

Original Article : Open Access

Effect of diverse nutrient management options on proximate composition, antioxidants, amino acids profile and nutritional quality of *Solanum melongena* L.Lakshmi Charitha Vejendla*, Ponnusamy Janaki**[◆], Mariappan Suganthi**, Ramanujam Krishnan** and Sadasivam Meena*

* Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

** Nammazhvar Organic Farming Research Centre, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

Article Info

Article history

Received 19 February 2025

Revised 1 April 2025

Accepted 2 April 2025

Published Online 30 June 2025

Keywords

Organic manures
Concoctions
Inorganics
Eggplant
Mineral nutrition

Abstract

Brinjal (*Solanum melongena* L.) is a nutrient dense vegetable known for its health benefits, attributed to its biochemical composition, antioxidant properties, and amino acid profile. Providing quality fruits to the consumers benefit them by increasing the medicinal value without contaminants in a sustainable way. Hence, this study evaluates the impact of diverse nutrient management options on proximate composition, antioxidants, amino acid composition and nutritional quality of brinjal. The study includes six treatments: T1-100% recommended nitrogen (N) as farm yard manure (FYM) (50%) and vermicompost (50%); T2-50% N as FYM and vermicompost with beejamrit, ghanajeevamrit @ 250 kg/ha as basal and jeevamrit 500 lit/ha at 15 days interval; T3-100% recommended dose of fertilizers (RDF) through inorganic sources; T4-State recommendation (FYM@25 t/ha + Azophos@2 kg/ha + 100% RDF); T5-50% N as FYM and vermicompost + 50% RDF through inorganic fertilizers; T6-25% N as FYM and vermicompost + 25% N through inorganic fertilizers + seedling treatment with beejamrit + basal application of ghanajeevamrit @250 kg/ha, jeevamrit @500 litres/ha along with irrigation at fortnight interval. The results showed that combining organic sources with mrits (microbial concoctions) impacted positively and significantly the proximate compounds, total phenol (7.34 mg/100 g), flavonoid (132.47 mg GAE/ g) and ascorbic acid (13.49 mg/100 g) contents. A wider range of amino acids was also found, in particular a higher content of alanine (696.82 mg/kg), serine (5101.73 mg/kg) and aspartic acid (526.14 mg/kg). The combined application of organic manure and inorganic fertilizer (T5) had a considerable effect on the nutrient concentration and quality of brinjal, followed by the purely inorganic fertilizers. The nutrient content and fruit quality in T2 are also high, confirming the potentiality of organic fertilizers and mrits to improve the quality parameters of brinjal fruits, which in turn benefits human health.

1. Introduction

Fruits and vegetables are essential protective foods that play a crucial role in human health by supplying vital vitamins and minerals. Among vegetables, the important indigenous Indian vegetable brinjal (*Solanum melongena* L.) accounts for 9% of the total vegetable production in the country. It grows on 7.60 lakh hectares and produces 12.61 million tonnes annually with a productivity of 19.10 t/ha (Statista, 2025). Brinjal is rich in nutrients with many health benefits and is an important part of a balanced diet. Its high moisture content and low calorific value make it a perfect meal for weight control. It contains antioxidants (flavonoids, phenols and anthocyanins) that reduce oxidative stress (Kandoliya *et al.*, 2015) and a high fibre content that improves gut health. The high fibre content and low glycemic index make it suitable for diabetics and contains essential vitamins, including ascorbic acid and minerals such as potassium, calcium and iron, which are vital for various bodily functions (Hazra, 2023). The antioxidant properties of eggplant may reduce the risk of various cancers, protect against cardiovascular disease and prevent

acute respiratory infections. Additionally, the fibre in eggplant supports digestion by eliminating toxins and pollutants from the stomach, thereby reducing the risk of colon cancer. The plant polyphenols found in eggplants help protect cell membranes and enhance memory function in the brain (Naeem and Ugur, 2019; Sharma and Kaushik, 2021). Shamna and Poyil (2023) also highlighted the anticancer properties of anthocyanins present in red and dark-coloured vegetables, demonstrating their effectiveness against various cancer cell types.

In this context, the production of quality brinjal fruit without pesticide residues and heavy metals is essential. The quality of the fruit has been found to be highly affected by the sources of nutrients imparted (Paswan *et al.*, 2022). Organically grown fruits are reported to have the highest quality compared to conventional chemical farming (Palia *et al.*, 2021). The phenolic compounds, flavonoids and antioxidant properties correlated positively to the practices of organic farming contributing to better human health by enhancing nutraceuticals over regular practices. Brinjal fruit also contain a considerable amount of proteins (Sharma and Kaushik, 2021) and essential and non-essential amino acids that promote human health, which can be modified by the nutrient sources and types (Wang *et al.*, 2018). Organic farming has been reported to help maintain a balanced composition of these compounds. Beyond quality, consumer awareness of the health risks and benefits associated with different cultivation methods is also a key area of research. Therefore, the study, examined the impact of

Corresponding author: Dr. P. Janaki

Professor, Nammazhvar Organic Farming Research Centre, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

E-mail: janaki.p@tnau.ac.in

Tel.: +91-9443936160

Copyright © 2025 Ukaaz Publications. All rights reserved.

Email: ukaaz@yahoo.com; Website: www.ukaazpublications.com

various organic nutrient sources and regenerative farming practices on the nutrient composition and antioxidant content of brinjal fruits, contributing to their overall nutritional enhancement.

2. Materials and Methods

2.1 Experimental details

The field experiment with the *Solanum melongena* L. (authentication No. BSI/SRC/5/23/2024-25/Tech./388), a brinjal hybrid 'Lalitha' was investigated from August 2023 to February 2024. The study was conducted at Eastern Block Farm, Tamil Nadu Agricultural University (TNAU), Tamil Nadu, India. Experimental field soil was calcareous sandy clay loam, alkaline in reaction (>7.9 pH), normal in electrical conductivity (<0.50 dS/m) and medium to high in organic carbon, low, medium and high in available nitrogen, phosphorus and potassium status. The field was thoroughly ploughed and prepared for sowing. Thirty-day-old brinjal seedlings were planted at 60 cm x 60 cm spacing with two seedlings per hill and treated without synthetic fertilisers. A total of six combinations of nutrient sources, were applied to the experimental field by adopting randomised block design with plot size of 5 m x 10 m and replicated four times as follows: T₁-100 % recommended N as FYM (50%) and vermicompost (VC) (50%) (100% N through FYM and VC); T₂- 50 % N as FYM (25%) and vermicompost (25%) with beejamrit, ghanajeevamrit @ 250 kg/ha as basal and jeevamrit 500 lit/ha at 15 days interval (50% N as FYM and VC + mrits); T₃- 100% recommended NPK nutrients as fertilizers through inorganic sources (100% RDF); T₄-State recommendation (FYM @ 25 t/ha + azophos @ 2 kg/ha+100% RDF); T₅- 50% N as FYM and vermicompost + 50% RDF through inorganic fertilizers (50% organics + 50% inorganics); T₆- 25% N as FYM and vermicompost + 25% N through inorganic fertilizers + seedling treatment with beejamrit + basal application of ghanajeevamrit @ 250 kg/ha, jeevamrit @ 500 litres/ha/time twice a month with irrigation water (25% organic + 25% inorganic + mrits). The fertilizer dose recommended for brinjal in Tamil Nadu is 100:50:30 kg NPK / ha. While the digestate was applied as a basal fertiliser at the time of planting, the vermicompost was used as both a basal and a secondary fertiliser, depending on the treatment. The mrits were prepared by adopting methodology of Janaki *et al.* (2024). During the entire growing period, the brinjal crop was cultivated according to the organic farming methods recommended by TNAU. The brinjal fruits were harvested at the physiological maturity after 50 days of transplanting and totally 16 harvests at 5 days interval. During 2nd harvest, the brinjal fruits were harvested from each treatment replication wise and subjected to quality analysis.

2.2 Proximate composition and mineral nutrients analysis

The crude fibre, protein and carbohydrate content of brinjal were estimated as suggested by Abdullahi *et al.* (2016). Samples are digested to determine their mineral and nutritional content using a triple acid and diacid. After volume adjustment, 1% nitric acid was added to the digested clear solution, which was then filtered through Whatman No. 42 filter paper and determined for various mineral elements (AOAC, 1990). Potassium and phosphorus were measured using flame photometer and UV-Visible spectrophotometer, respectively, while all other elements were analysed using ICP-AES.

2.3 Quantification of antioxidants amino acid profiling in brinjal

From each treatment, representative brinjal fruits of about 500 g were collected, smashed using pestle and mortar and homogenized for sub sampling and analysis. The antioxidant parameters *viz.*, ascorbic acid, total phenol, and total flavonoid (Hao *et al.*, 2018) content were approximated following the standard protocol.

Fresh fruit samples were macerated to fine pulp and then a known weight was extracted with acetonitrile (Liu *et al.*, 2019), partitioned and cleaned up for analysis. The amino acid profiling of brinjal fruit was performed using Shimadzu LC-MS-MS equipped with an electrospray ionization (ESI) triple quadrupole mass detector and HILIC column (Zhang *et al.*, 2022). Shimadzu Lab Solution software was utilized to control data acquisition and 10 µl sample injection volume was employed. LC-MS-MS in MRM mode was used to identify the compounds.

2.4 Nutritional concentration and quality score

The nutrient quality score (NQS) was calculated based on the daily intake (DI) of each nutrient by serving 100 g of brinjal, using data from proximate composition, antioxidant levels and nutrient content obtained through chemical analysis. A serving size was chosen in accordance with the recommended portion for fresh vegetables (USDA, 2025). The DI was calculated using the following equation:

$$DI \text{ (mg day}^{-1}\text{)} = [\text{nutrient content (mg 100 g}^{-1}\text{)} / 100] \times \text{serving size (100 g)}$$

Subsequently, the percentage of nutritional contribution (NC) of each nutrient per serving was assessed using the dietary reference values (DRV) from Renna *et al.* (2020) and NHMRC (2025). The NC was determined using the equation:

$$NC(\%) = [DI \text{ (mg day}^{-1}\text{)} / DRV \text{ (mg day}^{-1}\text{)}] \times 100$$

2.5 Statistical analysis

The experimental data were analyzed using analysis of variance (ANOVA) to evaluate the effects of different treatments on the measured parameters in brinjal. Statistical analysis was performed using Microsoft Excel 2010. The results for each treatment were expressed as mean values with standard error (SE) to account for variability and ensure precision. To illustrate treatment variations, data was presented in the format (\pm), and error bars were included in graphical representations.

3. Results

3.1 Proximate compounds in brinjal

Proximate composition of the different nutrient management treatments revealed significant differences in moisture content, crude protein, crude fibre, carbohydrates and ash content (Table 1). The highest moisture content was observed in T₂ (50%N as FYM and vermicompost + mrits) with $94.397 \pm 0.30\%$, followed by T₁ (100% N as FYM and vermicompost) with $93.3 \pm 1.75\%$. The lowest moisture content was observed in T₃(50% organics + 50% inorganics) with $90.90 \pm 0.095\%$, indicating a slight reduction in moisture content due to the addition of inorganics.

Table 1: Proximate composition of brinjal fruit (%) as influenced by the diverse nutrient management practices

Treatment	Moisture (%)	Crude protein (%)	Crude fibre (%)	Carbohydrates (%)	Ash content (%)
T1-100% N as FYM and VC	93.30 ± 1.75	1.09 ± 0.015	1.23 ± 0.001	5.59 ± 0.108	0.62 ± 0.006
T2-50% N as FYM and VC+ mrits	94.40 ± 0.30	1.45 ± 0.003	1.55 ± 0.010	6.21 ± 0.052	0.78 ± 0.002
T3-100% RDF	90.90 ± 0.10	0.83 ± 0.015	1.03 ± 0.012	4.54 ± 0.007	0.47 ± 0.001
T4-25 ton FYM/ha +100%RDF	92.50 ± 0.43	0.93 ± 0.021	1.04 ± 0.001	5.64 ± 0.129	0.69 ± 0.012
T5-50% organics + 50% inorganics	91.70 ± 0.24	1.27 ± 0.021	1.12 ± 0.025	5.15 ± 0.021	0.54 ± 0.012
T6-25% organic + 25% inorganic + mrits	91.30 ± 0.95	1.05 ± 0.006	1.33 ± 0.026	5.33 ± 0.044	0.56 ± 0.014

± Standard error

The crude protein content was highest in T2 (50% N as FYM and vermicompost + mrits) with $1.45 \pm 0.003\%$, followed by T5 (50% organic + 50% inorganic) with $1.27 \pm 0.021\%$. The lowest protein content was observed in T3 (50% organics + 50% inorganics) with $0.83 \pm 0.015\%$, indicating a decrease in protein content with inorganic supplementation. Crude fiber content varied among treatments, with the highest value observed in T2 (50% N as FYM and vermicompost + mrits) at $1.55 \pm 0.010\%$, while the lowest value was observed in T3 (50% organics + 50% inorganics) at $1.03 \pm 0.012\%$. The other treatments had crude fiber values between 1.04% and 1.33%.

The highest carbohydrate content was observed in T2 (50% N as FYM and vermicompost + mrits) with $6.21 \pm 0.052\%$, while T3 (50% organic + 50% inorganic) had the lowest value with $4.54 \pm 0.007\%$. The other treatments had carbohydrate values between 5.15% and 5.64%, with T4 (farmer's practice) having a relatively higher carbohydrate content of $5.64 \pm 0.130\%$. Ash content, representing mineral composition, was highest in T2 (50% N as FYM and vermicompost + mrits) at $0.78 \pm 0.002\%$, followed by T4 (farmer's practice) at $0.69 \pm 0.012\%$. The lowest ash content was found in T3 (50% organic + 50% inorganic) with $0.47 \pm 0.001\%$.

3.2 Antioxidants composition of brinjal

Antioxidants are important for health as they scavenge free radicals. The levels of antioxidants such as ascorbic acid (vitamin C), total phenolics and flavonoids were estimated in the different treatments and T2 was found to perform well among others (Figure 1 and 2). Ascorbic acid content varied among treatments, with the highest concentration in 50% FYM and vermicompost on N equivalent basis and seedling dip with beejamrit, ghanajeevamirt and jeevamrit application at 15 days interval along with irrigation water (T2-50% N as FYM and VC + mrits) at 13.49 ± 0.34 mg/100 g, followed by T4 (25 tons FYM/ha + 100% RDF) at 12.33 ± 0.135 mg/100 g. The lowest ascorbic acid content was found in T3 (100% RDF) with 9.56 ± 0.05 mg/100 g, indicating that organic amendments contribute positively to ascorbic acid accumulation. The completely organic treatment T1 (100% N as FYM and vermicompost) also showed relatively high values (11.56 ± 0.024 mg/100 g), while integrated approaches such as T5 - 50% N as organic + 50% N as inorganic (10.54 ± 0.20 mg/100 g) and T6 - 25% organic + 25% inorganic with beejamrit, ghanajeevamirt and jeevamrit (10.59 ± 0.20 mg/100 g) recorded medium values. The results suggest that the combination of organic fertilizers with mrits (T2) increased ascorbic acid synthesis, while use of inorganic fertilizers alone (T3) may lead to lower accumulation.

Total phenol content, expressed as mg gallic acid equivalents (GAE) per g, followed similar pattern to ascorbic acid and treatment T2 (50% N as FYM and vermicompost along with beejamrit, ghanajeevamrit and jeevamrit) exhibited the highest level (7.34 ± 0.088 mg GAE/g), followed by state recommended practice of T4 with 25 ton FYM/ha + 100% RDF (6.24 ± 0.078 mg GAE/g). The lowest phenol content was recorded in T3-100% RDF alone (3.97 ± 0.066 mg GAE/g). The treatment T1 nitrogen 100% through organics (4.04 ± 0.076 mg GAE/g) showed slightly higher phenol content than 100% inorganic fertilizer treatment T3, but lower than integrated approaches such as T5 (4.55 ± 0.088 mg GAE/g) and T6 (4.41 ± 0.113 mg GAE/g). The results suggest that organic inputs, especially when combined with beejamrit, ghanajeevamirt and jeevamrit promote higher phenolic compound accumulation, contributing to enhanced antioxidant potential in brinjal.

Flavonoid content was highest in T2 where FYM and vermicompost was applied at 50% N equivalent basis along with beejamrit, ghanajeevamirt and jeevamrit (132.47 ± 0.28 mg/100 g), followed by treatment T4, receiving 25 ton FYM/ha + 100% recommended dose of inorganic fertilizers (124.77 ± 1.82 mg/100 g). The lowest flavonoid content was recorded in T3-100% RDF (103.54 ± 1.45 mg/100 g), reinforcing the trend observed for ascorbic acid, where organic inputs promoted higher antioxidant compound accumulation. The fully organic treatment T1 (100% N as FYM and vermicompost) (116.9 ± 2.55 mg/100 g) resulted in higher flavonoid levels compared to the combined application of organic and inorganic sources treatments viz., T5 (110.21 ± 2.23 mg/100 g) and T6 (107.98 ± 0.34 mg/100 g). The results indicate that integrating beejamrit, ghanajeevamirt and jeevamrit with solid organic manures (T2) and higher nutrients supplement through organic and inorganic fertilizer application (T4) enhances flavonoid biosynthesis, whereas a completely inorganic regime (T3) leads to lower flavonoid accumulation in brinjal fruits.

3.3 Amino acids profile in brinjal fruit

The amino acid composition of brinjal (*Solanum melongena* L.) fruits varied significantly under different nutrient management treatments (Table 2). The LC-MS-MS analysis of amino acid composition in brinjal fruits across the treatments showed significant variations in their accumulation. Among the treatments, T2 (50% N as FYM and vermicompost along with beejamrit, ghanajeevamirt and jeevamrit) exhibited the highest concentrations of alanine (696.82 mg/kg), serine (1510.173 mg/kg) and aspartic acid (526.14 mg/kg), suggesting enhanced nitrogen assimilation and protein synthesis under this treatment. T1 (100% N as FYM and vermicompost) recorded the highest levels of glycine (553.72 mg/kg), cysteine (234.83 mg/kg),

and glutamic acid (234.66 mg/kg), indicating its potential role in promoting antioxidant and structural protein formation. Essential amino acids such as methionine and tyrosine were prominently

recorded in T6 (25% organic + 25% inorganic + mrits) as 55.63 mg/kg and 67.78 mg/kg, respectively, emphasizing its role in sulfur-containing amino acid metabolism and neurotransmitter synthesis.

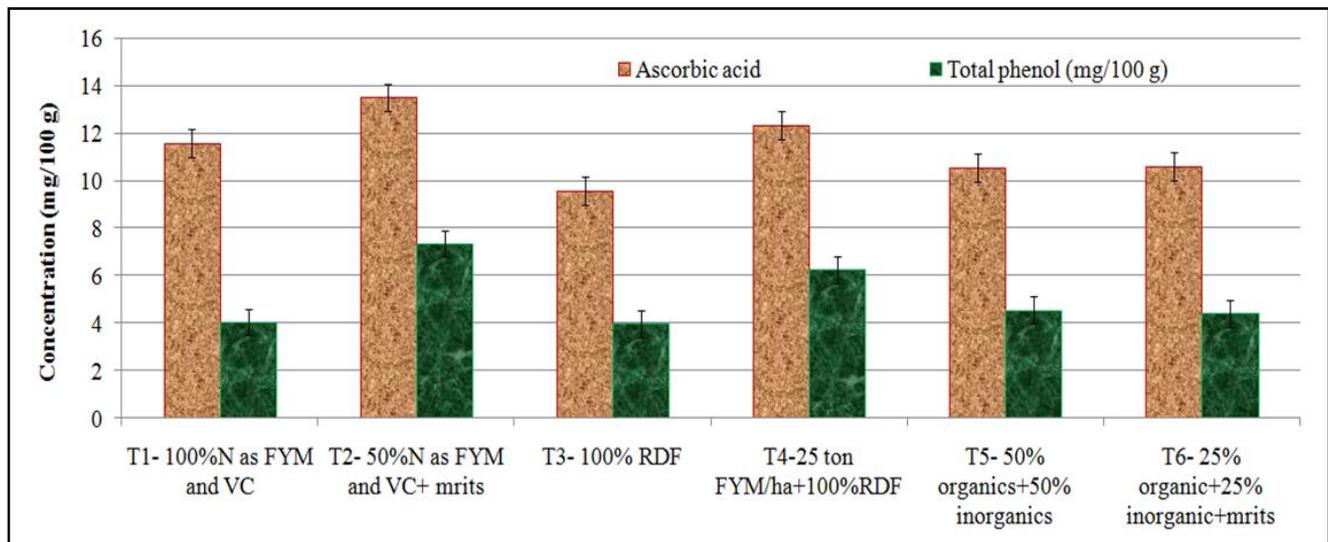


Figure 1: Effect of diverse nutrient management practices on ascorbic acid and total phenol in brinjal.

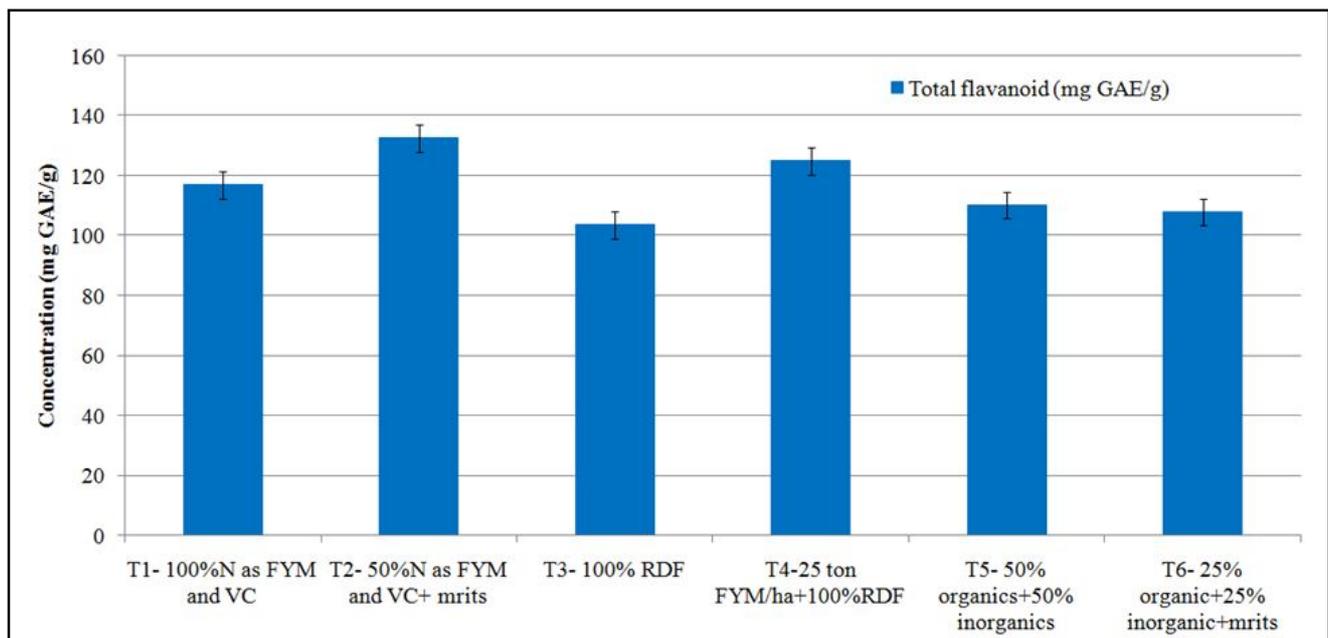


Figure 2: Effect of diverse nutrient management practices on total flavanoid content in brinjal.

In contrast, T3(100% RDF) and T4 (25 tons FYM/ha + 100% RDF) exhibited relatively lower amino acid concentrations, except methionine and tyrosine, which was recorded as 56.03 mg/kg and 56.89 mg/kg, respectively in T3 treatment. The combined organic and inorganic treatments (T5 and T6) resulted in a moderate enhancement of amino acids, in particular with histidine recorded as 19.95 mg/kg in T4 and 19.13 mg/kg in T5, suggesting a balanced approach of nutrient supply. However, lysine, leucine and phenylalanine were absent in most treatments, except treatment T2, where lysine was recorded at 163.19 mg/kg, highlighting its potential in improving protein quality. Overall, the findings indicate that organic and integrated nutrient management strategies significantly influence

amino acid accumulation, with T2 emerging as the most effective treatment in enhancing the nutritional profile of crops.

The total amino acid content in brinjal fruits exhibited significant variations across different nutrient management treatments (Figure 3). The treatment T2 (50% N as FYM and vermicompost + beejamrit, ghanajeevamrit and jeevamrit) recorded the highest total amino acid content (3515.52 mg/kg), followed by T1 (100% N as FYM and vermicompost) with 1753.7 mg/kg. These results suggest that organic amendments, especially with microbial stimulants, significantly enhance amino acid biosynthesis in crops. The total amino acid accumulation in T3 (100% RDF), T4 (25 tons FYM/ha + 100%

RDF), T5 (50% organics + 50% inorganics) and T6 (25% organics + 25% inorganics + beejamrit, ghanajeevamrit and jeevamrit) remained relatively low, ranging between 183.45 mg/kg and 194.28 mg/kg. The

negligible differences among these treatments indicate that sole inorganic or integrated nutrient applications do not significantly enhance amino acid content in brinjal fruits.

Table 2: Effect of diverse nutrient management options on influencing the amino acid composition in brinjal

Amino acids (mg/kg fruit on DW basis)	T1-100% N as FYM and VC	T2-50% N as FYM and VC + mrits	T3-100% RDF	T4-25-ton FYM/ha + 100%RDF	T5- 50% organics + 50% inorganics	T6- 25% organic + 25% inorganic + mrits
Alanine	94.83	696.82	3.48	4.85	7.8	<0.05
Lysine	<0.05	163.19	<0.05	<0.05	0.12	0.6
Aspartic acid	22.83	526.14	12.73	21.53	18.94	12.64
Arginine	<0.05	153.71	8.39	16.51	16.55	7.92
Cysteine	234.83	97.63	<0.05	<0.05	<0.05	8
Glutamic acid	234.66	100.51	<0.05	<0.05	<0.05	<0.05
Glycine	553.72	<0.05	10.04	17.71	18.14	8.17
Histidine	<0.05	56.54	9.64	19.95	19.13	9.35
Isoleucine	261.02	<0.05	<0.05	<0.05	<0.05	<0.05
Leucine	72.88	192.52	7.67	<0.05	<0.05	<0.05
Methionine	11.73	<0.05	56.03	43.72	44.67	55.63
Phenylalanine	66.69	<0.05	<0.05	<0.05	<0.05	<0.05
Proline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Serine	<0.05	1510.173	0.69	<0.05	<0.05	<0.05
Threonine	124.56	18.29	17.89	25.44	23.13	14.16
Tyrosine	39.13	<0.05	56.89	44.54	45.8	67.78
Valine	36.82	<0.05	<0.05	<0.05	<0.05	<0.05

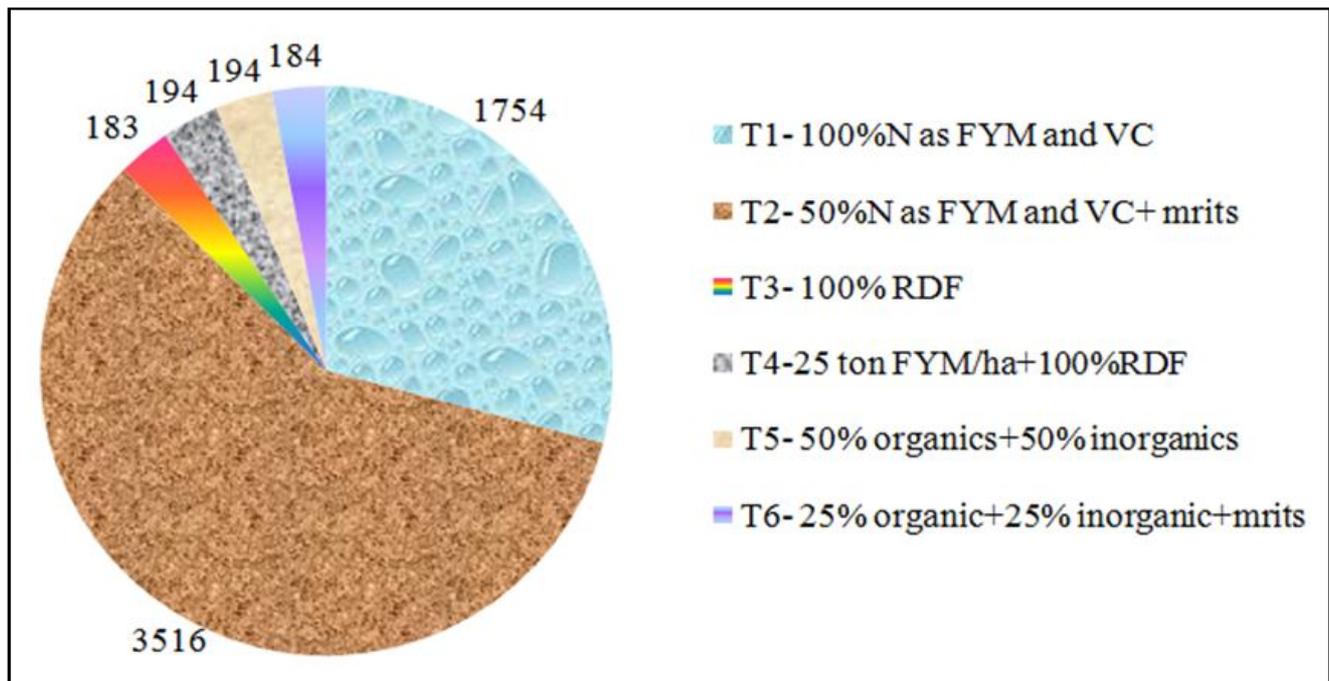


Figure 3: Effect of diverse nutrient management practices on amino acid (mg/kg fruit on dry weight basis) profile in brinjal.

3.4 Nutritional contribution and its quality score

The nutritional contribution of mineral elements, phenol, protein, fibre and vitamin C per 100 g serving of brinjal varied across the different nutrient management treatments. The results indicate that integrated nutrient management strategies influenced the bioavailability of essential nutrients in brinjal. The highest nutritional contribution was exhibited by T2 (50% N as FYM and vermicompost with mrits) suggesting that the combination of organic manure with microbial concoctions enhanced uptake and utilization of all the nutrients by brinjal crop efficiently. Serving of 100 g brinjal fruit

cultivated under different nutrient regimes provided 9.93-18.35% of the DRV for antioxidant phenols and 12.1-14.2% for crude fiber. Protein contribution ranged from 1.3-2.0% of the DRV (Table 3). The contribution of ascorbic acid was notably higher, ranging between 38.2-54.0%. Among mineral nutrients, iron had the highest contribution, ranging from 17.0-30.1% of the DRV, followed by potassium (8.7-11.2%) and phosphorus (5.29-7.86%). The contributions of calcium, magnesium, copper, zinc, and manganese were 2.6-3.1%, 0.5-0.6%, 0.8-0.9%, 0.3-0.5%, and 0.5-1.4% of the DRV, respectively. The contribution of sodium was minimal.

Table 3: Nutritional contribution (%) of mineral elements, phenol, protein, fibre and vitamin C per 100 g serving size of brinjal, according to the dietary reference values (DRV)

Nutrient/mineral	DRV Reference values	T1-100% N as FYM and VC	T2-50% N as FYM and VC + mrits	T3-100% RDF	T4-25 ton FYM/ha + 100%RDF	T5-50% organics + 50% inorganics	T6-25% organic + inorganic 25% + mrits
Ca (mg)	950	2.84	3.10	2.64	2.91	2.82	2.82
K (mg)	3500	10.86	11.24	8.74	11.15	10.48	10.34
Mg (mg)	350	0.5	0.6	0.5	0.6	0.5	0.5
Fe (mg)	11	2.8	3.0	1.7	2.3	2.0	2.0
Zn (mg)	11.7	0.5	0.5	0.3	0.4	0.4	0.4
Cu (mg)	1.6	0.9	0.9	0.8	0.9	0.9	0.9
Mn (mg)	3.0	1.0	1.4	0.9	0.9	0.5	0.9
Na (mg)	3000	0.03	0.04	0.05	0.04	0.04	0.04
P (mg)	700	6.57	7.86	5.29	7.43	6.71	7.14
Phenol (mg)	40	10.10	18.35	9.93	15.60	11.38	11.03
Protein (g)	62	1.76	2.34	1.34	1.50	2.05	1.69
Fiber (g)	25	12.92	14.20	12.12	12.16	12.48	13.32
Ascorbic acid (mg)	40	46.24	53.96	38.24	49.32	42.16	42.36

4. Discussion

Brinjal (eggplant) is a nutrient-rich, low-calorie vegetable known for its health benefits. It is one of the top ten healthiest vegetables due to its high phenolic content, which increases antioxidant activity and free radical absorption (Caguiat and Hautea, 2014; Naeem and Ugur, 2019). It is a valuable source of essential vitamins and minerals, including iron, calcium, potassium and magnesium, as well as beneficial phytochemicals. In particular, it contains phenolic compounds such as caffeic acid and chlorogenic acid, as well as flavonoids, which are concentrated in the peel and play a crucial role in its antioxidant properties (Trovato *et al.*, 2021). In recent decades, growing concerns about pesticide residues and heavy metal contamination have raised consumer awareness and increased the demand for organic products, including brinjal, a staple in the Indian diet. The results of the present study indicate that organic based treatments, especially those supplemented with mrits (50% N as FYM and vermicompost + beejamrit and jeevamrit), significantly improved the nutrient composition compared to inorganic treatments alone.

Moisture content plays a key role in maintaining the texture and freshness of brinjal. The better moisture retention in the organic treatments indicates improved soil structure and water holding capacity, leading to better hydration of the fruit. Treatment T2 had

the highest protein content, indicating improved nitrogen availability and uptake due to the application of mrits. In contrast, T3 and T4 had lower protein contents, probably due to lower microbial activity affecting nitrogen mineralization. The higher fiber content in the organic-based treatments (T2, T6) indicates improved cell wall development due to better nutrient uptake, while the lower fiber content in the inorganic-dominated treatments (T3, T5) could be due to nutrient imbalance affecting biosynthesis. The accumulation of carbohydrates was highest in T2 (6.21%) and T4 (5.64%), while the same was lowest in T3 (4.54%). The improved carbohydrate content in organic treatments indicates enhanced photosynthetic efficiency and microbial activity, whereas the lower levels in T3 suggest suboptimal nutrient synergy with inorganic fertilizers. The findings of Jabborova *et al.* (2024), indicate that the application of organic sources (biochar) along with inorganic fertilizers increases photosynthetic pigments and relative water content in okra. The ash content, which represents the total mineral composition, was highest in T2 (0.78%), followed by T4 (0.69%), while T3 had the lowest value (0.47%). The increased ash content in the mrits-based and organic treatments (T2, T4, T6) reflects a higher accumulation of essential minerals such as potassium, calcium and magnesium, which are essential for plant growth and metabolic processes. In contrast, the lower ash content in the inorganic treatments (T3 and T5) indicates

possible nutrient depletion, where over-reliance on synthetic fertilizers may have limited the bioavailability of micronutrients. The health benefits of brinjal crude fiber including improved digestion (Mritsunjay Tripathi *et al.*, 2014), maintenance of blood glucose levels due to its low glycemic index and carbohydrate content, contributes to a balanced diet (Rahim *et al.*, 2024; Guillermo *et al.*, 2014).

Diverse nutrient management strategies significantly influence the antioxidants composition of brinjal. Variations in ascorbic acid, flavonoid and phenol content among different treatments suggest that organic nutrient sources, especially in combination with microbial formulations such as beejamrit and jeevamrit, significantly enhance bioactive compound accumulation. The highest ascorbic acid content was recorded in T2 (50% N as FYM and vermicompos+mrits), indicating that organic nutrient sources combined with microbial stimulants enhance ascorbic acid biosynthesis in brinjal. Organic fertilizers improve soil microbial activity, increasing nutrient bioavailability and stimulating enzymatic pathways involved in ascorbic acid synthesis. Conversely, the relatively lower ascorbic acid levels in T3 (100% RDF) suggest that synthetic fertilizers alone may not sufficient to support antioxidant biosynthesis, likely due to their limited impact on soil microbiology and secondary metabolism. Integrated treatments such as T4 (25 tons FYM/ha + 100% RDF) also showed increased ascorbic acid levels, suggesting that inorganic fertilization contributes to nutrient supply, the addition of organic amendments enhances the synthesis and stability of ascorbic acid. The intermediate level treatments, *i.e.*, T5 (50% organic + 50% inorganic) and T6 (25% organic + 25% inorganic + mrits) greatly supports the notion of organic inputs addition tends to increase ascorbic acid accumulation.

Flavonoids, key secondary metabolites with strong antioxidant activity, accumulated in higher amounts in T2 (132.47 mg/100 g), underscoring the positive impact of organic fertilizers and microbial amendments on polyphenol metabolism. Microbial concoctions in mrits likely facilitated the conversion of organic substrates into precursors for flavonoid biosynthesis, leading to increased accumulation in brinjal. The lower flavonoid content in T3 (100% RDF) indicates that chemical fertilization alone may not effectively stimulate secondary metabolite production. This aligns with previous studies suggesting that high nitrogen availability from inorganic fertilizers tends to favour primary growth processes at the expense of secondary metabolite synthesis (Jaborova *et al.*, 2024). Phenolic compounds, essential for plant stress tolerance and antioxidant defense, were significantly enhanced in organic-dominated treatments. The highest phenol content in treatment T2 (7.34 mg GAE/g) confirms that organic matter and microbial concoctions enhance phenolic compound accumulation. The improvement observed in T4 (6.24 mg GAE/g) further suggests that chemical fertilizers contribute to growth and yield, their integration with organic inputs enhances secondary metabolite production. It was reported that integrating jeevamrit with 75% of the recommended fertilizer dose enhanced total phenol content in garlic.

Amino acids, vital for human health, serve as the fundamental building blocks of proteins and precursors to various biomolecules. Consequently, differences in amino acid accumulation across treatments have important implications for the nutritional quality of brinjal fruits. Organic treatments (T1 and T2) demonstrated the

highest accumulation of both essential and non-essential amino acids. Treatment T1 (100% N from FYM and vermicompost) showed elevated levels of glycine, cysteine and glutamic acid, while T2 recorded the highest concentrations of alanine, serine and aspartic acid. Additionally, T2 exhibited high lysine levels, which support calcium absorption, immune function and collagen synthesis. In contrast, the fully inorganic treatment (T3) resulted in moderate amino acid accumulation but significantly higher concentrations of methionine, tyrosine and threonine. Integrated nutrient management treatments (T4, T5 and T6) also followed the same trend of inorganic treatment, increasing substantially methionine, tyrosine and threonine with accumulating moderate levels of histidine, glycine, arginine and aspartic acid. Among all treatments, T6 (25% organic + 25% inorganic + beejamrit, ghanajeevamrit and jeevamrit) recorded the highest levels of tyrosine (67.78 mg/kg) and methionine (55.63 mg/kg).

Brinjal plants treated with 100% nitrogen from farmyard manure (FYM) and vermicompost, supplemented with beejamrit, ghanajeevamrit, and jeevamrit, exhibited the highest total amino acid concentration. This finding underscores the importance of organic nutrient sources and microbial formulations in promoting amino acid synthesis. In contrast, the fully inorganic treatment (T3, 100% RDF) recorded the lowest amino acid content (183.45 mg/kg). Glycine supports muscle and joint health, collagen formation, and wound healing, while also contributing to immune function and detoxification (Hertzler *et al.*, 2020; Li and Wu, 2022). Cysteine, a precursor to glutathione, enhances immune function and antioxidant defence (Hertzler *et al.*, 2020). Glutamic acid, acting as a neurotransmitter, plays a key role in cognitive health (Li and Wu, 2022). Alanine contributes to glucose metabolism, benefiting individuals with diabetes, while serine plays a crucial role in brain function and nerve transmission (Naeem and Ugur, 2019; Mukhtar *et al.*, 2022). Aspartic acid is vital for ATP production, nucleotide synthesis, and muscle endurance (Li and Wu, 2022). The significant accumulation of these amino acids in organic and integrated treatments suggests enhanced nitrogen assimilation and amino acid biosynthesis facilitated by microbial interventions. Lysine aids in calcium absorption, immune support and collagen synthesis, contributing to bone strength and skin repair (Mukhtar *et al.*, 2022). Methionine plays a key role in fat metabolism, liver function and cardiovascular health, while tyrosine serves as a precursor for neurotransmitters such as dopamine and adrenaline, influencing mood regulation and stress management (Ling *et al.*, 2023). Threonine supports protein synthesis, immune function, and gut health, while histidine contributes to haemoglobin production and immune defence by serving as a precursor to histamine (Hertzler *et al.*, 2020; Li and Wu, 2022). Arginine, known for promoting nitric oxide production, improves cardiovascular health by enhancing blood circulation (Naeem and Ugur, 2019). The higher accumulation of these amino acids in organic and integrated treatments, particularly in T2 and T6, suggests that microbial amendments such as beejamrit, ghanajeevamrit, and jeevamrit facilitate improved nutrient mineralization and amino acid biosynthesis. This study underscores the importance of organic and integrated nutrient management strategies in enhancing brinjal's nutritional profile, offering a sustainable approach to improving human dietary health.

Organic amendments and microbial concoctions improved the bioavailability of essential nutrients, enhancing the overall nutritional quality of brinjal. Calcium is crucial for bone health, muscle function, and enzymatic activity (Ross *et al.*, 2011). Treatments receiving

organic manure and microbial concoctions enhanced calcium availability in brinjal, making it a valuable dietary source for improving bone strength. Potassium, which plays a key role in maintaining electrolyte balance, nerve function and muscle contractions was observed in higher concentrations in organically managed treatments, reinforcing its potential benefits for cardiovascular health (Gritter *et al.*, 2019). Phosphorus is important for teeth, bones and is vital component of DNA, RNA is notably higher in organic enriched treatments, suggesting improved nutrient solubilization through microbial interactions. Further, it plays a major role in fats, carbohydrates utilization and helps the body to store energy by synthesizing ATP (Serna and Bergwitz, 2020). Magnesium, although present in relatively low amounts, is essential for energy metabolism and neuromuscular function and will help to improve the bioavailability and nutrition. The increase in the bioavailability of primary nutrients due to secondary nutrients and thereby improving overall dietary quality was reported (Luciano *et al.*, 2017). While the Mg is reported to be involved in around 300 biochemical reactions and S plays a role in the synthesis of amino acids and vitamins (Luciano *et al.*, 2017). Iron, a critical component for hemoglobin synthesis and oxygen transport, was higher in organic-based treatments, indicating better mobilization and uptake through enhanced microbial activity (Galaris *et al.*, 2019). Zinc, which supports immune function and enzymatic reactions, along with copper and manganese, essential for antioxidant defense and metabolic processes, showed moderate variations across treatments, with organic amendments slightly enhancing their bioavailability (Ghosh *et al.*, 2022; Lyu *et al.*, 2024). Sahil Hussain *et al.* (2023) reported similar findings in *Solanum torvum*, highlighting its fruits as a rich in minerals, phenolics and antioxidants, with high calcium, phosphorus, iron and vitamin C.

5. Conclusion

The findings reveal that nutrient management strategies significantly influence the biochemical profile and nutritional quality of brinjal. The application of organic manures and bio-concoctions as nutrient management options plays a crucial role in enhancing proximate compounds, ascorbic acid, flavonoids and phenol content while improving the amino acid composition, particularly methionine and tyrosine. Supplying nutrients to brinjal organically through farmyard manure (FYM) and vermicompost, along with bio-enhancers such as beejamrit, ghanajeevamrit, and jeevamrit, highlights the synergistic effects of organic matter and microbial concoctions. These inputs stimulate metabolic pathways involved in the synthesis of antioxidants and secondary metabolites. In addition to enhancing mineral bioavailability, these practices contribute to improved nutritional quality and health benefits. Overall, the study underscores the importance of incorporating organic inputs and bio-enhancers in sustainable agricultural practices to enhance the antioxidant potential and nutritional value of brinjal, with significant implications for human health and food quality. Future research should explore the long-term effects on soil health and their broader implications for sustainable agriculture and human nutrition.

Acknowledgements

The authors sincerely thank the Nammazhvar Organic Farming Research Centre at Tamil Nadu Agricultural University, Coimbatore, India, for granting access to research facilities.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

- Abdullahi, I.I.; Abdullahi, N.; Abdu, A.M. and Ibrahim, A. S. (2016). Proximate, mineral, and vitamin analysis of fresh and canned tomato. *Biosciences Biotechnology Research Asia*, **13**(2):1163-1169.
- AOAC-Association of Official Agricultural Chemists. (1990). *Official Methods of Analysis*, 15th ed.; AOAC: Washington, DC, USA, ISBN 9780935584752.
- Caguiat, X.G.I. and Hautea, D.M. (2014). Genetic diversity analysis of eggplant (*Solanum melongena* L.) and related wild species in the Philippines using morphological and SSR markers. *SABRAO Journal of Breeding and Genetics*, **46**(2):183-201.
- Galaris, D.; Barbouti, A. and Pantopoulos, K. (2019). Iron homeostasis and oxidative stress: An intimate relationship. *Biochimica et Biophysica Acta (BBA) - Molecular Cell Research*, **12**:118535.
- Gritter, M.; Rotmans, J.I. and Hoorn, E.J. (2019). Role of dietary K⁺ in natriuresis, blood pressure reduction, cardiovascular protection, and renoprotection. *Hypertension*, **73**(1):15-23.
- Guillermo, N.M.; Dolores, M.R.; Gardea-Bejar, A.; Gonzalez-Aguilar, G.; Heredia, B.; Manuel, B.S.; Siller-Cepeda, J. and De La Rocha, R. V. (2014). Nutritional and nutraceutical components of commercial eggplant types grown in Sinaloa, Mexico. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **42**(2):538-544.
- Hao, M.H.; Zhang, F.; Liu, X.X.; Wang, L.J.; Xu, S.J.; Zhang, J.H.; Ji, H.L. and Xu, P. (2018). Qualitative and quantitative analysis of catechin and quercetin in flavonoids extracted from *Rosa roxburghii* Tratt. *Tropical Journal of Pharmaceutical Research*, **17**(1):71-76.
- Hazra, P. (2023). Antioxidants and health benefits of brinjal. In: *Vegetables for Nutrition and Entrepreneurship*; Springer: Singapore, pp:203-216.
- Hertzler, S.R.; Lieblein-Boff, J.C.; Weiler, M. and Allgeier, C. (2020). Plant proteins: Assessing their nutritional quality and effects on health and physical function. *Nutrients*, **12**(12):3704.
- Jaborova, D.; Dustova, M.; Chaudhary, M. and Azimov, A. (2024). The impact of biochar and mineral fertilizers on photosynthetic pigments and relative water contents of okra (*Abelmoschus esculentus* L. Moench). *Ann. Phytomed.*, **13**(2):1133-1139.
- Janaki, P.; Lalid Kumar, S.P.; Parameswari, E.; Monica, M.; Kirshnan, R.; Sunitha, R.; Suganthi, M. and Kavitha, P.S. (2024). Impact of regenerative farming practices on soil quality and yield of cotton-sorghum system in semi-arid Indian conditions. *Environmental Monitoring and Assessment*, **196**:462.
- Kandoliya, U.K.; Bajaniya, V.K.; Bhadja, N.K.; Bodar, N.P. and Golakiya, B.A. (2015). Antioxidant and nutritional components of eggplant (*Solanum melongena* L.) fruit grown in the Saurashtra region. *International Journal of Current Microbiology and Applied Sciences*, **4**(2):806-813.
- Li, P. and Wu, G. (2022). Important roles of amino acids in immune responses. *British Journal of Nutrition*, **127**(3):398-402.
- Ling, Z.N.; Jiang, Y.F. and Ru, J.N. (2023). Amino acid metabolism in health and disease. *Signal Transduction and Targeted Therapy*, **8**:345.
- Liu, Z.; Tu, M.J.; Zhang, C.; Jilek, J.L.; Zhang, Q.Y. and Yu, A.M. (2019). A reliable LC-MS/MS method for the quantification of natural amino acids in mouse plasma: Method validation and application to a study on amino acid dynamics during hepatocellular carcinoma progression. *Journal of Chromatography B*, **1124**:72-81.

- Luciano, A.J.; Irineo, T.P.; Virginia, O.V.R.; Feregrino-Perez, A.A.; Hernández, A.C. and Gerardo, G.G.R. (2017). Integrating plant nutrients and elicitors for production of secondary metabolites, sustainable crop production, and human health: A review. *International Journal of Agriculture and Biology*, **19**(3):391-402.
- Lyu, J.; Jin, N.; Ma, X.; Yin, X.; Jin, L.; Wang, S.; Xiao, X. and Yu, J. (2024). A comprehensive evaluation of nutritional quality and antioxidant capacity of different Chinese eggplant varieties based on multivariate statistical analysis. *Antioxidants* (Basel), **14**(1):10.
- Mritunjay Tripathi, M.T.; Pratibha Singh, P.S.; Praveen Pandey, P.P.; Pandey, V. and Harendra Singh, H.S. (2014). Antioxidant activities and biochemical changes in different cultivars of brinjal (*Solanum melongena* L.). *American Journal of Plant Physiology*, **9**:24-31.
- Mukhtar, Z.G.; Ozer, D.; Karatas, F. and Saydam, S. (2022). Amino acid contents of some eggplant species grown in different regions. *Journal of the Institute of Science and Technology*, **12**(2):857-869.
- Naem, M.Y., and Ugur, S. (2019). Nutritional content and health benefits of eggplant. *Turkish Journal of Agriculture - Food Science and Technology*, **7**:31-36.
- NHMRC (National Health and Medical Research Council) (2025). Nutrient reference values for Australia and New Zealand. Retrieved June 12, 2025, from <https://www.eatforhealth.gov.au/nutrient-reference-values/nutrients/>
- Palia, M.; Saravanan, S.; Prasad, V.M.; Upadhyay, R.G. and Kasera, S. (2021). Effect of different levels of organic and inorganic fertilizers on growth, yield and quality of brinjal (*Solanum melongena* L.). *Agricultural Science Digest-A Research Journal*, **41**(spl):203-206.
- Paswan, A.; Raj, S.; Sonloi, P. and Forum, B. (2022). Effect of integrated nutrient management on yield of brinjal. *International Journal of Agricultural and Food Science*, **4**(1):12-16.
- Rahim, A.; Yeasmin, M.; Shoagh, M.; Mim, A.; Nuha, I.; Roy, B.; Hossain, M.F.; Islam, J.; Kulsum, U. and Sabuj, M. (2024). Evaluating the proximate compositions, antioxidants, and minerals of brinjal hybrids and their progenitor (*Solanum melongena* L.). *Journal of Pharmacognosy and Phytochemistry*, **13**(6):195-202.
- Renna, M.; Stellacci, A.M.; Corbo, F. and Santamaria, P. (2020). The use of a nutrient quality score is effective to assess the overall nutritional value of three Brassica microgreens. *Foods*, **9**:1226.
- Sahil Hussain, Arun Kumar, Kuldeep Singh, Shom Prakash Kushwaha, Muhammad Arif and Mohd. Mursal (2023). Phytochemical and biological studies of *Solanum torvum* L. in folklore medicine of Assam Ann. *Phytomed.*, **12**(1):124-131. <http://dx.doi.org/10.54085/ap.2023.12.1.40>.
- Serna, J. and Bergwitz, C. (2020). Importance of dietary phosphorus for bone metabolism and healthy aging. *Nutrients*, **12**(10):3001.
- Sharma, M. and Kaushik, P. (2021). Biochemical composition of eggplant fruits: A review. *Applied Sciences*, **11**:7078.
- Statista (2025). <https://www.statista.com/statistics/1038975/india-production-of-eggplant/#statistic> (accessed on 20th March, 2025).
- Trovato, M.; Funck, D.; Forlani, G.; Okumoto, S. and Amir, R. (2021). Editorial: Amino acids in plants: Regulation and functions in development and stress defense. *Frontiers in Plant Science*, **12**:772810.
- USDA - U.S. Food and Drug Administration. (2025). Code of Federal Regulations Title 21. Retrieved June 12, 2025, from <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=101.12>
- Wang, F.; Gu, S.; Yuan, T. and Wang, Z. (2018). Effects of slow-release compound fertilizer on eggplant (*Solanum melongena*) quality. **20**:2613-2619.
- Zhang, X.; Su, M.; Du, J.; Zhou, H.; Li, X.; Zhang, M.; Hu, Y. and Ye, Z. (2022). Analysis of the free amino acid content and profile of 129 peach (*Prunus persica* (L.) Batsch) germplasms using LC-MS/MS without derivatization. *Journal of Food Composition and Analysis*. **114**:104811.

Citation

Lakshmi Charitha Vejedla, Ponnusamy Janaki, Mariappan Suganthi, Ramanujam Krishnan and Sadasivam Meena (2025). Effect of diverse nutrient management options on proximate composition, anti-oxidants, amino acids profile and nutritional quality of *Solanum melongena* L. *Ann. Phytomed.*, **14**(1):1013-1021. <http://dx.doi.org/10.54085/ap.2025.14.1.101>.