

Effect of ripening media and season on postharvest quality of three tomato varieties

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Abstract

Studies were carried out during the early and late seasons of 2001/2002 to determine the postharvest qualities of three tomato varieties (Roma VF, Ibadan Local and NHL 158-13) that were ripened on the parent plant, transparent polythene, black polythene and laboratory tabletop. Results showed that the height at which 50% of the fruits cracked (cracking height 50% -CH₅₀) for Ibadan Local was between 100 cm and 125 cm while Roma VF and NHL 158-13 had CH₅₀ of 150 cm and 220 cm, respectively. The ripening media had no effect whatsoever on the cracking tendency of the three tomato varieties. For the three varieties of tomato, the lycopene contents were significantly higher ($P<0.05$) during the late season than the early season. During the late season, the crude fibre and ascorbic acid were significantly higher ($P<0.05$) than early season. The moisture content, crude fibre, lycopene and crude protein contents of fruits that ripened on the parent plant were significantly higher ($P<0.05$) than those ripened in other media. The ether extract content was neither affected by the variety nor season nor ripening method.

Key words: Tomato fruits, ripening media, season, quality, postharvest

Introduction

Tomatoes contain a significant amount of water and other liquid-soluble materials surrounded by semi-solid cell wall and pectic middle lamella materials, implying that they exhibit combined properties of ideal liquids, which demonstrate only viscosity (flow), and ideal solids, which exhibit only elasticity (deformation), hence they are described as *viscoelastic* (Barrett *et al.*, 1998). Thus loss of firmness during ripening has been attributed to changes taking place in the various constituents of the parenchymatous cell wall (Davies and Hobson, 1981). Eniayeju (1987) reported that ripe tomato fruits could not be held for more than 11 days in cane baskets with or without lining. Fresh tomato fruits sold in the USA are harvested at mature-green or breaker stage (first appearance of external pink colour) rather than the table ripe stage of ripeness. Such mature-green fruits can usually be kept for 12 days under ambient condition. The conversion of tomato fruit from the mature green to fully ripe state involves dramatic changes in colour, composition, aroma, flavour and texture (Grierson and Kader, 1990). Generally, ripening is considered simply as the result of a series of degradative processes, probably because some of the more obvious stages require the action of hydrolytic enzymes. However, it is now clear that ripening is dependent on a wide range of separate synthetic as well as degradative reactions (Grierson and Kader, 1990).

In tomato, quality is established by all the characteristics and attributes that are involved in satisfying the demands, needs and expectations of the person making the judgment. Generally, to a consumer, a good tomato is big, firm, non-cracking fruit, fully red with good shelf life and nutritive value. Many parts of Africa experience heavy losses of tomato fruits during the production season because of lack of proper handling and storage. This

study was therefore designed to investigate the qualities of tomato fruits that are ripened in different media with a view to determining that how long the fruits of these varieties can be held in a wholesome state after harvest and the quality thereof.

Materials and methods

The three tomato varieties *i.e.* Roma VF, Ibadan Local and NHL 158-13, were grown in three blocks, each 5 x 5 m during the early and late seasons of 2001/2002, at the Teaching and Research Farm (Longitude 03°50' E and Latitude 07°23' N, 224m above sea level), Obafemi Awolowo University, Ile-Ife, Nigeria. The spacings used were 50 x 50 cm, 50 x 70 cm and 50 x 70 cm for Roma VF, Ibadan Local and NHL 158-13, respectively.

At full flowering, eighty flowers that blossomed at the same time were tagged in each block. The resulting fruits were allowed to grow and reach "breaker stage" *i.e.* first appearance of external pink colour, by United States Department of Agriculture (1976) standard. At breaker stage, fruits were picked per variety. The fruits were stored twenty each in three different media *i.e.* black polythene, transparent polythene and laboratory tabletop. The remaining twenty fruits were left on the parent plant in the field. The three different media were left on tabletop under complete illumination. The fruits were examined for ripening on a daily basis. At full red colour development, the fruits were subjected to physical and chemical analyses.

Resistance to cracking in each variety was tested by dropping fruits on a concrete floor from ten different vertical heights measured along a wall *i.e.* 50, 75, 100, 125, 150, 175, 200, 225, 250 and 275 cm. For each variety, twenty fruits were selected on the basis of size uniformity and dropped from each height. The number of fruits that cracked at each height was recorded. The

height at which 50% of the fruits cracked for each variety was termed cracking height 50% (CH_{50}).

The tomato fruits were first homogenized in Wiley Micro-Hammer Stainless mill. The crude fibre was determined by digesting the 50 g homogenized pulp in 1.25% tetra-oxo-sulphate (IV) acid and 1.25% sodium hydroxide. The digest was put in crucible and transferred into a muffle furnace at 660 °C for three hours. The weight difference expressed as a percentage of the fresh weight constitutes the percent crude fibre. The crude protein content was determined by micro-Kjedhal method while the ether extract content was determined by Soxhlet extraction technique. The total soluble solids (TSS) was determined by using the hand refractometer and the ascorbic acid content was determined by indophenol dye method. The lycopene content was determined by grinding 20 ml of the homogenized pulp in 25 ml acetone and 20 ml hexane and the absorbance was read at 501 nm using a spectrophotometer (Model Spectronic-20, Japan). The absorbance of standard lycopene (Sigma, Germany) was used for the determination of the concentration of lycopene in the sample. All these methods are based on the Association of Official Agricultural Chemist (AOAC) (1980) methods and the several modifications that are available. Statistical analysis was carried out using the ANOVA according to Steel and Torrie (1980). Means were separated using the least significant difference (LSD) or Duncan's Multiple range test at $P=0.05$.

Results and discussion

Table 1 shows that Ibadan Local ripened significantly faster than Roma VF and NHLe 158-13 in all the media. All the varieties ripened earlier on the parent than in other media. Results showed that in black polythene, Roma VF and NHLe 158-13 could be held for eight and seven days, respectively if harvested at breaker stage; whereas on the parent plant in the field it took four days for full ripening after breaker stage. The season did not affect the time of ripening of the fruits.

Effect of variety on cracking of tomato fruits at different drop heights is presented in Table 2. Ibadan Local fruits dropped at 75 cm height recorded 10% fruit crack while Roma VF and NHLe 158-13 recorded no fruit crack. At 125 cm drop height when Ibadan Local and Roma VF recorded 65 and 35% fruit crack, respectively, no fruit crack was recorded for NHLe 158-13. Ibadan Local at 175, Roma VF at 225 and NHLe 158-13 at 275 cm drop height recorded 100% fruit crack. The CH_{50} for Ibadan Local was between 100 cm and 125 cm, while Roma VF and NHLe 158-13 had

Table 1. Days to full ripening after the breaker stage

Variety	Field ripened	Transparent polythene	Black polythene	Laboratory table-top	LSD ($P=0.05$)
Roma VF	4.0	6.0	8.0	6.0	1.5
Ibadan Local	2.0	3.0	4.0	3.0	1.2
NHLe 158-13	4.0	6.0	7.0	6.0	1.3
LSD(5%) ⁺⁺⁺	1.5	1.5	1.4	1.4	-

Table 2. Effect of different drop heights on cracking(%) in three varieties of tomato

Drop height(cm)	Ibadan Local	Roma VF	NHLe 158 - 13
50	0	0	0
75	10	0	0
100	40	10	0
125	65	35	0
150	85	50	10
175	100	70	30
200	100	85	50
225	100	100	65
250	100	100	85
275	100	100	100

*Fifty fruits tested for each variety.

CH_{50} at 150 and 220 cm, respectively.

Table 3 shows the effect of ripening media and seasons on the quality components of tomato fruits. The TSS content was neither affected by the ripening media nor by the season. The moisture content for each variety during early season was significantly higher than the late season under each ripening medium. The moisture contents of fruits under transparent polythene, black polythene and lab tabletop did not differ significantly but were significantly lower than those ripened on the field in both the seasons. For all the ripening media, the crude fibre content during late season was significantly higher than the early season. Ascorbic acid contents followed perfectly the same trend as the crude fibre content. Crude protein content was significantly higher during the early season than late season. Ether extract content of the fruits was neither affected by ripening media nor by the season. The lycopene content of fruits ripened in the field during the late season was significantly higher than during the early season.

The effect of ripening media and variety on postharvest qualities of tomato fruits are presented in Table 4. In each of the ripening medium, the total soluble solids of Roma was significantly higher

Table 3. Effect of ripening methods and season on quality components of tomato fruits across variety

Ripening method	Season	Quality components						
		Total soluble solid (%)	Moisture content (%)	Crude fibre (%)	Ascorbic acid ($\mu\text{g}/100\text{g}$)	Crude protein(%)	Ether extract(%)	Lycopene ($\mu\text{g}/100\text{g}$)
Field ripened	Early	3.51a	10.82a	0.68d	11.21c	0.64a	0.18a	20.6b
	Late	3.52a	10.31c	0.94b	14.21a	0.42b	0.18a	22.0a
Transparent polythene	Early	3.54a	10.43b	0.87c	12.10b	0.20c	0.18a	20.2b
	Late	3.51a	10.10d	1.20a	14.00a	0.43b	0.19a	22.8a
Black polythene	Early	3.51a	10.42b	0.81c	12.20b	0.41b	0.18a	20.1b
	Late	3.53a	10.12d	1.18a	14.20a	0.21c	0.18a	22.0a
Lab table top	Early	3.50a	10.44b	0.84c	12.02b	0.39b	0.19a	20.1b
	Late	3.52a	10.11d	1.14a	13.80a	0.22c	0.19a	22.4a

Means followed by different alphabet in each column are significantly different according to Duncan's Multiple Range Test.

Table 4. Effect of variety and ripening methods on quality components of tomato fruits

Ripening method	Variety	Quality components						
		Total soluble solids (%)	Moisture content (%)	Crude fibre (%)	Lycopene ($\mu\text{g}/100\text{g}$)	Crude protein (%)	Ascorbic acid ($\mu\text{g}/100\text{g}$)	Ether extract (%)
Field ripened	Ibadan Local	3.44b	11.31a	0.88a	28.09a	0.58a	11.42b	0.22a
	Roma VF	3.54a	11.24a	0.89a	23.0bc	0.59a	13.12a	0.21a
	NHLe 158-13	3.40b	11.30a	0.87a	23.0bc	0.56a	13.09a	0.22a
Transparent polythene	Ibadan Local	3.41b	10.04b	0.71b	24.0b	0.38b	11.38b	0.21a
	Roma VF	3.58a	10.01b	0.72b	20.1d	0.39b	13.14a	0.22a
	NHLe 158-13	3.40b	10.02b	0.70b	20.4d	0.37b	13.16a	0.21a
Black polythene	Ibadan Local	3.42b	10.03b	0.71b	22.1c	0.40b	11.40b	0.22a
	Roma	3.57a	10.01b	0.72b	20.0d	0.38b	13.13a	0.21a
	NHLe 158-13	3.41b	10.06b	0.70b	20.0d	0.38b	13.15a	0.22a
Lab table top	Ibadan Local	3.40b	10.04b	0.71b	24.7b	0.41b	11.36b	0.21a
	Roma	3.58a	10.03b	0.71b	20.0d	0.39b	13.14a	0.22a
	NHLe 158-13	3.40b	10.05b	0.72b	20.8d	0.38b	13.16a	0.21a

Means followed by different alphabets in each column are significantly different at $P=0.05$ based on Duncan's Multiple Range Test

than Ibadan Local and NHLe while that of Ibadan Local was significantly higher than NHLe. The ripening medium had no significant effect on the TSS content of the three tomato varieties. The moisture content, crude fibre and crude protein contents of fruits ripened on the field for each variety was significantly higher than fruits of the same varieties ripened in other media. In all the ripening media, the lycopene content of Ibadan Local was significantly higher than Roma and NHLe. The lycopene content of fruits ripened in the field was significantly higher than other ripening media for each variety. Ascorbic acid content of Ibadan Local was significantly lower than Roma and NHLe. The ripening media had no significant effect on the ascorbic acid contents of the three tomato varieties. The ripening media and variety have no effect on ether extract content of the tomato varieties evaluated.

The moisture content, crude fibre, lycopene and crude protein contents of fruits that ripened on the parent plant were significantly higher ($P < 0.05$) than those ripened in other media. The effect of stage of maturity at harvest has been investigated but reports are not consistent. Typical and advanced mature-green tomatoes will usually attain a much better flavour at the table-ripe stage than those picked at the immature or partially mature stages. The later according to Grierson and Kader (1990) are much more susceptible to physical injuries and water loss because of their thin exocarp. Kader (1986) reported that tomatoes picked at before table-ripe stage and ripened at 20°C were evaluated by panellists as being less sweet, more sour, less 'tomato-like' and having more 'off-flavour' than those picked at the table-ripe stage. Bisogni *et al.* (1976) however reported that ripening treatment had no significant effect on pH and titratable acid. Pantos and Markakis (1973) reported greater levels of ascorbic acid in field-ripened fruits while Hobson and Harman (1986) reported that the best flavour is induced when tomatoes are left to ripen on the plant, but this is often unacceptable commercially. Alternatively, the fruit should be harvested when partially-coloured, and then transported under modified-atmospheres to postpone over-ripening and deterioration. The contradictions in these results may be due to variation in the cultivars evaluated, cultural practices imposed on the plants, season, time of sampling and location of the studies. Also, if fruits are picked green, there may be difficulty in differentiating between mature and immature green fruits. These are possible reasons for the variations in the reported works.

For the three varieties of tomato studied, lycopene contents were significantly higher during early season than late season while crude fibre, ascorbic acid and crude protein were significantly higher during late season than early season. The late season in Nigeria is characterized by dryness, no rainfall and high sunlight radiation while early season is characterized by high rainfall and fairly high sunlight radiation. It has been reported that light intensity and quality are the most important environmental factors influencing quality changes in tomato (Kuo *et al.*, 1979). Both the size and total soluble solids content of tomato fruit are strongly influenced by the solar radiation received acting on the supply of leaf assimilates. It has been reported that illumination of detached mature green fruits produced significantly 'redder' colour and higher carotenoid level (Nettles *et al.*, 1965). There are, however, conflicting reports on the effect of illumination on reducing sugars. While Boe and Salunke (1967) and Fatunla and Ogunlua (1972) reported an increase in reducing sugars, Jen (1974) and Shewfelt (1970) found no significant increase that could be attributed to light effect. Also, while Boe and Salunke (1967) and Jen (1974) reported an increase in level of titratable acidity as a result of light treatment, Paynter and Jen (1976) and Shewfelt (1970) found no significant change.

The ripening media experiment showed that some of the most important changes in composition that take place when tomato ripens on the plant can also take place when the fruit is detached at mature breaker stage. It therefore follows that at least some aspect of ripening depend on the metabolism of components already existing in the fruit, and are not dependent on the import of materials from the plant. The result of this study however showed that the quality of fruit that ripened on the plant was better than that of fruits that were allowed to ripen in other media.

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