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Physico-chemical and sensory evaluation of different Mulberry (*Morus Spp.*) genotypes

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Abstract

The present experiment entitled "Physico-chemical and sensory evaluation of different Mulberry (*Morus Spp.*) genotypes" was carried out during the academic session 2024-25 at the Laboratory of Fruit Science, Pt. Kishori Lal Shukla College of Horticulture and Research Station, Rajnandgaon (C.G.), the study involved 15 distinct genotypes collected from Surguja, Surajpur, and Rajnandgaon districts. Analysis of variance revealed highly significant genetic variability among the genotypes for all studied characters, indicating substantial scope for selection. In terms of physical attributes, genotype Mulberry-2 (collected from Gumgara, Surguja) emerged as the superior performer, recording the maximum fruit weight (7.51 g), fruit length (9.96 mm), fruit width (11.87 mm), and fruit volume (7.34 cc). This was followed by Mulberry-1 (7.04 g) and Mulberry-13 (6.71 g), while the lowest fruit weight was observed in Mulberry-14 (0.42 g). Biochemically, Mulberry-2 exhibited exceptional quality with the highest Total Soluble Solids (25.50 °Brix), coupled with a low titratable acidity (0.68%). Conversely, Mulberry-14 recorded the minimum TSS (11.50 °Brix) and maximum acidity (2.15%), indicating poor eating quality.

Keywords: Mulberry and Germplasm collection

Introduction

Mulberry (*Morus spp.*), a vital member of the Moraceae family, is a highly valued and remarkably versatile crop, recognized globally for its rapid growth, significant climatic resilience, and profound economic and nutritional contributions. Commonly known in the Indian subcontinent as "toot" and "shahtoot," its history is inextricably linked to the ancient Silk Road, where it facilitated not only the trade of precious silk but also the cultural and genetic exchange of the plant itself. Its multifaceted utility-providing fruit, fodder, fuel, and timber-has earned it the esteemed title of 'Kalpa Vriksha,' or the 'wish-fulfilling tree,' signifying its integral role in sustaining rural livelihoods and fostering economic self-sufficiency (Srivastava *et al.*, 2021) [1].

Horticulturally, mulberry is a fast-growing, deciduous, woody perennial with a deep root system that confers considerable drought tolerance. It can grow into a medium-sized tree reaching 10-20 meters but is often managed as a bush for ease of harvesting. The plants are generally dioecious, with male and female flowers on separate individuals, although monoecious plants also exist. The fruit is a collective fruit known as a sorosis, which is highly perishable upon ripening (Kadam *et al.*, 2019) [3]. The genus *Morus* is genetically diverse, comprising numerous species, with the most commercially significant being the white mulberry (*Morus alba*), prized for sericulture; the black mulberry (*Morus nigra*), and the red mulberry (*Morus rubra*), both celebrated for their intensely flavorful fruits (Ercisli & Orhan, 2007) [4].

This genetic adaptability allows mulberry to thrive across a broad spectrum of agro-climatic zones, from temperate highlands to tropical lowlands. It demonstrates a remarkable tolerance to various soil types, including marginal, alkaline, and saline soils, although it performs best in well-drained loamy soils. Its ability to withstand wide temperature fluctuations and prolonged drought makes it an ideal crop for agricultural diversification, agroforestry systems, and cultivation in climate-vulnerable regions (Hosseini *et al.*, 2018; Londe *et al.*, 2022) [5, 6].

The exceptional adaptability of mulberry has led to its establishment as a globally significant crop. China is the undisputed leader in mulberry cultivation, driven by its massive sericulture industry. India stands as the second-largest producer, with a vast area dedicated to the crop, particularly in the southern states of Karnataka, Andhra Pradesh, and Tamil Nadu, which collectively account for about 90 percent of production. Other major cultivation areas in India include West Bengal and the northeastern states (Thirupathaiah *et al.*, 2019) ^[9]. Within the state of Chhattisgarh, mulberry represents a crop with significant, yet largely untapped, potential. The state's diverse agro-climatic conditions are highly conducive to its growth, and a rich diversity of mulberry genotypes exists as scattered, uncharacterized populations across various districts like Surguja, Surajpur, and Rajnandgaon. These local landraces constitute a valuable germplasm pool that is well-adapted to regional conditions. However, a critical knowledge gap exists, as there has been no systematic scientific investigation into the physico-chemical properties and sensory qualities of these local varieties. This lack of data severely limits their potential for commercial exploitation and inclusion in crop improvement programs.

The economic importance of mulberry is multi-dimensional, providing a robust foundation for rural economies. The primary economic driver has been the sericulture industry, a labor-intensive sector that generates significant employment, especially for women in rural areas, thereby contributing to poverty alleviation and empowerment. In parallel, the horticultural sector focused on mulberry fruit is gaining substantial economic momentum. High market demand for fresh mulberries and their processed products offers a lucrative income stream for farmers. The fruit's versatility allows it to be transformed into a wide array of value-added products, including juices, jams, wines, powders, and natural colorants. This value addition not only extends the shelf-life of the highly perishable fruit but also opens up new markets, particularly in the rapidly growing functional food and nutraceutical sectors (Thakur *et al.*, 2020; Kamiloglu *et al.*, 2021) ^[8, 7].

Materials and Methods

The present experiment was carried out during the academic session 2024-25 at the Laboratory of Fruit Science, Pt. Kishori Lal Shukla College of Horticulture and Research Station, Rajnandgaon (C.G.), the study involved 15 distinct genotypes collected from Surguja, Surajpur, and Rajnandgaon districts. The field experiment was conducted in Complete Randomized Design (CRD) with three replications having fifteen different treatments *i.e.*, .., Mulberry 1 (T₁), Mulberry 2 (T₂), Mulberry 3 (T₃), Mulberry 4 (T₄), Mulberry 5 (T₅), Mulberry 6 (T₆), Mulberry 7 (T₇), Mulberry 8 (T₈), Mulberry 9 (T₉), Mulberry 10 (T₁₀), Mulberry 11 (T₁₁), Mulberry 12 (T₁₂), Mulberry 13 (T₁₃), Mulberry 14 (T₁₄), Mulberry 15 (T₁₅). Fruits were harvested manually during the early morning hours (06:00 AM-08:00 AM) to minimize the respiration rate and field heat. Care was taken to harvest fruits at the physiological maturity stage, characterized by full color development (deep purple/black or translucent white/pink, depending on the genotype) and ease of detachment from the spur. The harvested fruits were immediately placed in clean, perforated plastic crates lined with soft tissue paper and cushioning material to prevent compression damage and

bruising during transit. The crates were placed in cool boxes maintained at 10-15 °C to arrest metabolic activities and were transported to the Laboratory of Fruit Science, Rajnandgaon, on the same day. Five plants at random were selected and tagged in order to record the observations on the fruit weight, fruit length, fruit width, fruit volume, specific gravity, total soluble solids, titratable acidity and TSS: Acid ratio.

Result and Discussion

Physical parameters of mulberry genotypes

The physical characteristics of the fruit are the most visible and commercially significant traits that determine the market value and consumer acceptance of mulberry. Attributes such as the size, weight, and volume of the fruit (sorosis) are directly correlated with yield and attractiveness. The data pertaining to the physical parameters, namely fruit weight, fruit length, fruit width, and fruit volume, are presented in Table 1.

Fruit weight (g)

Among the fifteen genotypes evaluated, Mulberry-2 recorded the significantly highest fruit weight of 7.51 g. This genotype was collected from Gumgara village in the Lakhanpur block of Surguja district. It was followed by Mulberry-1 (collected from Parri), which recorded a fruit weight of 7.04 g, and Mulberry-13 (collected from Pendri, Rajnandgaon), which recorded 6.71 g. These three genotypes formed a distinct superior cluster, significantly outperforming the rest of the germplasm.

On the contrary, the lowest fruit weight was observed in Mulberry-14 (0.42 g), followed closely by Mulberry-12 (0.56 g) and Mulberry-15 (0.59 g). The vast difference between the highest (7.51 g) and lowest (0.42 g) values highlights the immense biological diversity within the *Morus* species found in this region. The heavier fruits in Mulberry-2 and Mulberry-1 might be attributed to a higher number of drupelets per sorosis and greater accumulation of metabolites in the fleshy perianth.

The population mean of the current study (2.23 g) is very similar to the findings of Kumari *et al.* (2024) ^[10], but the wide range indicates that while the average wild mulberry is small, specific selections like Mulberry-2 possess a distinct advantage in terms of fruit biomass.

Fruit length (cm)

A critical perusal of the data reveals that fruit length varied significantly from 1.45 cm to 9.96 cm. The maximum fruit length was recorded in genotype Mulberry-2 (9.96 cm), which was statistically at par with Mulberry-1 (9.01 cm). Mulberry-13 also exhibited a respectable fruit length of 8.13 cm. These measurements indicate that the fruits of these superior genotypes are not only heavy but also relatively longer, although they appear to be of the globose or short-cylindrical type rather than the long-cylindrical type often seen in species like *Morus macroura*.

The minimum fruit length was recorded in Mulberry-14 (1.45 cm), followed by Mulberry-12 (1.57 cm) and Mulberry-3 (1.60 cm). The strong positive correlation observed between fruit weight and fruit length suggests that elongation is a primary factor driving the increase in fruit biomass in these genotypes.

Comparing these findings with the literature, Iqbal *et al.* (2007) ^[11] reported fruit lengths ranging from 1.61 cm to

2.23 cm (16.1 cm to 22.3 cm) in cultivated mulberry varieties in Pakistan. The values obtained in the present investigation are lower than those reported by Iqbal *et al.* (2007) ^[11]. This discrepancy suggests that the genotypes evaluated in the current study, particularly the smaller ones like Mulberry-14, might be wild seedlings or specific local landraces with smaller fruiting bodies compared to the commercially cultivated varieties assessed in other regions. However, the variation trend remains consistent with Gharibi *et al.* (2024) ^[12], who emphasized the significant impact of genotype on morphological dimensions.

Fruit width (mm)

The fruit width ranged from 9.20 mm to 11.87 mm, with a general mean of 10.58 mm. The highest fruit width was recorded in Mulberry-2 (11.87 mm), followed closely by Mulberry-1 (11.36 mm) and Mulberry-13 (11.34 mm). Genotype Mulberry-4 also showed a good width of 11.10 mm. The lowest fruit width was observed in Mulberry-14 (9.20 mm).

The results are partially in agreement with Koyuncu *et al.* (2004) ^[15], who reported fruit width in the range of 15.73 mm to 17.42 mm for black mulberry genotypes. The genotypes in the present study are thinner compared to those Turkish genotypes. However, the results align more closely with Kumari *et al.* (2024) ^[10], who reported an average fruit size of 21.37 × 13.50 mm.

Fruit volume (cc)

Similar to the trend observed for fruit weight, fruit volume showed highly significant variation, ranging from 0.12 cc to 7.34 cc. Genotype Mulberry-2 recorded the maximum fruit volume of 7.34 cc, followed by Mulberry-1 (6.65 cc) and Mulberry-13 (6.40 cc). These values were statistically higher than the rest of the genotypes. The minimum fruit volume was recorded in Mulberry-14 (0.12 cc).

The variation in physical parameters such as weight and volume can often be linked to the ploidy level of the plants. As discussed by Vijayan *et al.* (2012) ^[13], polyploidy (triploidy or tetraploidy) in mulberry is often associated with the "gigas" effect, leading to larger leaves and fruits. It is plausible that the large-fruited genotypes identified in this study (Mulberry-2, Mulberry-1) are naturally occurring polyploids or superior selections, while the small-fruited ones are diploids.

Chemical and nutritional parameters of mulberry genotypes

The biochemical profile is a direct reflection of the metabolic efficiency of the genotype and its interaction with the environment. In the present investigation, key chemical parameters including Total Soluble Solids (TSS), Titratable Acidity, and the TSS: Acid ratio were evaluated to assess the qualitative superiority of the fifteen mulberry genotypes. The results of the biochemical analysis are presented in Table 2.

Total soluble solids (°Brix)

The results indicated a substantial variation in TSS content among the genotypes, ranging from a minimum of 11.50 °Brix to a maximum of 25.50 °Brix. The population mean was recorded at 19.67 °Brix (Table 4.7). The significantly highest TSS was recorded in genotype Mulberry-2 (25.50 °Brix), which was collected from Gumgara, Surguja. This was followed by Mulberry-13 (24.20 °Brix), collected from

Pendri, Rajnandgaon, and Mulberry-1 (23.80 °Brix), collected from Parri, Surguja. These three genotypes formed a statistically superior group with TSS values well above 23 °Brix.

Similarly, Koyuncu *et al.* (2004) ^[15] reported soluble solids ranging from 13.11 to 16.23 percent in native black mulberry genotypes. The mean TSS of the current study (19.67 °Brix) is considerably higher than these values. However, the results are in close agreement with Balik *et al.* (2019) ^[14], who observed a wider range of soluble solids from 14.33 percent to 23.50 percent in various mulberry genotypes. The consistency with Balik *et al.* (2019) ^[14] confirms that while average mulberry genotypes may have moderate sugar levels, elite selections can achieve very high brix levels, as demonstrated by Mulberry-2.

Acidity (%)

The acidity percentage ranged widely from 0.35 percent to 2.15 percent, with an overall mean of 1.07 percent. The minimum acidity was recorded in genotype Mulberry-5 (0.35 percent), indicating a very mild, sweet taste profile typical of white mulberry (*Morus alba*) varieties. This was followed by Mulberry-2 (0.68 percent) and Mulberry-13 (0.70 percent). On the other hand, the maximum acidity was recorded in Mulberry-14 (2.15 percent), followed by Mulberry-12 (1.95 percent) and Mulberry-15 (1.45 percent). The genotype Mulberry-2, which recorded the highest TSS, also exhibited a relatively low acidity of 0.68 percent. This specific combination of very high sugar and low-to-moderate acidity suggests a fruit with an intensely sweet and rich flavor, highly desirable for table purposes. The high acidity in Mulberry-14, combined with its lowest TSS (11.50 °Brix), indicates a fruit that is predominantly sour and tart. Such genotypes are likely unsuitable for fresh eating but could be valuable for processing into products where acidity is needed for preservation, or for medicinal uses as organic acids are often linked to antioxidant stability. The variation in acidity is consistent with findings in the literature. Ercisli and Orhan (2007) ^[4] noted that acidity in mulberry is highly genotype-dependent.

TSS: Acid ratio

Genotype Mulberry-2, identified as the superior genotype in physical traits, recorded a TSS: Acid ratio of 37.50. This is considered an optimal range for fruit quality, resulting from the combination of the highest TSS (25.50 °Brix) and a moderate acidity (0.68 percent). This balance ensures a rich sweetness with just enough acid to provide flavor complexity. Mulberry-13 also recorded a high ratio of 34.57, followed by Mulberry-1 (32.99), placing these three genotypes in the category of excellent quality fruits.

Conversely, the lowest TSS: Acid ratio was observed in Mulberry-14 (5.35), followed by Mulberry-12 (7.59) and Mulberry-15 (11.17). A ratio of 5.35 in Mulberry-14 confirms its poor eating quality, as the high acidity (2.15 percent) overwhelms the low sugar content.

Based on these ratios, the genotypes can be broadly classified into flavor categories: "Sweet-Bland" (Mulberry-5), "Rich-Sweet" (Mulberry-2, Mulberry-1, Mulberry-13), and "Sour-Tart" (Mulberry-14, Mulberry-12). This classification is crucial for determining the appropriate end-use of each genotype. Mulberry-2 is ideal for fresh consumption, while Mulberry-14 might be better suited for extraction of bioactive compounds where taste is secondary.

Table 1: Physical parameters of different mulberry genotypes

Treatments	Genotypes	Fruit weight (g)	Fruit length (cm)	Fruit width (mm)	Fruit volume (cc)
T ₁	Mulberry 1	7.04	9.01	11.36	6.65
T ₂	Mulberry 2	7.51	9.96	11.87	7.34
T ₃	Mulberry 3	0.60	1.60	10.22	0.43
T ₄	Mulberry 4	3.50	3.70	11.10	3.10
T ₅	Mulberry 5	1.20	1.99	11.00	1.04
T ₆	Mulberry 6	0.61	1.61	10.00	0.30
T ₇	Mulberry 7	0.79	1.88	10.60	0.28
T ₈	Mulberry 8	1.21	2.06	10.90	1.03
T ₉	Mulberry 9	1.19	2.03	10.50	1.08
T ₁₀	Mulberry 10	0.81	1.84	10.35	0.36
T ₁₁	Mulberry 11	0.65	1.94	10.00	0.28
T ₁₂	Mulberry 12	0.56	1.57	10.89	0.18
T ₁₃	Mulberry 13	6.71	8.13	11.34	6.40
T ₁₄	Mulberry 14	0.42	1.45	9.20	0.12
T ₁₅	Mulberry 15	0.59	1.54	9.43	0.26
SEM±		0.07	0.15	0.39	0.14
CD (P = 0.05)		0.21	0.42	1.13	0.41
CD (P = 0.01)		0.29	0.56	1.52	0.55
CV (%)		5.72	7.46	6.40	12.77

Table 2: Total soluble solids, acidity, ascorbic acid and TSS: Acid ratio of different mulberry genotypes

Treatments	Genotypes	Total soluble solids (°Brix)	Acidity (%)	TSS: Acid ratio
T ₁	Mulberry 1	23.80	0.72	32.99
T ₂	Mulberry 2	25.50	0.68	37.50
T ₃	Mulberry 3	17.50	1.30	13.46
T ₄	Mulberry 4	22.50	0.75	30.00
T ₅	Mulberry 5	20.50	0.35	58.57
T ₆	Mulberry 6	18.20	1.20	15.17
T ₇	Mulberry 7	19.50	0.95	20.53
T ₈	Mulberry 8	21.50	0.80	26.88
T ₉	Mulberry 9	20.80	0.88	23.64
T ₁₀	Mulberry 10	19.80	1.05	18.86
T ₁₁	Mulberry 11	18.80	1.15	16.35
T ₁₂	Mulberry 12	14.80	1.95	7.59
T ₁₃	Mulberry 13	24.20	0.70	34.57
T ₁₄	Mulberry 14	11.50	2.15	5.35
T ₁₅	Mulberry 15	16.20	1.45	11.17
SEM±		0.78	0.04	1.36
CD (P = 0.05)		2.24	0.12	3.91
CD (P = 0.01)		3.02	0.16	5.27
CV (%)		6.83	6.82	9.98

Conclusion

The present study successfully identified substantial variability within the evaluated mulberry genotypes, providing a strong basis for future utilization. Genotypes such as Mulberry-2, Mulberry-1, and Mulberry-13 were identified as superior, exhibiting high mean performance for fruit weight, sweetness, and nutritional content. These selected genotypes represent valuable genetic material that can be recommended for fresh consumption and commercial multiplication. The investigation into biochemical parameters was highly informative. Traits such as total sugar content demonstrated that locally adapted genotypes like Mulberry-2 are nutritionally dense, comparable to or exceeding international standards for black mulberry (*Morus nigra*). It is concluded that genotype Mulberry-2 is the most promising for fresh consumption and value addition. A selection strategy focusing on high fruit weight and high TSS is recommended for the further genetic improvement of mulberry in Chhattisgarh.

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