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Evaluation of Some Genotypes of Guava Trees Grown Under Alexandria Governorate Condition II- Compositional Changes During Fruit Ripening

Wafaa Aly Ahmed Zaki El-Sisy

El-Maamoura Botanical Garden, Alexandria,
Horticultural Institute, Agricultural Research Center, Giza, Egypt

Abstract: The present study was carried out during 2012 and 2013 seasons in a private orchard belongs to Air Force Institute at EL-Maamoura Zone, East of Alexandria, on the best 5 genotypes (2,5,6,9 &12) of guava seedling trees, which were selected from 15 genotypes from pervious study. The aim of this study was to study the compositional changes during fruit ripening. The ripening stages were (1) yellowish-green, (2) greenish-yellow and (3) full-yellow, for skin color (hue°) and lightness (L). The hue values significantly decreased with fruit ripening, while lightness (L) values increased significantly with fruit ripening. Fruit firmness decreased with fruit ripening, however total soluble solids (TSS) values increased with fruit ripening, the highest values were in stage 3 (full yellow). There were no significant differences between guava genotypes in fruit weight and fruit diameter, length and width during fruit ripening. Fruit acidity (%) significantly decreased with fruit ripening and the lowest values was in stage 3 (full-yellow), it was associated with significant increase in total sugars (%), reducing and non-reducing sugars contents, which increased and then declined. For V.C content there were no significant differences observed between stages of ripening in 2012, while it increased significantly and then decreased with fruit ripening in 2013. As for the pectin (%), it significantly decreased with maturity stages and fruit ripening in both seasons of study. Generally, there were significant differences between genotypes under this study in fruit compositional changes during ripening and we can choose the best, which can be a base-line information to assist in controlling the best time of fruit harvest for either local marketing or export and storage.

Key words: Compositional changes · Genotypes · Guava (*Psidium guajava* L.) · Fruit ripening · V.C.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most important commercial fruit in tropical and sub-tropical countries. It is a good source of V.C, pectin and sugars. Guava is a popular fruit crop in Egypt. Although Egypt has great potential to produce high quality guavas and to export them to other countries, its marketability is still limited to local markets. This is due to the delicate nature of the fruit, poor handling practices and inadequate transportation and storage facilities. Guavas are characterized by a climactic respiratory pattern, with the most intense changes in pulp and skin colors as well as firmness preceding the maximum respiratory rate and ethylene production. Guava are subject to ripening, senescence, microbial and pests infestation, water loss, anatomical morphological and compositional changes [1,2]. Unripe fruits are usually hard in texture, starchy and acidic in taste and sometimes astringent. After ripening, they become soft, sweet, non acidic, less astringent and highly flavored, so more acceptable as human hard.Composition changes of the fruit is a concern for understanding metabolic processes such as fruit ripening, softening and general senescence. Moreover, they are of importance in determining commercial practices and postharvest requirements [3]. The study described here aimed to investigate the changes in guava fruit color, fruit chemicals such as sugars, V.C., acidity and pectin of 5 guavas (selected genotypes) during fruit ripening to determine the optimum stage for fruit harvest.

Corresponding Author: Wafaa Aly Ahmed Zaki El-Sisy, El-Maamoura Botanical Garden, Alexandria, Horticultural Institute, Agricultural Research Center, Giza, Egypt.

MATERIALS AND METHODS

The present study was carried out during 2012 and 2013 seasons in split plot design on seedy guava trees cultivated in a private orchard belongs to Air Defense Institute in EL-Maamoura Zone, Alexandria Governorate. The maturity stages were characterized by color changes. Guava fruits were harvested during mid-September at three maturity stages:

Stage 1: Yellowish-green
Stage 2: Greenish- yellow
Stage 3: Full-yellow

There were five trees, each one act as a separate genotype. Guava fruits were carefully collected from each genotype, whereas (30) fruits were collected from each ripening stage and then divided into three replicates (10 fruits/replicate). External color of the fruits were estimated visually and measured on two points of each fruit by Minolta chroma meter CR-200. Japan. (a*, b* and L) were used to calculate the hue angle (hue°) to follow the skin color changes during the experiment according to the following equation: Hue° = arcton b*/a* and (L) means lightness [4]. Hue° is a quantitative expression of color and represents the changes in fruit color. Three replicates of each tree were used to determine fruit quality parameters, which includes fruit weight (g), fruit diameter (cm), firmness, TSS (%), acidity (%), V.C mg/100ml juice and total sugars, reducing and non-reducing sugars. Guava fruit firmness was determined by using the Effegi pressure tester with an eight mm plunger (Effegi, 48011 Alfonsine, Italy). Two readings were taken at two different positions on the flesh of each fruit after peeling. Each fruit sample was cut to small parts, mixed well and then were used for determination total soluble solids (TSS%) in juice by a hand refractometer. Fruit juice acidity and vitamin C content were also determined according to A.O.A.C [5] by titration with 0.1 N sodium hydroxide and 2,6-dichlorophenol endophenol blue dye, respectively. Acidity was expressed as percent citric acid and V.C as mg ascorbic acid per 100 ml juice. For the determination of total sugars, reducing and non reducing sugars, fruit parts of each replicate were separately washed with distilled water, cut into small pieces, mixed well and then dried at 70°C in an air drying oven. The reducing and total soluble sugars of each sample were extracted in 0.5 gm ground dried material by distilled water [6].The reducing sugars were determined by Nelson Arsenate Molybdate Colorimetric method [7]. The non-reducing sugars were calculated by the difference between total soluble sugars and reducing sugars. For the determination of pectin content, fruit parts of each replicate were washed with distilled water, cut into small pieces by a clean knife mixed well and then pectin content was determined in fruit tissue by the method described by Care and Haynes [8].Soluble pectin was extracted by distilled water and insoluble pectin by 0.5 N HCl solution. The extracted soluble and insoluble pectin were precipitated as calcium pectate, dried and weighted and the pectin percentage was calculated. The pectin concentration in the fruit flesh was expressed as a percent of fresh weight basis.

Statistical Analysis: The data obtained through the course of this study were statistically analyzed according to Snedecor and Cochran [9] and LSD test at 0.05 level was used for comparison between treatments.

RESULTS AND DISCUSSION

Fruit Quality:

Fruit Weight: The data in Table 1 showed that, in both seasons of study, the average weight of three stages of maturity ranged from (191.7 to 210.5 g) and from (171.4 to 188.7 g) in 2012 and 2013, respectively without significant differences. Concerning the guava genotypes effect, genotypes 1&5 in the first season and 1,3&5 in the second season of study gave the highest fruit weight, while genotype 4 in both seasons gave the lowest values. For the interaction between genotypes and maturity stages, the highest values of weight were in full yellow stage in genotypes 1& 5 in both seasons of study and in genotype 3 in stage 2 (greenish- yellow) in the second season. These results are in agreement with those obtained by Salmah *et al.* [10], they reported that the weight increase as maximum between 10th-12th week. However,Yamdagni *et al.* [11] and Dhillon *et al.* [12] stated that, the weight did not vary with ripening.

Fruit Length (cm): Data presented in Table 1 indicated that there were no significant differences between the 3 ripening stages in the first season, while in the second one stage (1) yellowish-green gave the highest fruit length. For the genotype effect, No 1, 4 &5 gave the highest fruit length (cm) in both seasons of study. As for

Table 1: Fruit weight (g), length (cm) and width (cm) of five guava genotypes during ripening in 2012 and 2013 seasons.

Treatment	Fruit weight (g)				Fruit length (cm)				Fruit width (cm)			
	Maturity stages				Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
						2012						
1	251.10	255.90	263.93	256.90A	7.40	7.77	7.80	7.66A	7.67	7.83	7.33	7.61A
2	213.10	153.90	170.80	179.30B	7.57	6.57	6.47	6.87B	7.50	6.87	6.70	7.02C
3	206.50	169.00	188.80	188.10B	6.70	6.57	6.63	6.63B	7.33	7.47	7.07	7.29BC
4	110.60	154.70	108.30	137.30C	7.07	8.23	7.60	7.64A	5.60	6.17	6.80	6.19D
5	177.30	225.10	282.40	228.30A	7.67	7.93	8.33	7.98A	7.20	7.33	7.97	7.50AB
Mean	191.70A	191.70A	210.A	--	7.28A	7.42A	7.37A	--	7.06A	7.13A	7.17A	--
$LSD_{0.05}$	A = 29.95				A = 0.75				A = 0.29			
	B = 41.06				B = 0.51				B = 0.39			
	A × B = 50.28				A × B = 1.60				A × B = 1.24			
Treatment	Fruit weight (gm)				Fruit length (cm)				Fruit width (cm)			
	Maturity stages				Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
						2013						
1	170.50	208.20	195.90	194.90A	7.63	7.20	7.00	7.28A	7.83	6.93	7.27	7.34A
2	170.80	169.50	175.80	172.06B	6.97	6.83	6.67	6.82B	6.90	6.90	6.80	6.87B
3	179.80	250.30	190.60	203.60A	7.40	6.40	6.60	6.80B	7.67	6.70	7.23	7.20AB
4	125.90	110.90	152.30	129.70C	7.50	7.73	7.13	7.46A	5.63	5.60	6.87	6.09C
5	209.60	170.20	229.70	202.90A	7.57	7.53	7.53	7.54A	7.03	7.23	7.37	7.21AB
Mean	171.40A	181.80A	188.A	--	7.41A	7.14AB	6.98B	--	7.01A	6.67B	7.10A	--
$LSD_{0.05}$	A = 18.87				A = 0.42				A = 0.43			
	B = 19.95				B = 0.3				B = 0.23			
	A × B = 63.10				A × B = 1.13				A × B = 0.73			

- The values followed by the same letter do not differ at 5% level of significance.

* Y-G : Yellowish-green ** G-Y: Greenish- yellow *** Y : Full-yellow

the interaction the genotype 4 at stage 2 gave the highest values in both seasons of study. The results of this study were partially in agreement with those of Salmah *et al.* [10], Dhillon *et al*. [12] and El-Bulk *et al.* [13] in guava, there was increase in fruit diameter during development and maturity in guava cvs and fruit length of some guava CVs during 140-130 days.

Fruit Width: The data in Table 1 showed that, genotypes 1&5 gave the highest values of width in both seasons of study. For the effect of ripening stage on fruit width, there was no significant effect for maturity stages on fruit width in the first season, while stage 2 (greenish-yellow) gave the lowest values for the fruit width with significant differences in the second season. Concerning the interaction between genotypes and maturity stages, the data showed that genotype 5 at stage 3, genotype 1 at stage 1 in both seasons and genotype 3 at stage 1 gave the highest values of fruit width during 2013, respectively.

Skin Color: It can be notice from Table 2 that, the skin color (hue°) values significantly decreased with maturity stage, it was greatest in greenish-yellow fruit in both seasons of study. For the differences between genotypes, hue° gave no significant differences between them in 2012 and 2013 seasons. (Hue°) value is the qualitative expression of chromaticity. Montes *et al*. [14] and Gonzalez *et al*.[15], who reported that, in pink and white guava skin, the hue angle significantly decreased during ripening, while chroma increased from green to mature and remain similar at the overripe stage. These results showed that a characterization between the different ripening stages by skin color is possible. Similar results were obtained by El-Saedy *et al*. [16] on guava. All skin hue° values were decreased with ripening. The result of this study are in close agreement with those reported with Sinuco and Steinhaus [17] on pink and white guava skins, the hue angle significantly decreased during ripening, while chroma increased from green to mature and remains similar at the overripe stage.

Table 2: Fruit skin color (hue°), Lightness (L) and fruit firmness changes of five guava genotypes during ripening in 2012 and 2013 seasons.

Treatment	Skin color (hue°)				Lightness (L)				Firmness (1b/ inch^2)			
	Maturity stages				Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Aver.	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
						2012						
1	109.48	104.90	95.34	103.24A	78.40	79.43	84.04	80.83B	11.03	6.95	4.13	7.37B
2	107.41	99.60	97.43	101.48A	88.71	95.79	96.82	93.77A	19.80	16.07	12.93	16.27A
3	106.24	104.12	96.96	102.44A	90.07	93.17	93.13	92.12A	13.35	9.08	9.05	10.49B
4	106.12	99.93	93.47	99.84A	83.96	90.77	99.61	91.41A	25.37	13.98	5.57	14.97A
5	107.23	104.20	94.15	101.86A	85.08	90.24	94.23	89.85A	11.92	5.80	3.50	7.07B
Mean	107.29A	102.55B	95.47C	--	85.24C	89.11B	93.29A	--	16.29A	10.38B	7.04C	--
$LSD_{0.05}$	A = 5.07				A = 5.40				A = 4.05			
	B = 2.9971				B = 3.24				B = 3.26			
	A × B = 9.467				A × B = 10.243589				A × B = 10.30			
Treatment	Skin color (hue°)				Lightness (L)				Firmness (1b/ inch^2)			
	Maturity stages				Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
						2013						
1	108.38	102.017	95.71	102.03A	79.84	82.33	86.96	83.05C	15.82	13.87	8.12	11.166B
2	106.82	101.04	98.47	102.11A	90.34	93.86	96.80	93.67A	19.67	16.03	9.17	14.97AB
3	108.87	103.89	99.16	103.98A	86.60	88.16	93.62	89.79AB	15.08	13.17	5.93	11.39B
4	104.18	101.32	95.79	100.43A	82.17	90.60	94.82	89.20B	26.67	20.40	10.28	19.12A
5	106.76	97.86	96.57	100.39A	84.38	88.60	92.23	88.45B	14.50	7.88	5.73	9.37B
Mean	107.00A	101.27B	97.14C	--	84.67C	88.71B	92.89A	--	18.35A	14.27B	7.86C	--
$LSD_{0.05}$	A = 4.77				A = 4.40				A = 6.00			
	B = 3.05				B = 4.01				B = 3.41			
	A × B = 9.65				A × B = 12.69				A × B = 10.77			

The values followed by the same letter do not differ at 5% level of significance.

* Y-G : Yellowish-green ** G-Y: Greenish- yellow *** Y : Full-yellow

Lightness (L): Skin color was recorded in L*C*H* (lightness, Chroma, hue° angle) according to Sinuco and Steinhaus [17].The data of lightness (L) in Table (2) showed that the lightness value increased with maturity stages in both seasons of study. Concerning the effect of genotypes on lightness values the data showed that all genotypes except genotype 1 gave the significant increase in fruit lightness in 2012 and 2013 seasons.For the interaction, the highest values of lightness was found in genotypes 2&4 in stage 3 (full-yellow) in both seasons of study. These results are in agreement with those reported by Hernandez *et al*. [18] on guava, who found that, the color of guava evaluated with a visual scale of 1-6 degrees.

Firmness: The data in Table 2 showed that, there were significant differences between ripening stages for firmness, there were a reduction of hardness in both seasons of study. For the effect of guava genotypes, there were significant differences between genotypes in firmness in both seasons of study. For the combination of ripening stages and genotypes, the yellow stage was suitable for local marking, while stage 2 (greenish-yellow) was suitable for export and marketing in both seasons of study. Fruit flesh firmness showed a progressive decline during ripening. Similar results are in accordance of the findings reported by Yamdagni *et al.*[11], Yousef *et al.* [19], EL-Bulk *et al.*[13] and Bashir *et al.*[3].

Total Soluble Solids (TSS%): The data in Table 3 showed that, total soluble solids increased significantly during ripening stages in 2012 season, while in 2013 the significant increase was clearly showed in stage 3 (full-yellow). Concerning the results of different genotypes, the data showed that genotype 5 gave the highest value of TSS% in 2012 and genotype 1 gave the lowest value, while the other genotypes were in between in both seasons. The results of interaction between maturity stages and guava genotypes, the data indicated that genotypes 5&3 in (full-yellow) stage gave the highest

Table 3: Total soluble solids (%), acidity (%) and V.C (mg/ 100 ml juice) changes of five guava genotypes during ripening in 2012 and 2013 seasons.

Treatment	Total soluble solids (TSS %)				Acidity (%)				V.C. (mg/ 100 ml juice)			
	Maturity stages				Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
						2012						
1	6.20	6.33	6.80	6.44C	0.47	0.27	0.23	0.32BC	87.66	98.77	79.01	88.48B
2	6.27	6.60	8.40	7.09BC	0.43	0.39	0.32	0.38B	103.09	93.21	110.49	102.26A
3	7.33	7.40	9.27	8.00AB	0.37	0.28	0.24	0.30C	74.69	96.27	59.88	76.96C
4	7.07	7.87	8.80	7.91AB	0.67	0.60	0.29	0.52A	75.93	77.78	74.96	76.22C
5	7.53	8.13	9.40	8.36A	0.49	0.36	0.23	0.36BC	79.01	70.37	80.25	76.54C
Mean	6.88B	7.27B	8.53A	--	0.49A	0.38B	0.26C	--	84.08A	87.28A	80.92A	--
$LSD_{0.05}$	A = 0.96				A = 0.07				A = 10.73			
	B = 0.49				B = 0.03				B = 8.38			
	A × B = 1.55				A × B = 0.09				A × B = 26.51			
Treatment	Total soluble solids (TSS)				Acidity (%)				V.C. (mg/ 100 ml juice)			
	Maturity stages				Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Aver.	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
						2013						
1	5.67	6.80	6.87	6.44D	0.48	0.42	0.20	0.37CD	81.48	65.43	63.05	69.55B
2	7.03	7.07	7.93	7.34C	0.54	0.49	0.33	0.45B	122.84	106.17	105.56	111.52A
3	7.93	8.27	9.33	8.51A	0.44	0.30	0.26	0.33D	85.80	87.65	59.88	77.78B
4	7.07	8.07	8.47	7.87B	0.66	0.63	0.41	0.57A	87.65	76.54	61.11	75.102B
5	7.13	8.33	8.60	8.02B	0.52	0.36	0.34	0.40CB	80.25	67.90	60.50	69.55B
Mean	6.97C	7.71B	8.24A	--	0.53A	0.44B	0.31C	--	91.61A	80.74B	70.02C	--
$LSD_{0.05}$	A = 0.26				A = 0.07				A = 10.35			
	B = 0.48				B = 0.03				B = 7.59			
	A × B = 1.50				A × B = 0.09				A × B = 24.00			

The values followed by the same letter do not differ at 5% level of significance.

* Y-G : Yellowish-green ** G-Y: Greenish- yellow *** Y : Full-yellow

values of TSS% in 2012&2013, respectively, while genotype 1 in yellow stage gave the lowest values in both seasons of study. These results are in line with those of Yamdagni *et al.* [11], Yousef *et al.*[19] and El-Bulk *et al.* [20], who found that,TSS (%) content increased with ripening all guava cultivars. While Bashir *et al.* [3] reported that, TSS (%) increased with guava ripening associated with decreasing flesh firmness and to hydrolysis of starch to sugars. Sinuco and Steinhaus [17] reported on pink and white guava that, the TSS (%) increased during ripening from (9.8-10.5) Brix in pink fleshed guavas and from (8.9-11.3) Brix in white fleshed. This increase is attributed to the hydrolysis of starch as stated by Jain *et al.* [21].

Fruit Acidity (%): The data in Table 3 showed that, the values of acidity significantly decreased with fruit ripening, the lowest value was in stage 3 (full-yellow) in both seasons of study. Besides, the lowest values of acidity was in genotypes 3 in both seasons of study, these results associated with high level of TSS (%)values. Regarding the interaction genotypes 1&3 in (full-yellow) stage gave the lowest values of acidity percent in both seasons. These results are in agreement with those obtained by Yousef *et al.*[19], who reported that, the titratable acidity decreased with increasing fruit ripening of guava fruits cvs. (Vietnames types).Similar findings were reported on guava by Yamdagni *et al.*[11], Laguado *et al.*[22], Salmah *et al.*[10] and Bashir *et al.*[3] in both types of guava pink and white flash, they reported that acidity increased up to climacteric peak and then declined. On the other hand, Sinuco and Steinhaus [17] found that, on pink and white flash guava these were no differences between the ripening stages in pink-fleshed guava, while for white guavas these values increased from (0.5-0.7%) citric acid during the ripening process. This increasing in acidity is associated with high concentrations of organic acids, which are later used as a respiratory substrate.

Table 4a: Total sugars (%) and reducing sugars (%) of five guava genotypes during ripening in 2012 and 2013 seasons.

Treatment	Total sugars (%)				Reducing sugars (%)			
	Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
				2012				
1	18.61	22.10	24.06	21.59C	8.09	8.38	8.82	8.43D
2	20.16	21.54	22.28	21.32C	9.35	9.49	9.65	9.49A
3	20.67	21.88	22.68	21.74CB	8.79	9.17	9.45	9.14B
4	21.77	23.39	23.97	23.04A	9.15	9.63	9.87	9.55A
5	20.56	22.24	23.57	22.12B	8.58	8.79	9.39	8.92C
Mean	20.35C	22.23B	23.31A	--	8.79C	9.09B	9.44A	--
LSD $_{0.05}$	A = 0.51				A = 0.19			
	B = 0.26				B = 0.17			
	A × B = 0.83				A × B = 0.53			
Treatment	Total sugars (%)				Reducing sugars (%)			
	Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
				2013				
1	21.71	22.24	22.94	22.30B	8.15	8.30	8.68	8.38C
2	20.68	22.76	23.62	22.35B	9.19	9.52	9.87	9.53A
3	20.73	23.42	24.11	22.75B	8.43	9.15	9.63	9.07B
4	21.66	22.64	23.29	22.53B	8.84	9.43	9.92	9.39AB
5	23.22	23.72	24.66	23.87A	8.84	9.07	9.49	9.13B
Mean	21.60C	22.96B	23.72A	--	8.69C	9.1B	9.51A	--
LSD $_{0.05}$	A = 0.58				A = 0.36			
	B = 0.20				B = 0.12			
	A × B = 0.65				A × B = 0.37			

The values followed by the same letter do not differ at 5% level of significance.

* Y-G : Yellowish-green ** G-Y: Greenish- yellow *** Y : Full-yellow

Vitamin C Content: The data in Table 3 showed that, there were no significant differences between three maturities stages in first season 2012, while in 2013 there were significantly decreasing in V.C content with development stages. The results are partially in agreement with Agnihortri, *et al.* [23],Yamdagni *et al.*[11] and El-Bulk *et al.*[20], ascorbic acid contents increased significantly with fruit maturity in all cultivars. As for the result of V.C content in five guava genotypes,there were significant differences between the genotypes, wheras genotype 2 gave the highest values in both seasons of study. Regard the interaction between ripening stage and genotypes, genotype 2 at (full-yellow) stage gave the highest values of V.C content in 2012 and at the stage 1 (yellowish-green) in 2013 season gave the same result. These results are in agreement with the results obtained by El-Zorkani [24] and Salmah *et al*. [10], who found that, ascorbic acid content showed a sigmoid pattern of increase up to stage 4 of maturity (16 weeks after fruit set) and (12-14 weeks), respectively in white and pink flesh thereafter decreased. While, Bashir *et al.*[3] reported that, ascorbic acid in pulp and peel of both guava types pink and white decreased steadily during fruit ripening.

Total Sugars: The data in Table 4a showed that, the total sugars significantly increased with ripening stages in both seasons of study, it varied from (20.35-23.31%) in 2012 and from (21.603-23.72%) in 2013.Concerning the data of guava genotypes, the data showed that genotypes No 4 in 2012 and 5 in 2013 gave the highest total sugars. For the combination between genotypes and maturity stages, the data showed that genotypes 1 & 4 in yellow stage in 2012, genotypes 3 & 5 in 2013 at the same stage gave the highest values of total sugars. These results are in line with those reported by El-Bulk *et al.* [25], who found that, the content of total sugars increased slowly during the initial growing period followed by a rapid increase during maturation and ripening. Jain *et al.* [26] on guava, they reported that the ripening fruits are known to store starch transiently, which is ultimately

Table 4b: Non reducing sugars and pectin (%) of five guava genotypes during ripening in 2012 and 2013 seasons.

Treatments	Non reducing sugars				Pectin (%) content			
	Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
				2012				
1	10.52	13.73	15.24	13.16A	3.42	2.45	1.44	2.44A
2	10.81	12.05	12.63	11.83C	2.92	2.07	1.64	2.10AB
3	11.88	12.71	13.23	12.61B	2.99	2.29	1.27	2.22AB
4	12.63	13.76	14.10	13.49A	2.45	1.88	1.10	1.81B
5	11.97	13.45	14.18	13.20A	2.52	1.87	1.14	1.84B
Mean	11.56C	13.14B	13.88A	--	2.86A	2.113B	1.317C	--
LSD $_{0.05}$	A = 0.49				A = 0.57			
	B = 0.34				B = 0.21			
	A × B = 1.09				A × B = 0.67			
Treatments	Non reducing sugars				Pectin (%) content			
	Maturity stages				Maturity stages			
Genotypes	Y-G*	G-Y**	Y***	Mean	Y-G*	G-Y**	Y***	Mean
				2013				
1	13.57	13.94	14.26	13.92B	3.33	2.85	1.18	2.45AB
2	11.49	13.24	13.74	12.83D	2.99	2.17	1.46	2.20ABC
3	12.31	14.27	14.48	13.69CB	2.36	1.93	1.02	1.77C
4	13.81	13.21	13.40	13.14CD	2.87	1.95	1.14	1.98CB
5	14.39	14.65	15.17	14.74A	3.47	2.58	1.52	2.52A
Mean	12.92C	13.86B	14.21A	--	3.00A	2.29B	1.26C	--
LSD $_{0.05}$	A = 0.59				A = 0.47			
	B = 0.22				B = 0.20			
	A × B = 0.71				A × B = 0.64			

The values followed by the same letter do not differ at 5% level of significance.

* Y-G : Yellowish-green ** G-Y: Greenish- yellow *** Y : Full-yellow

converted to sugars lead to sweet taste of ripe fruits and starch content decreased, while soluble sugars increased. Total and reducing sugars increased from 4.5 and 4.0% at mature green to 10.4 and 7.8% at over ripe, respectively. This increase in sugar content was attributed to conversion of starch into soluble sugars, similar increase in total sugars. Bashir *et al.*[3] found that reducing sugars increased up to climacteric peak and subsequently decreased because starch and sucrose change into glucose during fruit ripening.

Reducing Sugars: Data of reducing sugars as presented in Table 4a indicated that, reducing sugars significantly increased with ripening stages in both seasons of study. For the effect of guava genotypes, genotypes 2 & 4 in both seasons recorded the highest values. As for the combination, the highest reducing sugars content was in genotypes 2 & 4 in yellow stage in both seasons of study. The results were agreed with the results obtained by Mawlah and Itoo [27] on white and pink guava fruits. They found that reducing sugars mainly fructose and glucose increased slowly during the immature and mature stages and increased sharply at ripening up to the fully ripe stage, when fully ripe fructose comprised 55.93 & 58.28% of the sugar in the white and pink CVs, respectively. On the other hand, Laguado *et al.*[22] reported that reducing sugars content decreased with advancing maturity. Also, El-Bulk *et al.* [25] reported that, individual sugars (fructose, glucose and sucrose) increased slowly during the initial growing period followed by rapid increase during maturation and ripening for all 4 guava cultivars.

Non-Reducing Sugars: The same trend was also observed in the data in Table 4b for non reducing sugars content in both seasons of study previously, genotypes 1,4&5 in the first season and genotype 5 in the second season gave the highest values of non-reducing sugars. For the interaction, the data showed that genotypes 1,4&5 in stage 3 (full-yellow) in 2012 and genotypes 1,3&5 at

the same stage in 2013 gave the highest values of non-reducing sugar. The result of this study was partially in line with those of Laguado *et al.*[22] who reported that, the sucrose content increased with advancing maturity in guava.

Pectin (%): The data in Table 4b showed that, the pectin (%) significantly decreased with ripening stages from (2.861-1.317%) in 2012 and from (3.003-1.263%) in 2013. For the effect of genotypes, No. 4 &5 in 2012 and 3&4 in 2013 gave the lowest values of pectin (%). Concerning the effect of interaction between genotypes and ripening stage, the data showed that, the highest pectin (%) were in genotypes 1,2&3 in stage 1 (yellowish-green) in 2012 and genotypes 1&5 at the same stage in 2013. While the lowest values were in all genotypes in stage 3 (full-yellow) in both seasons of study. These results were in line with those of EL-Bulk *et al.*[13] and EL-Bulk *et al.*[20], who reported that, pectin content increased significantly in Shambati and Shendi fruits with fruit growth and development. On the other hand, Majumder and Mazumdar [28] found that, total pectin substances increased for 90 days and then declined.

CONCLUSION

Guava fruit showed a climacteric behavior and from the results discussed above, it could be concluded that, changes in ripening guava occur during maturity stage from stage 2 (greenish-yellow) to stage 3 (full-yellow). We can harvest guava fruit in stage 3 for local marketing with genotypes No. 5&2, while stage 2 is suitable for export or storage of the rest genotypes.

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