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Cultivar and Maturity Influence on Colour Development, Visual Quality and Composition of Tomato Fruits

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ABSTRACT. Three commonly grown tomato cultivars (Pearson, Ace and Strain B) were harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages and stored in humidified air at 20ºC. Their ability to attain table ripe (TR) stage, their visual quality and chemical composition were evaluated.

No significant difference was observed among cultivars with regard to colour development and visual quality, but highly significant differences occurred among maturity stages. The MG and B fruits attained the normal TR stage and visual quality with the MG stage having an extended storage period.

Compositional analyses showed cultivar Ace to have highly significant difference with regard to total soluble solids (TSS) and TSS/acid ratio whereas Strain B had the highest ascorbic acid content. Cultivars showed no significant difference in tritrable acidity (TA).

Fruits picked at B stage accumulated the highest TSS. The MG fruits had the highest whereas the IMG fruits had the least ascorbic acid and TA. The pH value showed no significant difference among cultivars, maturity stages or interactions.

Introduction

Tomato fruits (*Lycopersicon esculentum* Mill.) are harvested at stages of ripeness that depend on the time between harvest and consumption. The longer period of transportation, storage or marketing depend to great extent on the maturity stage of fruits. Since vine-ripened tomatoes cannot stand the handling necessary to move them from the field to the consumer, it is standard procedure to harvest mature-green (MG) or breaker (B) stage fruits and to ripen them in transit or at destination (Kader *et al.* 1977).

The stage of maturity at which fruits are harvested therefore, dictates storability, method of handling and distance of transportation. So, for economic reasons, tomatoes

are harvested at stage of maturity that allows for maximum shelf life even though it may be at the expense of nutritional value.

Tomato cultivars vary in their characteristics. Culture of the plant, time of harvest, postharvest treatments and genetic potential may influence the quality attributes (Taha *et al.,* 1984, Mohamed and Ali 1986, Tong and Gross 1989, and Baldwin *et al.,* 1991).

Compositional changes in tomato fruits during maturation and ripening have been reviewed by Hobson and Davies (1971) and Salunkhe *et al* (1974). Total solids and total sugars increased progressively during ripening from MG to red stages (Winsor *et al.* 1962a, 1962b).

Some reports have indicated that reduced ascorbic acid content increases with ripening (Bisogni and Brecht 1976, Brecht *et al.* 1976, Malewski and Markakis 1971). Kader *et al.* (1977) reported a great variation in asorbic acid magnitude among cultivars.

Fabio and Saltveit (1988) found that mature green tomato fruit slices ripened normally and changes of lycopene, soluble solid contents, titratable acidity and pH were analogous to changes in whole fruit harvested mature-green and ripened.

The objective of this study was to compare 3 tomato cultivars, commonly grown in Khartoum area, at 3 maturity stages to test their ripening ability as well as their visual and compositional value at the desirable table ripe (TR) stage.

Materials and Methods

Three commonly grown cultivars of tomato (*Lycopersicon esculentum* Mill.) in Khartoum area, Sudan were sown by direct seeding in the field at El-Fakki Hashim, Khartoum North under normal cultural practices. The cultivars were: Pearson, Ace and Strain B. At the third harvest time, when the bulk of the fruit is normally picked, three classes of maturity were chosen. These were a) Immature-green (IMG), before the jelly-like material in the locules was formed, b) Mature-green (MG), when fruits represented the full size characteristics of the cultivar and the gel-like substance inside the fruit filled the space around the seeds and c) Breaker (B), when the green fruits showed the first appearance of the pinkish or reddish colour at the blossom- end.

Fruits were taken to the laboratory and stored at 12.8ºC overnight and the experiment for postharvest evaluation was set up the following day. Eighty fruits free from any visual defects representing each stage of maturity were taken from each cultivar and stored at 20ºC. Fruits were evaluated every 2 to 3 days for colour development and quality.

Colour development was evaluated visually on a ripeness score of 0 to 5 (partially modified from Kader *et al.* 1977) where 0 indicates green (G), I breaker (B) – first appearance of external pink colour, 2 light pink (LP) – approximately equal amounts of green and pink or red colour, 3 dark pink (DP), 4 full red – desirable table ripe (TR), and 5 canning ripe (CR).

Quality and shelf life were evaluated visually on an headonic scale of 9 to 1 where 9 indicates excellent, field fresh, 7 = very good, 5 = good, 3 fair, limit of salability and 1 = very poor, not usable, end of shelf life.

For compositional analyses one kg of each sample was taken randomly from each sample and chemical analyses were done for the extracted fruit juice on the following basis:

a) Total Soluble Solids (TSS): The percentage TSS was determined by an ABBE – 3L refractometer.

b) Ascorbic Acid: Was determined by the method of Loeffler and Ponting (1942) as mg/100 ml juice.

c) Titratable Acidity (TA): Was determined by titration of the juice against 0.1N NaOH to pH 8.1 and expressed as percent citric acid .

d) The Value of pH: Was measured by a Fisher pH-meter.

e) The TSS/TA ratio was calculated: The data was analysed as for a split-plot design with cultivars as the main plot and maturity stages as subplots with 4 replications.

Results and Discussion

Colour Development

Development of typical colour is very important for marketing of tomato fruit. Colour development of 3 cultivars harvested at 3 maturity stages resulted in highly significant difference (P = 0.01) among the maturity stages but no difference among the cultivars (Table 1). The rate of colour development indicates that the immature-green (IMG) fruits of the 3 cultivars did not attain the typical table ripe (TR4) stage in 21 to 23 days (Fig. 1a). Instead, the IMG fruits resulted in a change of colour to pale red and softening due to loss of turgor and the fruits became mealy. Watada *et al.* (1979) suggested that tomatoes that take more than 15 days to ripen probably do not have the potential to develop satisfactory flavour and that efforts should be made in selecting MG fruits which will take less than 10 days to ripen. Lyons and Pratt (1964) attributed the onset of ripening process to the tremendous increase of endogenous ethylene in fruits that were 93% mature. The failure to ripen probably may be due to the lack of ethylene production.

TABLE 1. Influence of 3 tomato cultivars harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages, and stored at 20ºC, on colour development.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.257		± 0.088
Pearson	1.84	2.45	4.02	2.77
Ace	0.87	2.87	4.21	2.65
Strain B	1.54	2.48	3.98	2.67
Mean	1.42	2.60	4.07	
		± 0.148***		

**highly significant difference (P = 0.01).

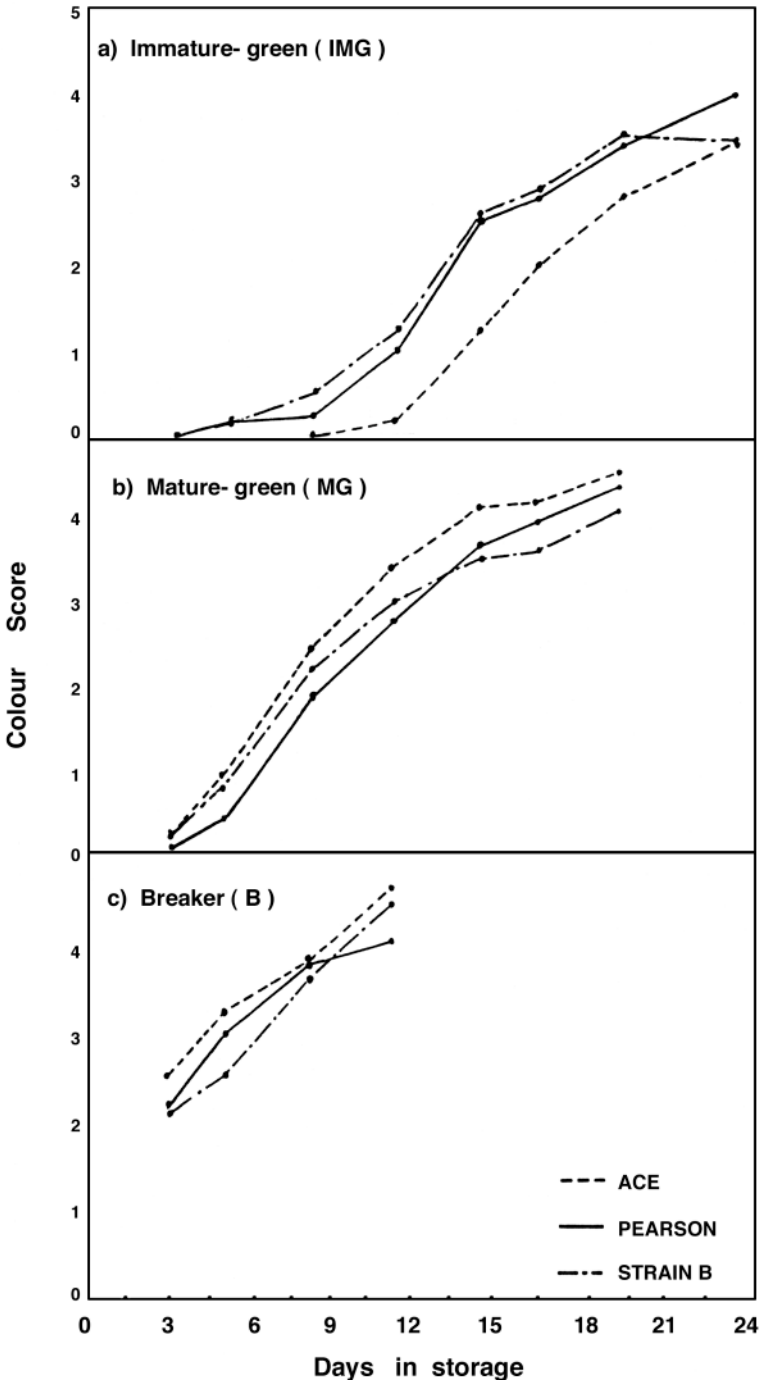

FIG. 1. Effect of cultivar and maturity on colour development.

The MG fruits attained the TR stage at 13, 16 and 19 days for Ace Pearson and Strain B respectively (Fig. 1b). For the breakers the ripening duration was 9 days for both Ace and Strain B and 10 days for Pearson (Fig. 1c). The importance of this period in transporting tomato from the areas of production to the areas of consumption could not be over emphasized. In addition to this, our previous study (Taha *et al.* 1984) showed that harvesting at MG stage resulted in higher yield compared to B and TR stages for cultivar Early Pak.

Visual Quality

The results on visual quality indicate highly significant difference (P = 0.01) among cultivars, maturity stages and their interactions (Table 2). The limit of usability (quality score 3) was reached within 11, 12 and 13 days for cultivars Ace, Strain B and Pearson – harvested at the B stage – respectively (Fig. 2). The MG stage of all cultivars attained QS3 within 20 to 21 days (Fig. 2b). This difference of 7 to 9 days of shelf life between the 2 stages of maturity, under the same conditions, should not be overlooked. The extended shelf life of the IMG fruits (Fig. 2a) is not of practical value since the fruits did not attain the desirable typical table ripe stage (TR 4).

TABLE 2. Influence of 3 tomato cultivars harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages, and stored at 20ºC, on visual quality.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.494**		± 0.079**
Pearson	6.45	5.90	3.40	5.25
Ace	5.90	5.58	2.94	4.80
Strain B	5.71	5.75	3.39	4.95
Mean	6.02	5.74	3.24	
		± 0.285**		

**highly significant difference (P = 0.01).

Compositional Analyses

Total Soluble Solids (TSS)

Compositional analysis showed highly significant difference among cultivars, stages of maturity and their interactions with regard to their percentage total soluble solids (TSS %) as shown in Table 3.

Cultivar Ace had the highest (4.17%) whereas Strain B had the lowest (3.37%) TSS. Fruits picked at the B stage accumulated the highest TSS (4.20%) and the highest interaction was exhibited by cultivar Ace and the B stage (5.13%) and the lowest by Strain B at the MG stage. These results are in general agreement with Kader *et al.* (1977) evaluation by panelists who showed that tomatoes picked at earlier stage of ripeness were less sweet than those picked at TR stage. Their objective tests showed that these fruits had less sugar. Bisogni and Brecht (1976) found that soluble solid content correlated with "sweetness" overall quality and flavour. Winsor *et al.* (1962a, 1962b) reported that total solids and total sugars increased progressively during ripening but they were only comparing the constituents of whole fruits and locules at different stages of ripeness.

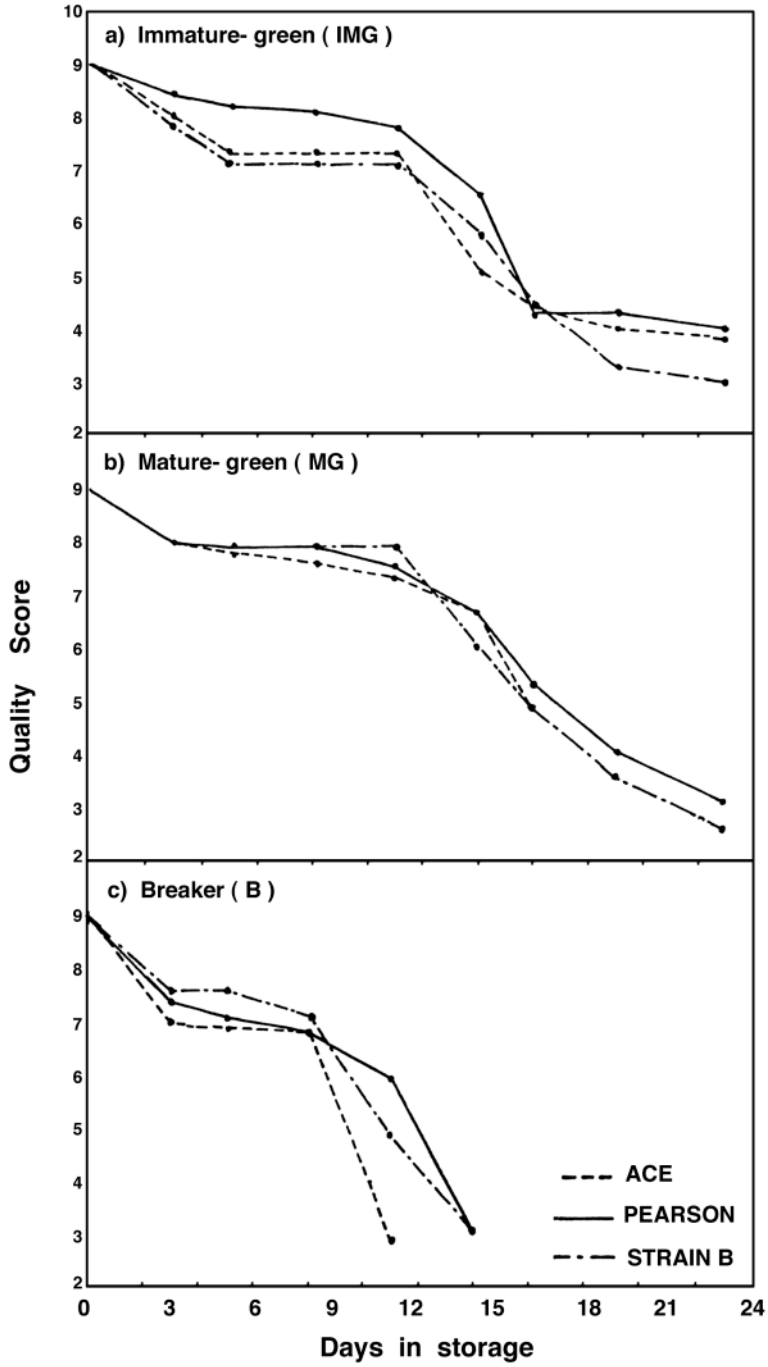

FIG. 2. Effect of cultivar and maturity on fruit quality.

TABLE 3. Percentage total soluble solids (TSS%), at table ripe (TR) stage, of 3 tomato cultivars harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages and stored at 20ºC.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.135**		± 0.031**
Pearson	3.93	3.48	4.10	3.83
Ace	3.65	3.73	5.13	4.17
Strain B	3.45	3.30	3.38	3.37
Mean	3.68	3.50	4.20	
		± 0.078**		

**highly significant difference (P = 0.01).

Ascorbic Acid Content

Ascorbic acid levels, at TR stage exhibited highly significant difference among the 3 cultivars, 3 maturity stages and their interactions (Table 4). Strain B had the highest ascorbic acid content (9.53 mg/100 ml juice) whereas cultivar Ace had the lowest (7.58 mg/100 ml). Fruits harvested at MG staged showed the highest content whereas those harvested at IMG had the lowest ascorbic acid level. The highest interaction (14.32 mg/100 ml juice) was observed with Strain B harvested at the MG stage.

TABLE 4. The ascorbic acid content (mg/100 ml juice), at table ripe (TR), of 3 tomato cultivars harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages and stored at 20ºC.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.83**		± 0.42**
Pearson	5.12	9.14	8.96	7.74
Ace	3.91	8.64	10.18	7.58
Strain B	6.33	14.32	7.94	9.73
Mean	5.21	10.75	9.02	
		± 0.48**		

**highly significant difference (P = 0.01).

The results in Table 4 also indicate that, in all cultivars, fruits harvested at the IMG stage had much lower ascorbic acid content at the TR stage compared to those harvested at MG or B stages. These results are supported by the findings of Bisogni and Brecht (1976), Brecht *et al.,* 1976, Betancourt *et al.,* 1977, who cleared that reduced ascorbic acid content increases with ripeness in tomato. However, other reports showed no change (Matthews *et al.,* 1974, Watada *et al.,* 1976) or a decrease (Pantos and Markakis 1973). The genetic constitution also seems to play a role in the ascorbic acid content. Gonzalez and Brecht (1978) reported that in normal tomato fruits the change in reduced ascorbic acid was related to ripening, but in *rin* fruits detached from the plant no change was observed from MG to yellow.

Titratable Acidity (TA)

No significant difference was observed among the 3 cultivars with regard to TA (Table 5). However, highly significant differences were observed among the 3 maturity stages.

TABLE 5. The titratable acidity (% citric acid), at table ripe (TR) stage, of 3 tomato cultivars harvested at immature-green (IMG), mature (MG) and breaker (B) stages and stored at 20ºC.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.012		± 0.005
Pearson	0.39	0.42	0.41	0.40
Ace	0.39	0.43	0.44	0.42
Strain B	0.38	0.43	0.43	0.41
Mean	0.38	0.43	0.42	
		± 0.007**		

**highly significant difference (P = 0.01).

Fruits harvested at MG stage showed the highest TA whereas those harvested at IMG stage had the least. Bisogni and Brecht (1976) found that TA correlated with acidity and Winsor *et al.* (1962a, 1962b) found that TA increased from green to green yellow stage, but no consistent changes were established after this stage. Other investigators have reported that acidity in tomatoes increased during development and reaches a maximum at the B stage, then decreases with further ripening (Davies 1966, Stevens 1972). This may explain the lower TA values (Table 5) for the IMG fruits compared to both MG and B stages.

The pH Value

The results in Table 6 show no significant difference among cultivars, maturity stages or their interactions. Bisogni and Brecht (1976) found that field ripened tomatoes had better flavour and over all quality than room – ripened tomatoes, although they found no significant differences in pH, TA or soluble solid content. Brecht *et al.* (1976) reported that TR tomatoes were lower in pH than MG fruits. Kader *et al.* (1977) found that pH correlated with "sourness". These results raise a question about the exact role of pH on tomato fruit quality.

The TSS/Acid Ratio

Table 7 shows significant difference (P = 0.05) among cultivars only in TSS/acid ratio, with Ace showing the highest ratio (10.38) and Strain B the least (8.23). The TSS/acid ratio plays a very important role in determining the flavour of tomato but the levels of sugars and acid may vary considerably among cultivars (Kader *et al.,* 1978, Stevens *et al.,* 1977). Volatiles also contribute largely to the fresh tomato flavour (Buttery *et al.,* 1971) and they show differences among cultivars (Baldwin *et al.,* 1991) So the genetic potential should always be bear in mind when considering quality characteristics.

TABLE 6. The pH, at table ripe (TR) stage, of 3 tomato cultivars harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages and stored at 20ºC.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.043		± 0.037
Pearson	4.36	4.27	4.33	4.32
Ace	4.33	4.33	4.35	4.35
Strain B	4.30	4.37	4.26	4.34
Mean	4.33	4.33	4.32	4.31
		± 0.025		

TABLE 7. The TSS/acid ratio, at table ripe (TR) stage, of 3 tomato cultivars harvested at immature-green (IMG), mature-green (MG) and breaker (B) stages and stored at 20ºC.

Cultivars	Maturity stage			Mean
	IMG	MG	B	
		± 0.78		± 0.41*
Pearson	10.23	10.75	10.18	10.38
Ace	9.53	8.80	11.83	10.05
Strain B	9.15	7.73	7.83	8.23
Mean	9.63	9.09	7.94	
		± 0.045		

*Significant difference (P = 0.05).

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تأثير الصنف وطور نمو الثمار في تكوين اللون والجودة المظهرية والتركيب الكيميائي لثمار الطماطم

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المستخلص . تمت دراسة تأثير ثلاثة من أصناف الطماطم المنزرعة هي : « بيرسون » و « آيس » و « إسترين بي » حصدت في ثلاثة أطوار نمو : الأول قبل اكتمال نمو الثمار ، الثاني عند اكتمال نمو الثمار الخضراء ، والثالث عند بداية ظهور اللون الأحمر في القمة الثمرية . وقد تمّ تخزين الثمار في غرفة مبردة عند درجة حرارة ٢٠م ، ومتابعة قابليتها لتكوين اللون وجودتها المظهرية حتى اكتمال النضج ، كما أجري تحليل الثمار كيميائيًا عند طور الاستهلاك الطازج .

لم تظهر الدراسة فروقًا معنوية للأصناف الثلاثة من حيث تكوين اللون والجودة المظهرية ، ولكن أطوار النمو أسفرت عن فروق معنوية عالية . فثمار الطورين الثاني والثالث بلغتا طور النضج الصالح للاستهلاك الطازج مع إتاحة فترة تسويقية أطول بلغت ٧ إلى ٩ أيام لثمار الطور الثاني ، في حين أن ثمار الطور الأول لم تبلغ الطور المرغوب للاستهلاك ، حيث كانت الثمار فجة شاحبة اللون .

أسفرت نتائج التحليل الكيميائي عن تفوق معنوي عالي للصنف « آيس » في محتوى المواد الصلبة الذائبة الكلية ، ونسبة المواد الصلبة الذائبة الكلية للحموضة . كذلك نتج من التحليل تفوق الصنف « إسترين بي » المعنوي في محتوى حمض الاسكوربيك . ولم تنتج أي فروق معنوية بين الأصناف في الحموضة المعايرة .

أظهرت دراسة أطوار النمو الثلاثة أن طور النمو الثالث أعطى أعلى قدر من المواد الصلبة الذائبة الكلية . أما ثمار الطور الثاني فقد أسفرت عن أعلى مستوى في حين أن ثمار الطور الثالث أسفرت عن أدنى محتوى من

حـمض الأسكوربيك ومن الحـمـوضـة المعـايرة . أمـا نتـائج الرقم الهـيدروجـيني فلم تظهـر أي فروق مـعنوية للأصناف الثـلاثة أو أطوار النضج أو تفاعلاتها البينية .