

A Comparison Between Postharvest Tomato Quality of Mature-green and Red-ripe Stages Produced in Hydroponic

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Abstract. Fruits of three tomato (*Lycopersicon esculentum*, Mill) hybrid cultivars; Tropic, Olympe and Dombito; were produced in a hydroponic culture and harvested at two maturity stages; mature-green and red-ripe; twice in the season.

Quality characters that were evaluated included total sugars (TS), reducing sugars (RS), total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, vitamin C (Vit.C), pH and electric conductivity (EC); to be compared between the two maturity stages. RS, EC and TSS/TA ratio were the only quality characters that showed significant differences between the two stages. Mature-green tomatoes were found to be less qualified for good flavor than those of red-ripe stage. Early season tomato fruits were lower in quality than late season fruits.

Introduction

Tomato quality means different things to different people. To consumer, the flavor gains the priority among other characters. Tomato flavor depends upon sweetness and sourness and each of them is correlated with the other [1]. Sweetness of tomato is mainly dependant upon the levels of total sugars (TS); reducing sugars (RS), like glucose; and nonreducing sugars, like sucrose. Sourness is mostly due to level of titratable acidity (TA), like citric acid. Sourness usually masks sweetness.

It was reported by many investigators [1-5] that tomatoes at mature-green stage taste more sour and less sweet [5] with lower vitamin C contents [1] than at red-ripe stage.

The objectives of this study were to compare mature-green tomatoes with those of red-ripe stage in the biochemical quality parameters TS, RS, TSS, TA, TSS/TA

ratio, Vit. C, pH and EC of the tomato juice, and to establish preferability between the two stages and seasonal harvestings.

Materials and Methods

Cultural practices

Three tomato hybrid cultivars; Tropic, Olympe and Dombito; were grown in a hydroponic culture at the Experimental Research Station in Dierab, College of Agriculture, King Saud University, Riyadh, Saudi Arabia, in a controlled environment greenhouse [27-34°C / day, 18-20°C / night and about 75% relative humidity]. Seeds were sown early in November 1988 and transplanted after about four weeks to the hydroponic culture. The solution used in irrigation contained all minor and major nutrients. Plants were trained to one main stem with 50 × 50 cm between plants [3,4]. The protection programs were followed as usual. Cultivars were randomized in the house with three replications.

Laboratory analysis

Tomato fruits were harvested at two ripening stages; i.e. mature-green and red-ripe and at two picking (harvesting) times; namely, early in the season and at the end of the same season (beginning of March and end of May 1989, respectively).

Fruits were brought to the laboratory for biochemical analyses to estimate TS, RS, TSS, TA, Vit. C, pH and EC of the juice.

Total soluble solids (TSS) were estimated by refractometer, vitamin C (Vit.C) and titratable acidity (TA) were measured by titration according to the A.O.A.C. [6]. Total sugars (RS) and reducing sugars (RS) were determined colorimetrically by reading at wave length of 540 nm in the method of Dubios *et al.* [7].

Statistical analysis were performed using SAS computer package [8] with L.S.D. for means comparison [9].

Results and Discussion

The analysis of variance and mean values for different sources of variation (stages, cultivars and harvesting times) were summarized in Tables 1 and 2 and in Figs. 1 and 2.

Table 1. Analysis of variance (ANOVA) of the effects of stages, seasons and cultivars and their interactions on different tomato characters, presented by their levels of significance

| S.O.V. | df | TS % | RS % | TSS % | TA % | TSS/TA Ratio | Vit.C mg/100 ml | pH | EC mmX 10 ⁻³ |
|----------------|----|---------|---------|----------|---------|-----------------|--------------------|----|----------------------------|
| Stages (ST) | 1 | NS | ** | NS | NS | * | NS | NS | * |
| Cultivars (CV) | 2 | NS | ** | NS | NS | NS | * | * | NS |
| Season (S) | 1 | ** | ** | ** | NS | ** | ** | NS | * |
| STX CV | 2 | NS | NS | NS | NS | NS | * | NS | NS |
| STXS | 1 | NS | NS | NS | NS | NS | NS | NS | NS |
| CVXS | 2 | NS | NS | NS | NS | NS | NS | NS | NS |
| STXCVXS | 2 | NS | NS | NS | NS | NS | NS | NS | NS |

* = Significant at 0.05

** = Significant at 0.01

NS = Not significant

TS = Total sugars

RS = Reducing sugars

TSS = Total soluble solids

TA = Titratable acidity

Vit.C = Vitamin C

EC = Electric conductivity

Table 2. Means of the three main factors, stages season and cultivars for different characters of tomato fruits

| Characters Main factor | TS % | RS % | TA % | EC mm X10 ⁻³ | TSS % | Vit.C mg/100ml | TSS/TA | pH |
|---------------------------|---------|---------|---------|----------------------------|----------|-------------------|--------|-------|
| Stages | | | | | | | | |
| Mature-green | 0.61a | 0.47b | 0.44a | 3.4a | 3.8a | 9.2a | 9.0b | 4.3a |
| Red-ripe | 0.68a | 0.53a | 0.41a | 3.0a | 4.0a | 9.2a | 10.0a | 4.3a |
| Season | | | | | | | | |
| Early | 0.56b | 0.47b | 0.41a | 3.3a | 3.4b | 8.0b | 7.8b | 4.3a |
| Late | 0.73a | 0.53a | 0.44a | 3.0b | 4.5a | 10.3a | 11.2a | 4.3a |
| Cultivars | | | | | | | | |
| Olympe | 0.64a | 0.46b | 0.41a | 3.3a | 3.9a | 8.0b | 9.5a | 4.34a |
| Dombito | 0.64a | 0.49b | 0.41a | 3.2a | 3.8a | 10.0a | 9.5a | 4.28b |
| Tropic | 0.66a | 0.55a | 0.44a | 3.1a | 4.0a | 9.6a | 9.4a | 4.27b |

Means followed by the same letter(s) are not significantly different at 0.05 level, according to L.S.D. (0.05).

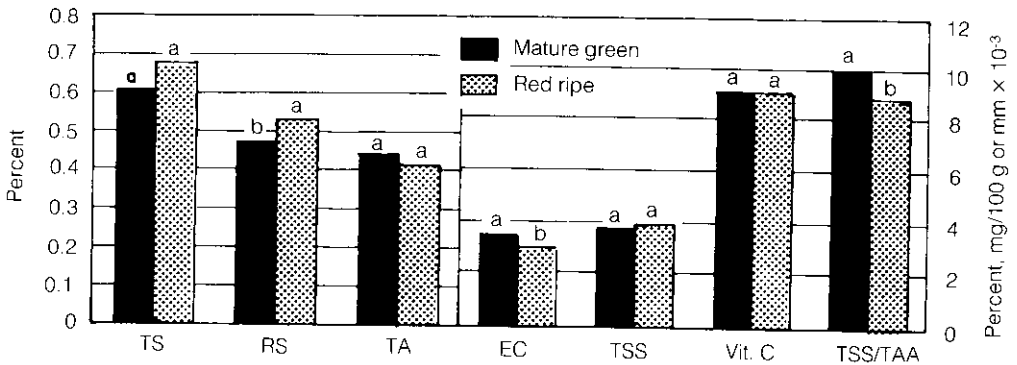


Fig. 1. Comparison between biochemical characters of mature-green and red-ripe tomatoes. Bars not labelled by the same letter differ significantly at 5% level. TS, RS, TA and TSS expressed in percent, Vit. C in mg/100 ml and EC in $\text{mm} \times 10^{-3}$

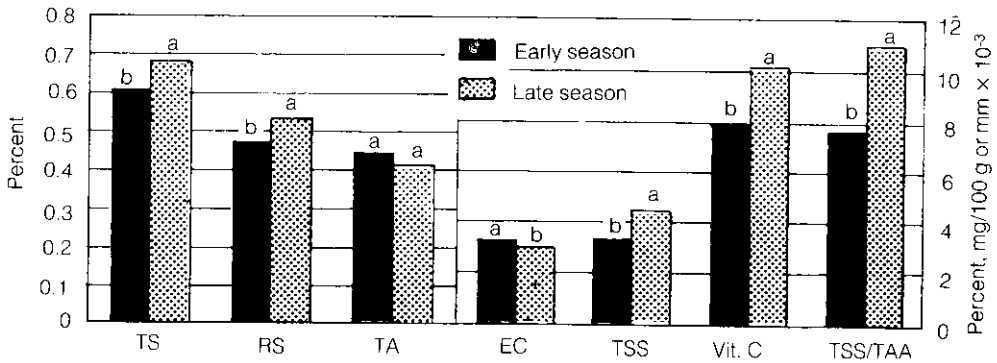


Fig. 2. Comparison between biochemical characters of early and late season tomatoes. Bars not labelled by the same letter differ significantly at 5% level. TS, RS, TA and TSS expressed in percent, Vit. C in mg/100 ml and EC in $\text{mm} \times 10^{-3}$

Ripening stages

Tomato fruits of the two stages; mature-green and red-ripe; were found highly significantly different in their contents of reducing sugars (RS) such as glucose and fructose, with red-ripe tomatoes being higher. The ratio of TSS/TA, an important factor for quality parameter [1], appeared to have a significantly higher value in red-ripe fruits (Table 2 and Fig. 1). These two characters (RS) and (TSS) are the main contributors to the (EC) of the juice, so the latter character, as well as (RS) showed significant differences between the two stages (Table 1). Since it is known that the sweetness and sourness of the tomato fruits are important criteria for flavor and that

the ratio of TSS to TA is, accordingly, an important quality factor, one can predict from the findings of this study that the matured-green tomatoes are of less quality than those of the red-ripe stage (Fig. 1). These findings seemed to be in a general agreement with those reported by some other investigators [1,2 and 5]. The other biochemical characters; TS, TA, vitamin C content and the pH of the juice showed insignificant differences for the two stages; though TS and TSS were higher in value in the red-ripe stage, TA was of a lower value. The latter comparisons mean that red-ripe tomatoes are sweeter than those of matured-green stage (Fig. 1).

Seasonal changes

It is generally known that fruits of many horticultural crops are much better in quality at the end of the season than at the beginning of the season. This statement seemed to agree with the data reported in Table 1 and Fig. 2. Early season and late season fruits differed significantly in all studied characters, with the exception of TA and pH. The late season tomatoes were found to be generally superior in quality over the early season harvest, since they appeared significantly higher in TS, RS, TSS, TS/TA ratio and Vit. C (Fig. 2).

It is worthwhile to notice that TA and pH of tomato juice did not change with ripening stages or seasonal harvesting seasons (Table 1 and Figs. 1,2), which agreed with results obtained from earlier work by the investigator [3].

It is apparent from the results of the present study that tomato fruits of the late season were significantly sweeter (high in TS, RS and TSS), nutritive (higher Vit. C) and superior in quality (high in TSS/TA ratio) than those of early season (Table 1 and Fig. 2).

Cultivars

The results, generally, indicated that the differences among the cultivars in RS, Vit. C and pH of the tomato juice appeared significant. On the contrary, the TS, TSS, TA, TSS/TA ratio and EC did not show significant differences among the three studied cultivars (Tables 1 and 2). From the data reported in Tables 1 and 2, the pH values reflected significant differences only among cultivars; but did not significantly vary due to stages or seasonal harvestings (Table 1). Such a result may suggest that the pH is cultivar characteristics; which means that some cultivars may possess high values and others not. In other words, the pH value of tomato fruits is more controlled with genetic factors and its response is stable over different environmental conditions and cultural practices [10].

The interactions among studied factors, of the two-way and three-way types showed insignificance for all investigated characters, with the exception of Vit. C (Table 1).

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مقارنة بين صفات الجودة بعد الحصاد للطماطم الخضراء والحمراء الناضجة المنتجة في الزراعة المائية (الهيدروبونيك)

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ملخص البحث . أنتجت ثلاثة أصناف من الطماطم وهي «تروبك» و«أولومبي» و«دمبيتو» في الزراعة المائية (هيدروبونيك)، وحصدت عند طورين من النضج وهما الثمار الخضراء والحمراء الناضجة وخلال مرحلتين في الموسم الزراعي وهما المرحلة المبكرة والمرحلة المتأخرة في الموسم . درست عدة صفات من مواصفات الجودة حيث قومت كل من السكريات الكلية والسكريات المختزلة والمواد الصلبة الذائبة الكلية والحموضة ونسبة المواد الصلبة الذائبة الكلية إلى الحموضة وفيتامين ج وقيمة PH والتوصيل الكهربائي لعصير الطماطم للمقارنة بين طوري النضج ومرحلتي الحصاد وكذلك بين الأصناف المدروسة .

ولقد أوضحت النتائج أن السكريات المختزلة والتوصيل الكهربائي ونسبة المواد الصلبة الذائبة الكلية إلى الحموضة من بين جميع الصفات المدروسة قد أوضحت فروقات معنوية بين مرحلتي نضج الثمار . وبصورة عامة كانت الطماطم الخضراء أقل نوعية في المذاق من الحمراء الناضجة، وكذلك فإن ثمار الطماطم المحصودة في نهاية الموسم الزراعي كانت أفضل نوعية من الثمار التي حصدت في بداية الموسم .

