*Acta Alimentaria, Vol. 43 (3), pp. 426–436 (2014)*
*DOI: 10.1556/AAlim.43.2014.3.9*

# CHARACTERIZATION OF QUALITY INDICES ON STORAGE OF PUREE OF MUTANT (*DG* AND *OG*$^{C}$) AND NORMAL TOMATOES

MD. W. Siddiqui[a]*, I. Chakraborty[b], P. Hazra[c] and J.F. Ayala-Zavala[d]

[a] Department of Food Science and Technology, Bihar Agricultural University, Sabour, Bhagalpur, Bihar (813210) India
[b] Department of Post Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (741252). India
[c] Department of Vegetable Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (741252). India
[d] Centro de Investigación en Alimentación y Desarrollo, A.C. (CIAD, AC). Carretera a la Victoria Km 0.6, La Victoria. Hermosillo, Sonora (83000). Mexico

(Received: 7 February 2013; accepted: 28 March 2013)

The investigations carried out so far on high pigment tomatoes are confined to their nutritional aspects only. We present the comparative results of the first study on the kinetics of changes in chemical and sensory quality attributes in puree prepared from two colour mutants [dark green (*dg*) and old gold crimson (*og*$^{c}$)] and seven normal tomato genotypes during storage. Puree of mutant tomatoes BCT-115 and BCT-119, carrying *dg* and *og*$^{c}$ genes, showed the less significant changes in TSS (7.52 and 6.02 °Brix), acidity (3.16 and 3.05%), pH (4.04 and 4.03), total sugar (12.4 and 11.13%), ascorbic acid (20.74 and 19.69 mg/100 g), lycopene (7.78 and 542 mg/100 g), and β-carotene (3.08 and 2.26 mg/100 g) during two months storage at 25 °C. Nevertheless, puree prepared from Berika and BCT-115 (*dg*) had higher colour (7.63 and 7.13), taste (7.4 and 7.37) and flavour (7.3 and 7.37) sensory scores during two months of storage at 25°C. These results provide new data on the effect of genotypes on the stability of quality for storage of tomato puree and insist on the utilization of these genotypes for breeding new processing cultivars in the near future.

**Keywords:** tomato puree, high pigment tomato, dark green, old gold crimson, quality indices

Tomato and tomato products have a plethora of the most important phytonutrients and secondary metabolites responsible for defence against several diseases, including chronic cancers (Siddiqui et al., 2012). They constitute the predominant source of carotenoids and phenols in the human diet because of their year-round availability and cheap price. Several factors affect the processing quality of tomato products, such as fruit peel and pulp (Marković et al., 2006), maturity (Helyes & Lugasi, 2006), growing location and climate (Helyes et al., 2008), processing conditions. Moreover, the genotype or cultivar (cvs) is probably the most important factor affecting the quality of the products (Helyes et al., 2009; Siddiqui, 2013).

The desirable qualities for tomato cvs to be used for processing includes high TSS (4–8 °Brix), acidity between 0.3 to 0.4%, uniform red colour, smooth surface, free from wrinkles, small core, firm flesh and uniform ripening (Adsule et al., 1980). Sugars, acids, and their interactions are important for sweetness, sourness, and overall flavour intensity in tomatoes. Organic acids, which influence the shelf life and sensorial properties such as colour brightness and texture, contribute to the acid-base balance of the consumer (Safdar et al., 2010). Lycopene and β-carotene are carotenoids that have antioxidant properties and impart the red

* To whom correspondence should be addressed:
Phone: +91-(641) 2451255; +91-9835502897; e-mail: wasim_serene@yahoo.com

pigment in tomatoes (Akbudak et al., 2009). Therefore, good quality tomatoes should be processed for the best quality products. TSS, sugar, acidity, flavour, and texture are the main processing quality parameters of tomato (Barrett et al., 1998), and lately the content of bioactive compounds is getting importance among quality parameters (Siddiqui, 2013).

A large number of new tomato cvs with increased lycopene content (high-lycopene tomato cvs) have been developed in order to satisfy the demand of growers, processors, and consumers for a high health- promoting functional food (Siddiqui et al., 2013). It is commonly due to the presence of high-pigment (*hp*) mutations (*dg*, *og*$^c$, *hp*-1, *hp*-2, and, recently, *hp*-3) leading to an increase in carotenoids, particularly lycopene, and flavonoid contents (Galpaz et al., 2008; Ilahy et al., 2011). Recently, only a few research papers have focused on the agronomic characteristics and the lycopene content of some high pigment cvs (Ilahy et al., 2011). There are negligible research reports on quality characteristics of high pigment tomato products during processing and storage. Therefore, in this work we attempted to study the quality parameters (physicochemical, bioactive compounds and sensorial attributes) of puree from different colour mutants (*dg* and *og*$^c$) of tomato fruits after processing and during storage.

## 1. Materials and methods

### *1.1. Raw material*

Total of nine diverse tomato genotypes consisting one high lycopene normal genotype, two colour mutants and seven ordinary tomato genotypes were collected from the Central Research Farm, Gayeshpur, Nadia, West Bengal, India and taken to the Laboratory of Post Harvest Technology of Horticultural Crops, Directorate of Research, BCKV, Kalyani. The specific features of the genotypes are presented in Table 1. From all genotypes intense red tomatoes were harvested manually as raw materials for the preparation of tomato puree.

### *1.2.Preparation of puree*

Fresh tomatoes were sorted and washed properly. To obtain the puree, 5 kg of fresh fruit of all tomatoes was crushed and passed through a 0.058 cm sieve to get rid of the skin and seeds. Afterward the puree was concentrated at around 40 °C for 30 min to 14–16 °Brix under vacuum. Tomato puree was immediately filled hot into pre-sterilized bottles (200 ml), capped air tight, processed in boiling water for 10 min, and subsequently cooled. The bottles were kept/stored at room temperature (25–28 °C) for 2 months.

### *1.3. Chemical analysis*

*1.3.1. Determination of TSS, titratable acidity, ascorbic acid, and pH.* Total soluble solids were determined using a digital refractometer (ATAGO PR-1, Japan). Titratable acidity (percentage anhydrous citric acid) and ascorbic acid (mg/100 g wet weight) of the puree were determined according to A.O.A.C. (2000) official methods. The pH of the sample was recorded with the help of a digital pH meter (Model: Systronics l pH system 361) after standardization with buffer solutions of 7.0 and 4.0 pH.

*1.3.2. Determination of carotenoids (lycopene and β-carotene).* The carotenoids (lycopene and β-carotene) were extracted and determined following the acetone/petroleum ether method according to Buret (1991). The concentrations of lycopene and β-carotene were determined spectrophotometrically using the following equations (Lime et al., 1957):

$C_{\beta\text{-carotene}} = 4.624 \times A_{450} - 3.091 \times A_{503}$

$C_{\text{lycopene}} = 3.956 \times A_{450} - 0.806 \times A_{503}$

where C is the concentration of carotenoid expressed in µg $ml^{-1}$ and $A_{450}$ and $A_{503}$ represent the absorbance at 450 nm and 503, respectively. Finally, the concentration is expressed in mg/100 g wet weight of tomato or puree.

*Table 1.* Description of the genotypes used in the experiment

| Genotypes | Specific features | Source |
|---|---|---|
| Berika | High lycopene containing variety, firm, deep red and oblong fruits | Institute of Genetics, Bulgarian Academy of Science, Sofia, Bulgaria |
| BCT-115 | Dark green and high-pigmented line carrying dark green (*dg*) gene, hard, very deep red and round fruits | United States Department of Agriculture (USDA), U.S.A. |
| BCT-119 | High pigmented line containing old gold crimson ($og^c$) gene, soft, deep red and round fruits | United States Department of Agriculture (USDA), U.S.A. |
| Punjab Chhuhara | Popular variety having good processing characteristics, firm, red and oblong fruits | AICRP on Vegetable Crops, BCKV, Mohanpur, West Bengal, India |
| FEB-2 | Early blight resistant variety, firm, orange- red and oblong flat fruits | Division of Vegetable Science, IARI, New Delhi, India |
| BCT-53 | A high yielding line with appreciable fruit quality, firm, red and semi oblong fruits | Department of Vegetable Crops, BCKV, Mohanpur, West Bengal, India |
| Patharkutchi | Local adaptable cultivar, low in pigment with stay-green shoulder, hard, deep red and round flat fruits | Department of Vegetable Crops, BCKV, Mohanpur, West Bengal, India |
| CLN B | Heat tolerant line, low in pigment, soft, red and small sized fruits | Asian Vegetable Research and Development Center (AVRDC), Taiwan |
| CLN R | Heat tolerant line, low in pigment, soft, orange-red and small sized fruits | Asian Vegetable Research and Development Center (AVRDC), Taiwan |

AICRP: All India Coordinated Research Project; BCKV: Bidhan Chandra Krishi Viswavidyalaya; IARI: Indian Agricultural Research Institute.

### *1.4. Sensory acceptability*

During preparation and after different storage periods (30 and 60 days), a panel of thirty consumers comprising 15 male and 15 female (20 to 55 years old) received samples of puree prepared from different tomatoes in unlabelled Petri dishes to evaluate their sensory attributes (colour, taste, flavour). Samples were presented in succession and panellists were asked to rate evaluation variables according to a 9-point hedonic scale, where 1=inedible, 3=fair, 5=good, 7=very good and 9=excellent.

### *1.5. Statistical analysis*

The experimental setup of this study was a completely randomized design. Differences among cvs and storage time for each parameter studied in tomato puree were determined by using the one-way ANOVA test at 95% confidence interval. Differences between means were determined using Duncan's multiple range test (DMRT). All quantitative analyses were expressed as mean value ± standard deviation for three replicates.

## 2. Results and discussion

### *2.1. Total soluble solids*

The total soluble solid (TSS) contents of tomato purees, which varied significantly ($P<0.05$) at the time of preparation (~14–16 °Brix) as well as in the course of storage (~6–9% at the end of storage), are presented in Table 2. The TSS contents tended to decrease during storage irrespective of genotype. Puree prepared from high pigment tomatoes lost about 45–58% (roughly) of their initial TSS, being the highest and the lowest in BCT-119 and Berika, respectively, whereas in case of ordinary tomatoes the loss ranged from 43–56% (roughly) being the highest and lowest for Punjab Chhuhara and Patharkutchi, respectively. Similar variation in TSS contents of puree as a function of cv was also observed by CHAKRABORTY and co-workers (2007). AKBUDAK and co-workers (2009) also pointed out the variation in TSS content of tomato paste of different light and red coloured tomatoes. The differences in TSS contents of puree may be due to inherent characteristics of genotypes (AKBUDAK et al., 2009). The results are compliant with the findings of GOWDA and co-workers (1994), and CHAKRABORTY and co-workers (2007) who reported decreased TSS contents of puree with an increased storage period. As reported, TSS is the sum of sugar, acids, and other minor components, and probably the consumption of one/some of them by microorganisms as food source reduced the TSS contents of puree during storage.

### *2.2. Titratable acidity and pH*

The results revealed that there was no significant ($P>0.05$) difference in the percent acidity (expressed as citric acid) of tomato puree of different genotypes, at the time of preparation (Table 2). Later on, the TA exhibited a gradual increase during storage with significant differences ($P<0.05$). The initial values were higher when compared with the others; for example, AKBUDAK and co-workers (2009) reported acidity values of puree and paste of different tomatoes range between 0.42 and 0.52%. The average acidity of puree of high pigment tomatoes increased up to 1.4 times of their initial concentration, whereas in case of normal tomato purees, the acidity increased up to 1.2–1.3 folds during storage. CHAKRABORTY and co-workers (2007) also observed a similar increase in acidity of tomato puree during storage because of phenolic acids produced by *B. coagulans*.

The pH of tomato puree decreased during storage irrespective of genotypes (Table 2). Among mutant genotypes, the highest reduction in pH was recorded in puree prepared from BCT-115 (1.30%), whilst in normal tomatoes maximum decrease was observed in BCT-53 (2.12%). SAFDAR and co-workers (2010) reported a similar decrease during the storage of tomato paste. The pH is very important, because acidity influences the thermal processing conditions required for producing safe products (AKBUDAK et al., 2009).

*Table 2*. Changes in TSS, titratable acidity, and pH of tomato puree prepared from different genotypes during storage at room temperature

| Genotypes | TSS (°Brix) | | | Titratable acidity (%) | | | pH | | | TSS:acid ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Storage duration (month) | | | | | | | | | | | |
| | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 |
| Berika | 15.0±0.36 bc | 11.71±0.54 b-d | 8.21±1.14 ab | 2.13±0.06 a | 2.48±0.23 bc | 3.04±0.11 a-c | 4.18±0.02 a | 4.16±0.01 a | 4.14±0.01 a | 6.10±0.12 ab | 5.11±0.46 a-c | 4.02±0.10 a-c |
| BCT-115 (*dg*) | 15.57±0.87 ab | 12.23±0.40 a-c | 7.52±0.90 a-c | 2.24±0.07 a | 2.89±0.20 a | 3.16±0.28 a | 4.09±0.03 b | 4.07±0.02 bc | 4.04±0.02 b | 6.04±0.31 ab | 4.50±0.28 cd | 3.92±0.46 a-c |
| BCT-119 (*Og*$^c$) | 14.34±0.73 d | 11.28±1.53 b-d | 6.02±0.20 c | 2.12±0.06 a | 2.56±0.23 a-c | 3.05±0.20 ab | 4.06±0.06 bc | 4.05±0.06 c | 4.03±0.07 bc | 5.94±0.07 ab | 4.53±0.48 cd | 3.65±0.27 c |
| Punjab Chhuhara | 16.05±0.17 a | 13.39±0.66 a | 9.06±1.35 a | 2.15±0.06 a | 2.56±0.09 a-c | 2.88±0.17 a-d | 4.10±0.01 b | 4.08±0.01 bc | 4.06±0.01 b | 6.23±0.15 ab | 4.82±0.10 b-d | 4.14±0.33 a-c |
| Feb-2 | 14.93±0.35 cd | 10.46±1.16 d | 6.89±1.56 bc | 2.09±0.10 a | 2.22±0.12 c | 2.61±0.21 d | 4.11±0.02 b | 4.09±0.02 b | 4.06±0.03 b | 6.37±0.44 a | 5.55±0.43 a | 4.36±0.31 ab |
| BCT-53 | 14.53±0.66 cd | 10.87±1.16 b-d | 6.40±1.62 bc | 2.04±0.22 a | 2.33±0.09 bc | 2.70±0.17 cd | 4.09±0.02 b | 4.05±0.02 c | 4.0±0.01 b-d | 6.18±0.80 ab | 5.16±0.27 a-c | 4.20±0.22 ab |
| Pathar-kutchi | 16.14±0.85 a | 12.51±0.72 ab | 7.03±0.79 bc | 2.18±0.04 a | 2.46±0.12 bc | 2.83±0.11 a-d | 4.03±0.02 cd | 3.99±0.02 d | 3.96±0.04 d | 6.30±0.08 ab | 5.43±0.16 ab | 4.47±0.22 a |
| CLN-B | 15.83±0.50 a | 10.84±0.70 b-d | 6.93±1.11 bc | 2.16±0.08 a | 2.46±0.38 bc | 2.85±0.13 a-d | 4.0±0.01 d | 3.98±0.02 d | 3.95±0.04 d | 6.55±0.29 a | 5.26±0.72 ab | 4.15±0.15 a-c |
| CLN-R | 14.62±0.82 cd | 10.57±0.72 cd | 6.45±0.95 bc | 2.23±0.11 a | 2.65±0.16 ab | 2.81±0.06 b-d | 4.01±0.02 d | 3.99±0.02 d | 3.97±0.02 cd | 5.59±0.14 b | 4.37±0.18 d | 3.86±0.18 bc |

Values are the mean of three replicates of each treatment ± standard deviation. Means in a column with the same letter are not significantly different ($P \geq 0.05$)

### *2.3. TSS:acid ratio*

The TSS to acid ratio of tomato purees decreased as the storage time increased (2 months) (Table 2). In case of high pigment tomato purees, maximum decrease was recorded in BCT-119 (38.51%) followed by BCT-115 (35.05%). However, in normal tomato purees, reduction in TSS:acid ratio ranged between 29.03 and 36.74, in which the highest decrease was recorded in CLN-B followed by Punjab Chhuhara (P<0.05).

### *2.4. Ascorbic acid*

Ascorbic acid (AsA) is an unstable compound decomposing easily under undesirable conditions. The AsA content of puree of all genotypes ranged from 22.37 to 28.41 mg/100 g and was positively influenced by genotypes (Table 3). The content of AsA fell within the values reported by CHAKRABORTY and co-workers (2007) and AKBUDAK and co-workers (2009), ranging from 13–34 mg/100 g for puree and paste of different tomato cvs. The AsA content gradually declined during storage irrespective of genotypes (P<0.05). Generally, puree of high lycopene tomato retained higher AsA content than that of normal tomatoes. In case of high pigment tomato purees, the minimum reduction was recorded in Berika (~25%). Considering the normal genotypes, the decline in AsA contents varied from 25 to ~36% being the highest in puree of FEB-2. These results are consistent with the findings of CHAKRABORTY and co-workers (2007) and SAFDAR and co-workers (2010), who reported a similar decrease in AsA content of puree and paste during storage. The loss of AsA is probably attributable to oxidation of ascorbic acid to dehydroascorbic acid followed by the hydrolysis of the latter into 2,3-diketogluconic acid, which then undergoes polymerization to other nutritionally inactive products (SAFDAR et al., 2010; SIDDIQUI et al., 2013).

### *2.5. Carotenoids (lycopene and β-carotene)*

The lycopene contents of purees differed significantly (P<0.05) among genotypes as well as during storage. The initial concentration ranged from 5.49 to 9.05 mg/100 g, which showed decreasing trend during storage in all nine genotypes independently (Table 3). As far as the high pigment genotypes are concerned, the maximum loss was recorded in BCT-119 (~18%), however, in case of normal genotypes the percent decline in lycopene contents of puree varied from 11.28–22.35%, being the lowest in Punjab Chhuhara (~11%). Similarly, the β-carotene contents also varied significantly (P<0.05) among genotypes at the time of preparation (2.15–3.54 mg/100 g) and during storage (1.84–3.08 mg/100 g) (Table 3). β-carotene contents of puree declined during storage. Among high pigment genotypes, the minimum loss was recorded in Berika (~11%), whereas in normal tomatoes, the lowest decline was observed in CLN-R (~12%). As respect to lycopene in tomato puree, our results fell within the concentrations (5–17 mg/100 g wet weight) reported in the literature (MARKOVIĆ et al., 2006). The β-carotene contents of puree were somewhat similar to the values reported by CHAKRABORTY and co-workers (2007) and AKBUDAK and co-workers (2009), ranging within 2.26–4.64 mg/100 g wet weight, particularly in case of normal genotypes.

*Table 3*. Changes in total sugar, ascorbic acid, and carotenoids contents of tomato puree prepared from different genotypes during storage at room temperature

| Genotypes | Ascorbic acid (mg/100 g) | | | Lycopene (mg/100 g) | | | β-carotene (mg/100 g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 |
| Berika | 26.64±1.46 a | 22.64±0.84 a | 19.95±1.14 a | 8.48±0.27 ab | 8.07±0.45 ab | 7.67±0.20 a | 3.30±0.54 ab | 3.14±0.05 a | 2.93±0.16 a |
| BCT-115 (*dg*) | 28.41±0.48 b | 24.54±0.85 bc | 20.74±1.95 b | 9.05±0.09 a | 8.25±0.65 a | 7.78±0.30 a | 3.54±0.39 a | 3.23±0.33 a | 3.08±0.03 a |
| BCT-119 ($Og^c$) | 25.21±0.73 bc | 22.79±1.07 c | 18.69±1.13 bc | 6.59±0.49 cd | 5.97±0.16 d | 5.42±0.30 d | 2.65±0.59 bc | 2.46±0.42 b | 2.26±0.15 b |
| Punjab Chhuhara | 27.69±1.08 b | 23.67±0.63 bc | 20.02±0.34 b | 8.09±0.17 b | 7.56±0.06 b | 7.18±0.23 b | 2.47±0.28 c | 2.28±0.14 bc | 2.15±0.05 b |
| Feb-2 | 22.40±1.17 b | 17.61±0.75 b | 14.41±0.81 b | 7.03±0.17 c | 6.57±0.18 c | 6.10±0.14 c | 2.25±0.32 c | 2.07±0.08 bc | 1.93±0.14 Cd |
| BCT-53 | 23.95±0.90 b | 20.65±1.51 c | 17.82±0.56 b-d | 6.77±1.18 cd | 5.86±0.45 d | 5.26±0.17 d | 2.16±0.36 c | 1.91±0.18 c | 1.84±0.10 D |
| Patharkutchi | 24.48±0.90 cd | 21.71±1.19 d | 18.36±0.35 d | 8.45±0.17 ab | 7.80±0.14 ab | 7.23±0.27 b | 2.39±0.27 c | 2.18±0.14 bc | 2.09±0.22 Bc |
| CLN-B | 22.37±1.03 d | 19.31±0.66 d | 15.50±1.95 d | 5.49±0.14 e | 4.96±0.07 e | 4.35±0.20 e | 2.15±0.18 c | 1.92±0.06 c | 1.86±0.11 D |
| CLN-R | 23.29±1.27 d | 20.41±1.85 d | 17.25±0.57 cd | 6.02±0.12 de | 5.55±0.21 d | 5.09±0.10 d | 2.31±0.16 c | 2.12±0.13 bc | 2.02±0.12 Bc |

Values are the mean of three replicates of each treatment ± standard deviation. Means in a column with the same letter are not significantly different ($P \geq 0.05$)

Evidences of compositional differences between tomato varieties can be found in the literature. For instance, Hackett and co-workers (2004) describe a faster thermal degradation of tomato lycopene in Tangerine variety than in Roma. Gowda and co-workers (1994) and Chakraborty and co-workers (2007), who reported similar declines in carotenoid contents of puree during storage, can further substantiate the results of this study. Oxidation is the major cause of carotenoids loss, and it depends on the carotenoids involved. Light, heat, metals, enzymes, and peroxides stimulate oxidation, and it is inhibited by antioxidants, such as tocopherols and ascorbic acid (Siddiqui, 2013). The difference in carotenoid contents and their stability between the high lycopene and normal tomatoes could be linked to different factors related to the composition of the tomatoes, because they do not have a specific genetic relationship. The high lycopene genotypes have been recognized to have higher amount of other antioxidants (ascorbic acid and phenols including flavonoids), which may have stabilized the lycopene and β-carotene contents of puree.

### *2.6. Sensory acceptability*

Colour is a very important quality factor in processed tomato products, particularly tomato puree, since it influences consumer acceptability. Changes in flavour are the most sensitive index to quality deterioration during storage followed by colour (Eckerle et al., 1984). The sensory attributes (colour, taste, and flavour) of puree differed significantly among all genotypes at the time of preparation as well as during storage (Table 4). Common for all genotypes, the scores for sensory parameters decreased with the length of storage time, however, the decline was more prominent in puree prepared from normal tomatoes than from the high pigment ones (Table 4).

Considering the overall acceptability, at the time of preparation, the highest rating was obtained by Berika followed by BCT-115 and Patharkutchi. On an average, loss of about 10–12% (high pigment tomato puree) and 6–16% (normal tomato puree) was observed in overall acceptability at the end of storage (Table 4). Safdar and co-workers (2010) also reported the similar trend in sensory scores in tomato paste during storage. Factors such as non-enzymatic (Maillard reactions) and enzymatic browning, and process conditions like pH, acidity, oxidation of ascorbic acid, time and temperature of storage are responsible for the loss of pigment or colour during the processing of foods affecting overall quality.

The amounts of sugar, acids (pH), and amino acids, as well as time of processing have been reported to affect the colour of processed tomato products by causing the formation of brown pigments (Gould, 1992). Additionally, the presence of residual chlorophyll that could be present in the juice as the result of grinding non-ripe tomatoes is converted to pheophytin of olive green colour. Regarding flavour characteristics, splitting of the lycopene molecule into smaller fragments, such as volatile aldehydes and ketones, due to autoxidation develops hay or grassy off-flavours (Schierle et al., 1997). The sensory variation in puree observed among genotypes may be explained by the hypothesis that these reactions can take place simultaneously but at a different reaction rate, depending on the genotypic make up, as well as by the hypothesis that the reaction does not necessarily take place in one step through a single mechanism (Siddiqui, 2013).

*Table 4.* Sensory attributes of tomato puree prepared from different genotypes during storage at room temperature

| Genotypes | Colour | | | Taste | | | Flavour | | | Overall acceptability | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Storage duration (month) | | | | | | | | | | | |
| | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 |
| Berika | 8.50±0.50 a | 8.10±0.56 a | 7.63±0.51 ab | 8.23±0.38 a | 7.83±0.35 a | 7.40±0.53 a | 8.23±0.25 a | 7.97±0.45 a | 7.30±0.26 ab | 8.32±0.36 a | 7.97±0.45 a | 7.44±0.38 a |
| BCT-115 (*dg*) | 8.13±0.32 ab | 7.57±0.80 ab | 7.13±0.81 a-c | 8.27±0.31 a | 7.90±0.36 a | 7.37±0.15 a | 8.43±0.21 a | 8.0±0.35 a | 7.37±0.32 a | 8.28±0.25 ab | 7.820.44 a | 7.29±0.24 a |
| BCT-119 ($Og^c$) | 7.77±0.25 ab | 7.0±0.20 bc | 7.07±0.31 a-c | 7.43±0.21 c | 6.63±0.32 bc | 6.10±0.79 bc | 7.23±0.25 b | 6.83±0.35 b | 6.50±0.30 bc | 7.48±0.07 b-d | 6.82±0.27 b | 6.56±0.34 b |
| Punjab Chhuhara | 8.0±0.20 ab | 7.73±0.12 ab | 7.17±0.32 a-c | 7.73±0.42 ab | 7.37±0.25 ab | 6.87±0.31 ab | 8.13±0.31 a | 7.87±0.70 a | 7.43±0.32 a | 7.96±0.27 a-c | 7.66±0.18 a | 7.16±0.10 a |
| Feb-2 | 6.97±0.15 b | 6.33±0.31 c | 5.90±0.36 b | 6.70±0.35 cd | 6.03±0.55 c | 5.50±0.50 C | 6.77±0.25 b | 6.20±0.20 bc | 5.73±0.64 cd | 6.81±0.10 d | 6.19±0.32 bc | 5.71±0.40 c |
| BCT-53 | 7.27±0.31 ab | 6.80±0.53 bc | 6.30±0.26 cd | 7.13±0.31 bc | 6.60±0.72 bc | 6.23±0.25 bc | 7.13±0.12 b | 6.67±0.31 b | 6.13±0.55 c | 7.18±0.23 cd | 6.69±0.44 b | 6.22±0.35 bc |
| Pathar-kutchi | 8.40±0.20 a | 8.07±0.31 a | 7.87±0.42 a | 7.23±0.25 bc | 7.07±0.46 a-c | 6.73±0.31 ab | 8.40±0.20 a | 8.07±0.31 a | 7.87±0.42 a | 8.01±0.13 ab | 7.73±0.13 a | 7.49±0.38 a |
| CLN-B | 7.20±0.40 ab | 6.87±0.61 bc | 6.60±0.20 b-d | 7.07±0.61 b-d | 6.73±0.64 bc | 6.40±0.20 b | 7.30±0.44 b | 6.80±0.53 b | 6.47±0.42 bc | 7.19±0.48 cd | 6.80±0.59 b | 6.49±0.25 b |
| CLN-R | 5.37±1.80 c | 5.13±0.83 d | 4.63±1.16 e | 6.40±0.40 e | 6.03±0.68 c | 5.40±0.53 c | 5.93±0.83 c | 5.57±0.93 c | 5.23±0.67 d | 5.90±0.98 e | 5.58±0.74 c | 5.09±0.34 d |

Values are the mean of three replicates of each treatment ± standard deviation. Means in a column with the same letter are not significantly different (P≤0.05)

## 3. Conclusions

There were important differences in the retention or degradation of quality parameters. The changes in the biochemical composition during storage were lesser in puree of mutant tomatoes such as BCT- 115 and BCT- 119 carrying *dg* and *og*$^{c}$ genes, respectively. The normal high lycopene tomato, i.e. Berika, also maintained the quality of puree up to two months. Regarding sensory attributes, the puree prepared from Berika and BCT- 115 (*dg*) had higher sensory scores throughout the storage, whereas puree of Feb-2 and CLN-R having orange-red colour, had lower scores. The results provide important information on the biochemical attributes of puree of diverse tomato genotypes. The high pigment genotypes can be included in the breeding strategies and production planning to fulfil the expectations of processing industry.

## References

A.O.A.C. (2000): *Official methods of analysis of AOAC International*. 17$^{th}$ ed.. Gaithersburg, MD, USA. (Method No. 942.15 and 967.21)

Adsule, P.G., Dan, A., Tikko, S.K. & Pal, A.B. (1980): Studies on the evaluation of tomato cultivars for making juice. *Indian Fd Pack.*, *34,* 18–20.

Akbudak, B., Bolkan, H. & Cohen, N. (2009): Determination of physicochemical characteristics in different products of tomato varieties. *Int. J. Fd Sci. Nutr., 60,* 126–138.

Barrett, D.M., Garcia, E. & Wayne, J.E. (1998): Textural modification of processing tomatoes. *Crit. Rev. Fd Sci. Nutr., 38,* 173–258.

Buret, M. (1991): Tomato sampling for quality assessment, -in: Eccher Zerbini P., Gorini F. & Polesello A. (Eds) *Measurement of the quality of tomato: Recommendations of an EEC Working Group.* IVTPA, Milano, pp. 1–36.

Chakraborty, I., Vanlalliani, Chattopadhyay, A. & Hazra, P. (2007): Studies on processing and nutritional qualities of tomato as influenced by genotypes and environment. *Vegetable Sci., 34*, 26–31.

Eckerle, J.R., Harvey, C.D. & Chen, T.S. (1984): Life cycle of tomato paste: Correlation between sensory and instrumental testing methods. *J. Fd Sci., 49*, 1188–1193.

Galpaz, N., Wang, Q., Menda, N., Zamir, D. & Hirschberg, J. (2008): Abscisic acid deficiency in the tomato mutant high-pigment 3 leading to increased plastid number and higher fruit lycopene content. *Plant J., 53*, 717–730.

Gould, W.A. (1992): *Tomato production, processing and technology*. CTI Publ., Baltimore, 550 pages.

Gowda, I.N.D., Raman, J.K.H., Anand, N., Sadashiva, A.T. & Tikoo, S.K. (1994): Studies on the physico-chemical characteristics and processing quality of two IIHR tomato varieties in relation to commercial cultivars. *J. Fd Sci. Technol., 31*, 126–129.

Hackett, M.M., Lee, J.H., Francis, D. & Schwartz, S.J. (2004): Thermal stability and isomerization of lycopene in tomato oleoresins from different varieties. *J. Fd Sci. 69*, 536–541.

Helyes, L. & Lugasi, A. (2006): Formation of certain compounds having technological and nutritional importance in tomato fruits during maturation. *Acta Alimentaria, 35*, 183–193.

Helyes, L., Pék, Z. & Lugasi, A. (2008): Function of the variety technological traits and growing conditions on fruit components of tomato (*Lycopersicon lycopersicum* (L) Karsten). *Acta Alimentaria, 37*, 427–436.

Helyes, L., Lugasi, A., Pogonyi, A. & Pék, Z. (2009): Effect of variety and grafting on lycopene content of tomato (*Lycopersicon lycopersicum* L. Karsten) fruit. *Acta Alimentaria, 38*, 27–34.

Ilahy, R., Hdider, C., Lenucci, M.S., Tlili, I. & Dalessandro, G. (2011): Antioxidant activity and bioactive compound changes during fruit ripening of high-lycopene tomato cultivars. *J. Food Compos. Anal., 24*, 588–595.

Lime, B.J., Griffiths, F.P., O'connor, R.T., Heinzelman, D.C. & Mccall, E.R. (1957): Spectrophotometric methods for determining pigmentation-beta-carotene and lycopene-in ruby red grapefruit. *J. Agric. Fd Chem., 5*, 941–944.

Marković, K., Hruškar, M. & Vahčić, N. (2006): Lycopene content of tomato products and their contribution to the lycopene intake of Croatians. *Nutr. Res., 26*, 556–560.

Safdar, M.N., Mumtaz, A., Amjad, M., Siddiqui, N. & Hameed, T. (2010): Development and quality characteristics studies of tomato paste stored at different temperatures. *Pakistan J. Nutr., 9*, 265–268.

Schierle, J., Bretzel, W., Buhler, J., Faccin, N., Hess, D., Steiner, K. & Schuep, W. (1997): Content and isomeric ratio of lycopene in food and human blood plasma. *Fd Chem., 59,* 459–465.

Siddiqui, M.W. (2013): *Variation in post harvest quality traits among tomato genotypes*. Ph.D. Thesis. Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. 145 pages.

Siddiqui, M.W., Ayala-Zavala, J.F. & Dhua, R.S. (2013): Genotypic variation in tomatoes affecting processing and antioxidant attributes. *Crit. Rev. Food Sci. Nutr*. DOI: 10.1080/10408398.2012.710278 (*In press*)