Biochemical and phytochemical characteristics of different cultivated tomato varieties and their juice

ABSTRACT

Tomato (Lycopersicon esculentum) is quantitatively the second highest vegetable consumed in the world after potato. Two different tomato varieties ('Abhinav' and 'Anand Roma') and their juices was analysed for biochemical and phytochemical characteristics and compared using independent T test. The results revealed that degree brix varied from 4.68˚ to 4.81˚ in tomatoes and 4.77˚ to 5.09˚ in juices, and a pH ranged from 4.18 to 4.35, corresponding to a total acidity of 0.32% to 0.41% citric acid equivalents in both varieties of tomatoes and juices. Ascorbic acid of both the variety ranged between 25.37 to 28.18 mg/100 g in tomato, while it varied between 24.98 to 25.83 mg/100 g in tomato juice. The lycopene content ranges from 7.41 to 8.83 mg/100 g and 6.05 to 6.68 mg/100 g in tomato and tomato juice, respectively. A significant ($p<0.05$) difference between 'Abhinav' and 'Anand Roma' varieties was found in acidity, ash, ascorbic acid and lycopene content, whereas the rest of the parameters were found non-significant ($p>0.05$).

Keywords: Tomato, Abhinav, Anand Roma, Ascorbic acid, Lycopene

1. INTRODUCTION

Tomatoes (*Solanum lycopersicum*) are widely recognized as one of the most popular and versatile vegetable consumed globally. It was originated in the lower Andes region of South America and were cultivated by the Aztecs in Mexico, forming a remarkable history over centuries (Bergougnoux et al., 1). The tomato, recognized as protective food, holds the distinction of being the second largest vegetable crop worldwide after the potato (Karniel et al., 2). The estimated area and production of tomatoes in India was about 8,45,000 ha and 21.181 million metric tonnes respectively, in the year 2021 and India is the second largest producer in the world after China (FAO, 3).

Tomatoes are commonly consumed raw in salads, cooked as a vegetable, and used in various dishes. Moreover, a significant portion of the global tomato crop is processed to produce products such as canned tomatoes, tomato juice, ketchup, puree, sun-dried tomatoes or dehydrated pulp (Meng et al., 4). Tomatoes are widely utilized for culinary purposes and are highly regarded for their nutritional and health benefits. They have a rich profile of vitamins, minerals, fiber, protein, carotenoids, and phytosterols (Ali et al., 5). Among these components, lycopene, beta-carotene, and phenolic compounds stand out and have been associated with numerous health-promoting properties, such as antioxidant, anti-inflammatory, and anticancer activities. Additionally, these compounds play vital roles in neutralizing harmful reactive oxygen species, regulating enzymatic activities, and inhibiting cellular damage and proliferation (Devasagayam and Sainis, 6). The chemical composition of different varieties has a moisture content ranging between 92.7 to 95.8% (Abdullahi et al., 7). The carbohydrate content is ranged from 3.92 to 5 g, 0.59 to 1.06 g, 0.2 to 0.8 g lipid content, 0.7 to 2 g fiber of

100 g tomatoes (USDA, 8). pH, TSS and titratable acidity of tomato ranges from 3.7 to 4.4, 4.07 to 5.5 ˚Brix and 0.39 to 0.55 %, respectively (Suárez et al., 9). Tomato also contains vitamins and phytochemicals especially vitamin C and lycopene. It differs according to the variety, cultivation type, processing methods. In tomatoes, vitamin C is in the range of 7.65 to 59.4 mg/100 ml and lycopene is 5.02 to 11.11 mg/100 ml (Sánchez-Moreno et al., 10; Ali et al., 5). The nutritional composition of tomatoes can vary significantly depending on factors such as variety, cultivation practice, ripeness, and storage condition.

This study aims to conduct a comprehensive nutritional and compositional analysis of two distinct tomato varieties (‘Abhinav’ and ‘Anand Roma’) commonly grown and consumed in middle Gujarat region to assess the change in the whole product and juice.

2. MATERIAL AND METHODS

In this study, different biochemical and phytochemical characteristics of two tomato varieties, ‘Abhinav’ and ‘Anand Roma’, were analyzed and are presented in Table 1. The tomato juices were also analyzed to find the changes after processing of tomato into juices and the results are shown in Table 2. The pH values of the ‘Abhinav’ tomato found to be 4.17, while it was 4.31 for ‘Anand Roma’ tomato. Total soluble solids (TSS) in tomatoes of ‘Anand Roma’ were higher i.e. 5.05 ˚Brix compared to ‘Abhinav’ tomatoes (4.51 ˚Brix). Indian tomato varieties like ‘Arka Vishesh’, ‘Arka Apeksha’ and ‘Arka Ashish’ are all having TSS in the range of 4 to 4.8 ˚Brix (IIHR, 13). High TSS in tomatoes is useful for making tomato juice and also for ketchup, sauce, and puree.

3. RESULTS AND DISCUSSION

Table 1. Comparison of Physiochemical, proximate and phytochemical of Abhinav and Anand Roma variety tomatoes

Parameters	Abhinav var.	Anand Roma var.	t-test value	Significance
pH	4.18	4.35	-1.13	NS
TSS (˚Brix)	4.68	4.81	-0.61	NS
Total acidity (% of citric acid)	0.41^{a}	0.32^{b}	4.13	*
Moisture (%)	95.31	95.19	0.89	NS
Protein (g)	0.61	0.73	-3.40	NS
Lipid (g)	0.17	0.21	-2.75	NS
Carbohydrate (g)	3.55	3.38	1.73	NS
Total fiber (g)	0.31	0.37	-1.40	NS
Ash (g)	0.36^{b}	0.49^{a}	-5.63	**
Ascorbic acid (mg/100 g)	28.18^{a}	25.37^{b}	6.01	**
Lycopene (mg/100 g)	7.41^{a}	8.83^{a}	-2.83	*

Note: Results were expressed as mean ± SD. The rank symbols (a to b) were assigned based on the t-test values and significance level at α = 0.05. "NS" indicates a non-significant, *significant and ** highly significant difference between the two varieties for the respective parameter.

The total acidity was found significantly (p = 0.05) higher in ‘Abhinav’ varieties as compared to the ‘Anand Roma’ variety. The mean values of pH, TSS and total acidity are in line with the previously reported values in the range of 3.7 to 4.4, 4.07 to 5.5 ˚Brix and 0.39 to 0.55 %, respectively (Boulbiga et al., 14; Suárez et al., 9). The moisture content of ‘Abhinav’ and ‘Anand Roma’ varieties were respectively 95.31% and 95.19%, which is consistent with the findings of Suarez et al. (9). The protein and fat content of tomatoes, were 0.61, 0.73 % and

0.17 and 0.21 %, respectively, for ‘Abhinav’ and ‘Anand Roma’ varieties and were not having significant difference. However, ‘Abhinav’ tomatoes contained 0.36 g of ash, while ‘Anand Roma’ tomatoes had 0.49 g which is similar to data reported in the literature (Oke et al., 15; Suárez et al., 9). The difference in ash content between the two varieties was highly significant (p = 0.01), with ‘Anand Roma’ showing a higher ash content. In fresh tomatoes, the ‘Abhinav’ variety exhibited a higher content of ascorbic acid (28.18 mg/100 g) compared to the ‘Anand Roma’ variety (25.37 mg/100 g), which is within the range of 7.65 to 59.4 mg/100 g (Sánchez-Moreno et al., 10). The vitamin C content in the two varieties of tomato juices was found highly significant (p = 0.05). In fresh tomatoes, the ‘Abhinav’ variety had a lower lycopene content (7.41 mg/100 g) compared to the Anand Roma variety (8.83 mg/100 g) which was statistically significant (p = 0.05), with Anand Roma tomato.

Processing of food results in a change or decrease in the nutritional and phytochemical compounds, those changes were evaluated for different biochemical characteristics of ‘Abhinav’ and Anand Roma varieties tomato juice as shown in Table 2.

Table 2. Comparison of Physiochemical, proximate and phytochemical of Abhinav and Anand Roma variety tomato juice

Parameters	Abhinav var.	Anand Roma var.	t-test value	Significance
pH	4.17	4.31	-2.19	NS
TSS (˚Brix)	4.77[b]	5.09[a]	-3.73	*
Total acidity (% of citric acid)	0.43[a]	0.35[b]	2.99	*
Moisture (%)	95.23	94.92	2.70	NS
Crude protein (g)	0.58	0.71	-3.15	NS
Crude fat (g)	0.15[b]	0.20[a]	-4.84	*
Carbohydrate (g)	3.71	3.78	-0.32	NS
Crude fiber (g)	0.27	0.31	-2.37	NS
Ash (g)	0.33[b]	0.41[a]	-9.81	**
Ascorbic acid (mg/100 g)	25.83	24.98	1.37	NS
Lycopene (mg/100 g)	6.05[b]	6.68[a]	-2.91	*

Note: Results were expressed as mean. The rank symbols (a to b) were assigned based on the t-test values and significance level at α = 0.05. "NS" indicates a non-significant, *significant and ** highly significant difference between the two varieties for the respective parameter.

The TSS of Anand Roma was found higher compared to ‘Abhinav’ variety tomato juice, so the Anand Roma varieties juice might be suitable for the preparation of juices that will meet the FSSAI standards viz. TSS should be a minimum 5 ˚Brix. Whereas the ‘Abhinav’ varieties tomato can be utilized for the preparation of tomato crush, puree, paste, sauce, ketchup etc. However, the paired t test between the ‘Abhinav’ variety tomato before and after processing into juice shows non-significant of TSS (Table 3). The lipid, ash content in ‘Abhinav’ variety juice was shown a significant difference between the varieties.

Table 3. Paired sample t test for Abhinav variety tomato before and after processing into juice

Pair	Parameters	Paired Differences				t value	Sig. (2-tailed)
		Mean	SD	95% Confidence Interval of the Difference			
				Lower	Higher		
Pair 1	pH BP - pH AP	0.01	0.27	-0.66	0.67	0.04	0.970^{NS}
Pair 2	TSS BP - TSS AP	-0.22	0.18	-0.66	0.21	-2.20	0.159^{NS}
Pair 3	Titratable acidity BP - Titratable acidity AP	-0.02	0.08	-0.22	0.18	-0.43	0.707^{NS}
Pair 4	Moisture BP - Moisture AP	0.08	0.09	-0.13	0.29	1.56	0.259^{NS}
Pair 5	Protein BP - Protein AP	0.03	0.06	-0.13	0.19	0.90	0.464^{NS}
Pair 6	Fat BP - Fat AP	0.02	0.01	0.00	0.03	5.00	0.038*
Pair 7	Carbohydrate BP - Carbohydrate AP	-0.16	0.19	-0.63	0.31	-1.45	0.284^{NS}
Pair 8	Crude fibre BP - Crude fibre AP	0.03	0.01	0.02	0.05	10.00	0.010**
Pair 9	Ash BP - Ash AP	0.03	0.05	-0.08	0.15	1.22	0.346^{NS}
Pair 10	Ascorbic acid BP - Ascorbic acid AP	2.35	0.20	1.85	2.85	20.28	0.002**
Pair 11	Lycopene BP - Lycopene AP	1.36	0.60	-0.13	2.85	3.92	0.049*

(BP: Before processing; AP: After processing; SD: Standard deviation; Sig.: Significance; *Significant; ** Highly significant; ^{NS} Non significant)

The ascorbic acid content in 'Abhinav' and Anand Roma variety were 25.83 and 24.98 mg/100 g, respectively. The t test showed a non-significant (p = 0.05) difference between these varieties of tomato juice. However, paired t test shows that the highly significant difference for 'Abhinav' variety, that is interesting to note that the ascorbic acid content decreased in the tomato juices compared to fresh tomatoes, similar decrease in ascorbic acid while juicing was reported by Adubofuor et al. (16). This reduction could be attributed to the processing and storage of the juice, and while extracting juice, oxygen comes in to contact with the ascorbic acid which might change the ascorbic acid into dehydroascorbic acid, which might lead to a slight degradation of ascorbic acid in tomato juice (Mills et al., 17; Koh et al., 18). The lycopene content was 6.05 and 6.68 mg/100 g in 'Abhinav' and Anand Roma varieties tomato juice, the independent t-test showed a significant (p = 0.05) difference between the two variety and paired t test shows that the lycopene content was not changed even after processing (Table 3 and 4).

A high amount of lipid, ash and lycopene content and a similar range of other characteristics as 'Abhinav' was depicting that the Anand Roma varieties was having comparatively good nutritional value as compared to 'Abhinav' varieties tomato juice. The Anand Roma varieties tomato juice also has a high amount of total soluble solids that might be useful for industrialists look the varieties for particularly juicing purposes and whereas 'Abhinav' varieties had a

comparatively higher amount of ascorbic acid. These findings could be valuable for consumers and processors looking to incorporate specific nutrients, such as ascorbic acid or lycopene, into their processed food products such as juices, purees, ketchup etc.

Table 4. Paired sample t test for Anand Roma variety tomato before and after processing into juice

Pair	Parameters	Paired Differences				t value	Sig. (2-tailed)
		Mean	SD	95% Confidence Interval of the Difference			
				Lower	Higher		
Pair 1	pH BP - pH AP	0.04	0.24	-0.54	0.63	0.32	0.78^{NS}
Pair 2	TSS BP - TSS AP	-0.11	0.15	-0.49	0.27	-1.20	0.35^{NS}
Pair 3	Titratable acidity BP - Titratable acidity AP	-0.03	0.01	-0.05	-0.01	-3.20	0.14^{NS}
Pair 4	Moisture BP - Moisture AP	0.29	0.23	-0.29	0.86	2.16	0.16^{NS}
Pair 5	Protein BP - Protein AP	0.02	0.07	-0.16	0.20	0.56	0.63^{NS}
Pair 6	Fat BP - Fat AP	0.01	0.03	-0.06	0.07	0.44	0.70^{NS}
Pair 7	Carbohydrate BP - Carbohydrate AP	-0.40	0.41	-1.42	0.62	-1.70	0.23^{NS}
Pair 8	Crude fibre BP - Crude fibre AP	0.06	0.06	-0.09	0.21	1.80	0.21^{NS}
Pair 9	Ash BP - Ash AP	0.08	0.02	0.03	0.14	6.24	0.03*
Pair 10	Ascorbic acid BP - Ascorbic acid AP	0.40	1.22	-2.63	3.42	3.56	0.08^{NS}
Pair 11	Lycopene BP - Lycopene AP	2.15	0.99	-0.30	4.61	3.77	0.06^{NS}

(BP: Before processing; AP: After processing; SD: Standard deviation; Sig.: Significance, *Significant; ^{NS} Non significant

4. CONCLUSION

The comparison between the 'Abhinav' and Anand Roma tomato varieties observed notable distinction in the total soluble solids, acidity, ash and phytochemical contents, where Anand Roma exhibited significantly higher levels compared to Abhinav in both fresh tomatoes and their respective juices except in ascorbic acid where Abhinav varieties had slightly higher amounts than 'Anand Roma'. The high levels of TSS, lycopene and ascorbic acid is useful for making good quality tomato based processed products such as canned tomatoes, juices, purees, ketchup, sauce and other tomato based products.

REFERENCES

1. Bergougnoux, V. 2014. The history of tomato: from domestication to biopharming. *Biotechnol. Adv.*, 32, 170-189.

2. Karniel, U. Koch, A. Zamir, D. and Hirschberg, J. 2020. Development of zeaxanthin-rich tomato fruit through genetic manipulations of carotenoid biosynthesis. *Plant Biotechnol. J.*, 18, 2292-2303.
3. Food and Agricultural Organization of United Nations. 2023. *Crops and Livestock Products*. Retrived from https://www.fao.org/faostat/en/#data/QCL.
4. Meng, F. Li, Y. Li, S. Chen, H. Shao, Z. Jian, Y. ... and Wang, Q. 2022. Carotenoid biofortification in tomato products along whole agro-food chain from field to fork. *Trends in Fd. Sci. & Technol.*, 124, 296-308.
5. Ali, M.Y. Sina, A.A. Khandker, S.S. Neesa, L. Tanvir, E.M. Kabir, A.... and Gan, S.H. 2020. Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: A review. *Foods*, *10*, 45.
6. Devasagayam, T.P.A. and Sainis, K.B. 2002. Immune system and antioxidants, especially those derived from Indian medicinal plants. *Indian J. of Experimental Biol.,* 40, 639-655.
7. Abdullahi, I.I. Abdullahi, N. Abdu, A.M. and Ibrahim, A.S. 2016. Proximate, mineral and vitamin analysis of fresh and canned tomato. *Biosciences Biotechnol. Res. Asia*, 13, 1163-1169.
8. U.S. Department of Agriculture. 2016. Tomatoes, red, ripe, raw, year-round average. U.S. Dept. Agr., Washington, D.C. Retrieved from https://fdc.nal.usda.gov/fdc-app.html#/food-details/170457/nutrients
9. Suárez, M.H. Rodríguez, E.R. and Romero, C.D. 2008. Chemical composition of tomato (*Lycopersicon esculentum*) from Tenerife, the Canary Islands. *Fd. Chemistry*, 106, 1046-1056.
10. Sánchez-Moreno, C. Plaza, L. De Ancos, B. and Cano, M.P. 2006. Nutritional characterisation of commercial traditional pasteurised tomato juices: carotenoids, vitamin C and radical-scavenging capacity. *Fd. Chemistry*, 98, 749-756.
11. Ranganna, S. 1986. *Handbook of analysis and quality control for fruit and vegetable products*. Tata McGraw-Hill Education.
12. A.O.A.C. Association of Analytical Chemists. 2000. Official Methods of Analysis of A.O.A.C. International, 18th *ed*. A.O.A.C. International: Gaithersburg, MD, USA.
13. Indian Institute of Horticultural Research. 2023. Tomato. *ICAR-IIHR*, Bengaluru. Retrieved from https://iihr.res.in/varieties-crop-name/tomato
14. Oboulbiga, E.B. Parkouda, C. Sawadogo-Lingani, H. Compaoré, E.W. Sakira, A.K. and Traoré, A.S. 2017. Nutritional composition, physical characteristics and sanitary quality of the tomato variety Mongol F1 from Burkina Faso. *Fd. and Nutr. Sci.*, 8, 444.
15. Oke, M. Ahn, T. Schofield, A. and Paliyath, G. 2005. Effects of phosphorus fertilizer supplementation on processing quality and functional food ingredients in tomato. *J. of Agri. and Fd. Chemistry*, 53, 1531-1538.
16. Adubofuor, J. Amankwah, E.A. Arthur, B.S. and Appiah, F. 2010. Comparative study related to physico-chemical properties and sensory qualities of tomato juice and cocktail juice produced from oranges, tomatoes and carrots. *African J. of Fd. Sci.*, 4, 427-433.
17. Mills, M.B. Damron, C.M. and Roe, J.H. 1949. Ascorbic acid, dehydroascorbic acid, and diketogulonic acid in fresh and processed foods. *Analytical Chemistry*, 21, 707-709.

18. Koh, E. Charoenprasert, S. and Mitchell, A.E. 2012. Effects of industrial tomato paste processing on ascorbic acid, flavonoids and carotenoids and their stability over one-year storage. *J. of the Sci. of Fd. and Agri*., 92, 23-28