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Assessment of Elite Mulberry Genotypes for Fruit Traits and Biochemical Composition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study aimed to identify the most promising mulberry genotypes for fruit production by evaluating fruit characteristics, biochemical traits and nutritional composition. Eight elite mulberry genotypes were selected from the mulberry germplasm unit at the Department of Sericulture, GKVK, Bengaluru. The saplings were raised and transplanted into the main field 90 days after planting, following a Randomized Complete Block Design (RCBD) with a spacing of 5 × 3 feet, with three replications per genotype. The results revealed that among the eight genotypes, ME-0006 exhibited superior fruit characteristics, with the highest values for fruit length (3.16 cm), fruit width (2.01 cm), fruit weight (3.02 g) and fruit yield per plant (166.55 g). Biochemical analyses indicated that ME-0220 had the highest total soluble solids (TSS) (19.71°B), carbohydrate content (166.49

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mg/g), anthocyanin (38.41 mg/g), and zinc content (mg/100g). Genotype ME-0006 recorded the highest calcium content (153.80 mg/100 g), while MI-0014 showed the highest levels of phosphorus, potassium, and magnesium. Additionally, ME-0086 was notable for its higher content of micronutrients and vitamin C (34.17 mg/100 g). These findings may provide valuable insights for selecting mulberry genotypes with superior fruit yield and biochemical properties, which can be further utilized in breeding programs and commercial mulberry fruit cultivation.

Keywords: Elite mulberry genotypes; mulberry fruit; fruit purpose; biochemical analysis; nutritional composition.

1. INTRODUCTION

Mulberry (*Morus* spp.) is a perennial woody deciduous tree from the Moraceae family, traditionally cultivated for its leaves, which are the primary food source for silkworms (*Bombyx mori*) in sericulture. However, the fruit of the mulberry tree has gained increasing attention due to its nutritional and medicinal properties. The tree produces succulent, oval-shaped berries composed of multiple drupes, typically 1 to 2 centimeters long, in various colours. These colours, resulting from the presence of anthocyanins and flavonoid pigments highlight the genetic diversity within the mulberry genus [1,2]. Mulberry fruits are rich in vitamins, minerals, antioxidants, anthocyanins, flavonoids and other bioactive compounds and can potentially serve as a valuable functional food. Additionally, mulberry extracts exhibit a range of bioactivities, including hypolipidemic effects [3], macrophage activation [4], neuroprotection [5] and antitumor properties [6] all linked to the phenolic compounds present in the fruits. The phytonutrient content of mulberry fruits, including anthocyanins, flavonoids, vitamins, minerals, and dietary fibre, varies significantly among cultivars, influenced by genotype, environmental conditions and developmental stressors.

The growing demand for natural products with health benefits has spurred interest in the cultivation and breeding of mulberry genotypes that produce high-quality leaves and yield fruits with superior nutritional profiles. Given the nutritional and health-promoting properties of mulberry fruits, selecting cultivars with high fruit yield, excellent quality and superior nutritional profiles is of paramount importance. Identifying mulberry genotypes that optimize fruit yield and nutritional content is crucial for fully harnessing the potential of this fruit. In light of this, the present study aims to evaluate the fruit characteristics of selected elite mulberry genotypes, focusing on their potential for higher yields, improved quality and enhanced nutritional profiles.

2. MATERIALS AND METHODS

The study was carried out at the Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru, during 2022-2023. The experimental material included eight elite mulberry genotypes (Table 1) selected for their fruit production potential from the germplasm unit at UAS, GKVK, Bengaluru. Saplings were produced and planted on 90th day in the main field using 5 × 3 feet spacing in a randomized complete block design (RCBD) with three replications. On 150th day, the plants were pruned to a height of three feet from ground level. The analysis is conducted for both growth periods February to March and July to August (2023) growth, shedding light on the genotypic variations and the impact of seasonal conditions.

Table 1. List of elite mulberry genotypes and their accession number used in the study

Treatments	Genotypes/scientific name	Accession number	National accession number
T_1	*Morus indica*	MI-0516	IC-314082
T_2	*M. cathayana*	ME-0018	EC-493775
T_3	*M. latifolia*	ME-0067	EC-493765
T_4	*M. macroura*	ME-0220	EC-493947
T_5	*M. alba*	ME-0086	EC-493843
T_6	*M. multicaulis*	ME-0006	EC-493763
T_7	*M. indica* (S-34)	MI-0160	IC-313779
T_8	*M. indica* (M-5)- Standard check	MI-0014	IC-313679

To assess performance, five vigorous plants from each replication were selected for evaluating fruit traits. Hand-picking of mulberry fruits was employed to maintain quality and the harvested fruits were covered in polythene to protect them from external factors. Due to differences in growth and characteristics among genotypes, fruit availability varied. To ensure sample integrity, fruits were stored at -18°C until a sufficient quantity was collected for analysis. The collected fruits were then categorized into two groups for further examination.

1. Wet basis analysis: The stored fruits were kept at a constant temperature of -18°C to preserve their natural state, important for assessing certain biochemical parameters.
2. Dry-powder analysis: This involved additional steps to prepare the samples. Initially, the stored fruits were air-dried, followed by further dehydration in a 60°C hot-air oven for 44 to 48 hours to remove remaining moisture. After drying, the fruits were transformed into a powdered form and stored in polythene covers for analysis.

Statistical analysis was performed by using OP STAT software [7]. The mean values of the experiments were compared by using Duncan's Multiple Range Test (DMRT) [8]. This study aims to assess the fruit traits *viz.,* fruit length (cm), width (cm) and weight (g), number of fruits per plant, fruit yield per plant (g) and biochemical composition (pH of the fruit, TSS (°Brix), carbohydrate (mg/g), protein (mg/g), anthocyanin (mg/g), vitamin C (mg/100 g), P, K, Ca, Mg, Fe, Zn, Cu, Mn of selected elite mulberry genotypes. By analysing key parameters, this research seeks to identify genotypes with superior traits for fruit production. The findings may provide valuable insights into the potential for developing dual-purpose mulberry varieties, contributing to the diversification of mulberry utilization and supporting the economic resilience of sericulture farming communities.

The procedure for estimation of biochemical's as follows

1. pH of mulberry fruit - digital pH meter
2. Total soluble solids - Hand refractometer
3. Carbohydrates - Anthrone method [9]
4. Proteins - Lowry's method
5. Total anthocyanin - acidic methanol (99:1 Methanol: HCl)
6. Ascorbic acid - colorimetrically by AOAC 2000.
7. Phosphorous - vanadomolybdo-phosphoric yellow colour method described by Piper [10].
8. Potassium - flame photometer as outlined by Piper [10].
9. Calcium and magnesium – EDTA titration.
10. Estimation of micronutrients - estimated using the specified reagents in the atomic absorption spectrophotometer (AAS).

3. RESULTS AND DISCUSSION

3.1 Fruit Traits

Performance of elite mulberry genotypes for fruit traits is given in Table 2. Significant variation in fruit traits was observed in all the elite mulberry genotypes.

3.1.1 Fruit length (cm)

The genotype ME-0006 exhibited a significantly longer fruit length of 3.16 cm, followed by MI-0516 with 3.12 cm and shorter fruit length by ME-0018 (1.55 cm) (Table 2). These results align with the findings of [9] who evaluated 35 mulberry accessions for fruit characteristics, reporting fruit lengths ranging from 0.90 cm (Surat local) to 3.0 cm (Karanahalli). Similarly, [11,12] studied the fruit length of three species *viz., Morus alba, M. nigra* and *M. rubra* documenting a range of 1.5 to 2.5 cm. Genotypes like ME-0006 and MI-0516 consistently produced longer fruits, suggesting a genetic predisposition for enhanced fruit elongation.

3.1.2 Fruit width (cm)

Significant differences in fruit width were observed among the eight elite genotypes. ME-0006 recorded the highest fruit width at 2.00 cm, followed by MI-0516 with 1.84 cm, while ME-0220 had the smallest fruit width at 0.98 cm (Table 2). The consistent variation in fruit width across growing periods suggests a stable genetic foundation governing this trait. Genotypes like ME-0006 consistently displayed broader fruits of 24.05 per cent wider than the control genotype, indicating a genetic predisposition to enhanced fruit width. Considering the potential influence of inflorescence width on subsequent fruit width, genotypes with broader inflorescences may provide more space for fruit development, resulting in broader fruits.

3.1.3 Fruit weight (g)

The genotype ME-0006 recorded significantly higher fruit weight of 3.02 g followed by MI-0516 (2.72 g) and the lower fruit weight was recorded by ME-0018 (1.63 g) (Table 2). The present findings were confirmed by [13] reported that four mulberry cultivars *viz*., *Morus nigra*, *M. alba, M. rubra* and Kabli mulberry differed significantly in average fruit weight ranging from 2.54 to 3.02 g. [14] reported that MS - 9404 recorded a higher fruit weight of 1.891 g among the five mulberry cultivars studied. The variations in fruit weight among different mulberry genotypes, each genotype possesses its own genetic traits that influence fruit development, size and weight. Additionally, environmental conditions, such as temperature, humidity and nutrient availability, can substantially impact fruit growth [15].

3.1.4 Number of fruits per plant

Number of fruits per plant were significantly differed among the genotypes (Table 2). ME-0220 recorded higher number of fruits per plant (77.32), followed by ME-0018 (57.07) and lower number of fruits per plant was recorded by ME-0086 (40.90) for both growing periods. The results were supported by [14] who reported the fruit characteristics of five mulberry cultivars in which MS-9404 recorded a higher total number of fruits per tree (59.02).

3.1.5 Fruit yield per plant (g)

The genotype ME-0006 recorded higher fruit yield of 166.55 g followed by MI-0516 (134.87 g) and lower fruit yield was recorded by ME-0018 (93.84 g) (Table 2). The present findings were consistent with the study by [16] who conducted a study on a visualization of mulberry and the industrial exploitation of mulberry fruits for the global scenario. Among the selected varieties *Morus multicaulis* produces a higher fruit yield of 10.85 kg per tree under Indian climatic conditions. [14] reported the fruit characteristics of five mulberry cultivars Among all the cultivars MS-9404 recorded a higher fruit yield per tree (11.021 kg). ME-0006's consistent top performance of 19.95 per cent over the control genotype MI-0014 across both growing periods might be attributed to its genetic predisposition for larger fruit size and optimal utilization of varying environmental conditions.

3.2 Biochemical Constituents of Mulberry Fruits of Elite Genotypes

Biochemical composition of fruits in elite mulberry genotypes is given in Table 3. Significant variation in biochemical constituents was observed in all the elite mulberry genotypes.

3.2.1 pH of the fruit

Among the genotypes examined, ME-0067 exhibited the highest pH value at 4.93 followed by ME-0086 (4.74). In contrast, the genotype MI-0516 displayed the lowest pH value at 4.12 (Table 3). These findings were supported by [17] Lee and Hwang [17] who investigated the physiochemical changes in mulberry fruits during seven maturity stages of the ripening phase observing pH within the range of 3.9 to 5.5. [18] explored 112 mulberry genotypes and reported pH values ranging from a minimum of 4.22 to a maximum of 5.87. the variation in pH among

Table 2. Performance of elite mulberry genotypes for fruit traits

Genotypes	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	No. of fruits per plant	Fruit yield (g)
MI-0516	3.12^{a}	1.84^{ab}	2.72^{b}	48.68^{d}	134.87^{b}
ME-0018	1.55^{e}	1.10^{d}	1.63^{f}	57.07^{b}	93.84^{e}
ME-0067	2.83^{b}	1.33^{cd}	2.43^{c}	49.07^{d}	121.48^{c}
ME-0220	1.60^{e}	0.98^{d}	1.70^{f}	77.32^{a}	135.06^{b}
ME-0086	1.84^{d}	1.20^{cd}	2.09^{e}	40.90^{e}	87.40^{e}
ME-0006	3.16^{a}	2.00^{a}	3.02^{a}	54.40^{bc}	166.55^{a}
MI-0160	2.49^{c}	1.00^{d}	2.09^{e}	51.07^{cd}	109.13^{d}
MI-0014	2.83^{b}	1.52^{bc}	2.25^{d}	54.67^{bc}	125.38^{c}
F test	*	*	*	*	*
S.Em±	0.041	0.035	0.032	1.445	2.264
CD @ 5%	0.125	0.106	0.097	4.384	6.869
CV (%)	2.950	4.439	2.474	4.623	3.223

** Significant at 5%; Figures with the same superscript are statistically on par*

Fig. 1. Phenotypic variations in the fruit size among elite mulberry genotypes

Table 3. Biochemical composition of fruits in elite mulberry genotypes

Genotypes	pH	TSS (ºBrix)	Carbohydrate (mg/g)	Protein (mg/g)	Anthocyanin (mg/g)	Vitamin C (mg/100 g)
MI-0516	4.69^{ab}	12.03^{c}	131.57^{cd}	10.61^{d}	25.65^{c}	29.57^{bcd}
ME-0018	4.12^{c}	15.40^{bc}	140.79^{c}	8.84^{e}	18.52^{e}	26.77^{d}
ME-0067	4.93^{a}	12.25^{c}	139.37^{cd}	12.11^{c}	32.52^{b}	28.61^{cd}
ME-0220	4.27^{c}	19.71^{a}	166.49^{a}	13.49^{b}	38.41^{a}	31.51^{abc}
ME-0086	4.74^{ab}	13.70^{c}	149.50^{b}	13.94^{ab}	4.49^{f}	34.17^{a}
ME-0006	4.24^{c}	19.47^{a}	155.43^{b}	11.85^{c}	23.31^{cd}	32.46^{ab}
MI-0160	4.61^{b}	12.40^{c}	130.26^{d}	12.39^{c}	20.99^{de}	30.25^{bcd}
MI-0014	4.23^{c}	17.47^{ab}	139.36^{cd}	14.52^{a}	20.27^{de}	31.56^{abc}
F test	*	*	*	*	*	*
S.Em±	0.091	0.994	2.820	0.220	1.066	1.124
CD @ 5%	0.275	2.982	8.456	0.660	3.197	3.371
CV (%)	3.547	11.260	3.390	3.123	8.024	6.363

** Significant at 5%; Figures with the same superscript are statistically on par*

different mulberry genotypes is primarily a result of genetic differences that affect the levels of organic acids and other compounds in the fruit. Environmental factors and the stage of fruit maturity further influence these pH levels [15].

3.2.2 TSS (°Brix)

Among the genotypes evaluated, TSS differed significantly (Table 3). ME-0220 exhibited the highest TSS value with 19.71°Brix followed by ME-0018 with 19.47°Brix. Genotype MI-0516 displayed the lowest TSS value with 12.03°Brix. The findings of this study were corroborated by [19] who reported TSS content varying between 15.65 °Brix and 22.1 °Brix. Additionally, [18] examined 112 mulberry genotypes, observing TSS values ranging from a minimum of 11.20 °Brix to a maximum of 24.80 °Brix.

3.2.3 Carbohydrate (mg/g)

Among the examined genotypes, ME-0220 recorded notably elevated carbohydrate content at 166.49 mg/g, followed by ME-0006 at 155.43 mg/g and ME-0086 at 149.50 mg/g. MI-0160 displayed the lowest carbohydrate content at 130.26 mg/g (Table 3). Genetic variability within mulberry genotypes is a key factor influencing carbohydrate accumulation. Sunlight availability profoundly influences photosynthesis, a pivotal process that drives carbohydrate production. Genotypes such as ME-0220 might have optimized photosynthetic mechanisms that enable them to harness more sunlight, resulting in increased carbohydrate synthesis.

3.2.4 Protein (mg/g)

Among the genotypes examined, MI-0014 exhibited significantly higher protein content of 14.52 mg/g followed by ME-0086 (13.94 mg/g) and ME-0220 with 13.49 mg/g. The genotype ME-0018 recorded lower protein content of 8.84 mg/g (Table 3). The results were consistent with the study by [20] who reported the protein content ranged from 8.21 to 8.94 mg/g on fresh fruit basis [8]. Huang et al. [6] reported the composition of mulberry fruit protein ranged from 9.60 mg/g to 17.31 mg/g on dry weight basis. Genotypes with higher protein content, such as MI-0014 and ME-0086 could exhibit optimized pathways for amino acid synthesis and accumulation [21].

3.2.5 Anthocyanin (mg/g)

Among the examined genotypes, ME-0220 had the highest anthocyanin concentration (38.41 mg/g), followed by ME-0006 (32.52 mg/g) and ME-0006 at 25.65 mg/g. While ME-0086 showed the lowest (4.49 mg/g) on dry weight basis (Table 3). These findings align with [22] who reported 193.85 mg/kg of total anthocyanins in wild purple mulberry. [23] found 48.23-67.58 mg/100 ml of anthocyanins in mulberry fruit wine. Similarly, [24] observed anthocyanin content ranging from 28.61 mg/g to 0.95 mg/g on a dry weight basis across 12 mulberry genotypes during processing.

3.2.6 Vitamin C (mg/100 g)

Among the elite genotypes examined, ME-0086 exhibited the highest levels of vitamin C at 34.17 mg/100g followed by ME-0006 (32.46 mg/100 g). Genotype ME-0018 displayed lower vitamin concentrations at 26.77 mg/100g (Table 3). The results of the present findings were supported by [25] who reported the vitamin C content of black mulberry ranged from 14.9 and 18.7 mg/100 ml. [22] reported that 28.42mg/kg ascorbic acid content is present in wild purple mulberry grown in Turkey. Various genotypes may exhibit unique metabolic pathways influencing vitamin C production, potentially resulting in differing content. Furthermore, the stage of fruit ripening, which can impact vitamin C accumulation, may lead to variations among genotypes with varying ripening rates.

3.3 Nutritional Composition of Fruits in Elite Mulberry Genotypes

Nutritional composition of fruits in elite mulberry genotypes is given in Table 4. Significant variation in nutritional constituents was observed in all the elite mulberry genotypes.

3.3.1 Phosphorous (mg/100 g)

The genotypes MI-0014, ME-0086 and ME-0006 exhibited the highest phosphorus levels at 241.89 mg/100 g, 238.32 mg/100 g and 224.18 mg/100 g, respectively. While ME-0018 displayed a lower phosphorus content of 198.25 mg/100 g (Table 4). [26] reported phosphorus content ranging from 226.13 to 247.83 mg/100 g in black (*M. nigra*), white (*M. alba*) and red (*M. rubra*) mulberries in Turkey. Similarly, [27] found phosphorus levels between 198.71 and 229.28 mg/100 g across various mulberry species. [28] recorded phosphorus content ranging from 150.85 to 228.48 mg/100 g in black mulberries (*Morus nigra* L.) from Mahmatlar, Turkey.

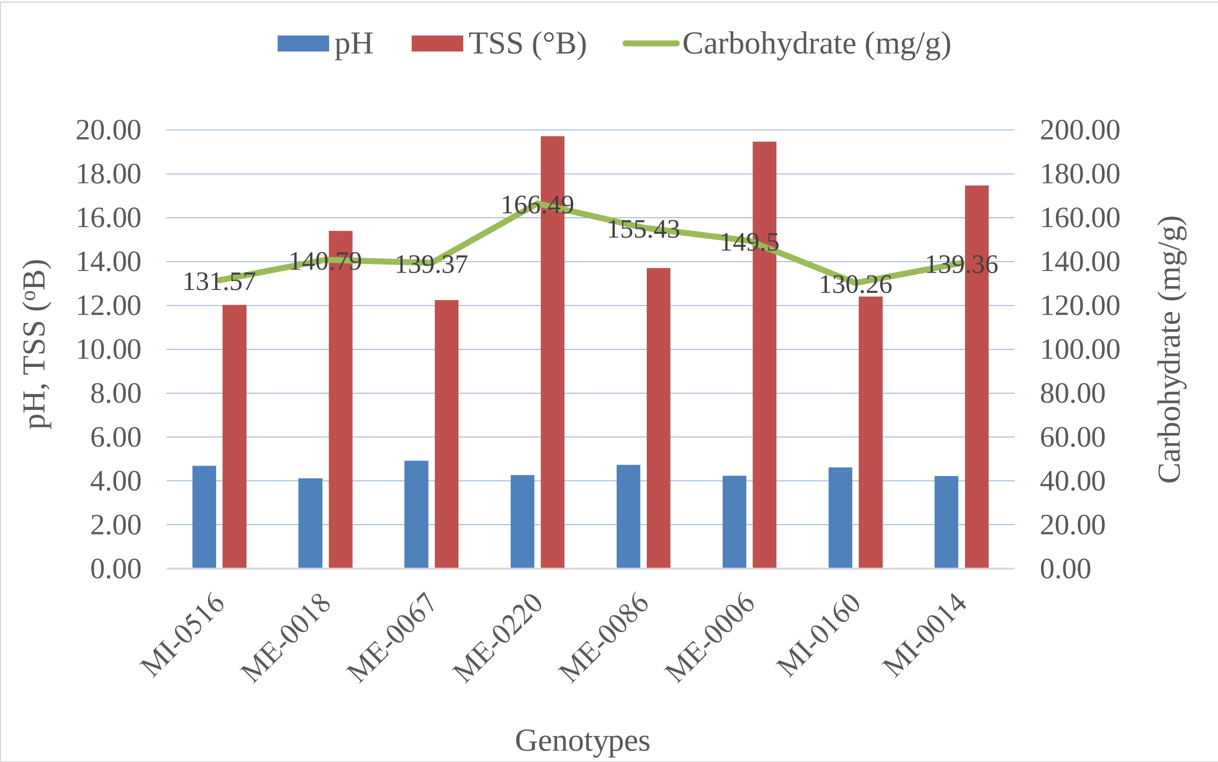

Fig. 2. pH, TSS and carbohydrate composition of fruits in elite mulberry genotypes

Table 4. Nutritional composition of fruits in elite mulberry genotypes

Genotypes	Phosphorous (mg/100 g)	Potassium (mg/100 g)	Calcium (mg/100g)	Magnesium (mg/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)	Copper (mg/100 g)	Manganese (mg/100 g)
MI-0516	205.87^{cd}	847.10^{f}	107.73^{c}	76.99^{d}	3.06^{f}	2.14^{c}	0.39^{c}	3.05^{c}
ME-0018	198.25^{d}	982.39^{de}	124.47^{b}	94.19^{bc}	3.85^{bc}	2.04^{c}	0.35^{d}	2.94^{c}
ME-0067	203.81^{cd}	934.11^{e}	105.62^{c}	100.35^{ab}	4.14^{a}	1.91^{c}	0.40^{c}	2.81^{c}
ME-0220	214.64^{bc}	681.48^{g}	112.73^{bc}	88.95^{c}	3.33^{e}	3.08^{a}	0.35^{d}	3.99^{a}
ME-0086	238.32^{a}	1155.63^{ab}	141.97^{a}	99.23^{ab}	4.26^{a}	2.45^{b}	0.48^{a}	4.09^{a}
ME-0006	224.18^{b}	1050.43^{cd}	153.80^{a}	90.85^{c}	3.56^{d}	2.64^{b}	0.41^{bc}	3.54^{b}
MI-0160	221.78^{b}	1104.17^{bc}	126.11^{b}	88.16^{c}	3.71^{cd}	1.99^{c}	0.40^{c}	2.89^{c}
MI-0014	241.89^{a}	1193.93^{a}	143.34^{a}	103.79^{a}	4.05^{ab}	2.58^{b}	0.43^{b}	3.48^{b}
F test	*	*	*	*	*	*	*	*
S.Em±	4.525	24.557	4.571	2.361	0.074	0.088	0.007	0.106
CD @ 5%	13.567	73.623	13.704	7.080	0.224	0.264	0.021	0.319
CV (%)	3.585	4.280	6.235	4.407	3.464	6.494	3.069	5.505

** Significant at 5%; Figures with the same superscript are statistically on par*

3.3.2 Potassium (mg/100 g)

Among the genotypes, MI-0014 had the highest potassium concentration (1193 mg/100 g), followed by ME-0086 (1155.63 mg/100 g) and MI-0160 (1104.17 mg/100 g), while ME-0220 had the lowest (681.48 mg/100 g) (Table 4). These results align with [26] who reported potassium levels of 834.65 to 1668.01 mg/100 g in mulberry fruits, [27] who found levels of 1180.67 to 1420.57 mg/100 g, and [28], who observed 599.34 to 1254.85 mg/100 g in black mulberries.

3.3.3 Calcium (mg/100 g)

Among the genotypes analysed, ME-0006 exhibited significantly elevated calcium levels at 153.80 mg/100 g followed by MI-0014 at 143.34 mg/100 g, and ME-0086 at 141.97 mg/100 g. Conversely, the genotype ME-0067 displayed comparatively lower calcium content at 105.62 mg/100 g (Table 4). The present findings align with [26], who examined the chemical composition of black (*Morus nigra*), white (*Morus alba*), and red (*Morus rubra*) mulberry varieties grown in Turkey, reporting calcium concentrations ranging from 132 mg/100 g to 152 mg/100 g.

3.3.4 Magnesium (mg/100g)

Among the genotypes, MI-0014 had the highest magnesium concentration (103.79 mg/100 g), followed by ME-0067 (100.35 mg/100 g) and ME-0086 (99.23 mg/100 g), while MI-0516 had the lowest (76.99 mg/100 g). These findings are consistent with [24], who reported magnesium levels of 106-115 mg/100 g in mulberries, [27] who found 95.04-117.09 mg/100 g, and [28], who observed 92-152 mg/100 g in black mulberries.

3.3.5 Iron (mg/100 g)

Among the genotypes evaluated, genotype ME-0086 displayed the highest iron content at 4.26 mg/100 g followed closely by ME-0067 at 4.14 mg/100 g. In contrast, the genotype MI-0516 exhibited lower iron levels at 3.06 mg/100g (Table 4). These findings align with [26], who reported iron levels of 4.2-4.5 mg/100 g in black, white, and red mulberries grown in Turkey. Similarly, [27] found iron content ranging from 3.47 to 4.45 mg/100 g in mulberries, while [28] observed iron concentrations of 4.47 to 10.59 mg/100 g in black mulberry genotypes.

3.3.6 Zinc (mg/100 g)

Among the genotypes, ME-0220 had the highest zinc content (3.08 mg/100 g), followed by ME-0006 (2.64 mg/100 g) and MI-0014 (2.58 mg/100 g), while ME-0067 had the lowest (1.91 mg/100 g). These results align with [26], who reported zinc levels of 2.8-3.2 mg/100 g in mulberries, [27], who found 1.8-3.6 mg/100 g and [28], who observed zinc content ranging from 2.07 to 4.36 mg/100 g in black mulberries.

3.3.7 Copper (mg/100 g)

Copper concentrations varied significantly among genotypes, with ME-0086 showing the highest content (0.48 mg/100 g), followed by MI-0014 (0.43 mg/100 g) and ME-0006 (0.41 mg/100 g). ME-0018 had the lowest (0.35 mg/100 g). [26] reported copper levels of 0.4-0.5 mg/100 g in mulberries, while [28] found copper content ranging from 0.22 to 0.58 mg/100 g in black mulberries. ME-0086 showed a 10.41% increase over MI-0014, likely due to genetic diversity affecting copper uptake and accumulation.

3.3.8 Manganese (mg/100 g)

Among the genotypes, ME-0086 had the highest manganese concentration (4.09 mg/100 g), followed by ME-0220 (3.99 mg/100 g) and ME-0006 (3.54 mg/100 g), while ME-0067 had the lowest (2.81 mg/100 g). These findings are consistent with [26], who reported manganese levels of 3.8-4.2 mg/100 g in mulberries. [27] found levels ranging from 1.8 to 2.6 mg/100 g, and [28] observed manganese content between 3.8 and 5.9 mg/100 g in black mulberries.

These differences may be due to ecological factors, growing conditions and genetic factors. Mineral nutrition is controlled by environment, soil and plant factors. Since the uptake of nutrients from the soil is genetically controlled, plant species and varieties show different responses to nutrients even when they are grown in the same conditions [28]. The black mulberry genotypes showed valuable phytochemical properties and have the potential to be used in food and healthcare industries. The results on the phenolic and phytochemical properties of the mulberry genotypes may be of use to both consumers and agricultural companies that supply important genetic sources for breeding studies [29].

The levels of essential minerals such as Calcium (Ca), Potassium (K), Phosphorus (P) and Magnesium (Mg) in mulberry fruits were observed to surpass the standard reference values. On the other hand, the concentrations of various other elements present in the fruits remained within the expected normal ranges. It is noteworthy that the recommended dietary allowance (RDA) values for the major macro-elements, namely Calcium, Potassium, Magnesium and Phosphorus, are set at 1200, 4700, 420 and 700 milligrams, respectively on a daily basis. Interestingly, the concentrations of these elements in mulberry fruits suggest their potential significance as a valuable dietary source.

In summary, mulberry fruits exhibited elevated levels of Ca, K, P and Mg compared to established standards, while the concentrations of other elemental components fall within the expected ranges. Given that the RDA values for these essential macro-elements are well met by consuming mulberry fruits, they hold promising nutritional importance as a favourable and abundant source of these essential minerals.

4. CONCLUSION

This study highlights the mulberry genotypes, chosen for fruit purpose such as quality and production. Mulberry fruits provide significant health advantages due to high essential mineral and bioactive compound levels. Concentrations of key macro-elements exceed recommended dietary values, suggesting mulberries as a valuable source of essential minerals for overall health. The elite genotype ME-0006 emerged as a standout performer, demonstrating superior fruit length, width, weight, and overall yield per plant. ME-0220 also exhibited notable performance, particularly in terms of the number of fruits per plant. These findings suggest that certain genotypes possess genetic predispositions that contribute to their exceptional fruit characteristics. The biochemical analysis revealed significant variations in the composition of mulberry fruits among the genotypes. ME-0220 stood out with higher total soluble solids (TSS), carbohydrate, anthocyanin, and zinc content. ME-0006 displayed elevated calcium levels, while MI-0014 exhibited higher concentrations of phosphorus, potassium, magnesium, and protein. ME-0086 recorded a higher content of micronutrients and vitamin C.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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