Aminoethoxyvinylglycine (AVG) affects cv. Royal Gala apple fruit quality at harvest and after storage – Short communication

N. Magazin, Z. Keserović, B. Milić, M. Dorić

Faculty of Agriculture, University of Novi Sad, Novi Sad, Serbia

Abstract

Magazin N., Keserović Z., Milić B., Dorić M., 2012. **Aminoethoxyvinylglycine (AVG) affects cv. Royal Gala apple fruit quality at harvest and after storage – Short communication**. Hort. Sci. (Prague), *39*: 195–198.

Aminoethoxyvinylglycine (AVG), an inhibitor of ethylene synthesis was applied at a concentration of 125 g/l of active ingredient on Royal Gala apple trees 4 weeks before the anticipated harvest in two consecutive years. Immediately after harvest fruits were stored at 1°C and 90% of relative humidity for up to 90 days. Quality assessments of total soluble solids (TSS), titratable acidity (TA) and firmness were done on 30-days intervals after harvest. Treating Royal Gala apples with AVG significantly slowed down starch degradation in fruits but in the same time increased fruit weight. Also, the development of over colour was negatively affected. A positive influence on fruits' firmness was also evident, while there was no influence of AVG on TSS and TA.

Keywords: ethylene; colour; firmness; starch index; weight

While one of the leading apple cultivars in the world, Gala has several production disadvantages that often reduce the fruits' commercial value. These are: poor colouring, often inadequate fruit size and rapid firmness loss during storage (Johnston et al. 2001).

Aminoethoxyvinylglycine (AVG) is an inhibitor of ethylene synthesis. Treating apple trees with AVG prior to harvest reduces preharvest fruit drop (Greene 2006; Fallahi 2007), slows down starch degradation in the fruits (Layne et al. 2002; Drake et al. 2006), influences fruit size (Lawes, Woolley 2001; Fallahi 2007), alters the development of ground and over skin colour (Layne et al. 2002), and increases fruit firmness at harvest time and during storage (Amarante et al. 2010). The fruits treated with AVG have a lower content of soluble solids than the untreated fruits at harvest time (Drake et al. 2005; Fallahi 2007). On the other hand, there is no effect of AVG treatment on total acid content in fruits at the moment of harvest (Silverman et al. 2004).

The aim of this trial was to determine the effect of AVG on fruits' quality at the time of harvest, and to determine how long the effect of AVG on fruits quality is during cold storage with a normal atmosphere.

MATERIAL AND METHODS

The experiment was set up in a commercial apple orchard of cv. Tenroy Royal Gala® established in 2002 with a planting distance of 3.2 × 1.2 m on M.9 rootstock and slender spindle training system. The apple orchard is located in Maradik, in the north of Serbia (45°05'28"N, 20°00'15"E, 144 m a.s.l.). Forty uniform trees were selected, of which 20 were treated with AVG and 20 were control trees (untreated),

and where every other tree was a border tree. All treated and untreated trees were grouped into five repetitions of four trees. The treatments were performed 4 weeks before the anticipated harvest, on 27th July 2006 and 30th July 2007. Agent VBC 30033 (ValenBioSciences, Libertyville, USA; 4.15% w/w AVG) was applied at a concentration of 125 mg/l of active ingredient with the addition of ABG 7011 adjuvant (Abbot Laboratories, North Chicago, USA) in a concentration of 0.05%. Harvest dates were 25th August in 2006 and 27th August in 2007. At each harvest all fruits from the trees were picked and transported to the laboratory; where each fruit was weighed and its percentage of over colour subjectively estimated. Fruit samples (20 fruits per replication) were taken for maturity analysis, and 180 randomly selected uniform fruits per replication were placed in cold storage with a regular atmosphere. The fruits' maturity was assessed from measurements of total soluble solids (TSS), titratable acidity (TA), starch-iodine test (ST) and fruits flesh firmness. TSS (%) in extracted juice was measured using a temperature compensated hand-held refractometer (RHS-10ATC) (Xin instruments, Xiamen, China) and TA was measured by titration of filtered juice with 0.1 NaOH to the pH stabilization point of 8.2. The amount of NaOH used was multiplied by 0.67, the correction factor for dominant malic acid, and results were expressed as percentages (%). Firmness was measured using a hand-held penetrometer FT 627 (Winopal Forschungsbedarf GmbH, Ahnsbeck, Germany) fitted with an 11 mm probe and expressed as kg/cm^2. The starch colouration was assessed using starch-iodine 1–10 points scale (Vaysse 2002). Immediately after harvest fruits were stored at 1°C and 90% of relative humidity for up to 90 days. At 30-day intervals a batch of 60 fruits per repetition was removed from cold storage for quality assessments of TSS, TA and firmness. The data were analyzed using analysis of variance (ANOVA) and the means were compared using the Fisher's least significant difference (LSD) test ($P < 0.05$) with Statistica 10 (StatSoft Inc., Tulsa, USA).

RESULTS AND DISCUSSION

In both study years (Table 1), the treated fruits had significantly lower scores for the degree of starch colouration. Slow starch degradation under the influence of AVG was expected in Royal Gala apples as similar results were previously obtained with Gala (Layne et al. 2002; Drake et al. 2006).

Table 1. Effect of aminoethoxyvinylglycine (AVG) at 125 mg/l on starch index, fruits weight and over colour of Royal Gala apples at harvest in 2006 and 2007

Year	Treatment	Fruit traits		
		starch test (1–10)	mass (g)	over colour (%)
2006	control	8.15^{c}	171.91^{a}	55.22^{a}
	AVG	7.50^{d}	174.42^{a}	51.67^{b}
2007	control	9.35^{a}	137.72^{c}	45.30^{c}
	AVG	8.59^{b}	148.69^{b}	35.25^{d}

$^{a–d}$means with different letters are significantly different (Fisher's LSD, $P < 0.05$)

Similarly to Lawes and Woolley (2001), who noted that apple fruits treated with AVG are larger, our research in 2007 shows that AVG encourages greater fruit weight, although in 2006 the weight was the same with treated and untreated fruits (Table 1). Since the treated and untreated fruits were harvested on the same day, these results oppose the claims of Greene (2006) that the larger fruits are consequences of delayed harvest times, rather than the direct impact of AVG.

As for the development of over colour, our results from both years (Table 1) confirmed the results of Layne et al. (2002) and Amarante et al. (2010) that Gala fruits treated with AVG have a poorer colouration.

Table 2. Firmness, total soluble solids (TSS) and titratable acidity (TA) of Royal Gala apples at harvest and after different storage periods in 2006

Storage period	Treatment	Fruit traits		
		firmness (kg/cm^2)	TSS (%)	TA (%)
Harvest	control	8.30^{a}	14.20^{a}	0.56^{a}
	AVG	8.29^{a}	12.85^{cd}	0.53^{a}
30 + 1 day	control	7.39^{c}	13.65^{ab}	0.36^{b}
	AVG	7.82^{b}	13.75^{ab}	0.36^{b}
60 + 1 day	control	7.19^{c}	12.75^{d}	0.30^{bc}
	AVG	7.35^{c}	13.65^{ab}	0.36^{b}
90 + 1 day	control	6.27^{d}	13.50^{b}	0.25^{c}
	AVG	6.26^{d}	13.40^{bc}	0.28^{bc}

$^{a–d}$means with different letters are significantly different (Fisher's LSD, $P < 0.05$); AVG – aminoethoxyvinylglycine

Table 3. Firmness, total soluble solids (TSS) and titratable acidity (TA) of Royal Gala apples at harvest and after different storage periods in 2007

Storage period	Treatment	Fruit traits		
		firmness (kg/cm^2)	TSS (%)	TA (%)
Harvest	control	8.26^{b}	14.35^{a}	0.32^{a}
	AVG	8.69^{a}	14.25^{ab}	0.28^{a}
30 + 1 day	control	7.91^{cd}	13.50^{ab}	0.23^{b}
	AVG	8.20^{bc}	13.20^{b}	0.22^{bc}
60 + 1 day	control	6.93^{e}	14.13^{a}	0.24^{b}
	AVG	7.62^{d}	13.99^{ab}	0.24^{b}
90 + 1 day	control	6.80^{e}	14.16^{a}	0.20^{bc}
	AVG	6.84^{e}	13.65^{ab}	0.18^{c}

$^{a–e}$means with different letters are significantly different (Fisher's LSD, $P < 0.05$); AVG – aminoethoxyvinylglycine

Layne et al. (2002) and Drake et al. (2006) found a significant difference in the firmness of treated and untreated Gala fruits at harvest time, which was supported by our results in only one year of the trials. In 2006 no differences in firmness between treated and untreated fruits at harvest time were observed (Table 2), but after 30 days of storage in regular atmosphere cold storage, the treated fruits were by almost 0.5 kg/cm^2 firmer than the untreated fruits. After 60 days of storage, the difference was not statistically significant. After 90 days the firmness of treated and untreated fruits was almost equal. In contrast to 2006, in 2007 significant differences in fruits' firmness were observed at harvest time (Table 3), when treated fruits were significantly firmer than the untreated after 30 and 60 days of storage, the results which are similar to those reported by Amarante and Steffens (2009). Since Neri et al. (2005) in their research found that the optimal storage period in a regular air atmosphere for late harvested Gala apples is 60 days, the conclusion is that AVG does not prolong this period.

A number of authors (Drake et al. 2005; Fallahi 2007) argue that AVG reduces the TSS content at harvest time, similarly to our results from 2006 (Table 2), while the results from 2007 (Table 3) showed that AVG did not affect the TSS content at harvest time. In 2007 fruits were probably too ripe to observe the differences.

AVG does not affect the total acid content (Silverman et al. 2004), which is almost completely confirmed in our experiments (Tables 2 and 3).

Royal Gala apples treated with AVG clearly show slow starch degradation, which thus entails slower ripening. Also, AVG improves fruits' weight in some years but has a negative effect on the development of over colour. Regarding quality parameters, AVG treated fruits can have better firmness up to 60 days after harvest when stored in regular atmosphere cold storage. There is no influence of AVG on TA, neither at the moment of harvest, nor during storage, while influence on TSS can be observed in some years at the moment of harvest.

Acknowledgements

We wish to thank to ValenBioSciences, Libertyville, USA for sending us an AVG sample.

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Received for publication October 24, 2011
Accepted after corrections May 14, 2012

Corresponding author:

Nenad Magazin, Assistant Professor, University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovica 8, 210 00 Novi Sad, Serbia
phone: + 381 214 853 254, fax: + 381 216 350 702, e-mail: nmagazin@polj.uns.ac.rs