

# PHYSICO-CHEMICAL AND MINERAL COMPOSITION OF FRUIT OF DIFFERENT MULBERRY VARIETIES UNDER TEMPERATE CONDITIONS

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## ABSTRACT

The fruit of five mulberry varieties viz; Enshutakasuke, Rokokayaso, Koku-21, Botatul and Brentul differed significantly for various physico-chemical and mineral compositions with average fruit weight ranging from 0.45 to 1.68g, length and width ranging from 16.00 to 29.75mm and 8.75 to 12.75mm respectively. The number of seeds per fruit, pulp yield and moisture content of fruit ranged from 6.25 to 32.00 seeds per fruit, 75.16 to 79.76 % and 78.13 to 80.73 % respectively. The chemical properties viz; titrable acidity, total sugars, reducing sugars, total soluble solids, vitamin C, anthocyanins and protein of fruit of these mulberry varieties also showed significant variation which ranged from 0.12 to 1.02 %, 16.05 to 22.08 %, 10.69 to 18.45 %, 19.19 to 25.96 %, 18.74 to 31.23 mg/100g, 69.32 to 209.34mg/100g and 0.81 to 1.43 % respectively. Among macro-nutrients Potassium was the predominant element which ranged from 695.3 to 1218.8 mg/100g. The results indicated that fruit of varieties Enshutakasuke and Botatul are having higher anthocyanin and protein content, thus are nutritionally better as compared to other varieties.

## INTRODUCTION

The Mulberry, *Morus* spp. a deciduous and perennial plant is cultivated as a primary host plant for rearing domesticated silkworm, *Bombyx mori* L. for the production of mulberry silk which contributes to about 80 per cent of all the types of silk being produced in India. The fruit of mulberry has abundant nutritional and medicinal properties. Mulberry fruits are rich in phenols and have a unique sour and refreshing taste (Kutlu, 2011). Mulberry fruits are generally excellent sources of natural antioxidant and vitamins especially ascorbic acid or vitamin C (Khomdram and Shantibala Devi, 2010). Since mulberry fruit is rich in anthocyanins, it is exploited for the production of natural colours which are used in the food industry (Giusti and Wrolstad, 2001). Giusti and Wrolstad (2003) reported mulberry fruits as rich in sugar, glucose, sucrose, carotenes, tartaric acid etc., and are used for curing sore throat, fever, dyspepsia and melancholia. The mature mulberry fruits also contain significant amounts of resveratrol which has many health effects such as anti-cancer, anti-viral, neuro-protective, anti-inflammatory have been reported in the studies conducted on animal subjects (Kumarasen *et al.*, 2008).

The nutritional status of different mulberry varieties is ascertained by their biochemical constituents which differ in various mulberry varieties (Ercisli and Orhan, 2007; Iqbal *et al.*, 2010).

Keeping in view the nutritional and health benefits of mulberry fruit this study was conducted aimed at evaluating the quality

parameters of some temperate mulberry fruit varieties through physico-chemical and mineral analysis.

## MATERIALS AND METHODS

### Collection and preparation of mulberry fruit samples

The fruits of five mulberry varieties were collected from the Mulberry Germplasm Bank of Temperate Sericulture Research Institute, SKUAST-Mirgund. Fresh mulberry fruit of each variety was mashed in a homogenizer and processed for biochemical analysis.

### Physical characteristics

The moisture content in fruits was determined by hot air oven method as recommended by AOAC (1995). For each variety ten fruits were randomly selected and weighed to compute mean weight. The overall length of mulberry fruits was measured with the help of a slide caliper. Mean width of fruits of each variety was calculated from the distance between the extreme points of two sides. Fruit of each variety were mashed in water to count the seeds/fruit. The colour of mature/ripe fruits was determined by visual observation and the pulp yield was also determined.

### Chemical characteristics

Chemical analysis of the fruit was carried out as per the methods prescribed by AOAC (1995). Acidity (%) was determined by titration and values expressed as percentage of malic acid (Rangana 1986). The total soluble solids of different mulberry fruit varieties was determined by hand refractometer (range 0-

32 °Brix). Total and reducing sugars were estimated by the method of Lane and Eynon (1923). Protein content was estimated by the modified Kjeldahl method using Kjel Tec (Kjel Tech-2100, FOSS). Vitamin C was estimated by the method as described by Rangana (1986) using 2, 6, dichlorophenol as dye. Anthocyanins were also calculated as per the method described by Rangana (1986).

#### Mineral analysis

In order to determine the mineral contents of mulberry fruits, samples were oven-dried at 68°C for a period of 48 h and ground to pass through 1-mm sieve. The Kjeldahl method and Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Königswinter, Germany) were used to determine total P, K, Ca and, Mg and were detected after wet digestion of dried and ground sub-samples using a HNO<sub>3</sub>-H<sub>2</sub>O<sub>2</sub> acid mixture (2:3 v/v).

Phosphorus in fruit was determined by Vanadate Molybdate method as described by Jackson (1973). Potassium content in sample was determined by flame photometric method as described by Rangana (1986). Calcium and magnesium content of samples was determined by Atomic Absorption Spectrum (AAS) by the method as described in AOAC (1995).

#### Statistical analysis

The data was statistically analyzed through Minitab software using Completely Randomized Design (CRD) in factorial experiment as suggested by Snedecor and Cochran (1989).

## RESULTS AND DISCUSSION

The observations recorded during the study and presented in tables 1 and 2 show significant variations in physico-chemical parameters among fruits of different mulberry varieties. These are discussed as under:

#### Physical parameters of mulberry fruit (Table 1)

##### Moisture content

The moisture content (78.13-80.73%) varied significantly among fruits of different mulberry varieties, the highest moisture content was recorded in Botatul (80.73%) and the lowest in Brentul variety (78.13%). This variation in moisture content in mulberry fruit has also been observed by Imran *et al.* (2010) who reported moisture content in the range of 73.03 to 82.40 per cent in mulberry fruits. Liang *et al.* (2012) also reported 71 to 75 per cent moisture content in fresh mulberry fruits.

##### Weight of the fruit (g)

Significant difference was observed with respect to fruit weight of different mulberry varieties. Maximum fruit weight (1.68g)

was recorded in Koks-21 and minimum (0.45g) in Rokokayaso. Polat (2004) and Islam *et al.* (2006) have reported average fruit weight of different mulberry varieties in the range of 1.13 to 6.41g where as Iqbal *et al.* (2010) reported fruit weight of 2.54 to 3.02g in various varieties.

##### Size of Fruit (mm)

A significant variation in fruit length of different mulberry varieties was observed which ranged between (16.00 - 29.75mm). The maximum fruit length (29.75mm) was observed in Enshutakasuke and minimum (16.00mm) in Brentul variety of mulberry. The width of the fruit also varied significantly among different varieties of mulberry. The maximum fruit width was recorded in Koks-21 (12.75mm) and the minimum (08.75mm) in Rokokayaso variety of mulberry.

Ozgen *et al.* (2009) while studying morphological characterization of several *Morus* species from Turkey recorded 35.0 mm length and 21.1mm width in *Morus alba* fruit. Koyuncu *et al.* (2004) recorded an average length and width of 15.34 and 16.29mm respectively in *Morus nigra*.

##### Number of seeds per fruit

The maximum number of seeds (32.00 per fruit) was found in Enshutakasuke and the minimum in Brentul variety (6.25 seeds per fruit). Ozgen *et al.* (2009) reported 12.8 to 21.3 seeds per fruit in *M. alba*.

##### Colour of the fruit

Mulberry fruit are of different colours. The varieties of mulberry under study showed colour variations like purple for Enshutakasuke, reddish purple for Rokokayaso, Botatul and Brentul whereas Koks-21 had mulberry fruit of light purple in colour. The colour variations among different mulberry varieties have also been observed by Orhan and Ercisli (2010).

##### Pulp Yield (%)

The highest pulp yield (79.27%) was found in Enshutakasuke and the lowest pulp yield of 75.16 per cent was found in Brentul variety of mulberry. The variation in pulp content of various mulberry fruit varieties was due to fruit size and flesh thickness.

#### Chemical analysis of mulberry fruit (Table 1)

##### Acidity (% as mallic acid)

The acidity per cent determined in terms of malic acid varied significantly among different mulberry varieties (0.12 – 1.02 %). The highest acidity (1.02 %) was recorded in Rokokayaso and minimum (0.12 %) in Enshutakasuke. Ercisli and Orhan (2007) also reported acidity in mulberry fruit in the range of 0.25-1.40 per cent. However, Orhan and Ercisli (2010)

**Table 1: Physical parameters of different mulberry fruit varieties**

| Variety                    | Colour of Fruit | Weight of Fruit (g) | Length of Fruit (mm) | Width of Fruit (mm) | No. of seeds per fruit | Pulp yield (%) | Moisture content (%) |
|----------------------------|-----------------|---------------------|----------------------|---------------------|------------------------|----------------|----------------------|
| Enshutakasuke              | Purple          | 1.29                | 29.75                | 12.00               | 32.00                  | 79.27(8.90)    | 80.16(8.95)          |
| Rokokayasu                 | Reddish Purple  | 0.45                | 20.75                | 08.75               | 21.25                  | 79.06(8.93)    | 80.24(8.95)          |
| Koks-21                    | Light purple    | 1.68                | 23.25                | 12.75               | 25.75                  | 78.07(8.83)    | 79.44(8.91)          |
| Botatul                    | Reddish Purple  | 0.76                | 22.75                | 11.50               | 24.00                  | 79.19(8.89)    | 80.73(8.98)          |
| Brentul                    | Reddish Purple  | 0.62                | 16.00                | 11.00               | 06.25                  | 75.16(8.66)    | 78.13(8.83)          |
| C.D (pd <sup>0</sup> 0.05) |                 | 0.286               | 5.032                | 2.468               | 4.441                  | NS             | NS                   |

Values within parenthesis are square root transformed.

**Table 2: Chemical compositions of fresh fruit of different mulberry varieties**

| Variety       | Acidity (malic acid) (%) | Total Soluble Solids (°Brix) | Reducing sugars (%) | Total sugars (%) | Protein (%) | Vitamin C (mg/100g) | Total phenolics as anthocyanin (mg/100g) | Phosphorus (mg/100g) | Potassium (mg/100g) | Calcium (mg/100g) | Magnesium (mg/100g) |
|---------------|--------------------------|------------------------------|---------------------|------------------|-------------|---------------------|--|----------------------|---------------------|-------------------|---------------------|
| Enshutakasuke | 0.12(0.34)               | 25.96(5.09)                  | 16.86(4.11)         | 19.92(4.46)      | 1.43(1.19)  | 18.74               | 209.34                                   | 776.00               | 1156.3              | 156.43            | 125.20              |
| Rokokayasu    | 1.02(0.94)               | 20.11(4.48)                  | 16.25(4.02)         | 18.27(4.27)      | 0.81(0.89)  | 31.23               | 110.20                                   | 445.75               | 710.9               | 111.70            | 74.70               |
| Koksu-21      | 0.89(0.91)               | 21.85(4.67)                  | 15.08(3.88)         | 18.41(4.29)      | 0.90(0.95)  | 24.99               | 69.32                                    | 453.75               | 695.3               | 112.40            | 85.35               |
| Botatul       | 0.13(0.36)               | 19.19(4.38)                  | 10.69(3.26)         | 16.05(4.01)      | 1.34(1.16)  | 19.63               | 172.96                                   | 724.00               | 1218.8              | 147.60            | 132.45              |
| Brentul       | 0.25(0.48)               | 25.79(5.08)                  | 18.45(4.29)         | 22.08(4.69)      | 0.85(0.92)  | 23.20               | 104.50                                   | 369.50               | 742.2               | 115.65            | 82.05               |
| C.D (pd*0.05) | 0.544                    | 0.309                        | 0.195               | 0.094            | 0.030       | 3.585               | 2.755                                    | 55.910               | 65.32               | 5.618             | 6.06                |

Values within parenthesis are square root transformed.

reported 1.10 to 5.55 mg/100ml of malic acid in two different cultivars of mulberry fruits viz; black mulberry (*Morus nigra* L.) and purple mulberry (*Morus rubra* L.).

#### Total soluble solids (° Brix)

Among the five varieties, Enshutakasuke was found to have a higher amount of TSS (25.96 %) while as the lowest content of TSS (19.19 %) was found in Botatul. Yilmaz *et al.* (2009) reported 12.9 to 22.3 per cent of TSS in blackberry fruit while as Koyuncu *et al.* (2004) reported 13.11 to 16.23 per cent TSS in black mulberry genotypes.

#### Reducing Sugars (%)

Reducing sugars in fresh fruits of different mulberry varieties varied from 10.69 - 18.45 per cent. Highest content of reducing sugar (18.45 %) was observed in Brentul and lowest (10.69%) in Botatul. Difference in sugar content amongst cultivars has also been reported by other scientists. Iqbal *et al.* (2010) reported reducing sugar content in mulberry cultivars ranging from 21.16 to 34.77 per cent. However, Orhan and Ercisli (2010) reported 8.45 to 14.0 per cent of reducing sugars in different mulberry fruit.

#### Total sugars (%)

Total sugar content in five different mulberry varieties ranged from 16.05 to 22.08 per cent. Mulberry variety Brentul possessed significantly higher total sugars (22.08 %) while as the minimum amount of total sugars (16.05 %) was found in Botatul variety of mulberry. These observations are in agreement with those of Iqbal *et al.* (2010) who reported total sugars content ranging from 12.11 to 19.57 per cent in four different mulberry cultivars.

#### Protein Content (%)

Among all the five varieties, Enshutakasuke contains highest protein content (1.43 per cent) while as the less amount of protein (0.81 %) was found in Rokokayaso. Imran *et al.* (2010) reported 1.55 per cent of protein content in *M. laevigata*.

#### Vitamin C content (mg/100g)

The vitamin C content varied significantly among different varieties of mulberry fruit (18.74 - 31.23mg/100g). Rokokayaso contained significantly higher amount of vitamin C (31.23mg/100g) while as the lowest amounts of Vitamin C was found in Enshutakasuke (18.74mg/100g). The results are in conformity with those of Iqbal *et al.* (2010) who recorded 25.20 to 32.25mg/100g of Vitamin-C content in black mulberry fruits. However, Imran *et al.* (2010) reported 15.20 to 17.03mg/100g of Vitamin-C content in mulberry fruits.

#### Total phenolics as anthocyanins (mg/100g)

Mulberries are rich source of phenolics, with high levels in *M. nigra* (1422mg GAE/100g) and *M. rubra* (1035mg GAE/100g) as reported by Ercisli and Orhan (2007). However, in the present study the total phenolic content of different mulberry fruit varieties ranged from (69.32–209.34mg/100g) being highest (209.34mg/100g) in Enshutakasuke and lowest (69.32 mg/100g) in Koksu-21. Liu *et al.* (2004) found that the total anthocyanins content of different mulberry fruit cultivars ranged from 147.68mg/l to 2725mg/l. Kumar and Chauhan (2011) reported total anthocyanin content from 19.94 to 102.76mg/2gm in different mulberry varieties.

Differences in terms of phenolics and flavonoids content are due to genetic derivations. The variation of phenolic compounds in the fruits depends on many factors, such as degree of maturity at harvest, genetic differences, conditions during fruit development, etc. (Zadernowski *et al.*, 2005).

#### Mineral content of mulberry fruit

Mulberry fruit is a good source of minerals which could provide nutritionally useful amounts of Phosphorus, Potassium, Calcium and Magnesium. Significant differences were observed in the levels of minerals among the test mulberry varieties. The content of K was especially higher than other elements. The maximum K content (1218.8mg/100g) was recorded in Botatul and minimum (695.3mg/100g) in Koksu-21. The maximum P content (776.00mg/100g) was observed in Enshutakasuke while as minimum (369.50mg/100g) in Brentul. The relatively high amount of Ca (156.43mg/100g) was recorded in Enshutakasuke and minimum (111.70mg/100g) in Rokokayaso. The highest content of Mg (132.45mg/100g) was recorded in Botatul while as minimum (74.70mg/100g) in Rokokayaso. Koyuncu *et al.* (2014) also reported Potassium as the main mineral of mulberry fruits.

The variation in the physico-chemical parameters of mulberry fruits is attributed to different species, cultivars, rootstock used, environmental conditions and the nutritional status of the mulberry farm. Overall, the present results provided basic data for choosing mulberry fruits with higher nutritional and antioxidant activity for direct consumption or for production of mulberry fruit products like juice and jam.

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