Superficial Scald versus Ethanol Vapours: A Dose Response

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Abstract

Early picked 'Granny Smith' apples (Malus domestica Borkh.) were stored under air or CA (controlled atmosphere at 2 kPa O_2 and <1 kPa CO_2) at 1°C. During the first week of storage, fruit was subjected to ethanol vapours in doses from 0 to 8 g/kg of fruit. Ethanol at 4 g/kg protected fruit against superficial scald in CA storage for at least 5.5 months, plus two weeks in cold air storage, plus a week at ambient temperature. Ethanol at 6 g/kg protected fruit in cold air storage for 3 months, plus a week at ambient temperature. Effects of ethanol vapours and CA on headspace ethylene levels are discussed. Ethanol vapours did not cause significant off-flavours in 'Granny Smith' apples (consumer panel, hedonic scale), or purpling of the skin of Red Delicious apples (visual assessment).

INTRODUCTION

Ethanol vapours are efficient in controlling scald of various apple cultivars (Gharahmani and Scott, 1998; Wang and Dilley, 1996). We have observed that the combination of CA storage with ethanol vapours is very effective in preventing superficial scald development (Chervin et al., 2001), especially when fruit in part of a storage room has to be sold and the remaining fruit is held in air for later sale.

The purpose of the present study was to determine an optimal dose of ethanol for both CA and air storage of 'Granny Smith' apples and to check for any detrimental effects on flavour and skin colour (Ghahramani et al., 2000).

MATERIALS AND METHODS

'Granny Smith' apples were picked from a local orchard at an early date, 6th October 2000 (Montauban, South Western France), firmness 70 N, starch index 4 in a scale from 1 to 10 (100% to 0% iodine coloration). They were placed in cold storage overnight, then transferred into 560 L cabinets (150 kg per cabinet). Ethanol was applied during the first week of storage as described previously (Chervin et al., 2001) at 0, 2, 4, 6 and 8 g/kg. Fruit was stored in air for 2, 3, 4 and 5 months or in CA for 4, 5, 6 and 7 months. Ethanol headspace concentrations were assessed with a Dräger pump (model "Accuro", Lübeck, Germany), using Dräger tubes (ref. "alcohol 25/a"). Headspace ethylene concentrations were assessed using a GC fitted with a FID detector. CA fruit were held under air cold storage for two weeks before transfer to ambient. All fruit were left one week at 20°C to enable scald development. Scald was assessed visually and expressed as the % of scalded area on 45 fruit. Treatments (cabinets) were not replicated.

Sensory analyses were run using a 9-point hedonic scale (Poste et al., 1991) with peeled fruit segments randomly organised and numbered on a white plate. Data were analysed using ANOVA (SPSS Inc, Chicago).

Visual assessment of the Red Delicious apple skin was performed by comparison to colour pads (Royal Horticultural Society, London, UK).

RESULTS AND DISCUSSION

When used in combination with CA storage, ethanol vapours reduced the development of superficial scald (Fig. 1); this response was relative to the ethanol dose. For researchers wanting to develop this method in their own region, we recommend to test various doses around 4 g/kg, which protected the fruit at a commercial level. This dose gave 80 % of saleable fruit in April, with controls already down at 9 % in February and 0 % in March (data not shown).

Within the first month of storage, the headspace ethanol concentrations reached 300 ppm in cabinets treated with 6 and 8 g/kg, only 150 ppm in 4 g/kg and 100 ppm in 2 g/kg. All ethanol concentrations dropped below 100 ppm after 2 months and were nil after 4 months.

The ethanol vapours were also effective in air storage, to a lesser extent (Fig. 2). In January, 6 and 8 g/kg generated 60 % of saleable fruit when no control fruit were saleable. These ethanol concentrations would be more efficient with fruit picked at a later date (less prone to scald).

This is a new result compared with our previous research (Chervin et al., 2001) in which ethanol in air storage gave poor results. The main change was to get the void volume of the cabinet down to 70 % in this experiment, compared with 85 % the previous season.

Ju and Curry (2000) recently demonstrated that ethylene regulates the gene expression associated to farnesene biosynthesis, a compound that is a precursor of brown metabolites linked to superficial scald. In an attempt to explain the role of ethanol vapours, we measured ethylene headspace concentrations. The ethylene headspace concentrations showed two peaks; in CA at 40 and 130 days (Fig. 3a) and in air storage at 25 and 55 days (Fig. 3b). We can conclude that CA delayed ethylene production and this is well known. Secondly, the first ethylene peak was decreased by ethanol vapours in CA storage (Fig. 3 a) but not in air storage (Fig. 3b). This surely deserves more work, but it indicates that ethanol could prevent scald without a direct link to ethylene (i.e. ethanol prevented scald without inhibiting the first ethylene peak). However, there is still some uncertainty about the relevance of these two peaks, the ethylene drop between the two peaks could be due to some flushing by the atmosphere control system.

Sensory analyses were performed to check whether ethanol vapours had an impact on taste. A few differences were perceived (Table 1), but globally, there was no consistent effect on the taste.

Finally, we treated Red Delicious apples with similar ethanol doses in order to check the influence of the ethanol on the redness of the skin. It was found that none of the ethanol doses in our experiments induced purpling of the apple skin. All skin colours were corresponding to either 178 B, or 183 A, or 187 B of the RHS colour chart. However, it is worth noting that the Red Delicious apples were picked one month before the Granny Smith apples, and kept in cold air storage before the ethanol treatment. We noticed that the presence of ethanol changed the taste of Red Delicious apples stored in air but not in CA (data not shown).

CONCLUSION

Here we confirmed that the combination of CA storage and ethanol prevents superficial scald development of ‘Granny Smith’ apples. According to our initial estimate (Chervin et al. 2001), the cost of ethanol at doses below 8 g/kg would be comparable to diphenylamine (DPA). For a better comparison of technical results, we need controls treated with DPA. The present study gives indications of effective ethanol doses as a function of storage time. However, pilot studies are necessary for each type of storage, as we observed over the last two seasons that void volume, atmosphere flushing and mixing influence the result.

In addition to that, we obtained for the first time effective scald control for ethanol in air storage (60 % of saleable fruit 3 months after harvest when controls were at 0%). The control of scald by ethanol vapours in air storage could be of commercial interest, especially on less susceptible cultivars and later picked fruit. We found that none of the ethanol doses induced changes of taste detectable by a consumer panel.

Finally, we observed some influence of the ethanol vapours on the ethylene concentration of the storage cabinet, suggesting that part of the scald control by ethanol is not ethylene dependent.

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Literature Cited

Chervin, C., Raynal, J., André, N., Bonneau, A. and Westercamp, P. 2001. Combining controlled atmosphere storage and ethanol vapors to control superficial scald of apple. HortScience, 36, in press.

Ghahramani, F., Scott, K.J and Holmes, R. 2000. Effects of alcohol vapors and oxygen stress on superficial scald and red color of stored 'Delicious' apples. HortScience, 35:1292-1293.

Ghahramani, F. and Scott, K.J. 1998. The action of ethanol in controlling superficial scald of apples. Aust. J. Agric. Res., 49:199-205.

Ju, Z. and Curry, E.A. 2000. Evidence that α-farnesene biosynthesis during fruit ripening is mediated by ethylene regulated gene expression in apples. Postharvest Biol. Technol., 19:9-16.

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.

Wang, Z. and Dilley, D.R. 1996. Ethanol vapour treatment: a new alternative approach to control superficial scald of apples. Proc. Mich. State Hort. Soc., 126:35-40.

Tables

Table 1. Influence of ethanol vapours applied at various rates (in g per kg of fruit) on the taste of Granny Smith apples analysed by a consumer panel using a hedonic scale. Results of ANOVA and mean comparison (SNK test). Fruit in group "a" was more appreciated than fruit in group "b", mean comparisons within rows.

	Month	Significance	Control	2 g/kg	4 g/kg	6 g/kg	8 g/kg
Air Storage	**December**	no	a	a	a	a	a
	January	no	a	a	a	a	a
	February	yes	b	ab	a	ab	ab
	March	untested					
CA storage	**February**	yes	ab	b	ab	ab	ab
	March	yes	b	ab	ab	ab	a
	April	no	a	a	a	a	a
	May	no	a	a	a	a	a

Figures

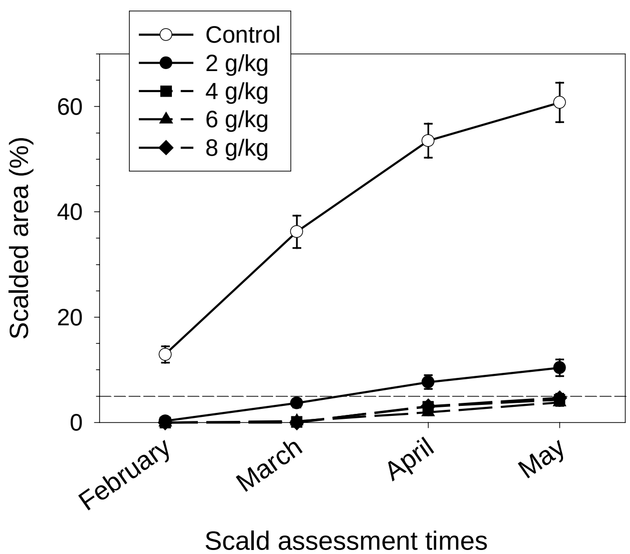

Fig. 1. Superficial scald development of Granny Smith apples after CA storage as a function of time and ethanol applied in g per kg of fruit (vapour phase). Data show the mean of 45 fruit, error bars show SE. The dashed line tentatively represents a commercial threshold.

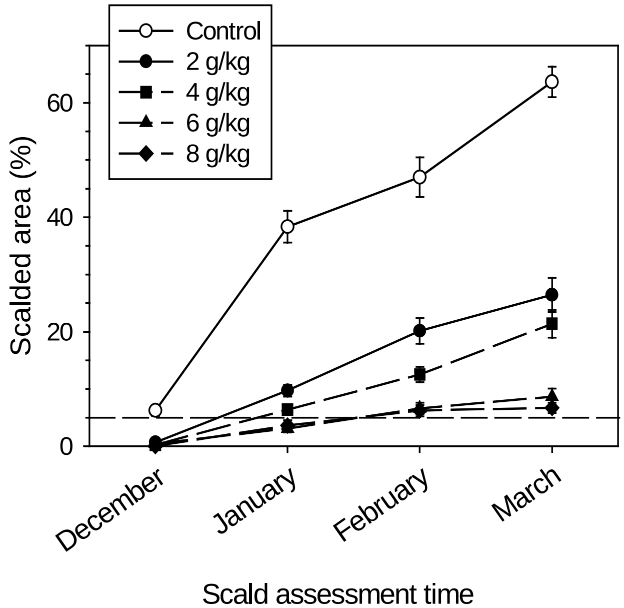

Fig. 2. Superficial scald development of Granny Smith apples after air storage as a function of time and ethanol applied in g per kg of fruit (vapour phase). Data show the mean of 45 fruit, error bars show SE. The dashed line tentatively represents a commercial threshold.

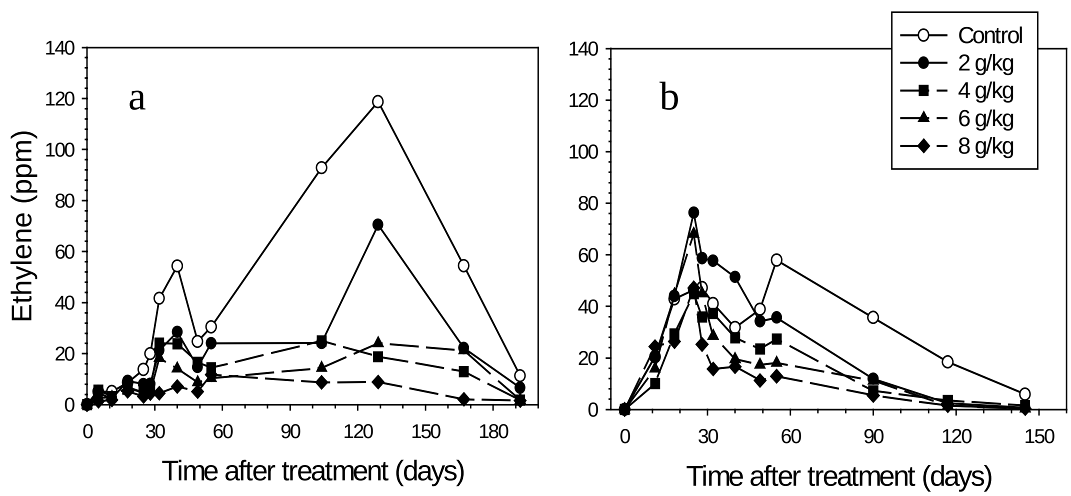

Fig. 3. Ethylene concentration around Granny Smith apples in CA storage (a); and in air storage (b); as a function of time and applied ethanol dose (g per kg of fruit).