

PHYSICO-CHEMICAL CHARACTERISTICS OF DIFFERENT MULBERRY CULTIVARS GROWN UNDER AGRO-CLIMATIC CONDITIONS OF MIRAN SHAH, NORTH WAZIRISTAN (KHYBER PAKHTUNKHWA), PAKISTAN

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ABSTRACT

In a study conducted in the Department of Horticulture, Gomal University, Dera Ismail Khan, Pakistan during 2007, four mulberry cultivars Mulberry Black (*Morus nigra*), White Mulberry (*Morus alba*), Red Mulberry (*Morus rubra*) and Kabli Mulberry were collected from Miran Shah, North Waziristan (NWFP) to study their physico-chemical characteristics. The results revealed that cultivars differed significantly in average fruit weight and length that ranged from 2.54 to 3.02 and 1.61 to 2.23 cm, respectively. The fruit of Red Mulberry was more heavier and longer followed by Kabli Mulberry that was statistically similar. Kabli Mulberry was superior in sensory assessment in terms of taste, colour and flavour followed by Black Mulberry, which was comparable to Kabli Mulberry. Red Mulberry fruits were more juicy (74.62% moisture) as compared to fruits of other cultivars. The pH of cultivars ranged from 4.32 to 4.90, being minimum for Red Mulberry and maximum for Kabli Mulberry while acidity varied from 0.137 to 0.307 percent. White Mulberry fruits were more acidic as compared to other cultivars. Kabli Mulberry and Red Mulberry differed statistically in acidity. Significant variation existed among mulberry cultivars for TSS, reducing sugars, non-reducing sugars, total sugars and vitamin-C contents, which ranged from 7.23-9.62, 12.111-19.563, 7.829-14.658 and 21.163-34.777 percent and 25.20-32.25 mg/100 g, respectively. Cultivar Kabli Mulberry contained significantly more TSS, reducing, non-reducing sugars and total sugars, followed by Black Mulberry, while vitamin-C content was more in Black Mulberry followed by Red Mulberry. The study suggests that Kabli Mulberry and Black Mulberry can be exploited for commercial cultivation under agro-climatic conditions of Miran Shah, North Waziristan Agency of NWFP.

Keywords: *Morus alba*; *Morus nigra*; *Morus rubra*; organoleptic properties; Pakistan.

INTRODUCTION

Mulberry belongs to the family Moraceae and genus *Morus*. Mulberry species origin is reported since immemorial times from various countries of the world

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viz. white mulberry (*Morus alba*) is a native to eastern and central China, Red mulberry (*Morus rubra*) is from USA and black mulberry (*Morus nigra*) is native to western Asia and grown for its fruit in Europe since before Roman times (2).

Mulberry fruit is consumed fresh and in dry state and has unique nutritional value among the fruits (4). Its fruits are juicy and rich in sugar (10%) and iron (2.3 mg/100 g). Its juice is used for curing sore throat, fever, dyspepsia and melancholia, Also jam, cooling beverage and wine are made from it (14).

Physico-chemical characteristics of mulberry cultivars are important for commercial and dietary values. Hussain (9) determined the composition of mulberry and reported that mulberry fruits contain 0.04 mg/100 g thiamin, 0.08 mg/100 g riboflavin and 30 g/100g vitamin-C, 80.8 percent moisture, 1.5 percent protein, 1.4 percent lipid, 14.3 percent carbohydrates, 1.0 percent fibre and 0.8 percent ash. Elmac and Altuq (6) investigated the flavour characteristics of three black mulberry (*M. nigra*) cultivars from Aegean region of Turkey using GC/MS and sensory analysis techniques. Total sugar content varied between 11.3 and 16.2 percent, pH between 3.60 and 3.80 and total acidity between 1.51 and 1.79 percent. The sensory assessment indicated that black mulberry has fruity, sweet, sour, musky and woody flavour. Koyuncu *et al.* (11) surveyed native black mulberry genotypes for fruit and tree characters. A range of 3.74-5.67 g for average fruit weight, 15.73-17.42 mm for fruit diameter, 21.66-27.04 mm for fruit length, 13.11-16.23 percent for soluble solids, 1.35-1.86 percent for acidity and 2.8-23.0 mg/g for vitamin C was noted. All genotypes had an attractive black-purple colour and medium-large sized fruits. Ahmad and Sadozai (1) revealed that ripe fruit of black mulberry contains about 9 percent sugars with malic and citric acid. The average sugar content in mulberry fruit is about 12 percent but in some varieties it is more than 20 percent. Ercisli and Orhan (7) investigated the chemical composition of mulberry white (*M. alba*), mulberry red (*M. rubra*) and mulberry black (*M. nigra*) in the East Anatolia region of Turkey and found that total soluble solids content of mulberry species varied from 15.9 to 20.4 percent, acidity 0.25 to 1.40 percent, pH 3.52 to 5.60 and ascorbic acid 19.4 to 22.4 mg/100 g.

The climate of Miran Shah, North Waziristan of Khyber Pakhtunkhwa is congenial for mulberry production and mulberry orchards are found frequently in this area. The present investigations were undertaken to study physical characteristics and chemical composition of fruits of different mulberry cultivars grown under agro-climatic conditions of this area.

MATERIALS AND METHODS

The fruits of four prominent cultivars of mulberry (White Mulberry, Black Mulberry, Red Mulberry and Kabli Mulberry) were collected from orchard of a progressive grower in village Tapi of Miran Shah, North Waziristan, Pakistan during the year 2007. The fresh samples were brought to agricultural chemistry laboratory at Agricultural Research Institute, D. I. Khan for studying the physico-chemical characteristics of these cultivars.

Physical characteristics

Twenty fruits randomly selected from each cultivar were weighed in gram with electric balance (Ogawa Seiki Co. Ltd., Japan) and mean was computed. Fruit length of selected fruits from each cultivar was measured with vernier caliper in centimeter and mean was calculated. For sensory evaluation of mulberry fruits eight judges were employed to evaluate taste of overall acceptability by rating from 0 to 10 according to hedonic test. The score '0' represents the non-acceptability while '10' denotes the highly acceptable condition.

Chemical characteristics

The moisture content in fruits was determined by direct heating method as recommended by AOAC (5). The pH of blended samples was determined directly with pH meter indicating the effective acidity. Present acidity was determined in terms of citric acid according to Ruck (12). Total soluble solids (TSS) was determined according to AOAC (5). The sugar contents of fruits were determined by Lane and Annon method (5). Ascorbic acid (vitamin-C) was determined by titration method of reduction of 2, 6-dichlorophenol-indophenol dye (12).

Statistical analysis

The data regarding each parameter were analyzed statistically using MSTAT computer program, in which cultivars were considered as treatments and triplicate determinations as replications being RCBD. The comparison of means was computed applying Duncan multiple range test according to Steel and Torrie (13) and Snedecor and Cockron (15).

RESULTS AND DISCUSSION

Physical composition

Fruit length: Significant variation (1.61-2.231 cm) in fruit length of different cultivars was noted (Table 1). The longest fruits were found in cv. Red Mulberry (2.231 cm) which differed significantly from other cultivars. It was

followed by Kabli Mulberry (2.11 cm) and Black Mulberry (1.926 cm). These three cultivars were statistically non-significant. The smallest fruits were recorded in White Mulberry (1.61 cm). These results are in agreement to the findings of Koyuncu *et al.* (11) who reported that fruit length of Black Mulberry genotypes ranged from 2.166 to 2.704 cm. However, Iqbal and Dandin (10) reported different fruit length (3.5 to 4.5 cm) which may be due to difference in genetic make-up and agro-climatic conditions.

Table 1. Physico-chemical composition of fruits of mulberry cultivars.

| Cultivars | Fruit length (cm) | Fruit weight (g) | Moisture(%) | pH | Acidity(%) |
|------------------|-------------------|------------------|-------------|-------|------------|
| Black Mulberry | 1.926b | 2.54b | 68.529b | 4.83a | 0.307a |
| White Mulberry | 1.610c | 2.84ab | 72.188ab | 4.23b | 0.141c |
| Red Mulberry | 2.231a | 3.02a | 74.620a | 4.33b | 0.205b |
| Kabli Mulberry | 2.110ab | 2.90 ab | 62.190c | 4.90a | 0.137c |
| LSD at P = 0.05% | 0.219 | 0.456 | 3.663 | 0.447 | 0.063 |

Fruit weight: The average fruit weight (2.54-3.02 g) differed significantly among the mulberry cultivars (Table 1). The fruits of Red Mulberry were heavier (3.02 g) than fruits of other cultivars. The average weight of Kabli mulberry was 2.90 g which was statistically non-significant to Red Mulberry. Variation in weight of different genotypes of mulberry has also been reported by Koyuncu *et al.* (11) mentioning that average fruit weight of black mulberry genotypes varied from 3.74 to 5.67 g. However, in present study less values have been noted. The difference in average fruit weight may be due to difference in genotypes, climatic conditions and fertility status of the soils.

Chemical composition

Moisture content: The moisture content varied (62.19-74.62%) significantly among different cultivars of mulberry. The significant higher amount of water was present in cv. Red Mulberry (74.62%) followed by White Mulberry (72.19%). Other cultivars differed non-significantly. The least amount of water (62.19%) was noted in Kabli Mulberry. Difference in moisture percentage in mulberry genotypes has also been reported by other scientists. Hussain (9) reported more moisture content (80.8%) in mulberry fruit than that observed in present study. This may be due to variation in cultivars, soil and climatic conditions.

pH: The pH of blended samples of mulberry cultivars also differed significantly (4.23 to 4.90) being maximum in Kabli Mulberry and minimum in White Mulberry (Table 1). The significantly higher pH in Kabli Mulberry rendered it less acidic than other cultivars. It was followed by Black Mulberry

(4.83). Similarly, White Mulberry and Red Mulberry were also statistically similar (4.23 and 4.33). These results are in line with earlier findings (7), which revealed that White mulberry genotypes possessed pH 3.52 to 5.60. Elmac and Altuq (6) reported a pH range of 3.60-3.80 for black mulberry genotypes.

Acidity percent: The acidity percent was determined in terms of citric acid which varied significantly among cultivars (0.137 to 0.307%) (Table 1). The highest value (0.307%) was noted in Black Mulberry, followed by Red Mulberry (0.205%). Both these cultivars differed significantly from one another. White Mulberry and Kabli Mulberry with 0.141 and 0.137 percent acidity were statistically identical. Elmac and Altuq (6) observed 1.51 to 1.79 percent acidity in black mulberry genotypes while Koyuncu *et al.* (11) estimated 1.35 to 1.86 percent acidity in black mulberry genotypes. However, Ercisli and Orhan (7) reported 0.25-1.40 percent acidity. The present results do not coincide with earlier findings due to difference in estimating procedures, cultivars and agro-climatic conditions.

Table 2. Physico-chemical composition of fruits of mulberry cultivars.

| Cultivars | TSS (%) | Reducing sugars (%) | Non-reducing sugars (%) | Total sugar (%) | Vitamin-C (mg/100 g) |
|-----------------|---------|---------------------|-------------------------|-----------------|----------------------|
| Black Mulberry | 8.88 b | 18.270a | 14.658a | 33.699a | 32.25a |
| White Mulberry | 7.42 c | 14.140b | 7.829b | 22.381b | 25.20c |
| Red Mulberry | 7.23 c | 12.111b | 8.599b | 21.163 b | 30.60ab |
| Kabli Mulberry | 9.62 a | 19.563a | 14.453a | 34.777a | 29.00b |
| LSD at P =0.05% | 0.505 | 3.050 | 1.828 | 3.103 | 1.841 |

TSS: Significant variations existed among total soluble solids of mulberry cultivars (7.23 to 9.62%) (Table 2). Maximum TSS (9.62%) was recorded in Kabli Mulberry followed by Black Mulberry (8.88%). Both these cultivars differed significantly in TSS. The significantly less TSS was found in Red Mulberry (7.23%), which was statistically similar to White mulberry (7.42%). Ercisli and Orhan (7) reported 15.9 to 20.4 percent TSS in white mulberry genotypes while Koyuncu *et al.* (11) reported 13.11 to 16.23 percent TSS in black mulberry genotypes. Lower values in present study may be due to difference in methods adopted for estimation of TSS. Moreover, cultivars, soil and climatic conditions do have influence on the composition of fruits.

Non-reducing sugars: Non-reducing sugars in fresh fruits of different mulberry cultivars varied from 7.829 to 14.658 percent (Table 2). Black Mulberry possessed maximum amount of non-reducing sugars (14.658%) followed by Kabli Mulberry (14.45%) being statistically at par. Significantly minimum non-reducing sugars (7.829%) were found in White Mulberry. The

Red Mulberry with 8.599 percent non-reducing sugars was statistically at par with White Mulberry.

Total sugar content: The data on total sugar content in mulberry cultivars (Table 2) ranged from 21.163 to 34.777 percent with significant variation. Cultivar Kabli Mulberry possessed significantly higher total sugars while Red Mulberry contained minimum total sugars. Statistically Black Mulberry was similar to Kabli Mulberry in this character. Similarly, Red Mulberry (21.163%) and White Mulberry (22.381%) were also statistically alike. Difference in sugars content amongst cultivars has also been reported by other scientists (1, 6, 8, 9). However, values noted in present study were higher than those of Hussain (9) and Elmac and Altuq (9) and lower than those of Gosh *et al.* (8).

Vitamin C: The perusal of data (Table 2) indicated that vitamin -C content varied significantly among the cultivars (25.20 to 32.25 mg/100 g). The Black Mulberry contained significantly higher vitamin -C (32.25 mg) followed by Red Mulberry and Kabli Mulberry (30.60 and 29.00 mg/100 g). Black Mulberry and Red Mulberry were statistically similar whereas, Red Mulberry and Kabli Mulberry were also significantly alike. The lowest amount of ascorbic acid was found in cv. White Mulberry (25.20 mg). Difference in vitamin -C content among various cultivars has also been found by various workers (7, 9, 11). Values of vitamin-C content in present study were similar to those reported by Hussain (9) but were slightly higher than those noted by Ercisli and Orhan (7) and Koyuncu *et al.* (11).

Sensory evaluation of fruits (1-10 score)

The sensory assessment of mulberry fruits was done by eight judges according to Hedonic scales (0-10). It ranged from 6.125 to 8.625 (Table 3). The highest score was achieved by Kabli Mulberry (8.625) followed by Black Mulberry (8.375) although both cultivars were significantly at par suggesting that these two cultivars were liked by judges. Likewise, White Mulberry and Red Mulberry cultivars were also statistically alike possessing 6.625 and 6.125 score. The results indicated that Kabli Mulberry and Black Mulberry cultivars were superior in taste to White Mulberry and Red Mulberry cultivars. Elmac and Altuq (6) and Koyuncu *et al.* (11) reported difference in taste, colour and flavour among various cultivars of mulberry. They found that mulberry had black, white, red and purple colour. The fruits were categorized as fruity, sweet, sour, musky and woody flavour.

Table 3. Sensory assessment of mulberry fruits (0-10 score).

| Cultivars | Judges | | | | | | | | Total score | Mean |
|----------------|--------|----|----|----|----|----|----|----|-------------|--------|
| | J1 | J2 | J3 | J4 | J5 | J6 | J7 | J8 | | |
| Black Mulberry | 8 | 10 | 9 | 7 | 7 | 9 | 8 | 9 | 67 | 8.375a |
| White Mulberry | 8 | 7 | 8 | 5 | 7 | 5 | 8 | 5 | 53 | 6.625b |
| Red Mulberry | 6 | 5 | 7 | 8 | 5 | 6 | 5 | 7 | 49 | 6.125b |
| Kabli Mulberry | 9 | 9 | 10 | 10 | 6 | 7 | 10 | 8 | 69 | 8.625a |

LSD at P 0.05 = 1.3%

Table 4. Descriptive statistics of different quality parameters of mulberry cultivars.

| S. No. | Parameter | Minimum | Maximum | Mean | SD | CV *(%) |
|--------|-----------------|---------|---------|--------|---------|---------|
| 1. | Fruit weight | 1.563 | 2.352 | 1.969 | + 0.248 | 5.57 |
| 2. | Length (g) | 2.200 | 3.400 | 2.825 | + 0.291 | 8.04 |
| 3. | pH | 4.00 | 5.50 | 4.575 | + 0.337 | 4.89 |
| 4. | Sensor-tests | 5.00 | 10.00 | 7.437 | + 1.621 | 16.89 |
| 5. | Moisture (%) | 59.097 | 76.040 | 69.405 | + 4.537 | 2.64 |
| 6. | Acidity (%) | 0.130 | 0.320 | 0.197 | + 0.069 | 5.98 |
| 7. | TSS (%) (Brix) | 7.02 | 9.73 | 8.287 | + 1.016 | 3.05 |
| 8. | R. sugars (%) | 11.628 | 20.833 | 16.105 | + 3.167 | 9.48 |
| 9. | N/R. sugars (%) | 6.944 | 15.625 | 11.385 | + 3.258 | 8.03 |
| 10. | T. sugars (%) | 19.671 | 35.529 | 28.005 | + 6.397 | 5.55 |
| 11. | Vitamin-C | 24.500 | 33.000 | 29.263 | +2.693 | 3.15 |

The descriptive statistics of various quality parameters of mulberry was also computed (Table 4). Each replicated determination of all four cultivars was taken into consideration to compute mean, standard deviation and coefficient variation of each parameter. The data reveal that average weight of fruit ranged from 1.563 -2.352 g with mean value of 1.969 g. Length of fruit varied from 2.20-3.40 cm with mean of 2.825 cm. The mulberry juices contained 4.0-5.5 pH with mean value of 4.575. Moisture percentage in mulberry fruits varied from 59.097-76.040 percent with average of 69.405 percent. Acidity and TSS ranged from 0.13- 0.32 percent and 7.02 -9.73 percent with mean values of 0.197 and 8.287 percent, respectively. Similarly reducing, non-reducing and total sugars in fresh mulberry fruits ranged from 11.628-20.833. 6.944-15.625 and 19.671-35.529 percent, respectively with mean values of 16.105, 11.385 and 28.005 percent. The vitamin-C content varied from 24.50-33.00 mg/100 g with mean value of 29.263 mg/100 g.

CONCLUSION

Among different cultivars cv. Red Mulberry possessed maximum fruit weight, length and moisture content. Cultivar Kabli Mulberry excelled in TSS, reducing and total sugars and pH while cultivar Black Mulberry had more acidity, non-reducing sugars and vitamin-C contents. Cultivars Kabli Mulberry and Black Mulberry were found superior in sensory evaluation i.e. taste, colour and flavour. The study suggested that Kabli Mulberry and Black

Mulberry can be exploited for commercial cultivation under agro-climatic conditions of Miran Shah, North Waziristan Agency of Khyber Pakhtunkhwa.

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