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*Full Length Research Paper*

# Estimation of certain chemical constituents of fruits of selected tomato genotypes grown in Turkey

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**This research was carried out in years 2005 and 2006 in order to compare quality characteristics of some tomato genotypes grown in Turkey. In the study, 33 tomato (*Lycopersicon esculentum* Mill.) genotypes were used as plant material. Research was laid out in randomized block design with 3 replications, 10 plants in each replication. The fruit was analyzed for dry matter weight, sugar content, soluble solid content, titratable acids and pH contents. According to the results, 40443 and 62573 genotypes with their high values of dry matter content, sugar, soluble solid content and appropriate levels of titratable acids and pH contents should be considered potential candidates in future breeding, fresh and processing tomato programs.**

**Key words:** Tomato, genotype, quality.

## INTRODUCTION

Tomato is a widely distributed annual vegetable crop, which is consumed fresh, cooked or after processing. Tomato crop is adapted to a wide variety of climates ranging from the tropics to within a few degrees of the Arctic Circle. However, in spite of its broad adaptation, production is concentrated in few warm and rather dry areas. More than 30% of the world production comes from the Mediterranean (Cuartero and Fernandez-Munoz, 1999). Turkey, located in the East of the Mediterranean, is also one of the dominant producers of the crop, whose production in 2007 was 9.920 million tons (FAO, 2007).

There are three types of tomatoes: cultivars for fresh consumption, cultivars for industrial use and cherry tomatoes (Rodriguez, 2007) . According to Powell et al. (2003), the tomato is grown for fresh consumption or for processing. Several characteristics such as dry matter, soluble solid, sugar, acidity and pH are essential quality parameters for both fresh market and processed tomatoes. Other characteristics such as taste and shelf life are important only for the fresh market. Quality is a rather vague term that must be stated precisely depending on what the fruit would be used for and who will be the consumer (Cuartero and Fernandez-Munoz, 1999; He et al., 2005). Consumers often complain about the flavor of fresh market tomatoes (Bruhn et al., 1991). Tomato flavor involves perception of the tastes and aroma of many chemical constituents. The flavor of a tomato is deter-mined by the amount of sugar and acid present. Sugars, acids and their interactions are important to sweetness, sourness and overall flavor intensity in tomatoes (DeBruyn et al., 1971; Stevens et al., 1977). High sugars and relatively high acids are required for the best flavor. High acids and low sugars will produce a tart tomato while high sugars and low acids will result in a bland taste, insipid tomato (Kader, 1986). Soluble solid content and titratable acidity, the main components responsible for tomato flavor (Kader, 1986; Flores et al., 2008), are properties of the tomato most likely to match the consumer perception of the internal quality (Baldwin et al., 1998; Artes et al., 1999; Arazuri et al., 2007).

Tomato is a major vegetable crop for the tomato processing industry. High dry matter and soluble solids are desirable characteristic for the canned tomatoes industry since they improve the quality of the processed product (DePascale et al., 2001). Higher solid content in fruits is a target characteristic, as this would reduce the cost for processing. Tomato fruit is 94 - 95% water and 5

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**Table 1.** Tomato Genotypes and site of collection in Turkey.

| No | Genotypes | Site of collection |
|---|---|---|
| 1 | 40351 | Mardin, Derik |
| 2 | 40395 | Diyarbakır |
| 3 | 40443 | Siirt |
| 4 | 40507 | Van, Ercis |
| 5 | 43484 | Istanbul, Catalca |
| 6 | 46349 | Kayseri, Bünyan |
| 7 | 46511 | Tokat, Pazar |
| 8 | 47839 | Adıyaman, Kahta |
| 9 | 47865 | Sanlıurfa, Bozova |
| 10 | 49449 | Samsun, Tekkeköy |
| 11 | 49646 | Izmir, Kiraz Karabur |
| 12 | 52263 | Agrı, Eleskirt |
| 13 | 52361 | Kars, Kötek |
| 14 | 52428 | Erzurum, Tortum |
| 15 | 55711 | Trabzon, Araklı |
| 16 | 61658 | Aydın, Cine |
| 17 | 61675 | Mugla, Bodrum |
| 18 | 61796 | Denizli, Cameli |
| 19 | 62367 | Canakkale, Kepez |
| 20 | 62573 | Balıkesir, Dursunbey |
| 21 | 66330 | Afyon, Sandıklı |
| 22 | 68513 | Bartın, Ulus |
| 23 | 68519 | Burdur, Bucak |
| 24 | 69162 | Konya, Doganhisar |
| 25 | 69165 | Karaman |
| 26 | 69185 | Aksaray, Güzelyurt |
| 27 | 69785 | Corum, Ortaköy |
| 28 | 69796 | Ankara, Kızılcahamam |
| 29 | 69800 | Cankırı, Kızılırmak |
| 30 | 69805 | Kırsehir, Mucur |
| 31 | 69807 | Kırıkkale, Yahsihan |
| 32 | 70425 | Amasya, Göynücek |
| 33 | 70452 | Sinop, Gerze |

Collection of genotypes, Aegean Agriculture Research Institute /Izmir, Turkey.

- 6% organic compounds (solids) of which about 1% is skin and seeds. Dry matter content and the balance of the accumulation also determines percentage assimilates and water (Marschner, 1995). The percentage of solid in tomato varies over wide limits for a number of reasons, such as variety, character of soil and especially the amount of irrigation and rainfall during the growing and harvesting season (Jongen, 2002). According to Mizrahi et al. (1988), total soluble solids (TSS) content is the most important quality criterion for tomato paste processing and serves as the base for fixing the price to be paid to the producer. Thus, majority of the research in this area were centered on the soluble solids content or acidity (pH), which is also a key element in tomato selection. Values of pH are crucial for processing tomatoes since values higher than 4.4 mean susceptibility of the pulp to thermophilic pathogens (Paulson and Stevens, 1974). Thus, pH values as low as possible (up to the point that it does not adversely affect taste) should be breed into tomato cultivars for industrial use (Georgelis, 2002) . Chemical analysis reveals that sugar and organic acids make major contribution to the total dry solid (Davies and Hobson, 1981). It has been shown that sugar content is positively correlated with total soluble solids content in tomato fruit and in most cases this correlation is high (Jones and Scott, 1984; Kader et al., 1977; Malundo et al., 1995; Saliba-Colombani et al., 2001; Stevens et al., 1977). Hence, generally, soluble solids' content measurements may give a fair estimate of the sugar level in tomato fruit. The sugars are mostly glucose and fructose and constitute about 65% of total soluble solid in expressed fruit juice (Winsor et al., 1962). Whereas, the acids are mostly malic and citric acids, organic acids comprise about 15% of the dry content of fresh tomatoes. Citric acid is the most abundant organic acid with some malic acid also present (Gould, 1983). In the ripe red tomato, the malic to citric acid ratio is 0.5 or lower. At higher levels of citric acid, the sweetness effect of glucose were found to be more than that of fructose (Petro-Turza, 1987). Fresh fruit and vegetables are very important sources of vitamins that are essential for healthy human diet (Sablani et al., 2006). Vitamins only account for a small portion of the total dry matter. Minerals commonly found in tomato fruit are K, Ca, Mg and P and may reach to 8% of the dry matter (Davies and Hobson, 1981). Minerals have an effect on pH and titratable acidity and have buffering capacity as well; therefore, they influence the taste of tomatoes. Free amino acids form about 2 - 2.5% of the total dry matter of tomatoes (Petro-Turza, 1987).

In this research, quality components (dry matter, soluble solids content, total sugar, pH, titratable acidity) of certain tomato genotypes grown in different geogra-phical regions of Turkey has been studied, in order to identify genotypes with desirable fruit quality parameters.

## MATERIALS AND METHODS

As plant material, 33 tomatoes (*Lycopersicon esculentum* Mill.) genotypes collected from different parts of Turkey were used. The name of all these genotypes and site of origins collection are presented in Table 1 and Figure 1.

Field experiments were conducted for two consecutive summer seasons (2005 and 2006) to examine certain quality criteria of tomato genotypes at the Research and Training Centre of the Mustafakemalpasa Vocational School, Uludag University, Bursa, Turkey (40°01'N, 28° 22'E, 25 m above sea level). The soils of the trial field are clayey loam (23.6% sand, 43.6% silt and 32.8% clay content), having 0.15% total nitrogen content (Kjeldhal method), 0.79 kg $ha^{-1}$ phosphorus (Olsen method, $P_2O_5$), 6.10kg $ha^{-1}$ exchangeable potassium (ammonium acetate method, $K_2O$) and

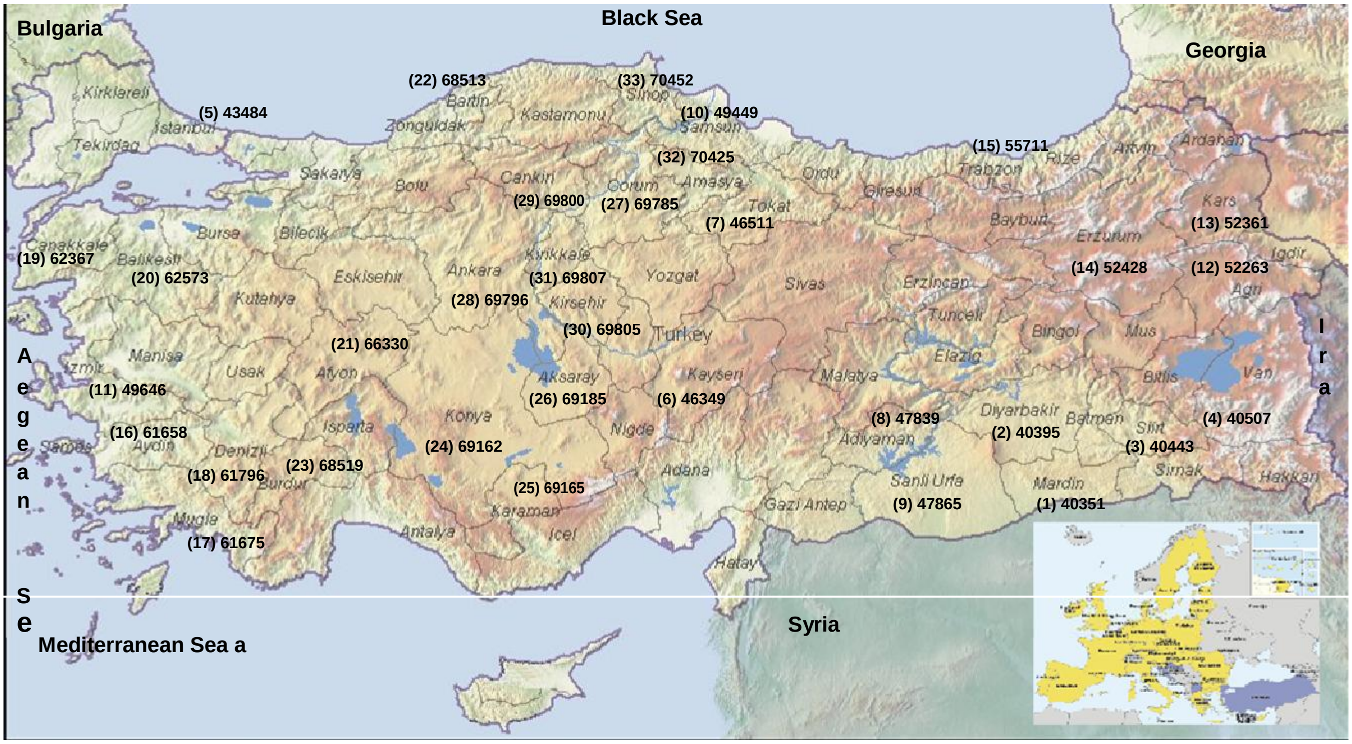


**Figure 1.** The name of all these genotypes and site of collection.

1.8% organic matter (Walchey-Black method), respectively. The soil pH was 7.8.

Local climate is temperate, summers are hot and dry and winters are mild and rainy. According to long- term meteorological data (1975 - 2006), average annual rainfall, temperature and relative humidity were 679 mm, 14.2°C and 70%, respectively. A sub-humid climate prevails in the region according to mean rainfall amount (from 600 to 700 mm of annual precipitation) (Jensen, 1980), but rainfall amounts are extremely low in the summer period. There was limited rainfall during the crop-growing season. Total rainfalls from May to August were 60.0, 77.4, and 95.1mm in 2005, 2006, and 1975 to 2006, respectively. This corresponds to 14% of the annual precipitation, which is insufficient for tomato production as expected. Mean air temperature during the growing period was 22 to 23.0°C. Climatologic data of the trial year was measured at the Mustafakemalpasa meteorological station nearby the experimental area.

The experiments were laid out separately with a completely randomized block design with three replications, each plot having 10 plants within a total area of 7.5 sq m. Fertilizer applications were based on soil analyses recommendations. Before planting, experimental plots received 124 kg ha$^{-1}$ N, 128 kg ha$^{-1}$ $P_2O_5$ and 145 kg ha$^{-1}$ $K_2O$.

The seeds were initially germinated in organic enriched peat with vermiculite cover to facilitate aeration, in open plastic trays. The average greenhouse temperature was 17°C at night and 26°C at day, whereas the relative humidity was maintained at 70%. Forty days old seedlings (3 - 4 true leaf) were transplanted on May 2nd with a spacing of 1.5 m and a spacing of 0.5 m between plants. Standard cultural practices were adopted during the crop-season.

Tomatoes were harvested within the period of late July to early August. The plants were harvested at bright red fruit maturity and daily harvests were made periodically. Five ripe fruits (judged by appearance) from all plants within each plot were selected for analysis. Juice of each fruit was extracted by dividing the fruit into halves and pressing them to pass through a 1 mm metallic sieve, facilitating removal of the fruit coat and the seeds. The fruit juice extracts were used for estimation of total soluble solids (%), pH value, total titratable acidity (%) and total sugar (%).

Measurements of pH level was conducted on freshly thawed frozen juice samples after shaking vigorously. Determination of soluble solid content (SSC, in °Brix) was done using a refractometer as per the procedure described by Tigchelaar (1986), reading for tomato juice, using Abbe-type refractometer (model 60/DR, UK) methods was used: 1 - 2 ml of the fruit juice was filtered using a syringe fitted with a 0.45 m pore diameter filter, two drops of the filtrate were then carefully applied on the refractometer and the reading was obtained directly as percentage (brix range 0 - 32%). Determination of soluble solids and pH levels was accomplished at 20°C (Agong et al., 1997). For estimating titratable acidity, 10 g of extracted juice was thoroughly mixed with 50 ml of de- ionized-distilled water. The mixture was then titrated by adding 0.1 N NaOH until a pH of 8.1 was attained. The volume of the sodium hydroxide, added to the solution, was multiplied by a correction factor of 0.064 to estimate titratable acidity as percentage of citric acid (Anonymous, 1968). For analysis of total sugars content (%); Luff - Schoorl method was used (Gormley and Maher, 1990). Methods, diluted to an appropriate concentration of sugar solution with the example Luff oxides of sugar to a boil and reduced by the unused item back titrate with the sodium sulfate tip is done in the way. Dry matter percentage after was determined at 105°C for 16 h in a ventilated oven (Basoglu and Uylaser, 2000).

### Statistical analysis

Data were analyzed using MSTAT- C (version 2.1, Michigan State University, 1991) and Minitab 14.0 software. Analysis of variance

**Table 2.** Tomato genotypes fruit dry matter weight (DM), total sugar content (TS), pH, soluble solids content (SSC) and titratable acidity (TA).

| Genotypes | Dry matter (%) | Total Sugar (%) | pH | Soluble solids content (%) | Titratable acidity (%) |
|---|---|---|---|---|---|
| 40351 | 5.72 c-ı | 2.39 c-ı | 4.76 ab | 5.20 a-c | 0.36 bc |
| 40395 | 4.97 ıj | 1.88 g-ı | 4.20 c-g | 4.75 c-g | 0.39 ab |
| 40443 | 6.93 a | 3.65 ab | 4.50 b-f | 5.35 ab | 0.24 jk |
| 40507 | 6.22 a-c | 2.62 c-h | 4.06 fg | 4.28 f-j | 0.30 fg |
| 43484 | 5.93 b-e | 2.73 c-g | 4.50 b-f | 4.02 ı-k | 0.30 fg |
| 46349 | 5.15 e-ı | 2.31 c-ı | 4.63 b-e | 3.85 ı-l | 0.35 cd |
| 46511 | 5.70 c-ı | 2.93 a-e | 4.65 b-d | 4.32 e-ı | 0.31 e-g |
| 47839 | 5.07 f-j | 1.83 hı | 3.78 g | 4.20 g-j | 0.29 f-h |
| 47865 | 6.59 ab | 3.12 a-d | 4.71 bc | 4.88 b-e | 0.24 jk |
| 49449 | 6.43 a-c | 3.08 a-d | 4.09 fg | 5.12 a-c | 0.22 k |
| 49646 | 5.69 c-ı | 3.18 a-c | 4.51 b-f | 4.70 c-g | 0.31 e-g |
| 52263 | 5.90 b-f | 2.31 c-ı | 4.25 b-g | 3.73 ı-l | 0.28 g-ı |
| 52361 | 4.98 h-j | 2.37 c-ı | 4.46 b-f | 3.88 ı-l | 0.32 d-f |
| 52428 | 6.30 a-c | 2.85 b-f | 4.51 b-f | 3.72 j-l | 0.30 fg |
| 55711 | 3.83 k | 1.73 ı | 4.10 e-g | 3.45 kl | 0.37 a-c |
| 61658 | 5.27 d-ı | 2.34 c-ı | 4.43 b-f | 4.68 c-g | 0.25 ı-k |
| 61675 | 5.89 b-g | 2.79 b-f | 4.14 d-g | 4.03 ı-k | 0.23 jk |
| 61796 | 5.82 b-h | 2.81b-f | 4.50 b-f | 5.17 a-c | 0.25 ı-k |
| 62367 | 6.07 b-d | 2.63 c-h | 4.37 b-f | 4.95 a-d | 0.31 e-g |
| 62573 | 7.00 a | 3.73 a | 4.67 b-d | 5.50 a | 0.30 fg |
| 66330 | 6.30 a-c | 1.68 ı | 4.42 b-f | 4.38 d-ı | 0.35 cd |
| 68513 | 5.11 e-j | 2.07 e-ı | 4.66 b-d | 4.25 f-j | 0.23 jk |
| 68519 | 6.48 a-c | 3.09 a-d | 4.32 b-f | 4.92 a-d | 0.22 k |
| 69162 | 5.83 b-g | 2.93 a-e | 4.30 b-g | 3.85 ı-l | 0.22 k |
| 69165 | 6.22 a-c | 1.99 f-ı | 4.34 b-f | 5.38 ab | 0.34 c-e |
| 69185 | 5.05 g-j | 2.82 b-f | 4.36 b-f | 3.98 ı-l | 0.29 f-h |
| 69785 | 5.29 d-ı | 2.11 e-ı | 4.72 a-c | 4.82 b-f | 0.35 cd |
| 69796 | 6.37 a-c | 1.67 ı | 5.25 a | 5.22 a-c | 0.29 f-h |
| 69800 | 5.83 b-g | 2.42 c-ı | 4.49 b-f | 4.65 c-h | 0.40 a |
| 69805 | 6.51 a-c | 2.23 d-ı | 4.21 c-g | 4.27 f-j | 0.36 bc |
| 69807 | 6.07 b-d | 1.82 hı | 4.32 b-f | 4.98 a-c | 0.32 d-f |
| 70425 | 6.60 ab | 3.05 a-d | 4.40 b-f | 3.40 l | 0.26 h-j |
| 70452 | 4.27 jk | 2.51 c-ı | 4.47 b-f | 4.08 h-j | 0.28 g-ı |
| LSD (%5) | 0.84 | 0.26 | 0.54 | 0.59 | 0.034 |

Values with the same letter are not significantly different.

(ANOVA) was conducted and significance of differences among treatment was tested using the least significant difference (LSD). Differences were declared significant at $P < 0.05$ probability levels by the F test. The F-protected LSD values calculated at 0.05 probability levels according to Steel and Torrie (1980).

## RESULTS AND DISCUSSION

Significant dissimilarities were observed within dry matter (DM) components among different genotypes grown in Turkey, as shown in Table 2. The dry matter content of tomato fruit ranged from 7.00 to 3.83%. The results are similar to those reported by Majkowska et al. (2008) and Kolota and Winiarska (2005). Genotypes 62573 and 40443 had the highest DM within the classification of average genotype measurements, by 7.00 and 6.93%, respectively, According to Cuartero and Fernandez-Munoz (1999), several characteristics such as dry matter are important quality parameters for both fresh market and processing tomatoes. The high DM is desired in processing paste products because they improve the quality of the processed product (DePascale et al., 2001). In addition to this, Salunke and Desai (1984) also reported DM of Fireball (fresh tomatoes) cultivars as

6.20%. Petro-Turza (1987) reported that average dry matter of the ripe fresh tomato fruit must be at least 5%. When these studies are considered, it is determined that 55711 (3.83%), 70452 (4.27%), 40395 (4.97%) and 52361 (4.98%) genotypes DM contents are below 5% and they are members of low DM- content genotype group. The remaining 29 genotypes have acceptable criterion for both industry and fresh tomatoes with their high DM (%) content.

The total sugar (TS) content and acidity are the most important characteristics of tomatoes taste (Rodica et al., 2008). High sugars are required for best flavor (Kader, 1986). In this study, the TS content of tomato fruit ranged from 1.67 to 3.73% (Table 2) . Our results also agree with Petro-Turza (1987) in whose study the total sugar content of ripe tomato was measured between 1.7 and 4.7%. In another study with different fresh tomato cultivar (Marglobe), findings showed that total sugar content varied between 3.44 and 0.54% of fresh weight (Melkamu et al., 2008). According to Jongen (2002), total sugar content of fresh tomato fruit is found to vary from 2.19 - 3.55%. In this study, TS content was found to be lower than 2.19% in 47839, 66330, 69796, 68513, 69785 40395, 69165, 69807, 55711 genotypes. The remaining 22 genotypes may be considered as fresh tomatoes with higher TS content. In these genotypes, highest sugar content (TS); on the other hand was found in 62573 and 40443 genotypes, as 3.73 and 3.65%, respectively. TS content of 40443 and 62573 genotypes coincides with the findings reported by Salunkhe and Desai (1984) for Fireball cultivars as 3.65%. According to Cemeroglu et al. (2003), TS content of industrial tomato fruit was found to vary from 2.30 - 2.85%. In accordance with this data, sugar contents of 52263 (2.31), 69185 (2.82), 61658 (2.34), 62367 (2.63), 69800 (2.42), 52428 (2.85), 43484 (2.73), 52361 (2.37), 46349 (2.31), 40351 (2.39), 61675 (2.79), 70452 (2.51), 40507 (2.62) genotypes was found between 2.30 and 2.85%. The mentioned 13 genotypes may be evaluated as industrial tomatoes when only the TS content is considered.

In the present study, pH of tomato fruits was in the range of 3.78 and 5.25 (Table 2). According to Giordano et al. (2000), pH below 4.5 is a desirable trait, because it halts proliferation of microorganisms in the final product during industrial processing. Many studies have centered on pH, which is also a key element in tomato selection (Hong and Tsou, 1998). According to Campos et al. (2006), appropriate pH value for industrial tomato varies from 4.3 to 4.4 and to Cemeroglu et al. (2003) from 4.18 to 4.34. In our analysis of measurements, it was determined that pH contents of 69796 (5.25), 69785 (4.72), 47865 (4.71), 62573 (4.67), 68513 (4.66), 46511 (4.65), 46349 (4.63), 52428 (4.51) genotypes are above 4.5% and thus not suitable for industrial tomatoes. Sen et al. (2004), reported that Uno and Rio Grande have a pH value of 4.39 and 4.48 in industrial tomatoes, and 4.32 in fresh tomato H-2274. In accordance with the above stated study results, 40395, 69805, 52263, 69162, 68519, 69807, 69165 genotypes with 4.20, 4.21, 4.25, 4.30, 4.32, 4.32, 4.34 pH values are suitable for both industrial and fresh tomatoes.

Campos et al. (2006) and Kader et al. (1987) have reported minimum value of soluble solid to be around 4.5%, which is considered low for industrial tomatoes. According to Cemeroglu et al. (2003) as SSC content in industrial tomatoes increases, it generally increases tomato paste efficiency and this value must be between 5 and 6.5% in industrial tomatoes. In this present study, the maximum value of soluble solid content (SSC) were found in 62573, 69165, 40443, 69796, 40351, 61796 and 49449 genotypes (5.50, 5.38, 5.35, 5.22, 5.20, 5.17 and 5.12 %) (Table 2). Maximum value of soluble solid content (SSC) found in 62573, 69165 and 40443 genotypes (5.50, 5.38 and 5.35%) (Table 2), which is similar to the results obtained by Giordano et al. (2000) who state that tomato cultivar IPA6 (industrial tomato) should present about 5.0 to 5.5 %. In another studies of Alcantar et al. (1999); De Pascale et al. (2001) and Cramer et al. (2001) commonly obtained SSC of tomato fruits (fresh) ranged from 4 to 6%. Similar SSC of 4.5 and 4.2% for Elvano F1 and Delfin F1 (green house tomato cultivars) by Sen et al. (2004), 4.58% for Uno (industrial tomato), 5.26% for Rio Grande (industrial tomato), and 5.40% for H-2274 (fresh tomato) (Kuzucu et al., 2004), have been reported. As it can also be seen from the studied results; aforementioned 7 genotypes are suitable for industrial tomatoes and fresh tomatoes cultivation with their high SSC contents.

Titratable acidity (TA) content of tomato fruit ranged from 0.22 to 0.40 % in the study (Table 2). George et al. (2004) reported that; titratable acidity in fruits of 12 different tomato genotypes varied from 0.25 to 0.70. Giordano et al. (2000) also suggests a TA value greater than 0.35 for processing tomato. In this study, TA values greater than 0.35 was obtained for 69800 (0.40), 40395 (0.39), 55711 (0.37), 40351 (0.36), 69805 (0.36), 66330 (0.35), 69785 (0.35), 46349 (0.35) genotypes. The highest TA on the other hand, attained for 69800 and 40395 as 0.40 and 0.39%, respectively (Table 2). Low TA, 0.22 were observed for some of the genotypes; such as, 68519, 69162, and 49449. Similar low values were reported by Salunkhe and Desai (1984) as 0.28 for Fireball and by Kuzucu et al. (2004) as 0.25 for Uno, 0.26 for Rio Grande and 0.29 for H -2274 cultivar. However, Sen et al. (2004) measured as 0.45 for Elnova F1, and 0.44 for Delfin F1 green house cultivars. According to Kamis et al. (2004), high sugar and acid content is a sign of good taste and flavor.

In the present study, 40443 and 62573 genotypes with their high values of dry matter content, sugar, soluble solid content and appropriate levels of titratable acids and pH contents should be considered potential candidates in near future breeding and fresh tomato programs. Values of dry matter content and soluble solid content, which are important quality criterion for industrial tomatoes, were found to be high in tomato genotypes, 40443 and 62573. On the other hand, these tomato genotypes' sugar content and pH values were found to be close to the desired values, but a little bit higher than they are and titratable acidity content was found to be low.

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