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NUTRITIONAL PROFILE AND SHELF LIFE OF TOMATOES (*Solanum Sp.*) OF MEGHALAYA, INDIA

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ABSTRACT

This research assessed the nutritional qualities of tomatoes cultivated in different parts of Meghalaya, an Indian plateau state with a chilly environment where tomato farming takes place all year round. In the research lab of the Department of Horticulture at North-Eastern Hill University (NEHU), Tura campus, the analysis was carried out from 2021 to 2023. In order to evaluate characteristics including ascorbic acid, lycopene, proteins, carbohydrates, phenols, total sugars, reducing and non-reducing sugars, total soluble solids, moisture content, and dry matter, a completely randomized design (CRD) utilized. The results showed that the maximum levels of ascorbic acid and moisture were found in the genotypes collected from Resubelpara village. The highest levels of lycopene and total sugars were found in genotypes collected from Williamnagar. Protein and phenol levels were highest in genotypes collected from Nongpoh. Whereas total soluble solids and carbs were highest in genotypes collected from Khliehriat. Genotypes collected from Tura and Dalu displayed the highest levels of reducing sugars and dry matter, respectively. The genotypes collected from Mawkyrwat have the highest levels of non-reducing sugars. When compared to Food Agriculture Organisation and United States Department of Agriculture criteria, Meghalayan tomatoes were found to have greater nutritional quality overall, particularly in dry matter and ascorbic acid. Improved shelf life was shown by the fact that all eleven genotypes exceeded the FAO's dry matter standard (4.6–5.6 mg). Additional research on breeding, processing, and adaptability is supported by these findings, which point to nutritional superiority and longer shelf life.

(Key words: Antioxidant, ascorbic acid, dry matter, lycopene,shelf life, tomato)

INTRODUCTION

Second only to China in terms of agricultural output, India accounts for 15% of the world's vegetable production (Rajkumar and Anusuya, 2023). The majority of Northeastern agriculture is subsistence-based, rainfed, and monocropped (Ezung *et al*., 2012). Vegetables such as tomatoes (*Solanum Sp*.) are consumed both raw and cooked, and they are the most economically important crop in the world in terms of cultivation area. It is a fruit or vegetable that is eaten as part of a diet and contains vital nutrients and bioactive substances that lower the risk of coronary heart disease and numerous types of cancer, among other health issues (Pernice *et al*., 2010). Researchers have highlighted that tomatoes described as full-flavoured are characterized by a low level of titratable acidity, a high content of total sugars and soluble solids, and are a good source of vitamins A and C (Purkayastha , 2011). All tomato-based products include a number of micronutrients, including potassium, vitamin C, vitamin E, folate, and antioxidants (Siddiqui *et al*., 2015). Rutin [quercetin 3-O-rutinoside; quercetin-3-(6-rhamnosylglucoside)] has been observed to be the main flavonoid component in ripe tomatoes. With its antioxidative, antiproliferative, and anti-inflammatory qualities, flavonoids are a class of chemicals with a C6–C3–C6 structure (Selahle *et al*., 2014). Two cultivars, Alida F1 and Ege F1, have ascorbic acid contents ranging from 7.13 to 11.94 mg 100^{-1} g fresh weight. Trans-ferulic acid, rutin, p-coumaric acid, caffeic acid, and chlorogenic acid are the primary phenolic chemicals found in both cultivars (Kara *et al*., 2017). Tomato fruits have important nutraceutical properties and rich in carotenoids, polyphenols, organic acids, soluble sugars, minerals, and especially vitamins C and E along with various volatile compounds (Kurina *et al.*, 2021). Lycopene, which makes up to 90% of all carotenoids, has the strongest antioxidant properties and is primarily responsible for tomatoes' red colour (Levya *et al*., 2014). Approximately 25 mg of lycopene day^{-1} seems to be the most advantageous intake. Additionally, Rahangdale and Wadhai (2023) noted that tomato fruits kept their freshness for a long period following organic coating.

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This work's primary objective was to identify the kinds and concentrations of chemical characteristics and ingredients found in the different genotypes of tomatoes that are accessible in Meghalaya, as well as to assess the nutritional value of each kind. An attempt was made to determine how closely the experimental tomatoes' specifications and constituents match the ideal values set by the United States Department of Agriculture (USDA) and the Food and Agriculture Organization (FAO).

MATERIALS AND METHODS

Table 1 lists the eleven tomato genotypes that were gathered every February for three years (2021–2023) from eleven different places. Analyses were conducted at the NEHU Tura campus's Department of Horticulture. The 2,6-dichlorophenol-indophenol titration was used to estimate an ascorbic acid (Ranganna, 1997). Anthrone method was used to determine carbohydrates (Morris, 1948) and Lowry method was used to determine proteins (Lowry *et al*., 1951). Using the Folin-Ciocalteu reagent and spectrometry, respectively, lycopene and phenol were examined (Ranganna, 1986). Fehling's method was used by Lane and Eynon (1923) to determine the total, reducing, and non-reducing sugars. Ranganna (1986) used a hand refractometer to quantify total soluble solids (TSS). Ranganna (1986) assessed the dry matter and moisture contents using gravimetric methods. Using ICP-OES, heavy metals and elements (P, Na, K, and Se) were examined.

Table 1.Tomato genotypes collection from different locations and their physical characteristics

Genotypes collection from location (Villages)	Districts	Shape	Average diameter (cm)
Ampati	South west Garo Hills	Egg like	5.0±0.2
Dalu	West Garo Hills	Round	5.1±0.2
Resubelpara	North Garo Hills	Egg like	4.4 ±0.2
Tura	West Garo Hills	Cherry like	1.9 ±0.1
Baghmara	South Garo Hills	Round	4.9±0.2
Williamnagar	East Garo Hills	Cherry like	2.0±0.1
Shillong	East Khasi Hills	Egg like	4.2±0.2
Jowai	West Jaintia Hills	Round	5.1±0.2
Nongpoh	Ri-Bhoi	Egg like	3.8±0.1
Mawkyrwat	South West Khasi Hills	Round	4.6 ±0.2
Khliehriat	East Jaintia Hills	Egg like	4.3 ±0.2

Sample preparation

Tomato pericarps were weighed air-dried for 7 days, ground into powder, then oven-dried at 60–70°C before analysis.

Statistical analysis

Data were statistically analyzed using ANOVA following Gomez and Gomez (1996), using SPSS v15.0.

RESULTS AND DISCUSSION

Dry matter

Variation in all eleven tomato genotypes was observed significantly. All samples had dry matter content above the FAO's permissible limit (4.6–5.6 mg), suggesting longer shelf life. The overall average of dry matter was 8.87%. Significantly higher dry matter content was found in genotypes collected from Dalu, Jowai, Williamnagar, Khliehriat and Mawkyrwat. Genotypes of Baghmara showed moderate dry matter and lower in genotypes collected from Shillong, Tura and Nongpoh but least in genotypes of Ampati and Resubelpara. Similar study conducted by Felföldi *et al*. (2022) recorded dry matter in the range of 3.77% (AS 300) to 6.88% (AS 400) across four different tomato genotypes.

Moisture content

Significant variation was observed among genotypes studied. All genotypes had moisture content below USDA's average range (94.2–95.2g), supporting improved shelf life. The average moisture content level was noted i.e 90.83%. Highest moisture content showed by genotypes collected from Resubelpara, Dalu, Shilling, ,Williamnagar and Nongpoh. Similarly moisture content was moderate in genotypes collected from Mawkyrwat, Khliehriat, Ampati, Tura and Jowai but lowest in Baghmara genotypes. Kedir *et al.* (2025) recorded that 95.31% was the average moisture content of fresh tomatoes.

TSS (Total Soluble Solids)

Significant variation in TSS was noted among the eleven genotypes studied. Highest TSS content was recorded by genotypes of Khliehriat, Jowai, Nongpoh, Shillong and Dalu. The moderate TSS showed by genotypes of Mawkyrwat, Tura Williamnagar, Ampati and Baghmara but lowest TSS content was observed by genotypes of Resubelpara. Average TSS of 5.40°Brix was found across the samples. Saviae *et al*. (2024) recorded TSS in the range of 4.77 - 6.47 °Brix in the tomato crops.

Ascorbic acid

Significant deviation in ascorbic acid concentration was recorded with in eleven genotypes. The average content of ascorbic acid was 58.48 mg100^{-1}g which was higher than the USDA average of 39.2 mg100^{-1}g. Highest ascorbic acid content was recorded in genotypes collected from Resubelpara, Khliehriat, Dalu and Baghmara and moderate in genotypes of Ampati, Tura and Nongpoh but lower in genotypes of Shillong and Williamnagar. The lowest ascorbic acid content was found in Jowai and Mawkyrwat. Felföldi *et al*. (2022) reported 20.65–28.03 mg100^{-1}g ascorbic acid in global genotypes.

Carbohydrates

All genotypes had lower carbohydrate content than the USDA average (55.8g100^{-1}g) with higher and significant variation. The average content of carbohydrate was 2.54%. Among the different genotypes studied, the genotypes of Khliehriat showed their significant over remaining genotypes in carbohydrate content but it was found higher in genotypes collected from Tura, Nongpoh, Baghmara, Jowai, Resubelpara, Ampati, Mawkyrwat and genotypes of Williamnagar showed the moderate content of carbohydrate . Least carbohydrate content was found in genotypes of Dalu and Shillong. Ali *et al*. (2020) found 5.96 g100^{-1}g carbohydrates content in average tomatoes.

Lycopene

High variation was observed in lycopene content among the eleven genotypes studied, with an average value of 2.84 mg. All genotypes had lycopene levels within the USDA permissible range (1.830–4.340 mg 100^{-1} g). Maximum content of lycopene was recorded in genotypes collected from Williamnagar and Nongpoh. Moderate level was found in genotypes from Tura, Resubelpara, Baghmara, Mawkyrwat, Dalu, and Khliehriat, while the lowest level was observed in genotypes from Shillong, Jowai, and Ampati. Felföldi *et al*. (2022) found that lycopene content in tomato in the range of 7.4 to 15.4 mg 100^{-1} g fresh weight, which was significantly higher than the values observed in this study.

Non-reducing sugar

The average quantity of non-reducing sugar was 1.83 g, with significant variation among the genotypes. The highest content was recorded in genotypes from Mawkyrwat and Khliehriat, followed by moderate level in genotypes from Williamnagar, Tura, Dalu, and Resubelpara. Lower level was noted in genotypes from Shillong, Baghmara, and Jowai, while the least content was observed in Ampati and Nongpoh. Raza *et al*. (2022) reported a range of 0.1–2% non-reducing sugar in tomatoes.

Phenols

Phenol content exhibited high variability across genotypes. All genotypes showed lower phenol content than the MDPI-reported value of 4.9 mg 100^{-1} g. Highest level of phenol was noted in genotypes from Nongpoh, followed by higher levels in Baghmara, Mawkyrwat, and Jowai. Moderate content was observed in genotypes from Khliehriat, Dalu, and Tura; lower level was seen in Resubelpara and Williamnagar, with the least content recorded in Shillong and Ampati. Marsic *et al*. (2011) reported phenol level in the range of 8.60 to 10.39 mg 100^{-1} g, depending on the growing conditions.

Protein

Protein content varied widely among genotypes, with an average of 5.66 g. All genotypes exceeded the USDA permissible limit (0.56–0.88 g 100^{-1} g). Highest protein content was found in genotypes from Nongpoh, followed by high levels in Resubelpara and Tura. Moderate level was recorded in Shillong, Khliehriat, Williamnagar and Dalu; lower level in Ampati and Mawkyrwat, and the least protein content was observed in genotypes from Jowai and Baghmara. Ali *et al.* (2020) reported an average protein content of 17.71 g 100^{-1} g in tomato.

Reducing sugar

Reducing sugar content showed the highest variation among traits. The average content across all genotypes was 1.87 g 100^{-1} g. The higher content of reducing sugar was observed in genotypes from Tura and Resubelpara, with high levels in Williamnagar and Dalu. Moderate level was noted in Shillong, Ampati and Nongpoh and lower in Jowai and Baghmara. Raza *et al*. (2022) reported reducing sugar contents in the range of 2.1% to 7.1% in tomato.

Total sugar

All genotypes had total sugar content below the reported average, with considerable variation among them. The uppermost level was observed in genotypes from Williamnagar and Tura, followed by higher values in Dalu and Resubelpara. Moderate level was noted in Shillong, Ampati and Jowai, lower in Khliehriat and Baghmara and the lowest in genotypes from Nongpoh and Mawkyrwat. According to Raza *et al*. (2022), total sugar content in tomatoes ranged between 2–8%.

Table 2. Average values of different physical constituents of the tomato genotypes 100^{-1} g

Genotypes collection from location (Villages)	Dry matter (%)	Moisture content (%)	TSS (^{0}Brix)
Ampati	7.69±0.01	90.67±0.03	4.78±0.02
Dalu	10.33±0.03	92.12±0.03	5.98±0.03
Resubelpara	7.39±0.01	92.54±0.03	3.97±0.01
Tura	8.02±0.02	90.19±0.03	5.02±0.03
Baghmara	8.89±0.02	87.02±0.02	4.77±0.02
Williamnagar	9.61±0.03	91.79±0.03	4.79±0.02
Shillong	8.61±0.02	91.88±0.03	6.01±0.03
Jowai	10.02±0.03	89.01±0.02	6.11±0.03
Nongpoh	8.00±0.02	91.58±0.03	6.02±0.03
Mawkyrwat	9.45±0.03	91.39±0.03	5.77±0.03
Khliehriat	9.57±0.03	90.98±0.03	6.23±0.03
Average	8.87	90.83	5.4
SE(m) ±	0.45	0.32	0.12
CD at 5%	1.35	0.96	036
Reference value	4.6-5.6mg 100^{-1}g, FAO,WHO	94.2-95.2g 100^{-1}g, USDA-NDB No. 100261	4.15-6.62g 100^{-1} g, FAO,WHO

1^{0}Brix: 1 gram of sucrose in 100 gram of solution. TSS: Total soluble solid, CD: Critical difference, SE(m): Standard error of the mean, USDA: United States Department of Agriculture, FAO: Food and Agriculture Organisation, NDB Number: National Nutrient Database Number, WHO : World Health Organisation

Table 3. Average values of different chemical parameters of the tomato genotypes 100^{-1}g

Genotypes collection fromlocation (Villages)	AA(mg)	CHO (g)	LC (mg)	NRS (g)	PN (mg)	PR (g)	RS (g)	TS(g)
Ampati	58.40±0.02	2.21±0.02	1.69±0.01	0.60±0.01	1.23±0.01	5.13±0.01	1.48±0.02	1.87±0.01
Dalu	59.92±0.02	1.71±0.01	2.69±0.02	1.40±0.02	1.97±0.01	5.21±0.01	2.77±0.02	3.76±0.03
Resubelpara	61.84±0.03	2.61±0.02	3.45±0.03	1.20±0.02	1.52±0.01	6.33±0.02	2.94±0.02	3.68±0.02
Tura	58.32±0.02	3.42±0.03	3.69±0.03	1.40±0.02	1.76±0.01	6.20±0.02	3.41±0.03	4.31±0.03
Baghmara	59.76±0.02	3.01±0.03	2.83±0.02	0.76±0.01	2.12±0.02	5.02±0.01	1.34±0.01	1.81±0.01
Williamnagar	57.02±0.02	1.86±0.01	3.98±0.03	2.40±0.02	1.45±0.01	5.23±0.01	2.83±0.02	4.52±0.03
Shillong	57.11±0.02	1.58±0.01	2.01±0.02	0.79±0.01	1.25±0.01	5.88±0.01	1.58±0.02	2.14±0.02
Jowai	56.32±0.01	2.69±0.02	1.78±0.01	0.70±0.01	2.08±0.02	5.04±0.01	1.38±0.01	1.86±0.01
Nongpoh	58.27±0.02	3.12±0.03	3.91±0.03	0.49±0.01	3.01±0.03	7.78±0.03	1.41±0.02	1.71±0.01
Mawkyrwat	56.28±0.01	2.11±0.02	2.79±0.02	5.21±0.03	2.11±0.02	5.12±0.01	0.49±0.01	1.41±0.01
Khliehriat	60.00±0.03	3.61±0.03	2.45±0.02	5.13±0.03	2.06±0.02	5.28±0.01	0.98±0.01	1.83±0.01
Average	58.48	2.54	2.84	1.83	1.87	5.66	1.87	2.63
SE(m) ±	0.51	0.06	0.11	0.15	0.07	0.07	0.18	0.14
CD at 5%	1.53	0.18	0.33	0.45	0.21	0.21	0.54	0.42
Reference value	12.3-25.9 mg100^{-1} g, USDA, NDB No.: 100261	3.84 g 100^{-1} g, USDA, NDB No. : 100261	1.830-4.340 mg100^{-1} g, USDA, NDB No. : 100261	0.011-1.425 g 100^{-1} g, FAO, WHO	4.9 mg 100^{-1} g, MDPI	0.56-0.88 g 100-1 g, USDA, NDB No. : 100261	1.130 - 2.273 g 100^{-1} g, FAO, WHO	1.67-5.52 g 100^{-1} g, FAO, WHO

AA: Ascorbic acid, CHO: Total carbohydrates, LC: Lycopene; NRS: Non-reducing Sugar; PN: Phenol; PR: Protein; RS: Reducing Sugar; TS: Total Sugar, CD: Critical difference, SE(m): Standard error of the mean, USDA: United States Department of Agriculture, NDB Number : National Nutrient Database Number, MDPI: Multidisciplinary Digital Publishing Institute and WHO: World Health Organisation, FAO: Food and Agriculture Organisation

Environmental, genetic, and agronomic factors combined to produce various chemical parameter levels in tomatoes from different regions, according to the results. Highest lycopene and total sugar contents were found in genotypes of Williamnagar. The highest levels of moisture and ascorbic acid content was found in Resubelpara genotypes. Phenol and protein contents were highest in Nongpoh genotypes, while total soluble solids and carbohydrate levels were highest in Khliehriat genotypes. Reducing sugar was highest in Tura genotypes and the highest dry matter content was noted in Dalu genotypes. Non-reducing sugar concentration was higher in Mawkyrwat genotypes. There are several elements that influence tomatoes' chemical makeup. Lycopene is enhanced by moderate temperatures and high levels of sunlight, while cooler climes retain moisture. Climate and weather, including temperature, rainfall, and sunlight, have an impact on metabolism.Nutrient intake is influenced by soil type, fertility, organic matter, and pH, which changes the amounts of protein, sugar, and phenol. Variation in nutrient accretion is caused by genetic variation among local genotypes. Topography and elevation can reduce ripening and increase antioxidants and sugars. Timing of harvest and agronomic techniques are also crucial. Lastly, the amount of acidity, sugar, lycopene, and ascorbic acid is affected by the maturity stage during harvest. Overall, Meghalayan tomatoes were found to have higher nutritional quality than average values reported by the Food and Agriculture Organization (FAO) and the United States Department of Agriculture (USDA), especially in terms of dry matter and ascorbic acid content. Interestingly, all eleven genotypes had dry matter contents over the FAO-recommended tolerable level of 4.6–5.6 mg, indicating a longer shelf life than normal tomatoes.

These findings demonstrate the improved nutritional value and longer shelf life of Meghalayan tomato genotypes. Subsequent studies might concentrate on increasing their commercial value via value-added processing, selective breeding, and assessing how well they adapt to different agroclimatic zones. Additionally, by providing recommendations for breeding, cultivation, and nutrition planning, the study emphasizes the significance of genetic variation in nutrient content

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