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# MORPHOLOGICAL AND QUALITY CHARACTHERISTICS OF MULBERRY (MORUS SPP.) UNDER CONDITIONS OF MOARA DOMNEASCĂ, ROMANIA

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## ABSTRACT

*This study evaluates the biometric and qualitative characteristics of mulberry (Morus spp.) fruits from two reference cultivars ('Riviera' and 'Beautiful Day') and seven ex situ genotypes cultivated at Moara Domnească Farm, Ilfov County, Romania. Fruit traits including length, weight, diameter, and soluble solids content (°Brix) were measured, and data were analyzed using two-way ANOVA and correlation tests. Results showed that 'Riviera' produced the longest and heaviest fruits, while 'Beautiful Day' displayed intermediate values. Ex situ genotypes were generally smaller, though ExS-G6 stood out with higher sweetness (17.3 °Brix) despite moderate fruit size. ANOVA revealed significant differences among cultivars for length, weight, and diameter ($p < 0.01$), but not for °Brix. Training system (open center vs. layered palmette) had no significant influence on morphometric traits or fruit acidity. 'Beautiful Day' exhibited higher pH values than black-fruited ones, indicating lower acidity. These findings highlight the potential of specific ex situ genotypes, particularly ExS-G6, as valuable resources for breeding and direct consumption, while confirming Riviera's superiority for fruit size and productivity.*

## INTRODUCTION

We all love and consume berry fruits, and their pharmaceutical, nutritional, and economic importance is highly valued by both producers and consumers. Mulberries (*Morus* spp.), although not true botanical berries but multiple fruits (soroses), are generally classified within the berry fruit category in horticultural and nutritional contexts. The mulberry tree belongs to the Moraceae family and is mostly known as the sole food source for silkworms (*Bombyx mori*) used in the sericulture industry. The importance of mulberry fruits in our country is still at an early stage, as most of the fruits available on the market are imported from non-EU countries. Mulberry fruits are generally consumed as fresh fruits, jams, and juices (H. Zhang et al., 2018).

The development of new mulberry orchards will strengthen the economic background of these areas through job creation. Moreover, the multiple purposes of mulberry cultivation—ranging from fruit production to the tea industry, pharmaceutical and medicinal uses of various micro-components from the fruit, leaves, and even wood, as well as artisanal uses of the wood—make these orchards a good investment. Mulberry trees can be grown on different soils and slopes, as they are excellent soil stabilizers. This means that all kinds of land can be used for this purpose.

Studies have reported that the presence of bioactive components in mulberry fruits, including alkaloids and flavonoids, is associated with bioactivities such as antioxidant effects. One of the most important compounds in mulberry fruits is anthocyanins that differ between fruit color (A.Pornanong et al. 2010) and are water-soluble bioactive ingredients of the polyphenol class. Studies have shown that mulberry fruits possess several potential pharmacological health benefits, including anti-cholesterol, anti-obesity, and hepatoprotective effects, which might be associated with the presence of these bioactive compounds (H. Zhang et al., 2018).

In Romania, mulberry trees are found everywhere: in big cities along boulevards, in private gardens, in rural areas, and by the roadsides, where both ornamental and fruit-bearing individuals can be observed. In the past, people consumed the fruits but were often annoyed by property stains caused by anthocyanins. Scientists used the staining property of mulberries in medicine as a natural dye for nervous tissues (T. Ehab, 2010). Furthermore, by using dye extracted from black mulberries, zoologists and parasitologists can identify and differentiate between various parasites (T. Ehab & A.Bahija, 2011).

Also, mulberry is a melliferous plant, and mulberry honey is made from the nectar of wild mulberry flowers and distinguished by its creamy texture (Heden.fr).

At the Research and Development Station for Fruit Tree Growing Băneasa, our aim is to promote the taste and consumption of mulberry fruits by maintaining local germplasm resources, creating new cultivars according to consumer demands, and supporting local farmers through the establishment and maintenance of mulberry orchards.

## MATERIAL AND METHODS

*Biologycal material*

We have 1 known variety Riviera- black fruits, 'Beautiful Day' (*Morus alba* L.)- white fruits and one Ex-situ genotypes row with black and white varieties.

'Riviera' is a black mulberry cultivar originating from Vista, California (B. K.Singhal et al, 2010). It produces elongated, deep purple-black fruits measuring 2.5-3.75 cm in length and about 1.27cm in diameter. The flesh is slightly juicy, very sweet, and of high dessert quality. The fruits ripen gradually over an extended period, from mid-spring to early summer (April–June) (S. Albert; CRFG, 2025).

'Beautiful Day' originated in College Park, Maryland, produced white colored fruits with mass that varied from 1.49g to 1.8g and length varied from 1.96 cm to 2.03 cm (cultivar.guide).

The ExS genotypes constitute a field-maintained collection of black- and white-fruited mulberry types that display relatively uniform biometric traits and a consistent flowering period.

*Study location*

We have established in 2021 a mulberry orchard. Moara Domnească Farm is located northeast of Bucharest, in Ilfov County, approximately 17 km from the city, within the Vlăsia Plain (a subunit of the Romanian Plain). The farm belongs to the Băneasa Research and Development Station for Fruit Growing and is characterized by a humid climate with hot summers and harsh winters. We made soil determination on eight soil horizons: Ao=10-20 cm, AB=32-42 cm, Bt1=47-57cm, Bt2=66-76cm, Bt3=90-100 cm, BC=120-130 cm, C=152-162 cm, Ck=180-190cm. As shown in Table 1, humus content decreases progressively from the surface to deeper horizons. The soil reactions change from slightly acidic at the surface to weakly alkaline at depth.

This reflects good buffering capacity and favorable conditions for mulberry cultivation, which tolerate a wide pH range.

Table 1

Chemical composition and fertility indices across soil horizons

| Horizons Properties | Ao | Ao/Bt | Bt | C |
|---|---|---|---|---|
| **Humus (%)** | 3.26 | 1.87 | 1.0 | 1.0 |
| **Soluble Ca (mg / 100 g soil)** | 55 | 32 | 32 | 30 |
| **Hydrolitic acidity (meq)** | 2.8 | 2.04 | 1.72 | 0.18 |
| **Exchangeable Bases (meq)** | 22.6 | 23.62 | 26.28 | - |
| **Total cation exchange capacity (meq)** | 28.65 | 28.04 | 30.01 | - |
| **Degree of saturation in bases (%)** | 78.94 | 84.28 | 87.53 | - |
| **pH** | 6.4 | 6.6 | 6.8 | 8.3 |
| **Total N (%)** | 0.144 | 0.102 | 0.075 | 0.07 |
| **Soluble P (mg / 100 g soil)** | 50 | 40 | 40 | 30 |

(Source: M.Olaru, 2025 Unpublished)

*Experimental design*

The study is conducted on experimental lot of 52 mulberry trees. As shown in Table 2, we have 2 different tree training systems-open center and layered palmette system, we have 7 Ex situ genotypes, 'Riviera' variety and 'Beautiful Day' (*Morus alba L.*). From every variety we choose 25 fruits for measures.

Table 2

Experimental scheme of mulberry varieties, fruit color, and training systems

| No. Crt | Variety | Fruit color | Tree training system |
|---|---|---|---|
| **1.** | ExS-G1 | Black | Open center |
| **2.** | ExS-G2 | White | Open center |
| **3.** | ExS-G3 | Black | Layered palmette system |
| **4.** | ExS-G4 | Black | Open center |
| **5.** | ExS-G5 | White | Layered palmette system |
| **6** | ExS-G6 | White | Layered palmette system |
| **7** | ExS-G7 | Black | Layered palmette system |
| **8.** | 'Beautiful Day'. | White | Open center |
| **9.** | 'Beautiful Day' | White | Layered palmette system |
| **10.** | Riviera | Black | Open center |
| **11.** | Riviera | Black | Layered palmette system |

ExS-A1= Ex situ genotype1; ExS-A2= Ex situ genotype 2; ExS-A3= Ex situ genotype 3; ExS-A4= Ex situ genotype 4; ExS-A5= Ex situ genotype 5; ExS-A6= Ex situ genotype 6; ExS-A7= Ex situ genotype 7.

*Measurments*

Soil determinations were made in our laboratory.

Fruit measurements were performed using a digital caliper for size determination, an electronic balance with 0.001 g accuracy for fruit mass, and analyses to determine pH, and total soluble solids (°Brix).

*Statistical analysis*

Statistical analysis was conducted using DATAtab software (DATAtab e.U., Graz, Austria; https://datatab.net). We performed Pearson correlations, multivariate analysis, two-way ANOVA, Bonferroni post hoc test.

## RESULTS AND DISCUSSIONS

We compared and analyzed the morphological parameters for ExS-genotypes (1 to 7),'Riviera cultivar' and 'Beautiful Day' as shown in Table 3.

Table 3
Biometric and Quality Parameters of Mulberry Cultivars (Fruit Length, Weight, Diameter, and Brix

| Cultivar | Fruit Length (mm) | Fruit weight (g) | Fruit mean diameter (mm) | $^0$Brix |
|---|---|---|---|---|
| **ExS-G1** | 16.592 | 1.018 | 10.279 | 14.2 |
| **ExS-G2** | 16.671 | 1.015 | 10.298 | 14.3 |
| **ExS-G3** | 15.532 | 0.963 | 10.145 | 14.2 |
| **ExS-G4** | 15.437 | 0.996 | 10.238 | 14.3 |
| **ExS-G5** | 14.356 | 0.818 | 10.369 | 14.2 |
| **ExS-G6** | 16.878 | 1.234 | 10.873 | 17.3 ↑ |
| **ExS-G7** | 16.878 | 1.234 | 10.873 | 14.3 |
| **'BEAUTIFUL DAY'** | 19.887 | 1.658 | 12.217 | 14.2 |
| **'RIVIERA'** | **21.227**↑ | **1.915**↑ | **12.675**↑ | 14.63 |

Fruit ranges from 14.36mm (ExS-G5) to 21.23 mm ('Riviera') that means 'Riviera' has the longest fruit and overall ExS genotype are generally shorter than 'Riviera' and 'Beautiful day'.

Fruit weight varies between 0.818g (ExS-G5) and 1.915g ('Riviera') followed by 'Beautiful day' with 1.658g. We can observe that most ExS genotypes produce lighter fruit except for ExS-G6 and G7 which stand out within this group.

Fruit medium diameter ranges from 10.15mm (ExS-G3) to 12.67mm ('Riviera'). We can see that 'Riviera' and 'Beautiful day' have noticeably larger diameters than ExS genotype that are relatively uniform with values between 10.2-10.8 mm.

Sugar content ($^0$Brix) for most samples is close to 14.2-14.3 $^0$Brix. ExS-G6 stands out with 17.3 $^0$Brix which means the fruits are sweeter. ExS-G6 is a white fruit genotype.

Based on this information we run a two-way ANOVA to analyze the morphological and sweetness data. The test revealed that the varieties had significant effect on fruit length ($F=17.53$, $p=0.00031$), fruit weight ($F=20.23$, $p=0.0022$), fruit mean diameter

($F=34.49$, $p=0.0005$) and for Brix ($F=0.08$ and $p=0.9263$) there was no significant differences between varieties.

Because there are several colors of mulberry fruits, even from the same species, we verified if training system can influence the fruit morphometric traits. We made a Bonferroni Post-hoc test for tree training system and the result was that there were no significant differences.

The mean pH of white mulberries was 6.01 (±0.10 SD), significantly higher than that of black mulberries (5.33 ±0.40 SD). This difference of 0.7 pH units indicates that white fruits are less acidic, with lower within-group variability compared to black fruits (Table 4).

Tabel 4

Mean pH values of white and black mulberries

| | Color | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| **pH** | White | 6.01 | 0.1 | 0.04 |
| | Black | 5.33 | 0.4 | 0.16 |

The table 5 shows the statistical key figures of the dependent variable *pH* for the two groups Open center and Layered palmette system. The average value of pH for the Open center group in this sample is 5.61, while it is 5.75 for the Layered palmette system group. This shows that the Open centre group in this sample has on average a lower value for the dependent variable *pH* than the Layered palmette system group. The standard deviation for Open center is 0.51 and for Layered palmette system it is 0.33. Fruits from trees trained as layered palmette had a slightly higher mean pH (5.75 ± 0.33) compared to those from open center trees (5.61 ± 0.51). However, the difference (≈0.14 pH units) was minor and fell within the range of standard deviation, indicating no substantial effect of training system on fruit acidity.

Tabel 5

Mean pH values dependent on training system

| | Color | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| **pH** | Open center | 5.61 | 0.51 | 0.19 |
| | Layered palmette system | 5.75 | 0.33 | 0.11 |

In Table 6, Pearson correlation revealed that cultivar was strongly associated with fruit height ($r = 0.79$, $p < .001$), indicating that fruit size is mainly determined genetically. In contrast, cultivar showed no significant relationship with training system, pH, or fruit color. Fruit height was not influenced by training system and showed no meaningful correlations with pH or color. A moderate positive correlation between pH and color was observed ($r = 0.50$, $p = .051$), suggesting a potential trend that darker fruits may have lower acidity, although this effect did not reach conventional statistical significance.

Tabel 6

Relationships between cultivar, tree training system, fruit size, pH, and color

| | | Cultivar | Fruit Height | Tree training system | pH | Color |
|---|---|---|---|---|---|---|
| Cultivar | Correlation | 1 | 0.79 | 0.27 | -0.37 | 0.22 |
| | p | | <0.001 | 0.318 | 0.157 | 0.417 |
| Fruit height | Correlation | 0.79 | 1 | -0.01 | -0.37 | 0.09 |
| | p | <0.001 | | 0.966 | 0.164 | 0.735 |
| Tree training system | Correlation | 0.27 | -0.01 | 1 | 0.17 | 0.27 |
| | p | 0.318 | 0.966 | | 0.532 | 0.312 |
| pH | Correlation | -0.37 | -0.37 | 0.17 | 1 | 0.5 |
| | p | 0.157 | 0.164 | 0.532 | | 0.051 |
| Color | Correlation | 0.22 | 0.09 | 0.27 | 0.5 | 1 |
| | p | 0.417 | 0.735 | 0.312 | 0.051 | |

## CONCLUSIONS

ExS-G6 is a white-fruited genotype, combining moderate fruit size with high sugar content, which may represent a valuable selection for breeding or direct consumption. Riviera consistently produces significantly larger and heavier fruits compared to ExS genotypes. 'Beautiful Day' shows intermediate values, significantly higher than ExS genotypes but lower than Riviera. Training system had no significant impact on fruit morphological characteristics. White Mulberries had a higher and more uniform pH compared with black varieties. This makes them less acidic and more consistent in fruit quality. The intake of 100 g of mulberries daily has a therapeutical effect (E.Said, 2006) and based on consumers preferences, they may choose between black or white mulberries.

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