caused by *B. cinerea* were not effectively controlled after seven weeks of cold storage (data not shown). There was no significant difference ($P > 0.05$) in stem browning between the control, 1.25 $ml.kg^{-1}$, 3.75 $ml.kg^{-1}$ and SO_2 treatments after four weeks of storage, and ethanol at 7.5 $ml.kg^{-1}$ tended to increase stem browning (data not shown), suggesting that high dose rates may induce phytotoxicity. The dose rate of 3.75 ml ethanol per kg of fruit gave headspace concentrations of 220 ± 80 ppm of ethanol, over four weeks of storage at 0°C, and this dose was sufficient to ensure fruit quality and control rot development without increasing stem browning. Co-workers at the experimental station in Montauban detected a slight ethanol taint with grapes treated with ethanol at 3.75 and 7.5 $ml.kg^{-1}$, so further sensory analyses were carried out on grapes treated with ethanol doses between 1.25 and 3.75 $ml.kg^{-1}$.

The following year, both ethanol doses (2 and 4 $ml.kg^{-1}$) and the SO_2 pad treatments significantly ($P<0.05$) reduced the rot development in comparison to the control and there was no significant ($P>0.05$) difference between SO_2 and the ethanol treatments (Figure 1a). All three treatments significantly ($P<0.05$) reduced stem browning (Figure 1b) compared to the control, but SO_2 and ethanol at the low dose of 2 $ml.kg^{-1}$ were significantly ($P<0.05$) more effective at reducing this disorder compared to ethanol at the high dose of 4 $ml.kg^{-1}$.

The sensory analyses showed that no consumer would detect a difference between postharvest treated berries by visually assessing the samples (Figure 1c). However SO_2 treated grapes

were significantly ($P<0.05$) less appreciated than the controls when assessors tasted the grape samples (Figure 1d). The results obtained after four weeks cold storage and three days at 20°C followed a similar pattern (data not shown).

In the preliminary study (Chervin et al., 2003), we showed that ethanol vapours also had the potential to reduce berry shatter. It would be worth checking this with other cultivars than 'Chasselas'.

Overall our results confirm that ethanol has a potential for improving postharvest shelf-life of table grapes, whether it is applied during a dipping treatment (Lichter et al., 2002) or with a pad generating vapours (*e.g.* a paper impregnated with liquid ethanol). Ethanol could be used in conjunction to SO_2, and this may allow a reduction of the dose of this latter, however further research is necessary to develop this combination. Further developments may include silica gel imbibed with alcohol, as previously described by Suzuki et al. (2004).

Acknowledgements: We wish to thank the Midi-Pyrénées regional council for a research grant, Daniel Lavigne and Marie-Eve Biargues (CEFEL) for providing the grapes and helping with quality assessment, Dr Patrick Varoquaux (INRA) for providing advices and plastic films for the experimental set-up, Pr Jean-Claude Pech and Dr Alain Latché (ENSAT) for their support, and the students Gaëlle Pierdet, Clément Pagès, Benoit Knibiehler, Mikaël Coquiller and Magalie Tanguy (ENSAT) for helping along the two season experiment, and Dr John Golding (NSW Agriculture) for comments and edition of the manuscript. Finally, thanks to anonymous referees for their time and comments.

Literature cited

Chervin, C., Westercamp, P., El-Kereamy, A., Rache, P., Tournaire, A., Roger, B., Goubran, F., Salib, S. and Holmes, R., 2003. Ethanol vapours to complement or suppress sulfite fumigation of table grapes. Acta Hort., 628, 779-784.

Dentener, P. R. Alexander, S. M. Bennett, K. V. and McDonald, R. M., 1998. Postharvest control of lightbrown apple moth using ethanol. Acta Hort., 464, 279-284.

Gabler, F. M. and Smilanick, J. L. 2001. Postharvest control of table grape gray mold on detached berries with carbonate and bicarbonate salts and disinfectants. Amer. J. Enol. Vitic., 52, 12-20.

Karabulut, O.A., Smilanick, J.L., Gabler, F.M., Mansour, M. and Droby, S., 2003. Near-harvest applications of *Metschnikowia fructicola*, ethanol, and sodium bicarbonate to control postharvest diseases of grape in central California. Plant Dis., 87, 1384-1389.

Lichter, A., Zutkhy, Y., Sonego L., Dvir O., Kaplunov T., Sarig P. and Ben-Arie R., 2002. Ethanol controls postharvest decay of table grapes. Postharvest Biol. Technol., 24, 301-308.

Podd, L. A. and Staden, J. van., 1998. The role of ethanol and acetaldehyde in lower senescence and fruit ripening - a review. Plant Growth Regul., 26, 183-189.

Poste, L.M., Mackie, D.A., Butler, G. and Larmond E., 1991. Hedonic scaling test. Laboratory Methods for Sensory Analysis of Food, ed. Agriculture Canada, publication 1864/E, pp. 64-67.

Suzuki, Y., Toshikazu, U. and Terai H. 2004. Inhibition of senescence in broccoli florets with ethanol vapor from alcohol powder. Postharvest Biol. Technol., 31, 177-182.

Table and Figure captions

Table 1: Percentage of weight of table grapes (cv. Chasselas), accepted for sale as a function of Botrytis development. Grape bunches were visually assessed in 2002 after four weeks of storage at 0°C plus three days at 20°C. The ethanol (EtOH) doses applied over cold storage are in ml per kg of fruit and the SO_2 was applied using a commercially available pad, LSD = least significant difference.

Treatment	Control	EtOH 1.25	EtOH 3.75	EtOH 7.5	SO2	LSD
% accepted	10.7	35.2	89.5	84.8	85.0	23.9

Figure 1: Percentage of Botrytis infected berries (a) and severity of stem browning (b) as a function of SO_2 or ethanol treatments (EtOH) after seven weeks at 0°C and three days at 20°C in 2003. Sensory evaluation of treated grapes by visual assessment (c) and tasting (d), using 0 to 10 scales. The ethanol doses are quantities in ml per kg of fruit and SO_2 was applied using a commercially available pad. Error bars represent standard error of the mean. LSD = least significant difference.

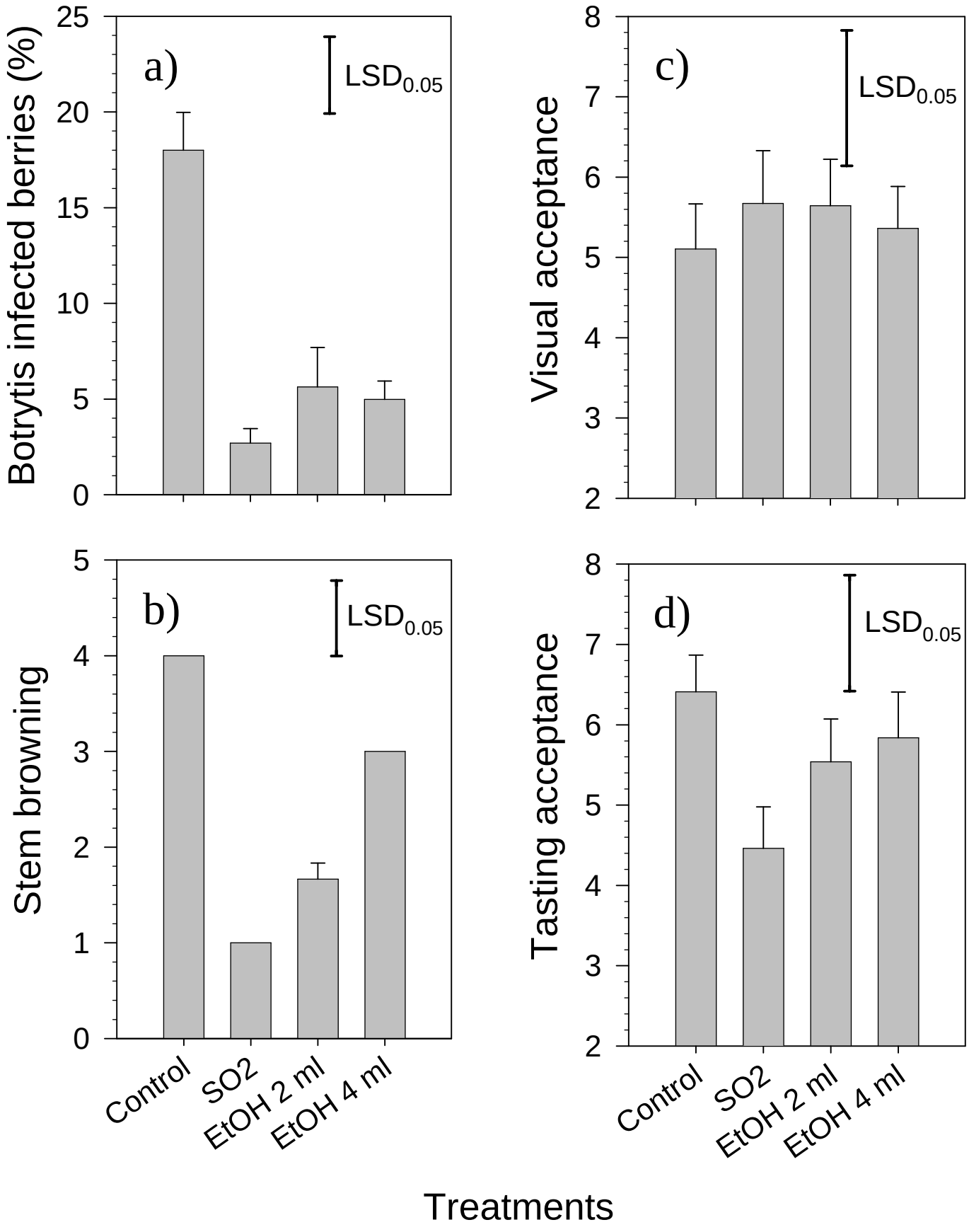
a)
LSD0.05
Botrytis infected berries (%)
0
5
10
15
20
25
c)
LSD0.05
Visual acceptance
2
3
4
5
6
7
8
b)
LSD0.05
Stem browning
0
1
2
3
4
5
d)
LSD0.05
Tasting acceptance
2
3
4
5
6
7
8
Control
SO2
EtOH 2 ml
EtOH 4 ml
Control
SO2
EtOH 2 ml
EtOH 4 ml
Treatments

Figure 1