



Acceptability Study of Tomato Puree using Less Explored Genotypes and Their Hybrids

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ABSTRACT

Background: Tomato puree, being abundant in nutritive value and having significant health advantages to consumers are widely used to improve the flavour and colour of food preparations. In the present study, tomato puree was prepared using seven genotypes having three different fruit colours. Color has played an essential role in consumer acceptability of tomato puree.

Methods: The present study used some difficult-to-ripe tomato genotypes (mostly used for breeding purposes due to their prolonged shelf life) to determine the quality parameters (TSS, titratable acidity, ascorbic acid, lycopene and β -carotene contents) of fresh tomatoes and their purees. The sensory attributes of purees were determined by a panel of 10 judges.

Result: The findings unequivocally show that processing significantly altered the chemical makeup of tomato puree, especially in terms of a decrease in ascorbic acid, β -carotene and titratable acidity and a notable increase in TSS and lycopene concentration following preparation. Non ripening mutants could effectively be processed to develop a unique orange coloured puree with high nutritive values. Overall, the results demonstrate how important genotype selection is for producing nutrient-dense processed tomato product that satisfy consumer preferences and offer a number of health benefits.

Key words: Acceptability study, Fresh tomato quality, Non-ripening genotypes, Tomato puree quality, Tomato puree, Yellow cherry tomato.

INTRODUCTION

Among fresh vegetables, tomato (*Solanum lycopersicum* L.) is one of the most significant agricultural products in India and the world, which belongs to the Solanaceae family. Western South America and Central America are the most tomato producing regions in the world. Tomato is also known as “poor man’s orange” and it is a climacteric fruits or berries, by nature. In terms of area, tomatoes rank second globally, after potatoes. In terms of global fruit and vegetable production, India is the second largest tomato producing country after China. However, about 25-40% of the product in developing country losts during the postharvest handling (Kitinoja and Kader, 2015; Arah *et al.*, 2015; Singh *et al.*, 2011).

Although processed foods are generally thought to be inferior to unprocessed foods, “processing” is not necessarily a negative word and processed foods are not always nutritionally poor or unhealthy. Food processing may offer beneficial effects such as improved digestibility and bioavailability of nutrients and certainly increases food safety (Wu *et al.*, 2022). To accurately assess nutrient intake from total fruit and vegetable consumption and their health outcomes, it is critical to understand the processing effects on the nutrients and bioactive compounds of processed tomato items.

Zhang *et al.* (2023) studied the comprehensive analysis that can distinguish between the three types of tomatoes; the quality of tasty tomatoes was better than cherry tomatoes, followed by regular tomatoes. The quality of the original raw materials like variety and ripening stages also affect the tomato paste’s quality and the storage conditions (Farahnaky *et al.*, 2010). In India and around the

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world, tomatoes are widely utilized as a processed products such as tomato juice, paste, sauce, ketchup and canned whole tomatoes (Anthon and Barrett, 2010; Hossain *et al.*, 2011). Tomatoes are a key source of antioxidants such as carotenes, lycopene, vitamin C, natural acids and phenolic compounds. Among all the vegetables, tomatoes are the most processed fruit in our nation (Perveen *et al.*, 2015). They are free of cholesterol, have few calories and fat and are an excellent source of protein and fibre (Borguini and Ferraz Da Silva Torres, 2009). Processed tomato products seem to have more bioavailable lycopene than raw tomatoes (Story *et al.*, 2010). In addition, lycopene is a primary

pigment that gives tomatoes their distinctive red colour properties (Zuorro and Lavecchia, 2010; Mirondo and Barringer, 2015) which is a crucial quality component in processed tomato products for consumer acceptability (Shatta *et al.*, 2017). A high concentration of anthocyanin is crucial for potent antioxidant effects. Increased demand for anthocyanin-rich foods reflects research on their potential to combat chronic diseases (Hassan and Abdel-Aziz, 2010).

Therefore, the objective of the present study was to evaluate the biochemical variations among different coloured tomato genotypes of fresh tomato juice and puree as well as the relation between the Hunter color readings, β -carotene and lycopene contents of tomato puree during processing.

MATERIALS AND METHODS

The present research program was carried out at Regional Nuclear Agricultural Research Centre (RNARC) and Department of Post Harvest Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India during two consecutive years (2022 and 2023). The tomatoes under the study were collected from the AICRP on Vegetable Crops, Kalyani centre, West Bengal. The investigation was undertaken to identify the differences among seven (7) tomato genotypes of (Punjab Chhuhara, Dg $\times$ 1422, Rin $\times$ Nr, Nor $\times$ Nr, Nor $\times$ Rin, BC Cherry-1, Bidhan Purple) (Plate 1) in fresh and processed (puree) states for their biochemical (TSS, ascorbic acid, titratable

acidity lycopene, β -carotene,) as well as sensory attributes. All the tomatoes especially the ripening mutant tomato genotypes were stored at ambient condition in the laboratory for a considerable period till they become softer and colour also turns from their pale green colour to light pinkish orange colour. Punjab Chhuhara, a commercial processing variety is used for comparison with the six other genotypes mentioned above.

Preparation of tomato puree

Tomato puree was prepared by heating 1 kg fresh tomato pulp (without skin and seed) adding salt, sugar as per requirement. Cooking continued at high temperature till the TSS of the final product was 18-22%. At this stage (just before the end of cooking), KMS @750 mg/kg was mixed. The final product was put into 200 g pre-sterilized bottles maintaining appropriate headspace which were then carefully sealed and labelled.

Biochemical properties of tomato

TSS, ascorbic acid (vitamin C), lycopene and β -carotene contents were estimated by standard methods of analysis given by (Ranganna, 2017). Titratable acidity was estimated by standard methods of analysis given by A.O.A.C. (2023).

Sensory evaluation

Sensory evaluation of tomato puree was carried out for colour, taste flavour and overall acceptability by a panel of ten judges immediately after the puree preparation. It was done using the 5 points Hedonic score (5 = Excellent; 4 = Moderately good; 3 = Good; 2 = Moderately poor; 1 = Poor) as given by Ranganna (2017).

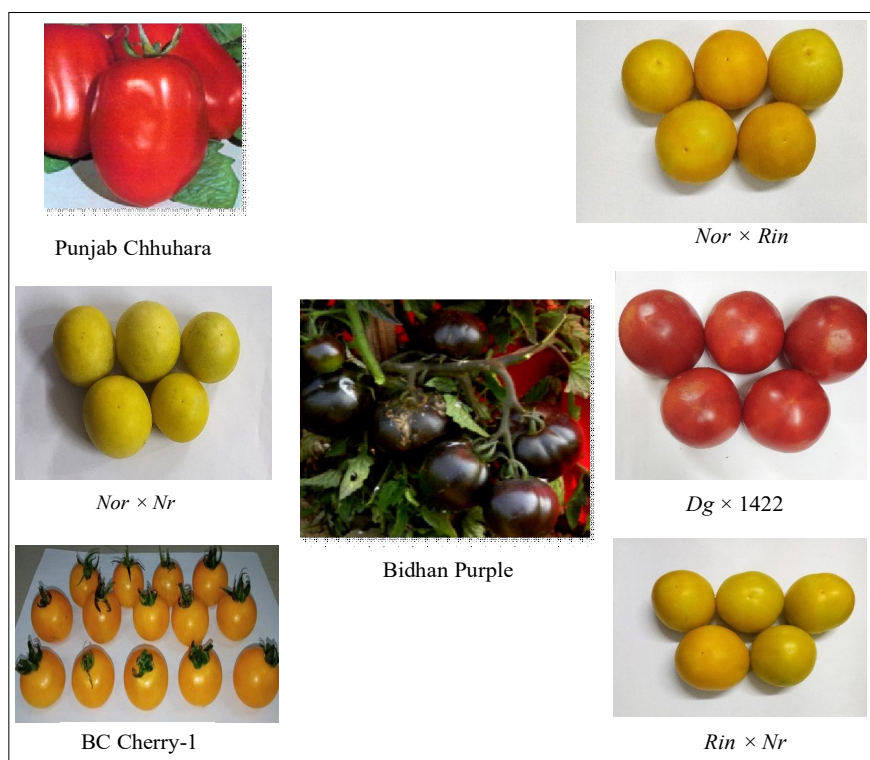


Plate 1: Photographs of seven tomato genotypes used in the study.

Data analysis

The data obtained in the present experiment was analysed statistically following completely randomized design method (CRD). All the data were subjected to ANOVA for the CRD analysis (Panse and Sukhatme, 1985). Treatment means were separated using critical difference ($p < 0.0001$) following Tukey's post hoc test and were tested for significance. Values in columns followed by the same letter are not significantly different.

RESULTS AND DISCUSSION

In the present investigation, sincere efforts were executed to collect the data on TSS, ascorbic acid, β -carotene, titratable acidity and lycopene contents of fresh and processed (tomato puree) tomatoes.

Total soluble solids content of fresh and processed tomato

High total soluble solids (TSS) are one of the major quality components for nutritional and processing purposes (Purkayastha and Mahanta, 2011). A significant variation in fresh tomato genotypes was recorded for TSS content, maximum being in Punjab Chhuuhara (5.33°Brix) and minimum in BC Cherry-1 (3.63°Brix) (Fig 1). We found that genotypes with reddish orange (Punjab Chhuuhara) and orange ($Rin \times Nr$) colored fruits were having more TSS contents (above 5.00°brix) than other shades of color. TSS content of processed tomato genotypes varied significantly. The maximum TSS was found in Bidhan Purple (19.22°Brix) as compared to Punjab Chhuuhara (19.07°Brix) and $Rin \times Nr$ (18.66°Brix) and the minimum was recorded in BC Cherry-1 (15.39°Brix) (Fig 1). From the results it was found that after processing tomato genotypes showed a dramatical increase in total soluble solid content. BC Cherry-1 and $Nor \times Rin$ showed the maximum increase of 323.96 % and 315.50% respectively in total soluble solids content (Table 1). It has usually been reported that total solids content increased with maturity (Salunkhe *et al.*, 1974; Kundan *et al.*, 2011). Young *et al.* (1993) reported that the soluble solids content of tomato increased after exposing to heat. Harshita *et al.* (2024) also observed increased TSS content of tomato blended papaya chutney. Increase in TSS content of tomato fruits after processing in

the present study could be due to excessive moisture loss which increases concentration as well as the hydrolysis of carbohydrates to soluble sugars (Waskar *et al.*, 1999; Nath *et al.*, 2011).

Titratable acidity content in fresh and processed tomatoes

Two important quality attributes of processing tomatoes are pH and titratable acidity (Anthon *et al.*, 2011). Citric acid is the most abundant acid in tomatoes and the largest contributor to the total titratable acidity (Turhan and Seniz, 2009). Minimum acidity requirement for processing tomato should be 0.40% as the processed product from low acid tomato may be affected by *Bacillus coagulans* (Thamburaj, 1998). The acid content of fresh tomato genotypes in the present study ranged from 0.27 to 0.56 per cent (Fig 2). The maximum fruit acidity was recorded in Punjab Chhuuhara (0.56%) followed by Bidhan Purple (0.50 %) and $Dg \times 1422$ (0.49%). Genotypic variation on the acid content of tomato fruits was highlighted by previous workers (Chakraborty *et al.*, 2007; Chattopadhyay *et al.*, 2013). Titratable acidity of processed tomato genotypes varied widely. The maximum acidity content was recorded in Punjab Chhuuhara (0.44%) followed by Bidhan Purple (0.37%) and $Dg \times 1422$ (0.34%) and the minimum was recorded in BC Cherry-1 (0.25%) (Fig 2). It was found that after processing of tomato caused drastic decline in acidity content of fruits. This decline was more pronounced in $Nor \times Rin$ (-37.03%) followed by $Rin \times Nr$ (-32.43) (Table 1). The decline in the content of organic acids during fruit ripening might be the result of an increase in membrane permeability which allows acids to be stored in the respiring cells.

Ascorbic acid content in fresh and processed tomato

High ascorbic acid in tomato not only improves the nutrition, it also aids in better retention of natural colour and flavour of the products (Akbulak *et al.*, 2009). Ascorbic acid is present in higher concentration in the locules than in the pericarp tissue of tomato. In the present study, a significant variation was recorded for ascorbic acid content of fresh tomatoes, the maximum in $Rin \times Nr$ ($45.27 \text{ mg}/100 \text{ g}$) followed by $Dg \times 1422$ ($35.74 \text{ mg}/100 \text{ g}$) and the minimum in $Nor \times Rin$ ($20.19 \text{ mg}/100 \text{ g}$) (Fig 3). A wide range of genotypic variation in the ascorbic acid content was

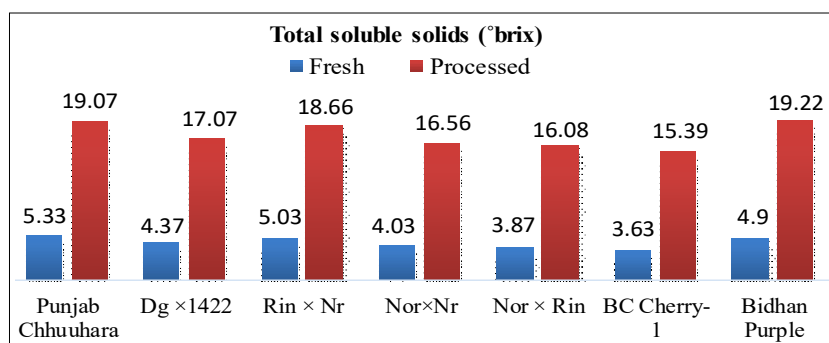


Fig 1: Effect of total soluble solids of fresh and processed tomato.

recorded by previous workers (Chakraborty *et al.*, 2007; Chattopadhyay *et al.*, 2013). Ascorbic acid content of processed tomato genotypes varied significantly. The maximum content was found in *Rin*×*Nr* (21.64 mg/100 g) followed by *Dg*×1422 (17.62 mg/100 g) and the minimum was recorded in *Nor*×*Rin* (8.13 mg/100) (Fig 4). It was found that processing of tomato caused a decrease in ascorbic acid content of fruits. The maximum decrease in ascorbic acid content was recorded in *Nor*×*Rin* (-59.73%) followed by Punjab Chhuuhara (-57.88%) (Table 1).

Ascorbic acid is water soluble and heat labile. Whenever heat is applied, enzymatic activity starts and degradation of ascorbic acid takes place, thus it easily leaches into boiling medium. More cooking time and more heat results more degradation of ascorbic acid, though it

depends on genotypes of tomatoes (Siddiqui *et al.*, 2014). Ascorbate is not a very stable ion and tends to give away its electrons under specific conditions.

β-carotene content of fresh and processed tomato

In the present study, a significant variation was recorded for β-carotene content of fresh tomatoes, the maximum being in BC Cherry-1 (0.77 mg/100 g) followed by *Rin*×*Nr* (0.65 mg/100 g) and the minimum in *Dg*×1422 (0.15 mg/100 g). Typical red-pigmented tomato fruits also contain a lesser amount of β-carotene and other carotenoids. Orange and orange-red tomatoes had 7-10 times more β-carotene in the fresh product than red-fruited ones which corroborated the present findings (Vyrodova *et al.*, 1988; Agarwal and Rao, 2000).

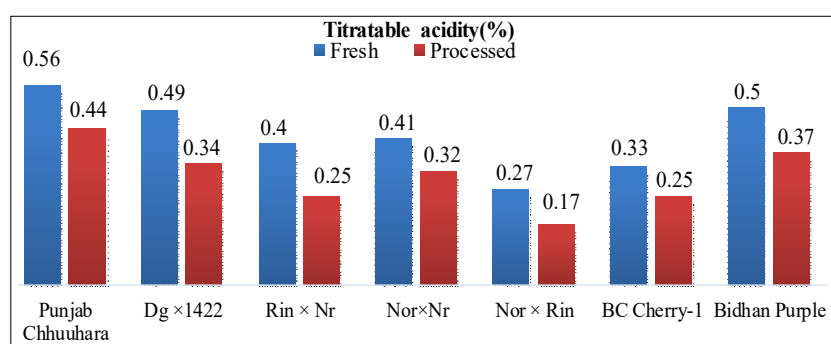


Fig 2: Effect of titratable acidity in fresh and processed tomatoes.

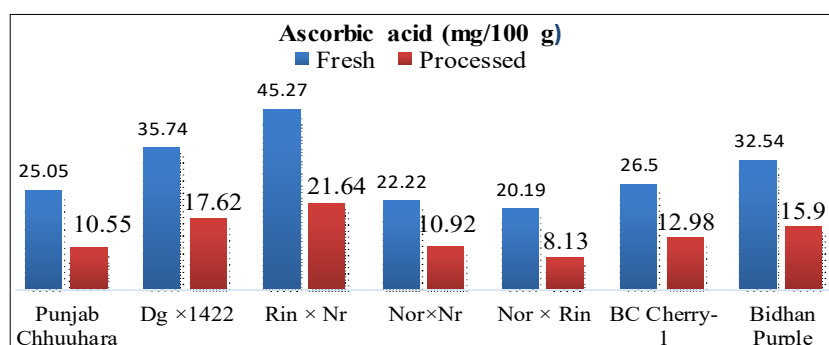


Fig 3: Effect of ascorbic acid in fresh and processed tomato.

Table 1: Per cent increase/decrease of biochemical composition of puree prepared from tomato genotypes having varied fruit colours.

Genotype	Increase in TSS (°Brix) (%)	Decrease in titratable acidity (%)	Decrease in ascorbic acid content (mg/100 g)	Increase in lycopene content (mg/100 g)	Decrease in β-carotene content (mg/100 g)
Punjab Chhuuhara	(+) 257.78	(-) 21.43	(-) 57.88	(+) 432.09	(-) 28.12
Dg × 1422	(+) 290.61	(-) 30.61	(-) 53.31	(+) 350.41	(-) 13.59
Rin × Nr	(+) 270.97	(-) 32.43	(-) 52.19	(+) 544.12	(-) 40.00
Nor × Nr	(+) 286.10	(-) 21.95	(-) 50.85	(+) 534.21	(-) 33.33
Nor × Rin	(+) 315.50	(-) 37.03	(-) 59.73	(+) 650.00	(-) 33.33
BC Cherry-1	(+) 323.96	(-) 24.24	(-) 51.01	(+) 263.63	(-) 20.77
Bidhan Purple	(+) 292.24	(-) 26.00	(-) 51.13	(+) 408.80	(-) 19.35
Mean	(+) 291.02	(-) 27.67	(-) 53.72	(+) 454.46	(-) 26.92

β -carotene content of processed tomato genotypes varied significantly. The maximum β -carotene content was recorded in BC Cherry-1 (0.61 mg/100 g) followed by *Rin* × *Nr* (0.52 mg/100 g) and the minimum in *Dg* × 1422 (0.10 mg/100 g) followed by Bidhan Purple (0.5 mg/100 g) and *Nor* × *Nr* (0.16 mg/100 g) (Fig 4).

From the above results it was noted that processing of tomato caused a drastic decline in β -carotene content compared to fresh product. β -carotene is a heat-sensitive carotenoid. High temperatures and prolonged processing times contribute to its isomerization (conversion to different forms) and degradation through oxidation. Thermal treatment normally leads to the destruction of phytochemical nutrients and antioxidant activity (Kaur and Aggarwal, 2025). Although heat and mechanical processing break down the cellular matrix and release the carotenoids from chromoplasts, making them more accessible for absorption in the human body (Wang *et al.*, 2023).

Lycopene content in fresh and processed tomatoes

Lycopene is the most abundant carotene in red tomato fruits and accounts for up to 90% of the total carotenoids. It is the pigment principally responsible for the characteristic deep-red color of ripe tomato fruit and tomato products. It is predominantly concentrated in the skin, with levels about five times higher than in the pulp. Research also highlights that lycopene functions as an antioxidant and natural colorant, helps to reduce the risk of chronic diseases and contributes to the development and stability of food products

(Rajan *et al.*, 2022; Kuvendzhev *et al.*, 2024). Lycopene content among fresh tomato genotypes varied significantly. The maximum content was recorded in Bidhan Purple (4.09 mg/100 g) which was significantly different from Punjab Chhuuhara (3.77 mg/100 g). A trace amount of lycopene was found in BC Cherry-1 (0.11 mg/100 g) (Fig 5). Red-fruited cultivars usually contain higher lycopene than yellow and orange cultivars (Cox *et al.*, 2000) which agreed well with our findings. Genotypes rich in lycopene generally produced bright red or deep red hues whereas genotypes with least amount of lycopene content were orange red or light red in colour (Chattopadhyay *et al.*, 2013; Siddiqui *et al.*, 2014). Lycopene content of processed tomato genotypes varied widely. The maximum Lycopene content was recorded in Bidhan Purple (20.81 mg/100 g) which was significantly different from Punjab Chhuuhara (20.06 mg/100 g) and the minimum was recorded in BC Cherry-1 (0.40%) (Fig 5). It was found that processing of tomato caused a dramatic increase in lycopene content of fruits which was more pronounced in *Nor* × *Rin* (650.00%) followed by *Rin* × *Nr* (544.12 %) among the non-ripening mutants and the minimum in BC Cherry-1 (263.63%) (Table 1). Both *Nor* × *Rin* and *Rin* × *Nr* exerted reddish-orange and orange color puree, respectively. Hegde *et al.* (2025) recorded that the processed forms of tomatoes contain high lycopene content thereby providing nutritious foods to the consumers. The increase in lycopene levels was due to the release of lycopene from the tomato matrix cell by

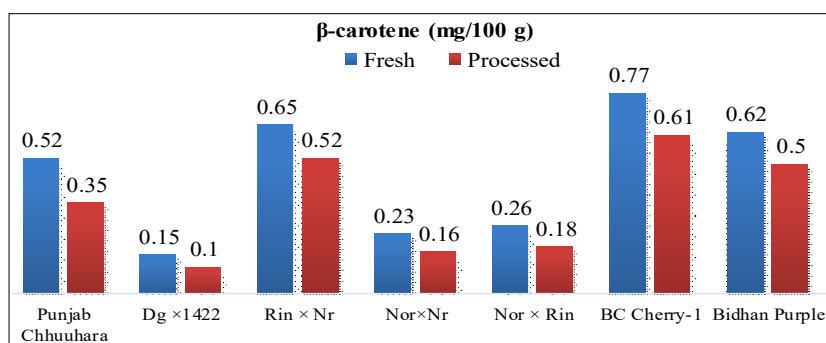


Fig 4: Effect of β -carotene content of fresh tomato and processed tomato.

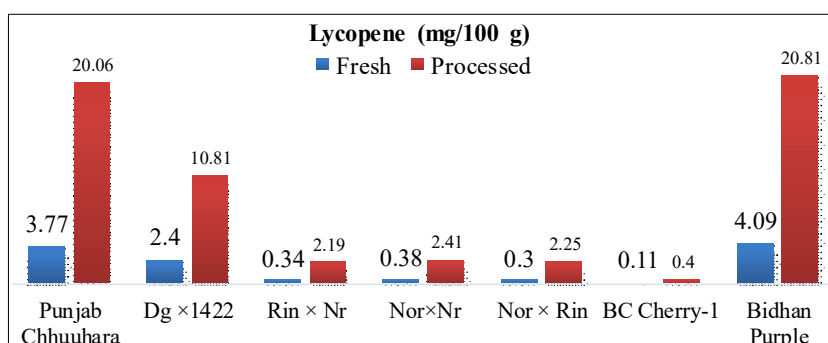


Fig 5: Effect of lycopene content in fresh tomato and processed tomatoes.

Table 2: Sensory attribute of tomato puree.

Genotype	Colour*	Taste*	Overall acceptability*
Punjab Chhuuhara	3.4	3.7	3.6
Dg × 1422	4.2	4.1	3.8
Rin × Nr	3.3	3.6	3.5
Nor × Nr	3.2	3.2	3.6
Nor × Rin	3.2	3.4	3.6
BC cherry-1	4.5	3.4	4.2
Bidhan purple	4.8	4.2	4.4

heating. Thus, lycopene bioavailability in processed tomato products is higher than unprocessed fresh tomatoes (Chakraborty *et al.*, 2007; Acharya *et al.*, 2018; Shi and Maguer, 2000).

Sensory evaluation of tomato puree

Colour

The result clearly showed that colour rating of puree increased after cooking. Colour rating of puree prepared from Bidhan Purple and BC Cherry-1 recorded higher values while Dg×1422 followed by Nor×Nr recorded the lowest values.

Taste

The data regarding organoleptic score for taste of tomato puree prepared from different genotypes under the study was given in Table 2. The result obtained from the taste score cards given the panellists clearly stated that puree prepared from Bidhan Purple and Dg×1422 was the best while least taste score was recorded in puree from genotype Nor×Nr followed by Nor× Rin and BC Cherry-1.

Overall acceptability

Overall acceptability of puree depended on colour and taste rating of the product. The overall acceptability was in its peak range in the puree from Bidhan Purple and BC Cherry-1. It was the least in puree made of Rin×Nr followed by purees from Nor×Nr, Nor×Rin and Punjab Chhuuhara.

According to the organoleptic observations, three exceptional colored purees (red, orange and yellow) were obtained from seven different colored genotypes. Among them, three genotypes have been acknowledged as ripening mutants on the foundation of their one-of-a-kind characters (*viz.* Rin×Nr, Nor ×Nr, Nor×Rin) which produced orange colored puree being low in their lycopene content. A shiny yellow colored cherry tomato (BC Cherry-1) was processed to obtain yellow colored puree. Rest three genotypes (Punjab Chhuuhara, Bidhan Purple and Dg×1422) produced normal red colored puree. However, amongst the seven genotypes studied, the best sensory scoring for brighter color was recorded in Bidhan Purple and BC Cherry-1. Additionally, in consideration to the overall acceptability ranking Bidhan Purple, Dg×1422 and BC Cherry-1 demonstrated higher scores.

CONCLUSION

Tomato puree was prepared from seven genotypes having different fruit colours. The appealing colors of the processed product contribute to enhanced consumer acceptability. An increase in TSS and lycopene contents and decrease in titratable acidity, ascorbic acid and β-carotene contents was recorded in processed product. Almost three-fold increase in TSS content and four and half-fold increase in lycopene content was observed from fresh to processed state. A significant reduction in the ascorbic acid content of the puree was observed across tomato genotypes. However, the decline in titratable acidity and β-carotene contents was not so much pronounced. Fruits of F₁ hybrids carrying three mutant genes (Rin×Nr, Nor×Nr, Nor×Rin) retained almost same nutritional values as compared to normal genotypes. The vibrant colours and high retention of nutritional quality of the processed products will also be attracted by the consumers as well as protect our health from cardiovascular diseases. Non ripening mutants were mostly used for breeding purposes, but once they harvested, these may remain unsold due to their unattractive colour. However, an attempt has been made in this study to process them and a unique orange coloured puree was obtained with fullest of their nutritive values.

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Conflict of interest

All authors declare that they have no conflict of interest.

REFERENCES

- Acharya, B., Dutta, S., Dutta, S. and Chattopadhyay, A. (2018). Breeding tomato for simultaneous improvement of processing quality, fruit yield and dual disease tolerance. *International Journal of Vegetable Science*. **24**(5): 407-423. doi:10.1080/19315260.2018.142764.
- Agarwal, S. and Rao, A.V. (2000). Tomato lycopene and its role in human health and chronic diseases. *Canadian Medical Association Journal*. **163**(6): 739-744.
- Akbudak, B., Bolkan, H. and Cohen, N. (2009). Determination of physicochemical characteristics in different products of tomato varieties. *International Journal of Food Sciences and Nutrition*. **60**: 126-138. https://doi.org/10.1080/09637480802446621.
- Anthon, G.E. and Barrett, D.M. (2010). Changes in tomato paste during storage and the effects of heating on consistency of reconstituted tomato paste. *Journal of Texture Studies*. **41**(3): 262-278. https://doi.org/10.1111/j.1745-4603.2010.00225.x.
- Anthon, G.E., LeStrange, M. and Barrett, D.M. (2011). Changes in pH, acids, sugars and other quality parameters during extended vine holding of ripe processing tomatoes. *Journal of the Science of Food and Agriculture*. **91**(7): 1175-1181. https://doi.org/10.1002/jsfa.4312.

- A.O.A.C. (2023). Official Methods of Analysis International. 22th Edn., Association of Official Analytical Chemists, Oxford University Press.
- Arah, I.K., Kumah, E.K., Anku, E.K. and Amaglo, H. (2015). An overview of post-harvest losses in tomato production in Africa: Causes and possible prevention strategies. *Journal of Biology, Agriculture and Healthcare*. **5(16)**: 78-88.
- Borguini, R.G. and Ferraz Da Silva Torres, E.A. (2009). Tomatoes and tomato products as dietary sources of antioxidants. *Food Reviews International*. **25(4)**: 313-325. <https://doi.org/10.1080/87559120903155859>.
- Chakraborty, I., Vanlalliani, Chattopadhyay, A. and Hazra P. (2007). Studies on processing and nutritional qualities of tomato as influenced by genotypes and environment. *Vegetable Science*. **34(1)**. 26-31.
- Chattopadhyay, A., Chakraborty, I.V.I. and Siddique, W. (2013). Characterization of determinate tomato hybrids: Search for better processing qualities. *Journal of Food Processing and Technology*. **4**: 222. doi:10.4172/2157-7110.1000222.
- Cox, S. (2000). I Say Tomayto, You Say Tomahto. Available online: <http://lamar.colostate.edu/~samcox/Tomato.html>.
- Farahnaky, A., Majdinasab, M., Majzoobi, M. and Mesbahi, G. (2010). A comparative study of physicochemical and rheological properties of Iranian tomato pastes. *International Journal of Food Engineering*. **6(1)**. <https://doi.org/10.2202/1556-3758.1571>.
- Harshita, G.T., Singh, G., Kondle, R. and Kathayat, K. (2024). Studies on the development and evaluation of tomato (*Lycopersicon esculentum*) blended papaya (*Carica papaya*) chutney. *Agricultural Science Digest*. **44(5)**: 982-986. doi: 10.18805/ag.D-5655.
- Hassan, H.A. and Abdel-Aziz, A.F. (2010). Evaluation of free radical-scavenging and anti-oxidant properties of black berry against fluoride toxicity in rats. *Food Chemistry and Toxicology*. **48**: 1999-2004.
- Hegde, V., Shilpa, R., Prasad, D., Theertha, D. and Raghotham, K. (2025). Development of tomato products and their nutrient composition. *Asian Journal of Dairy and Food Research*. **26(2)**: 94-97.
- Hossain, M.N., Fakrudin, M.D. and Islam, M. N. (2011). Effect of chemical additives on the shelf life of tomato juice. *American Journal of Food Technology*. **6(10)**: 914-923.
- Kaur, G. and Aggarwal, P. (2025). Effect of chemical preservation over thermal processing on storage stability of tomato juice. *Asian Journal of Dairy and Food Research*. **34(1)**: 49-53. doi: 10.5958/0976-0563.2015.00010.X.
- Kishore, K., Pathak, K.K., Rohit, K.A., Shukla, R.S. and Bharali, R.B. (2011). Effect of storage temperature on physico-chemical and sensory attributes of purple passion fruit (*Passiflora edulis sims*). *Journal of Food Science and Technology*. **48(4)**: 484-488.
- Kitinoja, L. and Kader, A.A. (2015). Measuring postharvest losses of fresh fruits and vegetables in developing countries. The Postharvest Education Foundation Paper 15-02. http://postharvest.org/PEF_White_Paper_15-02_PHFV_measurement.pdf.
- Kundan, K., Pathak, K.A., Rohit, S., Rinku, B. (2011). Effect of storage temperature on physico-chemical and sensory attributes of purple passion fruit (*Passiflora edulis Sims*). *Journal of Food Science and Technology*. **48**: 484-488. doi: 10.1007/s13197-010-0189-8.
- Kuvendziev, S., Lisichkov, K., Marinkovski, M., Stojchevski, M., Dimitrovski, D. and Andonovikj, V. (2024). Valorization of tomato processing by-products: Predictive modeling and optimization for ultrasound-assisted lycopene extraction. *Ultrasonics Sonochemistry*. **110**: 107055.
- Mirondo, R. and Barringer, S. (2015). Improvement of flavor and viscosity in hot and cold break tomato juice and sauce by peel removal. *Journal of Food Science*. **80(1)**: S171-S179. <https://doi.org/10.1111/1750-3841.12725>.
- Nath, A., Deka, B.C., Singh, A., Patel, R.K., Paul, D., Misra, L.K. and Ojha, H. (2011). Extension of shelf life of pear fruits using different packaging materials. *Journal of Food Science and Technology*. **49(5)**: 556-563. [10.1007/s13197-011-0305-4](https://doi.org/10.1007/s13197-011-0305-4).
- Panse, V.G. and Sukhatme, P.V. (1985). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.
- Perveen, R., Suleria, H.A.R., Anjum, F.M., Butt, M.S., Pasha, I. and Ahmad, S. (2015). Tomato (*Solanum lycopersicum*) carotenoids and lycopenes chemistry; metabolism, absorption, nutrition and allied health claims- A comprehensive review. *Critical Reviews in Food Science and Nutrition*. **55(7)**: 919-929.
- Purkayastha, M.D. and Mahanta, C.L. (2011). Physicochemical properties of five different tomato cultivars of Meghalaya and their suitability in food processing. *African Journal of Food Science*. **5(12)**: 657-667.
- Rajan, A., Kumar, S., Sunil, C.K., Radhakrishnan, M. and Rawson, A. (2022). Recent advances in the utilization of industrial byproducts and wastes generated at different stages of tomato processing: Status report. *Journal of Food Processing and Preservation*. **46(11)**: e17063.
- Ranganna, S. (2017). In: Handbook of Analysis and Quality Control for Fruits and Vegetable Products. 2nd Edition, Tata McGraw-Hill Publication Company Ltd. New Delhi.
- Salunkhe, D.K., Jadhav, S.J. and Yu, M.H. (1974). Quality and nutritional composition of tomato fruit as influenced by certain biochemical and physiological changes. *Qualitas Plantarum*. **24(1)**: 85-113.
- Shatta, A.A.B., Youssef, K.M., Al Sanabani, A.S. and El Samahy, S.K. (2017). Impact of processing steps on physicochemical and rheological properties of tomato paste (cold-break). *MOJ Food Processing and Technology*. **5(2)**: 263-271.
- Shi, J. and Maguer, M.L. (2000). Lycopene in tomatoes: chemical and physical properties affected by food processing. *Critical Reviews in Food Science and Nutrition*. **40(1)**: 1-42. <https://doi.org/10.1080/10408690091189275>.
- Siddiqui, M.W., Chakraborty, I., Hazra, P. and Ayala-Zavala, J. (2014). Characterization of quality indices on storage of puree of mutant (dg and og c) and normal tomatoes. *Acta Alimentaria*. **43(3)**: 426-436. doi:10.1556/aalim.43.2014.3.9.
- Singh, H., Kumar, S. and Mittal, S. (2011). Value chains of agricultural commodities and their role in food security and poverty alleviation- A synthesis. *Agricultural Economics Research Review*. **24(1)**: 169-181.
- Story, E.N., Kopec, R.E., Schwartz, S.J. and Harris, G.K. (2010). An update on the health effects of tomato lycopene. *Annual Review of Food Science and Technology*. **1(1)**: 189-210. doi: 10.1146/annurev.food.102308.124120.

- Thamburaj, S. (1998). Breeding for High Quality Vegetable. In: Souvenir of National Symposium on Emerging Scenario in Vegetable Research and Development Published by IIVR, Varanasi, India, pp. 53-59.
- Turhan, A. and Seniz, V. (2009). Estimation of certain chemical constituents of fruits of selected tomato genotypes grown in Turkey. *African Journal of Agricultural Research*. **4(10)**: 1086-1092.
- Vyrodova, A.P. (1988). Content of β -carotene in Different Vegetables, In: Physiology and Biochemistry of Cultivated Plants. **20(2)**: 167-171.
- Wang, C., Minhao, L., Xinyu, D., Abu-Izneid, T., Abdur, R., Khan, Z., Saikat, M., Emran, T.B., Aljohani, A.S.M., Alhumaydhi, F.A., Thiruvengadam, M. and Suleria, H.A.R. (2023). Phytochemical and nutritional profiling of tomatoes; Impact of processing on bioavailability- A comprehensive review. *Food Reviews International*. **39(8)**: 5986-6010.
- Waskar, D.P., Khedkar, R.M. and Garande, V.K. (1999). Effect of post-harvest treatments on shelf life and quality of pomegranate in evaporative cool chamber and ambient conditions. *Journal of Food Science and Technology*. **36(2)**: 114-117.
- Wu, X., Yu, L. and Pehrsson, P.R. (2022). Are processed tomato products as nutritious as fresh tomatoes? Scoping review on the effects of industrial processing on nutrients and bioactive compounds in tomatoes. *Advances in Nutrition*. **13(1)**: 138-151.
- Young, T.E., Juvik, J.A. and Sullivan, J.G. (1993). Accumulation of the components of total solids in ripening fruits of tomato. *Journal of the American Society for Horticultural Science*. **118(2)**: 286-292.
- Zhang, J., Liu, S., Zhu, X., Chang, Y., Wang, C., Ma, N., Wang, J., Zhang, X., Lyu, J. and Xie, J. (2023). Comprehensive evaluation of tomato fruit quality and identification of volatile compounds. *Plants*. **12(16)**: 2947. <https://doi.org/10.3390/plants12162947>.
- Zuorro, A. and Lavecchia, R. (2010). Mild enzymatic method for the extraction of lycopene from tomato paste. *Biotechnology and Biotechnological Equipment*. **24(2)**: 1854-1857. <https://doi.org/10.2478/V10133-010-0028-0>.