http://dx.doi.org/10.4314/ajtcam.v13i1.18

PHYSICAL, MECHANICAL AND CHEMICAL PROPERTIES OF PLUMS (cv. Santa Rosa) AFFECTED BY AMINOETHOXYVINYLGLYCINE APPLICATIONS

Ebubekir Altuntas* Mehmet Yaldiz

Gaziosmanpasa University, Faculty of Agriculture, Department of Biosystem Engineering, 60240, Tasliciftlik, Tokat , Turkey
*Corresponding author's **E-mail:** ebubekir.altuntas @ gop.edu.tr

Abstract

Background: The engineering properties (physical, mechanical and chemical) are importance to postharvest technologies of the agricultural materials. To plum fruits quality, the harvest and postharvest applications, the engineering properties of plum fruits should be considered. The effect of AVG (Aminoethoxyvinylglycine) treatments on some physical, mechanical and chemical properties of plum fruits (cv. Santa Rosa) were determined.
Materials and Methods: For this research, the plant material 'Santa Rosa' plum (*Prunus salicina L.*) fruits were obtained in Tokat/Turkey (39º51' N and 40º55' E), in 2012. AVG treatments were as 0 mg L^{-1}, 100 mg L^{-1} and 200 mg L^{-1}, and three different harvest dates including 25 July, 1 August and 7 August were used.
Results: The geometric mean diameter, volume of fruit and surface area values increased with AVG doses, whereas, fruit density decreased as AVG doses increased. L* and b* values decreased from 43.75 to 24.14 and 20.24 to 13.21, whereas, a* value increased from -9.03 to -2.63 for flesh plum, respectively. The fruit removal force of plum fruit increased from 19.09 N to 20.20 N in magnitude with an increase in AVG doses. The friction coefficients of fruits increased as AVG doses increased and harvest dates. Total soluble solids content was higher in AVG-0 (0 mg L^{-1}) as compared to AVG-1 and AVG-2 (100 mg L^{-1} and 200 mg L^{-1}) AVG-2 applications, whereas, pH and titratable acidity were lower in 200 mg L^{-1} as compared to 0 mg L^{-1} and 100 mg L^{-1} treatments.
Conclusion: Post-harvest technological applications of the plum fruits must be designed by taking criteria into consideration for plum engineering properties.

Key words: Color, friction coefficient, fruit removal force, firmness

Introduction

The plum fruit belongs to the Rosaceae family, and include the Japanese species (*Prunus salicina* Lindell) and the European species (*Prunus domestica* L.), which is consumed fresh or dried, mainly freshly consumed (Manganaris et al., 2008). Japanese plum species are mainly used for fresh purposes while European species are popular for post-harvest processing (Rieger, 2006). Some plum cultivars do not show the typical increase in ethylene production and respiration until late ripening. Plums are considered as climacteric fruits. Plum fruit decay with a 1-8 week periods. Plum has an important place in total fruit production in Turkey. Turkey ranks the 8th in the world in terms of plum production with 305 393 tons of production (FAO, 2013).

Plant growth regulators change the physical, mechanical and chemical of fruits and their use has been increased in fruit production. Plant growth regulators have been affected by the physiological events of the fruits (Shin et al., 2008). Recently, plant growth regulators such as Aminoethoxyvinylglycine (AVG), 1-MCP (1-methylcyclopropene), and NAA (1-naphthalene acetic acid), have been used for some fruits. Plant growth regulators are natural or synthetic compounds that affect one or more physiological events in a plant. They improve and protect plum fruit quality.

Physical, mechanical and chemical properties of plum are controlled by various factors (variety, growing site, growth period, environmental conditions, plant nutrients, type of production, harvest period and other cultural practices. Growth regulators such as AVG may also cause variations in these factors (Fan et al., 1997; Shin et al., 2008).).

AVG is commercially sold under the name of ReTain®. AVG (Aminoethoxyvinylglycine) is a human and eco-friendly organic product and it is an inhibitor of ethylene that cause to accelerate the maturation at period before harvest and it was used in apple, pear, peach, plum and nectarine in several countries (Greene and Schupp, 2004; Rath and Prentice, 2004; Singh and Khan, 2010). AVG increases fruit hardness and there is a positive effect on shelf life and delays harvest times of fruits. In addition, with the use of AVG post-harvest quality (size, shape, color development) have been manipulated to the control of plant growth periods (Autio & Bramlage, 1982; Greene, 2006).

Byers (1997) reported the inhibitory effect on ethylene biosynthesis and consequent suppression of ethylene production by AVG in various plant tissues. Autio and Bramlage (1982) observed that AVG treatments delayed ripening, harvest, and increased fruit firmness, and also prolonged the storage life of fruit. Fruit firmness of plums is a quality parameter directly related to fruit ripening, shelf life and fruit quality (Greene, 2005; Valero et al., 2007).

The engineering properties are important to post-harvest technologies of the agricultural materials. To plum quality in a harvest and post-harvest applications, the engineering properties of plum fruit must be considered. The mechanical behavior are must eventually be analyzed with knowledge of the mechanical behavior of the plum to the processed fruits as juice and marmalade. Fruit removal force of plum fruits was an important matter for pre-harvest fruit drop and machine harvesting. The lower fruit removal force lead to the drop of fruit on the tree, thus cause the most economic loss. The knowledge of engineering properties of the plum fruits is of importance to plant breeders, engineers, machine manufacturers, food scientists, processors, and consumers (Ozturk et al., 2009). Plum quality is the combination of visual appearance, flavor and texture of the fruit. The consumer demands the excellent appearance, firmness and optimal texture of plum fruits.

Santa Rosa plums are highly rich in vitamins A, C and E, fibre, mineral nutrients, flavonoids and phenolic acids, which may function as an effective natural antioxidant in our daily diet and beneficial health. Also, Santa Rosa plum variety is one of the most significant stonefruit commercially produced in Turkey. However, no detailed study have yet been conducted on postharvest characteristics of this fruit concerning

http://dx.doi.org/10.4314/ajtcam.v13i1.18

the physical, mechanical and chemical properties harvested plum fruit affected by AVG applications at the different dates. Thus, in the study, the physical, chemical, color and mechanical properties affected by the different AVG application doses for harvested plum fruits (cv. ‘Santa Rosa’) at the different dates.

Materıals and Methods

For this research, the plant material ‘Santa Rosa’ plum (*Prunus salicina*) fruits were obtained in Tokat/Turkey (39º51' N and 40º55' E), in 2012. The plum fruit trees planted were trained as the modified leader systems. For this study, the plum trees selected as had uniform fruit loaded. An ethylene inhibitor AVG was applied in ReTain formulation (ValentBioScience Corp. Libertyville, III), ReTain contains 15% AVG. Three doses of 0 (control, AVG-0), 100 mg L^{-1} (AVG-1) and 200 mg L^{-1} (AVG-2) for AVG applications were used in this study. AVG doses were selected based on previous studies carried out under field conditions (Ozturk et al., 2012c). And ın our research, the amount of ReTain to be applied was calculated based on active matter content. ‘Sylgard 309’ organosilicon surfactant [0.05%, v/v (Wilbur-Ellis, Fresno, Calif.)] was used in the different AVG treatments. The control trees (0 mg L^{-1}, non-treatment of AVG) were treated only with water (pH=6.48) + ‘Sylgard 309’ surfactant. For Santa Rosa variety, anticipated harvest time was considered 135-145 days after full bloom. The average fruit firmness and total soluble solids content at anticipated harvest date were 30-40 N and 13-14%, respectively. The design of the experiment was determined as randomized complete block design with three blocks. AVG was applied two weeks before anticipated harvest time (25 July 2012) studied. For each treatment of the experiment, the plum fruits were randomly harvested from each tree block to three harvest dates [25 July, 1 August (anticipated harvest time) and 7 August 2012]. Harvested plum fruits were transferred to laboratory analysis.

To the geometrical, volumetric analysis, geometric mean diameter, fruit volume, sphericity, and surface area of plum fruits were determined according to the method of Mohsenin (1970). Fruit density of a fruit is determined by the toluene (C_7H_8) displacement method and the bulk density was determined by hectoliters standard weight method (Singh and Goswami, 1996). The color characteristics (***L*, a*, b****) of skin and flesh plum fruits were measured by a colorimeter (Minolta CR-400 Chroma Meter; Minolta Corp. Ramsey, NJ). Color characteristics of the plum sample were measured and computed as the mean of each treatment according to the method of Jha et al. (2006). Fruit removal forces (FRF) of plum fruits, were measured by a hand dynamometer (Tronic; HF–10, Digital Dynamometer, 100 N, Taiwan). To determine of FRF of plums, twenty plum fruits (as three replicates) were measured for each AVG treatment (Jolliffe, 1975). The mass of fruit and *FRF* relationship *(M/FRF)* was calculated for each treatment according to the method of Sahin (2007).

Friction coefficients of plum samples, the tangent value of the angle of slope, were determined for different surfaces (Altuntas et al. 2011). To determine the skin firmness, 11.1 mm diameter stainless steel probe was penetrated along Y- axis (width) by biological materials test device (Sundoo, SH–2, 500 N, China). For each AVG application, TSSC (total soluble solids content), TA (titratable acidity) and, pH of plum fruits were determined by the method of the (Association of Official Analytical Chemists, 1984; Barrett et al. 2007).

In this experiment, a total sample of 450 plum fruits were used, the data was analyzed using a randomized complete block design with split block. In this design, the main factor is AVG doses and sub-factor is harvest date. Results were analyzed using analysis of variance and the means were compared using LSD test as described by Gomez & Gomez (1984). Statistical analyses were conducted with SPSS 13.0 software.

Table 1: Physical properties of Santa Rosa plums at different harvest dates affected by AVG applications

Physical properties	AVG applications	Harvest dates 25 July	1 August	7 August	
Geometric mean diameter, mm	AVG-0	44.02	43.70	44.02	*43.91 b**
	AVG-1	44.55	43.19	44.60	*44.11 b*
	AVG-2	46.77	42.33	46.77	*45.29 a*
	Mean	*45.11 a***	*43.07 b*	*45.13 a*	
Sphericity, %	AVG-0	0.990	0.994	0.991	*0.992 a**
	AVG-1	0.974	0.993	0.975	*0.981 b*
	AVG-2	0.996	0.988	0.995	*0.993 a*
	Mean	*0.987* ^{ns}	*0.992* ^{ns}	*0.987* ^{ns}	
Surface area, cm^2	AVG-0	60.76	61.53	58.15	*60.15*
	AVG-1	64.02	58.38	58.15	*60.18*
	AVG-2	70.32	56.44	58.13	*61.63*
	Mean	*65.03 a***	*58.78 b*	*58.14 b*	
Fruit volume, cm^3	AVG-0	45.20	45.99	42.25	*44.48*
	AVG-1	48.91	42.54	42.25	*44.57*
	AVG-2	56.65	40.52	42.23	*46.47*
	Mean	*50.25 a***	*43.02 b*	*42.24 b*	
Bulk density, kg m^{-3}	AVG-0	547.52	562.39	527.99	*545.97 b***
	AVG-1	557.32	526.90	514.63	*532.95 c*
	AVG-2	631.14	534.03	516.32	*560.50 a*
	Mean	*578.66 a***	*541.10 b*	*519.65 c*	
Fruit density, kg m^{-3}	AVG-0	1087.58	1258.99	1031.48	*1126.02 a***
	AVG-1	1111.83	1171.85	1067.22	*1116.96 b*
	AVG-2	1057.92	1214.94	1019.37	*1097.41 c*
	Mean	*1085.77 b***	*1215.26 a*	*1039.36 b*	

** P< 0.01, * P<0.05, ^{ns} :p>0.05.

http://dx.doi.org/10.4314/ajtcam.v13i1.18

Results and Dıscussıon

Geometric and Volumetric Properties

The physical properties of plum fruit (cv. Santa Rosa) affected by AVG applications are given in Table 1. The effect of AVG treatments and harvest date on the geometric mean diameters of plum fruits were statistically significant. The sphericity was not statistically significant with AVG treatments and harvest date. The geometric mean diameter values were found as 43.91; 44.11 and 45.29 mm for AVG-0, AVG-1 and AVG-2, respectively. The sphericity was higher in AVG-2 than the other AVG applications, and the geometric mean diameter were lower in AVG-0 than the other treatments. The geometric diameter of plum fruit increased from 43.91 mm to 45.29 mm (3.14% increases) with AVG treatment doses. The surface area and volume of plum fruits were higher in control than the other treatments according to harvest dates.

Surface area and fruit volume of Santa Rosa plum were affected by AVG treatments statistically significant (Table 1). With an increase in AVG doses from 0 to 200 mg L^{-1}, the surface area, and fruit volume were 15.73% and 25.31%, respectively. The surface and volume of plum for plant growth regulators (AVG) were higher than control. AVG treatments affected the pre-harvest drop and delayed the harvest of plum fruits. The surface area and the volume of plum fruit increased with AVG dose increases at the first harvest date. The bulk density and fruit density was statistically significantly affected by AVG applications (P<0.01). AVG-2 dose application was given the highest value for the bulk and fruit densities of plum fruits than AVG-0 application. While the fruit density decrease was 2.54% as AVG doses increased, the bulk density increase was 2.66% as AVG doses increased from 0 to 200 mg L^{-1} doses (Table 1).

AVG may indirectly affect the size dimensions of fruits by retarding ripening, and the dimensions and fruit weight are dependent upon the application of AVG doses (Greene, 2006; Greene and Schupp, 2004). Ozturk et al. (2012a) reported that the geometric mean diameter of Braeburn apple cultivar increase with AVG increasing doses. Altuntas et al. (2012) reported that AVG treatment significantly caused increasing of the fruit mass, due to the delay of the fruit harvest. And also, the highest fruit and bulk densities were as 1120.8 kg m^{-3} (NAA) and 385.11 kg m^{-3} (AVG) than the other treatments, respectively. Ozturk et al. (2012a) reported that the AVG-0 application was lower for values of the bulk and fruit densities than the other AVG application doses. In this study, the fruit geometric and volumetric characteristics values for Santa Rosa plum measured were similar to reported literature.

Table 2: Mechanical and chemical properties of plums at different harvest dates affected by AVG applications.

Properties	Parameters	AVG treatments	Harvest dates 25 July	1 August	7 August	*Mean*
	Fruit removal force, N	AVG-0	28.35	24.24	4.69	19.09 ns
		AVG-1	31.83	21.92	6.53	20.09 ns
		AVG-2	34.87	19.57	6.16	20.20 ns
		Mean	31.68 a**	21.91 b	5.79 c	
Mechanical properties	M/FRF (mass/fruit removal force)	AVG-0	1.860	2.202	11.474	5.179 ns
		AVG-1	1.739	2.373	8.867	4.326 ns
		AVG-2	1.826	2.399	10.340	4.855 ns
		Mean	1.808 b**	2.325 b	10.227 a	
	Firmness, N	AVG-0	37.141	39.162	32.442	36.248
		AVG-1	29.322	35.483	32.167	32.324
		AVG-2	31.912	33.766	32.962	32.883
		Mean	32.795 b**	36.130 a	32.520 b	
	TSSC (%)	AVG-0	13.60	14.17	14.83	14.20 a**
		AVG-1	13.47	13.17	12.30	12.98 b
		AVG-2	12.93	13.37	11.90	12.73 c
		Mean	*13.33 b***	*13.57 a*	*13.01 c*	
Chemical properties	pH	AVG-0	3.213	3.213	3.333	3.253 b*
		AVG-1	3.237	3.267	3.243	3.249 b
		AVG-2	3.267	3.310	3.220	3.266 a
		Mean	*3.239 b***	*3.263 a*	*3.266 a*	
	Titratable acidity (g 100 g^{-1})	AVG-0	2.427	2.182	2.046	2.218 c**
		AVG-1	2.471	2.216	2.237	2.308 b
		AVG-2	2.508	2.355	2.295	2.386 a
		Mean	*2.469 a***	*2.251 b*	*2.193 c*	

** P< 0.01, * P<0.05, ns :p>0.05.

Color Characteristics

In Figure 1, plum skin and flesh color characteristics were presented. The effect AVG treatments on the *L**, *a**, *b** color values of plum were statistically significant (P<0.01). *L**, *a**, *b** values of plum fruits increased from 22.68 to 23.18; 3.61 to 4.11; 4.70 to 4.78 for all the harvest dates. While *L** and *b** values of plum fruits varied from 35.13 to 33.75 (AVG-0); 17.30 to 17.01 (AVG-1), *a** values varied from -7.64 to -6.25 (AVG-2), respectively. While for the first harvest date (25 July), *b** value decreased from 7.73 to 5.66, for the third harvest date (7 August), *b** value increased from 4.30 to 6.91 with an increasing AVG application doses. *L**, *a**, *b** values of plum fruits increased from 22.68 to 23.18; 3.61 to 4.11; 4.70 to 4.78 for all the harvest dates. AVG applications delayed the red color development in different fruits (Greene and Schupp (2004). Ozturk et al. (2012b) reported that while the highest *L**, chroma color parameters of skin Red Chief apple were found for 600 mg L^{-1} AVG dose, the lowest *L**, chroma color parameters of skin Red Chief apple were found for 150 mg L^{-1} AVG dose. Ozturk et al. (2013) reported that the color characteristics for skin apple generally increased in magnitude with an increasing in AVG doses. Hue angle values for both skin and flesh apple fruits increased as AVG application doses increased from 0 to 500 mg L^{-1}, respectively. In this study, the fruit color characteristics values for Santa Rosa plum measured were similar to reported literature (Ozturk et al. 2012b; Ozturk et al. 2013).

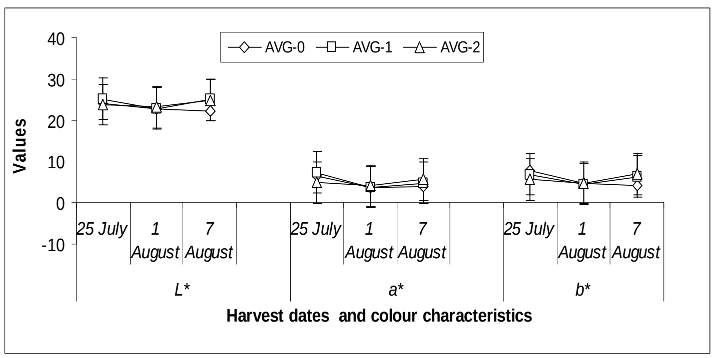
http://dx.doi.org/10.4314/ajtcam.v13i1.18

Mechanical Properties

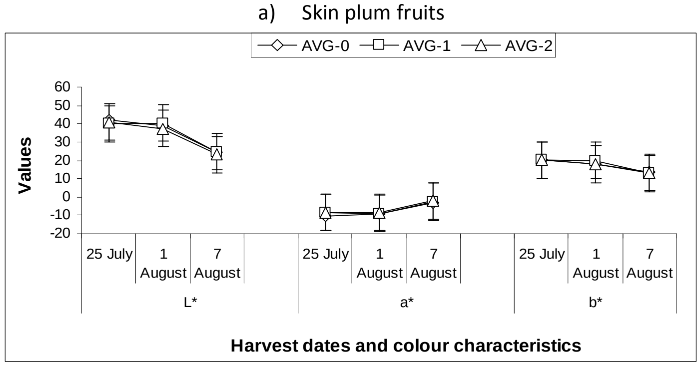
The effect of AVG treatment and harvest dates on fruit removal force, *M/FRF* and skin firmness was presented in Table 2. The effect of AVG treatments on the fruit removal force and *M/FRF* was not statistically significant. The fruit removal force values varied from 19.09 to 20.20 N with an increasing AVG application doses from 0 to 200 mg L^{-1}, while *M/FRF* decreased from 5.18 to 4.86 as AVG doses (from 0 to 200 mg L^{-1}).

Effect of AVG treatments on the skin firmness of Santa Rosa plum cultivar was not statistically significant (Table 2). While skin firmness decreased from 36.25 to 32.88 N by AVG increasing doses (from 0 mg L^{-1} to 200 mg L^{-1}), the skin firmness increased from 32.80 to 36.13 N by increasing harvesting times from the first harvest date to the second harvest dates (from 25 July to 1 August). FRF values increased with AVG doses for Braeburn and Red Chief apple cultivar (Ozturk et al. (2012a,b). Altuntas et al. (2012) reported the fruit removal force values decreased with increase in MeJA (methyl jasmonate) levels from 1120 to 4480 mg L^{-1}. In this study, the fruit removal force values for Santa Rosa plum measured was similar to that reported by Ozturk et al. (2012 a,b); Ozturk et al. (2013). Skin and flesh firmness gradually increased by increasing AVG doses reported by Ozturk et al. (2012a). Altuntas and Ozturk (2013) reported that the skin firmness increased as doses from 1120 to 4480 mg L^{-1}, and the fruit firmness (skin and flesh) were lower in MeJA-0 than the other MeJA treatments. In this study, fruit firmness values for Santa Rosa plum was not shown similar to this literature.

The effect of AVG treatment and the different harvest dates on the friction coefficient for friction surfaces was given in Figure 3. Effect of AVG applications and harvesting times on the friction coefficients for all test were significant, respectively. The friction coefficients for laminate and rubber friction surface increased by AVG increasing doses from 100 mg L^{-1} to 200 mg L^{-1} and harvesting times respectively. In contrast, the friction coefficients for chipboard and plywood friction surfaces increased at harvesting times at AVG-0 application. The friction coefficient (static) values of plum fruits varied from 0.159 to 0.177 for laminate; 0.206 to 0.261 for galvanized mild steel; 0.285 to 0.262 for chipboard; 0.320 to 0.355 for plywood and 0.253 to 0.242 for rubber with AVG application doses (from 0 to 200 mg L^{-1}), respectively. The friction coefficients of laminate, galvanized steel, chipboard, and plywood friction surfaces increased with AVG increased doses (from 0 to 200 mg L^{-1}). Generally, the friction coefficient was lower in laminate and galvanized metal than the rubber, chipboard and plywood surfaces. Ozturk et al. (2012a) reported that the friction coefficient for galvanized metal and rubber increased with an increase of AVG doses. Altuntas et al. (2012) evaluated the friction coefficient for MeJA treatments increased according to the friction surfaces. The friction coefficient for Santa Rosa plum was similar to that reported by Ozturk et al. (2012a) and Altuntas et al. (2012).



a) Skin plum fruits



b) Flesh plum fruits

Figure 1: Color characteristics *(L*, a*, b*)* of Santa Rosa plums at different harvest dates affected by AVG applications.

Chemical Properties

The effect of AVG treatment and the different harvest dates on chemical properties (TSSC, pH, and TA) were presented in Table 2. The effect of the AVG application and harvest date on TSSC, pH, TA of plum fruit was statistically significant ($P<0.01$). TSSC of plum fruits was as 14.20%, 12.98% and 12.73% for AVG applications (from 0 to 200 mg L^{-1}) respectively. pH and TA values of plum fruits were as 3.253 and 2.218 g 100 g^{-1} (AVG-0), 3.249 and 2.308 g 100 g^{-1} (AVG-1), 3.266 and 2.386 g 100 g^{-1} (AVG-2), respectively. While with increasing the doses of AVG, TSSC decreased, TA generally increased. The highest pH, TA and the lowest TSSC were obtained from AVG-2 as 12.73%, 3.266 and 2.386 g malic acid 100 g^{-1}, respectively. Ozturk et al. (2013) reported that TSSC, pH and TA of apple increased with the increasing doses of AVG. Ozturk et al (2012b) reported that the highest and the lowest TSSC values were obtained from 600 mg L^{-1} AVG application and control

http://dx.doi.org/10.4314/ajtcam.v13i1.18
(AVG-0), respectively for Red Chief apple cultivar. In this study, as the increasing doses of AVG, TSSC decreased, pH and TA generally increased.

Conclusion

The physical, mechanical and chemical properties are highly dependent on AVG application doses at all three harvest dates. The sphericity was higher in AVG-2 AVG applications, while the geometric mean diameter was lower in control than the other AVG applications doses. AVG treatments affected the pre-harvest drop and delayed the harvest of plum fruits. While the bulk density was increased by AVG doses, true (fruit) density was decreased by AVG doses increased. While for the *b** value decreased, date (7 August), *b** value increased in magnitude with AVG application doses for skin plum fruits in the first and third harvest dates, respectively. *L**, *a**, *b** values of flesh plum fruits increased from for each of the harvest dates. TSSC, pH, TA of plum fruit were significantly affected by AVG application and harvest date. While increasing doses of AVG, TSSC decreased, pH and TA generally increased. The lowest TSSC and the highest pH and TA values were obtained from the AVG-2 dose. As a result, post-harvest technologies of Santa Rosa plum fruits should be designed while taking the physical, mechanical and chemical parameters criteria into consideration.

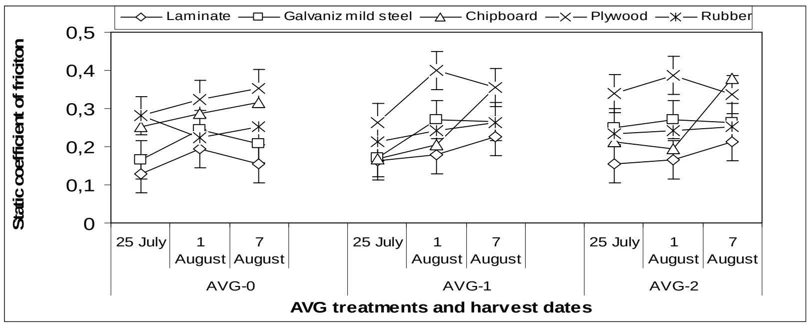


Figure 2: Friction coeffcient of Santa Rosa plums at different harvest dates affected by AVG applications.

References

1. Altuntas, E., Cangi, R. and Kaya, C. (2011). Some physico-chemical and mechanical characteristics of persimmon fruit cv 'Fuyu'. International Agrophysics, 25: 89-92.
2. Altuntas, E. and Ozturk, B. (2013). The effect of aminoethoxyvinylglycine treatments on mechanical properties of plum (cv. 'President'). Journal of Food Process Engineering, 36: 619-625.
3. Altuntas, E., Ozturk, B. Ozkan. Y. and Yildiz, K. (2012). Physico-mechanical properties and color characteristics of apple as affected by methyl jasmonate treatments. International journal of Food Engineering, 8(1). Article 19: 1-16.
4. Association of Official Analytical Chemists (1984). Official methods of analysis. 14th ed. Arlington, VA: Association of Official Analytical Chemists.
5. Autio, W.R. and Bramlage, W.J. (1982). Effects of AVG on maturation, ripening, and storage of apples. J. Amer. Soc. Hort. Sci. 107: 1074–1077.
6. Barrett, D.M., Weakley, C., Diaz, J.V. and Watnik, M. (2007).Qualitative and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems. Journal of Food Science, 72: 441–451.
7. Byers, R.E. (1997). Effects of aminoethoxyvinylglycine (AVG) on preharvest fruit drop and maturity of 'Delicious' apples. Journal of Tree Fruit Production 2, 53–75.
8. Fan, X., Mattheis, J.P., Fellman, J.K.C., Patterson, M.E. (1997). Changes in jasmonic acid concentration during early development of apple fruit. Physiologia Plantarum 101, 328–332.
9. FAO, 2013. http://faostat.fao.org. Statictic Database. (Accessed 23.04.2014).
10. Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for agricultural research. In K. A. Gomez and A.A. Gomez (Eds.). An international rice researches institute book (2nd ed.. pp. 137–186). Singapore: John Wiley and Sons. Ch. 4.
11. Greene, D.W. and Schupp, J.R. (2004). Effect of aminoethoxyvinylglycine (AVG) on preharvest drop, fruit quality, and maturation of 'McIntosh' apples. II. Effect of timing and concentration relationships and spray volume. HortScience, 39: 1036–1041.
12. Greene, D.W. (2005). Time of aminoethoxyvinylglycine application influences preharvest drop and fruit quality of McIntosh' apples. HortScience 40, 2056–2060.
13. Greene, D.W. (2006). An update on preharvest drop control of apples with Aminoethoxyvinylglycine (ReTain). Acta Horticulturae, 727: 311–319.
14. Jha, S.N., Kingsly, A.R.P. and Sangeeta, C. (2005). Physical and mechanical properties of mango during growth and storage for determination of maturity. Journal of Food Engineering, 72: 73-76.
15. Jolliffe, P.A. (1975). Seasonal variations in the characteristics of raspberry fruitdrop. Can. J. Plant Sci., 55: 421-428.
16. Manganaris, G.A., Vicente A.R. and Crisosto, C.H., (2008). Effect of pre-harvest and post-harvest conditions and treatments on plum fruit quality. CAB Reviews: Perspectives in Agriculture. Veterinary Science. Nutrition and Natural Resources, 3. No. 009.
17. Mohsenin, N.N. (1970). Physical properties of plant and animal materials. New York: Gordon and Breach Sci. Pub.,
18. Ozturk, B., Altuntas, E., Ozkan, Y., Yıldız, K. (2012a). Effect of AVG treatments on some physico-mechanical properties and color characteristics of apple (*Malus domestica* Borkh.). Bulgarian Journal of Agricultural Science, 18: 871-879.
19. Ozturk, B., Yildiz, K., Ozkan, Y., Cekic, C. and Kilic, K. (2012b). The effect of aminoethoxyvinylglycine (AVG) and napthalene acetic acid on the preharvest drop and fruit quality in red chief apple variety. Anadolu J Agr Sci., 27: 120-126. (in Turkish).

http://dx.doi.org/10.4314/ajtcam.v13i1.18
20. Ozturk, B., Kucuker, E., Karaman, S., Ozkan, Y., (2012c). The effects of cold storage and aminoethoxyvinylglycine (AVG) on bioactive compounds of plum fruit (*Prunus salicina* Lindell cv. 'Black Amber'). Postharvest Biol. Technol., 72: 35-41.
21. Ozturk, B., Ozkan, Y., Altuntas, E., Yıldız, K., Saracoglu, O. (2013). Effect of aminoethoxyvinylglycine on biochemical, physico-mechanical and color properties of cv. 'Braeburn' apple (*Malus domestica* Borkh). Semina: Ciencias Agrarias 34: 1111-1120.
22. Ozturk, I., Ercisli, S., Kalkan, F. and Demir, B. (2009). Some chemical and physico-mechanical properties of pear cultivars. African Journal of Biotechnology, 8: 687–693.
23. Rath, A.C., Prentice, A.J. (2004). Yield increase and higher flesh firmness of 'Arctic Snow' nectaries both at harvestin Australia and after exportto Taiwan following pre-harvest application of ReTain plant growth regulator (aminoethoxyvinylglycine, AVG). Australian Journal of Experimental Agriculture 44, 343–351.
24. Rieger, M. (2006). Plum (*Prunus domestica*, *Prunus salicina*). In: Introduction to Fruit Crops. Pp. 369–382. New York: Food Products Press.
25. Sahin, F. (2007). Determination of physical and mechanical properties of apple for harvest handling. Gaziosmanpasa University, Graduate School of Natural and Applied Science, Department of Agricultural Machines, Ms. thesis, Tokat-Turkey (in Turkish).
26. Shin, Y., Ryu, J.A., Liu, R.H., Nock, J.F. and Watkins, C.B. (2008). Harvest maturity storage temperature and relative humidity affect fruit quality, antioxidant contents and activity and inhibition of cell proliferation of strawberry fruits. Postharvest Biology and Technology, 49: 201–209.
27. Singh, K.K. and Goswami, T.K. (1996). Physical properties of cumin seed. Journal of Agricultural Engineering Research, 64: 93–98.
28. Singh, Z., Khan, A.S. 2010. Physiology of plum fruit ripening. Stewart Postharvest Review 2, 3.
29. Valero, C., Crisosto, C.H., Slaughter, D. (2007). Relationship between nondestructive firmness measurements and commercially important ripening fruit stages for peaches, nectarines and plums. Postharvest Biology and Technology 44, 248–253.