Journal of Food and Agriculture
Volume 17, Issue 02, December 2024
Print ISSN: 1800-4288, E. ISSN: 2613-8530
DOI: https://doi.org/10.4038/jfa.v17i2.5320

Impact of Transplants Age on the Nutritional Quality of Cherry Tomatoes

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ABSTRACT

The age of transplants for planting in a local environment is important for better quality cherry tomato (*Solanum lycopersicum* var. *cerasiforme)* production. A field experiment was conducted during the winter (October 2023 to March 2024) to evaluate the effect of transplant age at the time of planting on fruit quality parameters (total soluble solids (TSS), moisture, ash, fiber, fat, pH, and vitamin C) in two cherry tomato varieties: BARI tomato-11 (red-coloured fruits) and Philippines variety (yellow-coloured fruits). Cherry tomato plants were cultivated at four different transplant ages (21, 28, 35, and 42 days old) on the same day, and fruit quality parameters were measured in the ripe fruits. According to the results, there was a significant difference in all the studied fruit quality parameters, except for moisture content, among transplants of different ages, irrespective of variety. The TSS in fruit juice was higher (6.45) in 28-day-old transplants than in transplants of other ages. The vitamin C content in fruit pulp was higher (16.71 mg/100 mL) in 28-day-old transplants, which was statistically similar to that of fruits from 21-day-old transplants. Fat (0.20%) and ash (1.54%) contents in fruits were higher in 35-day-old transplants while the fruit fiber content (0.85%) was higher in 28-day-old transplants, which was statistically similar to that of 35-day-old transplants. Moreover, fruit quality parameters were significantly different between the varieties, except for TSS and moisture content. The BARI tomato-11 variety (red-coloured fruits) was more acidic (pH value of 4.03) and contained higher contents of ash (1.47%), fiber (0.85%), and vitamin C (16.56 mg/100 mL) than the Philippines variety (yellow-coloured fruits), irrespective of transplant age. Hence, it can be concluded that 28-day-old cherry tomato transplants are suitable for producing better quality fruits (higher TSS, fiber, and vitamin C contents).

Keywords: Cherry tomato, Nutritional value, Total soluble solids, Transplants age, Vitamin C.

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INTRODUCTION

The transplant age at the time of planting is an important factor affecting crop yield and quality (Silva *et al.*, 2021). The cherry tomato (*Solanum* *lycopersicum* var. *cerasiforme*) is a cultivated small variety of tomato, an important vegetable and economically important crop around the world (Lahoz *et al.,* 2016). Its fruits are consumed mainly as fruits than vegetables (Islam *et al.,* 2012; Ali *et al.,* 2021). It's a main source of vitamin C and B complexes in the form of beta-carotene, thiamin, niacin, riboflavin, and various important minerals for humans (Hanson 2003; Prema *et al.,* 2011; Dias, 2012; Koh *et al.,* 2012; Kumari *et al.,* 2017) and it plays an important role for preventing certain forms of cancers (Agarwal and Rao 2000; Radzevičius *et al.,* 2009). To improve the quality of different cherry tomatoes, it is essential to promote better varieties for growers (Saha and Rashid 2020). The nutritional and organoleptic quality of cherry tomatoes is one of the main objectives in the improved fresh tomato market (Rosello *et al.,* 2000). The optimum age of transplants affects both growth and yield however, generally, this factor is ignored by farmers (Saxena and Singh, 2019). Transplant age influences the desirable characteristics of fruit quality (Weston and Zandstra 1986; Widders, 1989). Therefore, it is necessary to conduct research on cherry tomato fruit quality at different transplant ages in different varieties (Utomo *et al.,* 2023). Little is known about suitable varieties and the effect of transplant age on the fruit quality of cherry tomatoes. Hence, this study aimed to assess the fruit nutritional quality of two cherry tomato varieties under different transplant ages to inform the best transplant age for cultivation.

MATERIALS AND METHODS

This field experiment was conducted at the Agricultural Field Research Center of Bangladesh Open University, Gazipur during the winter (October 2023 to March 2024). Monthly average maximum and minimum air temperature, mean temperature, rainfall, humidity, and sunshine hours of the experimental site during the study period are mentioned in Table 1.

The geographical location of the experimental site with the coordinates of latitude 23.9443^{0}N and longitude 90.3819^{0}E. The experimental area belongs to the Madhupur Tract Agro-ecological Zone (AEZ-28) (UNDP and FAO, 1988). In this experiment, four different transplant ages (21, 28, 35, and 42 days old) were used as treatments (factor A). Seeds were collected from BRAC Nursery at Gazipur in October

2023. To get different age seedlings, nursery sowing was started from 07 October 2023 at 7-day intervals up to 28 October 2023 in different nursery beds which were nourished similarly with the recommended practices. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 4 replications. Healthy and uniform-sized 21, 28, 35, and 42-day-old transplants were taken separately from the two different seedbeds. Transplanting of seedlings in all treatment plots was done on the same day i.e. 19 November 2023. The unit plot size was 2 m × 2 m and spacing was maintained at 50 cm × 50 cm between plants. The treatments were applied per raised bed. In each plot, 16 plants were grown. The tomato transplants were irrigated uniformly with one-day intervals to ensure good stand establishment in the field. Stalking was done with bamboo sticks to prevent plants fall on the ground due to their weak stems. Stacking facilitated management operations such as irrigation, inter tillage, pest control, and harvesting. In this experiment, red cherry tomato (cv. BARI tomato-11) and yellow cherry tomato (Philippines variety) were used as varietal treatment (factor B) (Figure 1). Five plants were randomly selected out of 16 plants from each experimental plot for data collection.

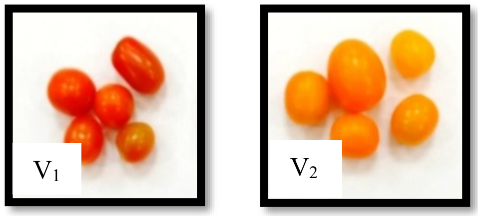

Figure 1. Cherry tomato varieties: BARI tomato 11 (V_1) and Philippines variety (V_2) used in the study.

Cherry tomato transplants that were 21, 28, 35, and 42 days old, all planted on the same date, took an average of 72 to 75 days to reach first harvest, regardless of the variety. Days to first harvest varied due to different genotypes (Hasan *et al.*, 2017). Two hundred grams of ripened fruit samples from each treatment were sent to the laboratory after harvesting for quality testing (Figure 2).

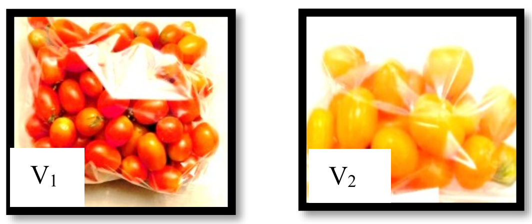

Figure 2. Lab samples of cherry tomato varieties: BARI tomato 11 (V_1) and Philippines variety (V_2) prepared for quality testing.

Table 1. Monthly average maximum and minimum air temperatures, mean temperature, rainfall, humidity, and sunshine hours of the experimental site during the study period (November 2023 to March 2024).

Month	Air temperature (^{0}C)			Rainfall (mm)	Humidity (%)	Sunshine Hrs.
	Max.	Min.	Mean			
Nov., 2023	31.09	20.03	25.56	28	85.93	7.55
Dec., 2023	26.67	16.24	21.46	45	86.20	4.56
Jan., 2024	22.72	12.73	17.72	00	84.42	3.70
Feb., 2024	27.84	15.73	21.78	18	73.59	6.15
Mar., 2024	31.72	18.87	25.29	58	75.47	7.15

Source: Weather Station, Gazipur.

Both physicochemical and nutritional parameters including moisture, pH, ash, Total Soluble Solids (TSS), fiber, fat, and Vitamin C were analyzed at the Food Science Laboratory of the School of Science and Technology of Bangladesh Open University, Gazipur following standard procedures. The moisture content of cherry tomato fruit was measured by using a Halogen Moisture Analyzer (Model: MS-110). The combined glass electrode was used in the pH measurement of fruit juice. TSS was determined using a Refractometer (Model: AM871). Vitamin C (Ascorbic acid) was determined by following the AOAC official method (AOAC, 2012). Fat content in cherry tomato fruit was measured by the Soxhlet extraction method. The fiber and ash were measured using the digestion method, which is based on the solubilization of non-cellulosic compounds by sulfuric acid and potassium hydroxide solutions (AOAC, 1984 and 2005). All the recorded data were analyzed using R statistical software to assess variance and performed mean separation following Duncan's Multiple Range Test at a 5% probability level (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Most of the fruit quality parameters of cherry tomatoes measured in the study were significantly influenced by transplant age, variety, and their interaction (Tables 2, 3, and 4).

Effect of Transplant Ages

There was a significant difference in all the studied fruit quality parameters, except for moisture content, across different transplant ages, regardless of the variety (Table 2).

Total Soluble Solids (TSS)

TSS showed a significant difference among different aged transplants at the 1% probability level ($p \leq 0.01$). It varied from 6.10% to 6.45%. The highest TSS (6.45%) was recorded in 28-day-old transplants (A_2), followed by 35-day-old transplants (A_3) at 6.30%, while the lowest TSS (6.10%) was observed in 42-day-old transplants (A_4). This result indicates that 28-day-old transplants (A_2) produced fruits with the highest TSS, which gradually decreased with increasing transplant age beyond 28 days.

Moisture Content (%)

There were no significant differences in moisture content among transplants of different ages (Table 2). Moisture content ranged from 91.14% to 91.68%, with the highest value recorded in fruits from 21-day-old seedlings (A_1) and the lowest in 42-day-old seedlings (A_4). Moisture content remained relatively stable across different transplant ages, showing no significant impact of transplant age.

Ash Content (%)

Ash content showed a significant difference at the 1% probability level ($p \leq 0.01$) among transplants of different ages. It ranged from 0.82% to 1.54%, with the highest value in fruits from 35-day-old transplants (A_3) and the lowest from 42-day-old transplants (A_4). The mineral content (ash) was highest in fruits from 35-day-old transplants, indicating this transplant age yielded fruits with a richer mineral composition.

Fiber Content (%)

Fiber content showed a significant difference at the 5% probability level ($p \leq 0.05$) among transplants of different ages. It ranged from 0.78% to 0.85%, with the highest fiber content in fruits from 28-day-old transplants (A_2) and the lowest in fruits from 42-day-old transplants (A_4). Seedlings transplanted at 28 days produced fruits with the highest fiber content, suggesting that this transplant age is optimal for maximizing fiber levels in cherry tomatoes.

Fat Content (%)

Fat content showed a significant difference at the 5% probability level ($p \leq 0.05$) among transplants of different ages. It ranged from 0.17% to 0.20%. The highest fat content (0.20%) was found in fruits from 35-day-old transplants (A_3) and 21-day-old transplants (A_1) while fruits from 28-day-old transplants had the lowest fat content. This indicates that transplant age slightly influenced the fat composition of the fruits.

pH Value

pH values of fruits ranged from 4.03 to 4.22 and it was significantly different ($p \leq 0.05$) among transplants of different ages. The lowest pH (4.03) was observed in fruits from 21-day-old transplants (A_1), while the highest pH (4.22) was found in fruits from 42-day-old transplants (A_4), which was statistically similar to those from 35- and 28-day-old transplants. This indicates that fruits from younger transplants were more acidic compared to those from older transplants.

Table 2: Effect of transplant age on quality parameters of cherry tomato.

Transplant age	TSS (%)	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	pH	Vitamin C (mg/100 ml)
A_1	6.22b	91.68	1.04c	0.80b	0.17b	4.03b	16.35ab
A_2	6.45a	91.27	1.22b	0.85a	0.18b	4.11ab	16.71a
A_3	6.30b	91.16	1.54a	0.82ab	0.20a	4.18a	16.06b
A_4	6.10c	91.14	0.82d	0.78b	0.19ab	4.22a	15.98b
Level of sig.	**	NS	**	*	*	*	**
CV (%)	1.72	0.77	5.87	5.09	8.33	3.07	2.24
LSD (0.05)	0.11	0.73	0.07	0.04	0.02	0.13	0.38

*Note: A column with a similar letter (s) is statistically similar and those with a dissimilar letter(s) differ significantly as per DMRT. **Significant at 1% probability level, *Significant at 5% probability [A_1= 21 days old transplants, A_2= 28 days old transplants, A_3= 35 days old transplants, A_4=42 days transplants].*

Vitamin C Content

Vitamin C content ranged from 15.98 mg/100 mL to 16.71 mg/100 mL, with the highest value recorded in fruits from 28-day-old transplants (A_2) and the lowest in fruits from 42-day-old transplants (A_4). The 28-day-old transplants produced fruits with the highest vitamin C content, followed by the 21-day-old transplants. Vitamin C levels decreased with increasing transplant age beyond 28 days.

Effect of Varieties

There was a significant difference in all the studied fruit quality parameters, except for moisture content and TSS, between two varieties (Table 3).

Total Soluble Solids (TSS)

The TSS value of red cherry tomatoes (V_1) was 6.26%, and that of yellow cherry tomatoes (V_2) was 6.27%. The difference in TSS between the two varieties was not statistically significant. The TSS, which reflects the sugar content and sweetness, is consistent across both red and yellow cherry tomato varieties.

Moisture Content (%)

Moisture content was 91.30% in red cherry tomatoes (V_1) and 91.33% in yellow cherry tomatoes (V_2). However, moisture content was not significantly different between varieties. This suggests that water content remains stable in fruits regardless of the variety.

Ash Content (%)

Ash content, which reflects the mineral composition, was significantly ($p \leq 0.01$) higher in red cherry tomatoes (1.47%) compared to yellow cherry tomatoes (0.83%) ($p \leq 0.01$). The red cherry tomato variety (V_1) had a higher mineral content (ash), making it a more nutrient-dense option compared to the yellow variety (V_2).

Fiber Content (%)

Fiber content was significantly ($p \leq 0.01$) higher in red cherry tomatoes (0.85%) compared to yellow cherry tomatoes (0.77%). The red cherry tomato variety (V_1) contained more dietary fiber than the yellow variety, which suggests it may be a better choice for those seeking a higher fiber intake.

Table 3: Effect of variety on quality parameters of cherry tomato.

Variety	TSS (%)	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	pH	Vitamin C (mg/100 ml)
V_1	6.26	91.30	1.47a	0.85a	0.17b	4.03b	16.56a
V_2	6.27	91.33	0.83b	0.77b	0.21a	4.24a	15.99b
Level of sig.	NS	NS	**	**	**	**	**
CV (%)	1.72	0.77	5.87	5.09	8.33	3.07	2.24
LSD (0.05)	0.08	0.52	0.05	0.03	0.01	0.09	0.27

*Note: A column with a similar letter(s) is statistically similar and those with a dissimilar letter(s) differ significantly as per DMRT. **Significant at 1% level of probability, *Significant at 5% level of probability, NS= Not significant [V_1= Red cherry tomato (BARI Tomato 11) and V_2= Yellow cherry tomato (Philippines variety)].*

Fat Content (%)

Fat content was significantly ($p \leq 0.01$) higher in yellow cherry tomatoes (0.21%) than in red cherry tomatoes (0.17%). The yellow cherry tomato variety (V_2) has a higher fat content than the red variety, though the overall fat content in both varieties remains low, as expected in cherry tomatoes.

pH Value

The pH value of yellow cherry tomatoes was significantly ($p \leq 0.01$) higher (4.24) than that of red cherry tomatoes (4.03). The red variety (V_1) is more acidic than the yellow variety (V_2).

Vitamin C Content

Vitamin C content was significantly higher ($p \leq 0.01$) in red cherry tomatoes (16.56 mg/100 mL) than in yellow cherry tomatoes (15.99 mg/100 mL). Red cherry tomatoes (V_1) have a higher vitamin C content than yellow cherry tomatoes (V_2), making them a better option for those seeking for more ascorbic acid (Vitamin C) in their diet.

Interaction Effect of Transplant Age and Variety

Significant differences in all studied quality parameters were observed due to the interaction effect between transplant age and cherry tomato varieties (Table 4).

Total Soluble Solids (TSS)

TSS values ranged from 5.80% to 6.70%. The highest TSS of 6.70% was observed in 35-day-old transplants of yellow cherry tomatoes (A_3V_2) and the lowest TSS was recorded in 28-day-old transplants of yellow cherry tomatoes (A_2V_2). When yellow cherry tomatoes were transplanted as 35-day-old seedlings (A_3V_2), they promote greater sugar accumulation.

Moisture Content (%)

Moisture content ranged from 90.59% to 92.60%. The highest moisture content (92.60%) was found in 21-day-old transplants of yellow cherry tomatoes (A_1V_2), while the lowest moisture content (90.59%) was recorded in 35-day-old transplants of yellow cherry tomatoes (A_3V_2). Younger seedlings, especially in yellow cherry tomatoes (A_1V_2), tended to produce fruit with higher moisture content, contributing to a juicier texture.

Ash Content (%)

Ash content ranged from 0.77% to 2.25%. The highest ash content (2.25%) was observed in 35-day-old transplants of red cherry tomatoes (A_3V_1), while the lowest (0.77%) was recorded in 42-day-old seedlings of yellow cherry tomatoes (A_4V_2). When red cherry tomatoes were transplanted as 35-day-old seedlings (A_3V_1), they promote greater mineral accumulation in fruits.

Fiber Content (%)

Fiber content ranged from 0.74% to 0.88%. The highest fiber content (0.88%) was recorded in 28-day-old transplants (A_2V_1) and 35-day-old transplants of red cherry tomatoes (A_3V_1), while the lowest fiber content of 0.74% was found in 42-day-old transplants of yellow cherry tomatoes (A_4V_2). Red cherry tomatoes, particularly when grown from 28 day-old and 35-day-old transplants (A_2V_1 and A_3V_1), exhibited higher fiber content, contributing to better dietary fiber intake compared to yellow tomatoes.

Fat Content (%)

Fat content ranged from 0.16% to 0.22%. The highest fat content of 0.22% was observed in both 21-day-old transplants (A_1V_2) and 35-day-old transplants of yellow cherry tomatoes (A_3V_2). The lowest fat of 0.16% content was found in 28-day-old transplants of red cherry tomatoes (A_2V_1). Yellow cherry tomatoes, especially those grown from younger (21-day-old) or older (35-day-old) transplants, tend to have a slightly higher fat content.

pH Value

pH values ranged from 4.01 to 4.42. The highest pH (4.42) was found in 42-day-old transplants of yellow cherry tomatoes (A_4V_2), while the lowest pH (4.01) was recorded in 21-day-old transplants of red cherry tomatoes (A_1V_1). Older transplants (42-day-old) of yellow cherry tomatoes (A_4V_2) produced fruits with the highest pH, which corresponds to a milder, less acidic flavour. Conversely, red cherry tomatoes grown from younger transplants (A_1V_1) were more acidic.

Vitamin C content

Vitamin C content ranged from 15.65 mg/100 mL to 16.98 mg/100 mL. The highest Vitamin C content (16.98 mg/100 ml) was recorded in 28-day-old transplants of red cherry tomatoes

Table 4: Interaction effect of transplant age and varieties on quality parameters of cherry tomato.

Interaction (Age X Variety)	TSS (%)	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	pH	Vitamin C (mg/100 ml)
A_1V_1	6.50bc	90.77b	1.21c	0.84ab	0.18bc	4.01c	16.70ab
A_1V_2	6.40c	92.60a	0.86d	0.77bc	0.21a	4.20bc	16.00cd
A_2V_1	6.65ab	91.43b	1.57b	0.88a	0.16d	4.02c	16.985a
A_2V_2	5.80f	91.12b	0.88d	0.82b	0.21ab	4.05c	16.45abc
A_3V_1	5.90ef	91.73ab	2.25a	0.88a	0.18cd	4.02c	16.25bc
A_3V_2	6.70a	90.59b	0.83d	0.75c	0.22a	4.30ab	15.87cd
A_4V_1	6.00e	91.28b	0.87d	0.82ab	0.18cd	4.02c	16.32bc
A_4V_2	6.20d	91.01b	0.77d	0.74c	0.21ab	4.42a	15.65d
Level of Sig.	**	**	**	*	*	*	*
CV (%)	1.72	0.77	5.87	5.09	8.33	3.07	2.24
LSD (0.05)	0.16	1.03	0.10	0.06	0.02	0.19	0.54

*Note: A column with a similar letter(s) is statistically similar and those with a dissimilar letter(s) differ significantly as per DMRT. *Significant at 5% level of probability [A_1= 21 days old transplants, A_2= 28 days old transplants, A_3= 35 days old transplants, A_4=42 days old transplants; V_1= Red cherry tomato (BARI Tomato 11) and V_2= Yellow cherry tomato (Philippines variety)].*

(A_2V_1), while the lowest of 15.65 mg/100 mL was found in 42-day-old transplants of yellow cherry tomatoes (A_4V_2). Red cherry tomatoes grown from 28-day-old transplants (A_2V_1) had the highest vitamin C content, indicating better antioxidant properties.

In this study, 28-day-old transplants performed better in terms of fruit TSS%, fiber, and vitamin C. It may due to the good growth performance of transplants at this specific age. Environmental factors like temperature, humidity, and light intensity were properly utilized in the specific seedling growing time. The younger transplants (21 to 28-day-old) had probably sufficient stored food for better performance in the field. These findings are similar to those of Shampa (2008), who states that the age of seedlings to be transplanted is important for proper establishment in the field and the production of good quality fruits. These results are also consistent with those of Ware and McCollum (1975), who reported that medium-aged seedlings can produce quality fruits due to their greater leaf area and higher quantity of stored food, especially carbohydrates. Further, the fruit dry mass quantity changed depending on the age of the seedlings (Shopova and Cholakov, 2014). Radzevičius (2013) reported that the transplant age of tomatoes has influenced fruit nutritional quality and dry matter content and it was related to good root development and a balanced shoot-to-root ratio for successful vegetable production (Tuzel *et al.*, 2014). Quality seedlings produce healthy foliage and work as good carbohydrate reserves. It helps to develop new roots for quick uptake of nutrients and water (Baudoin *et al.*, 2013).

Irrespective of transplant age, plant performance and fruit quality of tomato can vary due to environmental factors. For examples, the growth and physiological changes of tomato seedlings are influenced by light intensity (Zheng *et al.*, 2023). The synthesis rate of chlorophyll was influenced by soil moisture and light, temperature, humidity, and other environmental factors (Liming *et al.*, 2015). The leaf gas exchange, biological yield, and economic photosynthetic productivity reached their highest values for the 20 to 25-day-old seedlings (Shopova and Cholakov, 2014). Contrary to our findings, Nkurunziza *et al.* (2022) reported that the fruit quality of tomatoes did not depend on seedling quality. Fruit quality characters of tomato can vary due to genetic composition. For example, many studies found that TSS content differs among tomato varieties due to their distinct genetic compositions (Swaroop and Suryanarayana 2005; Marquez and Cano 2005; Ahmad *et al.*, 2007). Marquez and Cano (2005) recorded TSS values between 7.23 and 7.9° (brix) in cherry tomato varieties under greenhouse conditions, which were slightly higher than our findings. Further, genetic diversity influences the fruit quality parameters such as flavour, aroma, colour, and lycopene content (Aguirre and Cabrera, 2012). The use of younger transplants is a precondition for a greater physiological potential of the plants during the vegetative stage. The use of high-quality transplants is an important condition for the understanding of the biological potential of field-grown tomatoes for obtaining higher economic returns (Markovic *et al.*, 1997).

CONCLUSION

The study demonstrates that transplant age and variety significantly affect the nutritional quality of cherry tomatoes. These results suggest that selecting the appropriate transplant age and variety can improve the overall nutritional quality of the fruit. It can be concluded that 28-day-old transplants performed better with fruit TSS, fiber, and vitamin C content due to optimal physiological growth and development. Thus, it is recommended that cherry tomato seedlings should be transplanted 28 days after sowing in a nursery to get better quality fruits under suitable local planting time.

ACKNOWLEDGEMENT

The authors are grateful to the Bangladesh Open University authority for funding the project in the fiscal year 2023-2024 and School of Agriculture and Rural Development (SARD) and School of Science and Technology (SST) of Bangladesh Open University for providing field and laboratory support for carrying out the study.

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