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Postharvest quality of tomato (*Solanum lycopersicum*) varieties grown under greenhouse and open field conditions

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An experiment was carried out to evaluate performances of four tomato varieties (Bishola, Eshet, Marglobe and Moneymaker) harvested at ripe stage from greenhouse and open field condition at Jimma for post-harvest quality characters (total soluble solid, weight loss, titratable acidity, sugar-acid ratio, and pH). Bishola and Eshet had better chemical quality characteristics maintained throughout the end of the storage period. Varieties grown under open field condition showed highest fruit weight loss. The total soluble solid (TSS) values the open field grown tomatoes had highest than greenhouse grown tomatoes throughout storage period. The heighest TSS was obtained at 14 days storage while the lowest was at harvest. Titratable acidity of tomatoes after harvest tended to decrease throughout the storage period. Bishola had highest titratable acidity when compared with Eshet. There was increase in sugar/acid ratio throughout storage time for greenhouse growing condition, under open field condition there is a slight increment and rapid after harvest and then decrease at 14 days the storage period. This indicates that Greenhouse grown tomatoes have good flavor than open field grown. Tomato varieties grown under greenhouse condition were less weight loss, and higher sugar acid ratio and less prone to physical injuries than fruits of grown under open field condition. Variety Eshet and Bishola could be selected in maintaining better overall quality characteristics.

Key words: Tomato, variety, storage period, greenhouse.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most widely eaten vegetable crop in the world. Its popularity stems from the fact that it can be eaten fresh or in a multiple of processed forms. Growing crops in a greenhouse has many advantages. Huge quantities can be produced on a small piece of land. Plants can be

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harvested continuously because the irrigation and temperature can be controlled and enables farmers to supply off season markets when fresh food prices are at a premium. Greenhouse produced tomatoes have a longer shelf life (Muluken, 2011). Greenhouse tomato production is important to reduce production cost by involving less labor and application of minimum herbicides and insecticides (Muluken, 2011).

Among vegetables grown in Ethiopia Tomato is the most important and widely cultivated vegetable. Different tomato types (Fresh, processing and cherry) are produced. Cultivation of tomatoes improves diet of the people, as they are a part of every salad in combination with leaf vegetables, green onions, cucumbers, peppers, and other vegetables (AVRDC, 2005). As a processing crop, it ranks first among all vegetables grown throughout the world (Nileema and Sreenivasa, 2011).

According to Preedy and Watson (2008) and Wener (2000), high concentration of carotenoids is obtained from processed tomatoes. Tomatoes are important sources of lycopene, which is known to alleviate cancer, heart diseases and premature aging.

The function of antioxidant in tomatoes varies depending on the genotypic variability, ripening stage and growing conditions (Leonardi et al., 2000). Dry matter content of a tomato such as vitamin C, lycopene and potassium are also affected by genotype and growing environment. Orange-colored tomato cultivars have high contents of carotenoids and volatile compounds, while yellow fruit cultivars have a lycopene content 10-fold lower than red coloured fruit cultivars (Hart and Scott, 1995).

The quality of the produce begins with the growing conditions and the area where it's produced. Other subsequent factors that determine the quality of fruits and vegetables include the harvesting methods, biological maturity postharvest environment, handling and storage conditions (Kader, 2008).

The ripening processes and storage temperature have a direct effect on chemical and nutritional composition of tomatoes (Sahlin et al., 2004). Taste attributes such as sweetness, acidity and fruity-floral flavour increase with tomato maturity. On the other hand, fruit firmness can decrease during the postharvest handling. High storage temperatures induce softening and lead to reduced perishability of tomatoes (Rutkowski et al., 2008).

Postharvest qualities that developed during growing cannot be improved; it is maintained by applying different postharvest handling procedures, by growing varieties with better storage quality and by harvesting at proper stage (Vijay et al., 2010).

In addition to genotypic influence, dry matter content (acidity, vitamin C and lycopene) of tomatoes is also influenced by environmental factors such as temperature light intensity and humidity. For example, contents are strongly affected by light intensity and temperature (Venter, 1977). Thus this study was initiated to test the effect of variety and growing environment at different storage period, on the quality of tomato.

MATERIALS AND METHODS

Experimental design and treatments

The experiment consisted of four tomato varieties (Bishola, 'Eshete' 'Marglobe' and Money maker) grown at Jimma University College of Agriculture and Veterinary Medicine**)** at two growing conditions **(**greenhouse and open field) and three storage durations (0days (at harvest), 1(7days after harvest), and 2(14 days after harvest). The trial was set up in a randomized complete block design (RCBD) in 4 × 3 × 2 factorial arrangements with three replications. Each treatment combination was assigned randomly to experimental units within a block.

Sample fruits were harvested at ripe stage (full surface of skin have red color) from the central three rows (12 plants) per plot. Harvested fruits from greenhouse and open field growing environment was stored under ambient condition. There were 30 fruits per plot and fruits were packed in standard card board boxes for storage.

Experimental procedures

Uniform colored disease free and healthy fruits having similar size were harvested. Harvested, fruits were immediately transported to laboratory using standard plastic and hand washed with tap water to reduce microbial populations on the surface. Washed fruits was dried with soft cloth and then stored under ambient conditions. There were 30 fruits per replication for each variety, to evaluate the shelf life of fruits over the storage period. Ten sample fruits were randomly taken from each replication to collected data. The samples were taken to the Jimma University Post Harvest Laboratory at 7 days and 14 days of storage period.

Data collected

Data were collected from the middle three rows and twelve plants per plot for weight loss, total soluble solid (TSS), titratable acidity, pH and sugar acid ratio. From the following,

Weight loss (g): Fruits were weighed at harvest, 7 days and 14 days storage duration using sensitive balance. The $\text{Total weight loss of fruits} = \text{Initial weight} - \text{Final weight}$. **Titratable acidity (TA)**: determined by titration of homogenized powder sample with 0.01 N NaOH using fenolftaleine-indicator (expressed as % citric acid); **pH**: pH of juice squeezed from fruit was determined in 50 ml samples of pulp with a digital pH-meter; CP - 505 Clmeriron. **Total soluble solids (TSS)**: measured by refractometer (Bellingham + Stanley 45-02 BS eclipse) by placing one to two drops of clean juice on the prism. After sampling, the prism of the refractometer was washed with distilled water and dried before use. Fruits juice was extracted using a juice extractor and filtered using metallic sieve. **Sugar-Acid ratio**: a flavor indicator as described by Kader et al. (1978).

Statistical analysis

The collected data were first checked for meeting all the ANOVA assumptions and subjected to analysis of variance (ANOVA) by using SAS computer software version 9.2 (SAS Institute Inc., 2008). When ANOVA showed significant differences, mean separation

Table 1. Interaction effects of variety, growing condition and storage duration on weight loss of tomato.

Variety	Growing condition	Weight Loss	
		Storage duration(days)	
		7	14
Bishola	Open field	3.87^{jkl}	8.833^{fge}
Eshete	Open field	5.843^{hij}	12.84^{abc}
Marglobe	Open field	5.367^{ijk}	11.967^{bcd}
Money maker	Open field	8.570^{fgh}	15.013^{a}
Bishola	Greenhouse	2.837^{kl}	8.070^{fghi}
Eshet	Greenhouse	6.41^{ghij}	11.437^{cde}
Marglobe	Greenhouse	2.333^{l}	9.347^{def}
Money maker	Greenhouse	5.430^{ijk}	14.300^{ab}
LSD (0.05) = 2.80			
Significance level = ***			
CV (%) = 20.31			

Means followed by the same letter(s) within the same column are not significantly different at 5% level of significance.

was carried out using LSD (Least Significant Difference) test at 5% significance level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weight loss

Weight loss of tomato, was found to be highly significantly (P < 0.01) affected by varity, storage period, growing condition and the interaction of the three factors (Table1). As the storage period progress, there was a loss in weight of fruits. The present finding is in line with the findings of Lana et al. (2005) who reported that the firmness of tomatoes decreased during storage. The present study showed that varieties grown in greenhouse record less weight loss than the varieties grow under open field condition throughout the storage period. There is direct relationship between weight loss and water loss or shriveling. The weight of tomato fruits is different with cultivars (Kacem et al., 2013). Variety Eshet grown under open field recorded the highest weight loss throughout the storage period. Inside greenhouse the minimum weight loss was obtained from Marglobe throughout the storage period. Generally varieties grown under open field condition showed highest fruit weight loss.

There is highest weight loss in the fruits stored for fourteen day than fruits stored for seven days. Throughout storage period there was an increment in weight loss where this could be associated with physiological parameters that lead to higher respiration rate. The difference was also due to the reason that the fruits were stored for different storage duration (Hobson, 1981). Znidarcic and Pozrl (2006) reported similar result that tomato stored for longer period had greater weight loss.

Total soluble solids (TSS)

Variety, growing condition and storage duration showed highly significant difference (p<0.001) interaction effect on total soluble solid (Table 2). The TSS values the open field grown tomatoes had highest than greenhouse grown tomatoes throughout storage period. TSS value ranged from 5.53°Brix from Eshet which grown under open field to 4.13°Brix Momeymaker which grown under greenhouse at 14 days storage period. According to Tigist et al. (2011), TSS contents for different tomatoes varies between 4.23 °Brix and 5.22°Brix. At harvest, the TSS content of Marglobe and Eshet inside greenhouse and Eshet and moneymaker under openfield was the highest. At seven and fourteen day's storage period the highest TSS was obtained from Eshet and Marglobe in side greenhouse and Eshet which is on par with that of Bishola and moneymaker under open field condition. Wahundeniya et al. (2002) and Birhanu and Tilahun (2010), Tigist et al. (2011), reported that significant variation for total soluble solid due to varietal difference for TSS of the fruits. Storage period also have highly significant (P < 0.001) effect on mean total soluble solid of tomato.The heighest TSS (4.92°Brix) was obtained at 14 days storage while the lowest (4.08°Brix) was at harvest. The increase in TSS at 14 days storage was due to the direct relationship between total soluble solids increase and colour change with maturity (Salunkhe et al., 1974) which is in agreement with the present result. Increase in TSS of tomato fruits could be due to excessive moisture loss which increases concentration as well as the hydrolysis of carbohydrates to soluble

Table 2. Interaction effects of variety, growing condition and storage duration on total soluble solid of tomato.

Variety	Growing condition	Total soluble solid		
		Storage duration (days)		
		0	7	14
Bishola	Open field	4.3^{fgh}	4.63^{cdefg}	5.0^{abcde}
Eshete	Open field	4.53^{cdefg}	5.06^{abcd}	5.53^{a}
Marglobe	Open field	4.1^{ghi}	4.3^{fgh}	4.5^{defg}
Money maker	Open field	4.56^{cdefg}	4.86^{bcdef}	5.1^{abc}
Bishola	Greenhouse	3.63^{ij}	3.86^{hi}	4.46^{efg}
Eshet	Greenhouse	4.2^{gh}	5.0^{abcde}	5.43^{ab}
Marglobe	Greenhouse	4.2^{gh}	4.86^{bcdef}	5.23^{ab}
Money maker	Greenhouse	3.0^{j}	3.86^{hi}	4.13^{ghi}
LSD (0.05) = 0.593				
Significance level = ***				
CV (%) = 7.98				

Means followed by the same letter(s) within the same column are not significantly different at 5% level of significance.

Table 3. Interaction effects of variety, growing condition and storage duration on titratable acidity (% citric acid) of tomato.

Variety	Growing condition	Titratable acidity		
		Storage duration(days)		
		0	7	14
Bishola	Open field	0.78^{a}	0.74^{ab}	0.69^{bcd}
Eshete	Open field	0.75^{ab}	0.73^{abc}	0.66^{cd}
Marglobe	Open field	0.76^{ab}	0.72^{abc}	0.65^{d}
\Money maker	Open field	0.55^{efg}	0.52^{efgh}	0.44^{jk}
Bishola	Greenhouse	0.53^{efgh}	0.49^{ghij}	0.45^{ijk}
Eshet	Greenhouse	0.48^{hijk}	0.44^{ijk}	0.42^{k}
Marglobe	Greenhouse	0.56^{ef}	0.53^{efgh}	0.48^{hijk}
Money maker	Greenhouse	0.58^{e}	0.55^{efg}	0.51^{fghi}
LSD (0.05) = 0.066				
Significance level = ***				
CV (%) = 6.92				

Means followed by the same letter(s) within the same column are not significantly different at 5% level of significance.

sugars (Nath et al., 2011).

Titratable acidity

Titratable acidity was found to be highly significantly ($P < 0.01$) affected by varity, storage period, growing condition and the interaction of the three factors (Table 3). Titratable acidity of tomatoes after harvest has a trend to decrease throughout the storage period. The higher loss of titratable acidity during the storage time could be related to higher respiration rate as ripening advances where organic acids are used as substrate in respiration process. Under open field condition, varieties recorded higher titratbile acidity than greenhouse grown tomatoes during 14 days storage period; Bishola had 0.69% titratable acidity than Eshet that had the lowest value 0.42%.

Varieties with higher titratable acidity could have lower incidence of fungal infection and suitable processing (Tigist et al*.,* 2011).The environmental effect on fruit acidity is complex. Organic acids can be produced in the fruit itself from stored carbohydrates (Sakiyama and Stevens, 1976), while some of these acids may be translocated from the leaves and roots to the fruits (Bertin et al*.*, 2000).

Table 4. Interaction effects of variety, growing condition and storage duration on sugar acid ratio of tomato.

Variety	Growing condition	Sugar Acid Ratio		
		Storage duration(days)		
		0	7	14
Bishola	Open field	5.49^{k}	6.28^{ijk}	1.25^{l}
Eshete	Open field	5.99^{jk}	6.95^{hij}	1.24^{l}
Marglobe	Open field	5.4^{k}	5.92^{jk}	1.07^{l}
Money maker	Open field	8.26^{defg}	9.44^{cd}	1.23^{l}
Bishola	Greenhouse	6.84^{hij}	7.78^{fgh}	10.03^{bc}
Eshet	Greenhouse	8.91^{cdef}	11.28^{b}	12.83^{a}
Marglobe	Greenhouse	7.47^{ghi}	9.18^{cde}	10.90^{b}
Money maker	Greenhouse	5.29^{k}	7.03^{ghij}	8.10^{efgh}
LSD (0.05) = 1.29				
Significance level = ***				
CV (%) = 11.52				

Means followed by the same letter(s) within the same column are not significantly different at 5% level of significance.

Sugar-Acid ratio

Sugar acid ratio was found to be highly significantly (P < 0.01) affected by varity, storage period, growing condition and the interaction of the three factors (Table 4). There was increment in sugar/acid ratio throughout storage time for greenhouse growing condition and under open field condition slightly increased soon after harvest and then start to decrease at 14 days the storage period**.** This could have a better implication that Greenhouse grown tomatoes have better flavored than open field grown tomato varieties. This is due to the fact that tomato flavor characteristics are influenced by the balance of sugar and acid. The result showed that the higher sugar/acid ratio of greenhouse tomatoes compared with open field grown tomatoes was adequate evidence to confirm the superior flavor. Stevens (1972) reported that sugar/acid content is in large part a function of genotypic difference, which related with difference in metabolic propensity for the accumulation of volatile and nonvolatile (sugar, TA and soluble solids) responsible for determining flavor of the fruits (Pairin and Edgar, 2008).

pH

Variety and storage duration highly significantly (P<0.001) influenced the pH (Table 5). Eshet and Marglobe recorded the highest pH and money maker and Bishola recorded the lowest pH level. The highest pH is obtained from 14 days storage period and the lowest pH is from 0 days storage or at harvest. The result is in agreement with Tigist et al. (2011) who reported a significant effect of storage period on pH and pH increase with storage period. Similar results were also reported by Tigist et al. (2011) reported that, amount of organic acid usually decreases during maturity, because they are substrate of respiration. The pH of a produce depends the genotype and type for cultivation (Simmonds, 1969). One of the important factors that have an effect on the actual pH values of tomato are variety and stage of maturity.

Conclusion

Significant differences in quality properties among the tomato varieties, growing condition and storage period were observed. Throughout storage period, tomato fruits showed increase in weight loss. Variety Eshet grown under open field recorded the highest weight loss throughout the storage period. Inside greenhouse the minimum weight loss was obtained from Marglobe throughout the storage period. Generally varieties grown under open field condition showed highest fruit weight loss. The TSS values the open field grown tomatoes had highest than greenhouse grown tomatoes throughout storage period. The heighest TSS was obtained at 14 days storage while the lowest was at harvest. Titratable acidity of tomatoes after harvest start to decrease throughout the storage period Bishola had highest titratable acidity when compared with Eshet. There is increment in sugar/acid ratio throughout storage time for greenhouse growing condition and under open field condition and also showed slight increment after harvest and then start to decrease at 14 days the storage period**.** This could have a better implication that Greenhouse grown tomatoes contains better flavor than open field grown tomato varieties. Tomato varieties grown under greenhouse condition were less weight loss, and higher

Table 5. Effects of variety, growing condition and storage duration on pH of tomato.

Varieties	pH
Bishola	4.04[b]
Eshet	4.23[a]
Marglobe	4.15[a]
Moneymaker	3.96[b]
	***
Storage period	
0	3.87[c]
7	4.08[b]
14	4.33[a]
	***
Growing Condition	
Openfield	4.09
Greenhouse	4.10
	Ns
LSD (5%)	0.1
CV%	3.68

Means followed by the same letter within the same column are not significantly different at 5% level of significance.

sugar acid ratio and minimum damage to physical injuries compared with fruits of grown under open field condition. Variety Eshet and Bishola could be selected in maintaining better overall quality characteristics.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

AVRDC (2005). Training report of the fifth regional training program in vegetable production and research. Bangkok, Thailand. pp.118-126.

Bertin N, Guichard S, Leonardi C, Longenesse JJ, Langlois D, Navez B (2000). Seasonal evolution of the quality of fresh greenhouse tomatoes under Mediterranean con ditions, affected by air vapour pressure deficit and plant fruit load. Ann. Bot. 85:741–750.

Birhanu K, Tilahun K (2010). Fruit yield and quality of drip-irrigated tomato under deficit irrigation. Afr. J. Food Agric. Nutr. Dev. 10(2):1684-1715.

Gomez KA, Gomez AA (1984). Statistical procedures for agricultural research. National rice research institute, John Wiley and Sons, New York. pp. 188-210.

Hart DJ, Scott KJ (1995). Development and evaluation of an HPLC method for the analysis of carotenoids in foods, and the measurement of the carotenoid content of vegetables and fruits commonly consumed in the UK. Food Chem. 54:101-111.

Hobson GE (1981). The short-term storage of tomato fruit. J. Hortic. Sci. 56:363-368.

Kacem CN, Dehimat L, Meraihi Z, Destain J, Kahlat K, Thonart P(2013). Sensitivity of three tomato (Lycopersicon esculentum) cultivars – Akoma, Pectomech and power- to chilling injury. Agric. Biol. J. North Am. 2(5):799-805.

Kader AA, Morris LL, Chen P (1978). Evaluation of two objective methods and a subjective rating scale for measuring tomato firmness. J. Am. Soc. Hortic. Sci. 103(1):70-73.

Kader AA (2008). Perspective Flavor quality of fruits and vegetables. J. Sci. Food Agric. J. Sci. Food Agric. 88:1863-1868.

Lana MM, Tijskens LMM, Van Kooten O (2005). Effects of storage temperature and fruit ripening on firmness of fresh cut tomatoes. The Netherands. Posth Biol Technol 35:87-95.

Leonardi C, Ambrosino P, Esposito F, Fogliano V (2000). Antioxidant activity and carotenoid and tomatine contents in different typologies of fresh consumption tomatoes. J. Agric. Food Chem. 48:4723-4727.

Muluken Y (2011). Tomatoes in two thirds the time with new greenhouse. www.skyscrapercity.com/

Nath A, Bidyut CD, Akath S, Patel RK, Paul D, Misra LK, OjhaH (2011). Extension of shelf life of pear fruits using different packaging materials. J Food Sci Technol. 49(5):556-563.

Nileema SG, Sreenivasa MN (2011). Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersiconesculentum* Mill.) in the sterilized soil. Karnataka J. Agric. Sci. 24(2):153-157.

Pairin H, Edgar C (2008). A Lexicon for texture and flavor characteristics of fresh and processed tomatoes. J. Sens. Stud. 23(5):583-599.

Preedy VR, Watson R (2008). Tomatoes and tomato products nutritional, medicinal and therapeutic properties. Science Publishers, Enfield, NH, USA.

Rutkowski KP, Michalczuk B, Konopascki P (2008). Nondestructive determination of
'Golden Delicious' apple quality and harvest maturity. J. Fruit Ornam. Plant Res. 16:39-52.

Sakiyama R, Stevens MA (1976). Organic acid accumulation in attached and detached tomato fruits. J. Am. Soc. Hortic. Sci. 101:394-396.

Salunkhe DK, Jadhav SJ, Yu MH (1974). Quality and nutritional composition of tomato fruit as influenced by certain biochemical and physiological changes. Plant Foods Hum. Nutr. 24(1):85-113.

Sahlin E, Savage GP, Lister CE (2004). Investigation of the antioxidant properties of
tomatoes after ripening. J. Food Compos. Anal. 17(5):635-647.

SAS Institute Inc. (2008). SAS/STAT®9.2 User's Guide. Cary, NC: SAS Institute. Inc Cary, USA.

Simmonds NW (1969). *Bananas*.2nd Edition. London: Longman Publ.

Stevens MA (1972). Citrate and malate concentrations in tomato fruits: genetic control and maturational effects. J. Am. Soc. Hortic. Sci. 97:655-658.

Tigist M, Tilahun S, Kebede W (2011). Effects of variety on the quality of tomato stored under ambient conditions. J. Food Sci. Technol. Pp. 1-10.

Venter F (1977). Solar radiation and vitamin C content of tomato fruits. Acta Hortic. 58:121-127

Vijay P, Rakesh P, Girish CS (2010). Ripening of tomato (Solanum lycopersicum L.). Part II: Regulation by its stem scar region. J. Food Sci. Technol. 47(5):527-533.

Wahundeniya WM, Ramanan R, Wickramatunga C, Weerakkodi WA (2002). Comparison of growth and yield performance of tomato varieties under controlled environment conditions. Gannoruwa, Peradeniya.

Wener ZH (2000). Importance of the tomato. Agri-support online agricultural articles. Available at: http://www.agrisupportonline.com/Articles/importance_of_the_tomato.htm

Znidarcic D, Pozrl T (2006). Comparative study of quality changes in tomato. Acta Agric. Slov. 87(2):242-243.