

Some Chemical and Physical Properties of Fruits of Different Mulberry Species Commonly Grown in Anatolia, Turkey

MEHMET GUNES* and CETIN CEKIC

Department of Horticulture, Agricultural Faculty,

Gaziosmanpasa University, 60250, Tokat, Turkey

E-mail: mgunes2000@hotmail.com; Fax: ++90 356 252 14 88

Mulberry products known as pekmez, pestil and kome in Turkey have been widely consumed in Anatolia for a long time. Certain chemical and physical traits of mulberry affect the quality of these products. Soluble solid content (SSC), pH, titratable acid (TA), dry matter, must yield (unprocessed fruit juice) and fruit weight are some of the important characteristics of fruits to be processed. In this research, some physical and chemical characteristics of mulberry genotypes were determined. White (*Morus alba*), black (*Morus nigra*), red (*Morus rubra*) and pendulous (*Morus alba* var. *pendula*) mulberry genotypes were used in this study. The number of drupelets, percentage of parthenocarpy and number of full (not empty) seeds per fruit of species were also assessed. Bud burst, appearance of the inflorescence and harvesting dates were recorded as phenological traits. Smaller fruit size of pendulous mulberry, lower pH and higher acidity of black mulberry were the extreme characters when the species were compared.

Key Words: *Morus*, Mulberry, Fruit, Quality, Species.

INTRODUCTION

The genus *Morus* (mulberries) consists of 14 species of deciduous trees and shrubs. Well-known mulberry species are *M. alba*, *M. nigra*, *M. rubra*, *M. australis*, *M. latifolia*, *M. multicaulis* and *M. bombycis*¹. Mulberries are native to temperate and subtropical regions of Asia, Europe and North America^{2,3}. *M. alba* originated in China, Japan, Thailand, Malaysia and Birmania and it had also been widely cultivated for silkworms in Europe during the 18th and 19th centuries⁴. Although, wild population of *M. nigra* is quite common in the Aegean region and the place of origin of *M. nigra* is still under determination⁵. On the other hand, Bellini *et al.* reported that *M. nigra* is native to North Iran, Turkey, Syria, Arabia, South of Asian Russia, and is cultivated in Europe, USA, Australia, South of Asian Russia and India. *M. rubra* originally came from North America⁴. Several mulberry species, including white, black and red mulberries, are commonly grown in Anatolia⁶.

Different parts of mulberries are used for several purposes. Leaves are highly nutritious and contain vitamins B complex (except B12), C (200–300 mg/100 g), D

and flavonols. They are also sometimes used as a vegetable; fruit is consumed directly fresh or processed into juice and stews. In some cases, fruit juice is fermented to make liquor. The fruit contains approximately 32% tannin, good for tanning and colouring purposes, and cineole, geraniol, linalyl acetate, α -pinene and limone as major components of the essential oils. Bark is used in the treatment of stomach-ache, neuralgic pains and dropsy; leaves and young branchlets are used in treating heavy colds, cough, red eye, insect bites and wounds; fruits are used in the treatment of sore throat, dyspepsia and melancholia⁷⁻¹⁰.

Mulberries have spread in many regions of Turkey, because of the resistance to unsuitable soil and climatic conditions of mulberry. The annual mulberry fruit production of Turkey is approximately 60,000 tons¹¹.

The mulberry fruits have been consumed as food in different regions of Anatolia. In some regions, fruits are consumed as fresh (or as dessert) or especially, black mulberry is processed to jam, syrup or fruit juice. In some other regions, fruits are used in pastry and ice cream because of its exceptional colouring power and aroma. In south-east region, dried mulberry fruits are consumed as appetizer or fresh fruits are processed to "pekmez" (concentrated fruit juice under the sun), "pestil" (mixing fruit juice and starch, then boiling and drying under the sun as a thin layer), and "kome" (mixture of fruit juice, starch and walnut kernel and shaping as sausage and then drying under the sun). There are also some regions where the fresh leaves are used in meals or are consumed in salad.

Unfortunately only few studies on fruit characteristics of mulberry species were published. The aim of this study was to determine some chemical and physical characteristics of the promising genotypes of different mulberry species commonly grown in Anatolia, and to introduce the products made from mulberry fruits. This basic research will take part among few studies on the determination of mulberry fruit characteristics in scientific literature.

EXPERIMENTAL

M. alba, *M. nigra*, *M. rubra* and *M. alba* var. *pendula* genotypes were used in the study. The population of white mulberry genotypes (TB Nos. 1, 2, 3, . . . , 23) were widely distributed as compared to black (TK Nos. 1, 2, 3, 4, 5), red (TR Nos. 1, 2, 3) and pendulous mulberry genotypes (TS Nos. 1, 2, 3) in Turkey. So, only the trees bearing larger fruits of white mulberry genotypes were chosen in this study.

Fruit dimensions (width and length), weight, soluble solid content (SSC), pH, titratable acidity (TA) and dry matter content of species selected were determined. Twenty fruits for each species were evaluated to assess each measurable property. SSC and pH were read by a refractometer and pH-meter, and TA (as citric acid) was determined by titrimetric method. To determine the dry matter content, several fruits were weighed and put into an oven at 65°C, samples were kept in an oven until the weight become steady. Also must (unprocessed fruit juice) yields were determined by pressing fruits. The drupelet and seed number per fruit were also assessed. Bud burst, appearance of inflorescence and harvesting dates were recorded as phenological properties.

RESULTS AND DISCUSSION

Some chemical and physical characteristics of promising genotypes of black, red and pendulous mulberries are presented in Table-1 and of white mulberry in Table-2. The chemical and physical characters evaluated showed differences in the species or among the genotypes in the same species. Pendulous mulberry with smaller fruit size and black mulberry with lower pH and higher acidity rates showed extreme characters when the species were compared. The average or extreme values were discussed for each species.

TABLE-1
CHEMICAL AND PHYSICAL CHARACTERISTICS MULBERRY GENOTYPES

Genotype No.	Fruit width (mm)	Fruit length (mm)	Fruit weight (g)	SSC (%)	pH	Titratabl. acid (%)	Dry matter (%)
<i>Black mulberry</i>							
TK No. 1	18.84 ± 1.80	25.90 ± 2.19	4.50	14.8	3.50	2.05	14.68
TK No. 2	17.42 ± 1.04	21.21 ± 1.90	4.13	17.5	3.60	1.72	19.18
TK No. 3	20.53 ± 1.44	27.54 ± 2.87	5.72	15.0	3.42	1.98	15.42
TK No. 4	20.03 ± 1.38	26.11 ± 2.81	4.92	15.0	3.58	1.60	13.64
TK No. 5	17.92 ± 2.36	22.09 ± 2.37	3.02	15.0	3.34	2.11	13.84
<i>Red mulberry</i>							
TR No. 1	22.36 ± 1.86	35.18 ± 3.27	4.33	18.4	5.45	0.19	23.63
TR No. 2	22.33 ± 1.97	33.89 ± 3.21	8.70	18.0	4.69	0.42	18.28
TR No. 3	14.90 ± 0.69	23.93 ± 1.40	5.70	19.4	5.80	0.16	21.51
<i>Pendulous mulberry</i>							
TS No. 1	12.88 ± 0.56	19.67 ± 1.91	1.88	12.4	4.81	0.42	21.02
TS No. 2	11.70 ± 0.91	16.09 ± 1.63	1.08	17.0	4.87	0.70	23.21
TS No. 3	12.13 ± 0.96	18.82 ± 1.21	1.09	17.1	5.38	0.48	23.21

The width, length, and weight of black mulberry varied between 17.92–20.53 mm, 21.21–26.11 mm and 3.02–5.72 g, respectively. The fruits of black mulberry had higher acidity; pH ranged from 3.34 to 3.60 and TA ranged from 1.60 to 2.11%. The fruits also contained 14.8–17.5% SSC, 13.84–19.18% dry matter and 85.89% must yield. Although the pH and TA values were similar to the results of Lale⁶ and Martin *et al.*¹⁰, considerably bigger fruit weights were obtained from some of the black mulberry genotypes studied as compared to those reported by Lale⁶, Bellini *et al.*⁴ and Elmaci and Altug¹². The pH values reported by Guven and Basaran¹³ were similar to our research and their SSC and TA values were slightly lower.

The red mulberry genotypes are not very common in the region, therefore only three trees were found for evaluation. The fruit characteristics of red mulberry genotypes were: fruit widths 14.90–22.36 mm, fruit lengths 23.93–35.18 mm, fruit weights 4.33–8.70 g, SSC 18.0–19.4%, pH 4.69–5.80, TA 0.16–0.42%, dry matter content 18.28–23.63% and must yield 74.19%. Although the fruit textures were mostly similar to white mulberries, red mulberry fruits were slightly bigger and had higher dry matter content than those of white mulberries. The fruit characteristics of these genotypes were superior to the findings of Lale⁶. Wu *et al.*¹⁴ reported fruit characteristics of a new red mulberry. The new mulberry genotype, called “Guihuami”, had 3.8–6.5 g fruit weight and an SSC of 14.89%, both values being slightly less than our findings.

The fruits of pendulous mulberry, commonly used or known as ornamental plant, were smaller than those of the other species evaluated in the research (Table-1). The average fruit characteristics ranged as follows: fruit width 11.70–12.88 mm, fruit length 16.09–19.67 mm, fruit weight 1.08–1.88 g, SSC 12.4–17.1%, pH 4.81–5.38, TA 0.42–0.70%, dry matter 21.02–23.21% and must yield 75.00%.

White mulberry is a widely grown mulberry species of Anatolia. The fruits range from very small to large. The fruit dimensions and fruit contents of white mulberry investigated were ranged as follows: fruit width 15.32–21.28 mm, fruit length 25.75–34.85 mm, fruit weight 3.15–6.88 g, SSC 12.4–18.6%, pH 5.53–6.12, TA 0.10–0.26%, dry matter 12.37–18.50% and must yield 70.93%. Mulberry must yield is the main component of some regional products like “pekmez”, “pestil” or “kome”. Must yield contents of mulberries are also important to know since a higher must yield means a better quality product. The fruit characteristics of white mulberry genotypes investigated were slightly higher than those reported by Lale⁶, Aslan¹⁵ and Cam¹⁶. In contrast, Read and Barnes² recorded fruit characteristics similar to this research. The pH values were similar to results obtained by Gerasopoulus and Stavroulakis¹⁷. The SSC reported was, on the other hand, higher than that of our findings.

Some of the phenological characteristics of different mulberry species are presented in Table-3. Bud burst and appearance dates of inflorescence can vary from year to year depending on the ecological conditions of plants grown. As a matter of fact, in the west of Anatolia, bud burst occurs in the first week of April and the fruits start to mature from late May to late August, varying among species⁶. In the east of Anatolia, on the other hand, the bud appearance time of white mulberry is the middle of May and the fruits get mature from late June to early July¹⁶. Our research gives the phenological characters of mulberry species for central Anatolia which is warmer than east and cooler than west. Lamson³ reported that red mulberry buds appear in April and May and start to mature from June through August in New Orleans. In the eastern United States, *M. alba* and *M. rubra* flower in May and April, and mature from July to August and June to August, respectively². In our research, the harvesting periods of some ever bearing white mulberry genotypes and all black mulberry genotypes were quite longer than those of the other species (Table-3).

TABLE-2
CHEMICAL AND PHYSICAL PROPERTIES OF
WHITE MULBERRY GENOTYPES

Genotype No.	Fruit width (mm)	Fruit length (mm)	Fruit weight (g)	SSC (%)	pH	Titrat. acid (%)	Dry matter (%)
TB No. 1	18.68 ± 1.03	27.47 ± 2.10	4.90	16.2	5.95	0.13	15.40
TB No. 2	17.18 ± 1.06	29.35 ± 2.03	4.35	12.4	5.81	0.16	13.78
TB No. 3	19.27 ± 1.81	30.25 ± 2.26	5.24	14.2	5.99	0.17	15.42
TB No. 4	19.20 ± 1.31	34.85 ± 2.23	6.23	15.2	5.79	0.17	17.53
TB No. 5	19.76 ± 1.13	32.49 ± 2.20	5.90	16.0	5.89	0.16	15.73
TB No. 6	18.43 ± 0.92	30.10 ± 2.60	5.05	15.0	5.86	0.16	15.11
TB No. 7	20.26 ± 1.19	30.85 ± 1.81	5.80	13.0	5.73	0.13	14.57
TB No. 8	18.08 ± 1.08	31.54 ± 3.35	4.82	16.0	5.80	0.16	17.70
TB No. 9	17.25 ± 0.98	28.88 ± 3.35	4.15	16.2	5.99	0.16	18.14
TB No. 10	21.28 ± 2.09	33.06 ± 1.88	6.00	15.8	5.97	0.15	17.38
TB No. 11	18.62 ± 1.19	31.95 ± 1.55	5.32	15.0	5.98	0.16	16.07
TB No. 12	20.30 ± 1.53	33.95 ± 1.80	6.88	15.2	5.99	0.14	12.37
TB No. 13	21.10 ± 1.70	33.23 ± 2.81	6.30	18.0	5.88	0.13	18.19
TB No. 14	17.40 ± 1.01	31.35 ± 2.72	4.87	15.0	6.01	0.10	13.38
TB No. 15	18.60 ± 1.52	29.05 ± 2.29	4.08	17.0	5.73	0.13	18.09
TB No. 16	17.57 ± 1.37	27.96 ± 2.25	4.25	17.0	5.96	0.13	15.99
TB No. 17	19.40 ± 0.99	31.95 ± 2.37	6.48	18.0	6.12	0.13	14.82
TB No. 18	18.39 ± 0.87	29.30 ± 1.41	5.06	17.4	6.04	0.16	18.50
TB No. 19	19.43 ± 0.87	32.27 ± 1.96	5.60	17.4	6.04	0.11	15.27
TB No. 20	15.32 ± 0.92	27.72 ± 1.76	3.15	18.6	5.97	0.13	18.32
TB No. 21*	19.45 ± 0.70	32.82 ± 2.42	6.09	15.2	5.53	0.26	14.47
TB No. 22*	19.30 ± 1.93	25.75 ± 1.81	4.24	17.0	5.76	0.17	15.08
TB No. 23*	16.47 ± 0.70	27.60 ± 3.76	3.70	17.4	5.95	0.16	18.14

*These genotypes, having long harvesting period, are commonly named as ever bearing by growers.

TABLE- 3
SOME PHENOLOGICAL CHARACTERISTICS OF DIFFERENT MULBERRY SPECIES.

Species	Bud burst	Appearance of inflorescence	Harvesting period
White mulberry	10-15 April	25 April	15 June-25 July*
Black mulberry	15-20 April	5 May	25 June-30 September
Red mulberry	12-15 April	27 April	15 June-30 July
Pendulous mulberry	9-13 April	24 April	15 June-25 July

*Harvesting period of some white mulberries so-called ever bearing is longer than others (about 2 months).

The drupelet number, full or empty seed number and total seed number per fruit by mulberry species are presented in Table-4. Parthenocarpic drupelet formation is common in white mulberry. Most drupelets of white mulberry fruits have empty seeds or seeds were not observed at all¹⁸. Although 82.8 drupelets were counted per fruit, only 17.8 of these drupelets had seeds, and of these seeds only 2.8 were full. The remaining 78.5% of drupelets were parthenocarpic (Table-4). Among the species, the highest drupelet number was recorded in red mulberries. The parthenocarpic drupelet formation of red mulberries was low as compared to the other species studied (8.88%). The parthenocarpic drupelet percentage of pendulous mulberry was 41.05%. In contrast, black mulberry showed no parthenocarpic drupelet formation. The parthenocarpic and seedless drupelet formations were mostly affected by ecological conditions (wind, rain etc.) or by the morphology and biology of flowers. Griggs and Iwakiri¹⁹ investigated the parthenocarpic fruit formation of "Tufts" mulberry cultivar (*Morus rubra* L.) and reported 45% of seedless drupelets when open pollinated. When the flowers were covered, all drupelets became seedless. There were also no significant differences in development between seedless and seeded drupelets, which is in agreement with our observations on the parthenocarpy of mulberry fruits. So the seeds may not have an effective role in drupelet development.

TABLE-4
NUMBER OF DRUPELETS, FULL (LIVE) OR EMPTY SEED
AND TOTAL SEEDS PER FRUIT

Species	Drupelet number	Seedless drupelet number	Percentage of parthenocarpy	Full seed number	Empty seed number	Total seed number
White mulberry	82.80	65.00	78.50	2.80	15.00	17.80
Pendulous mulberry	36.30	14.90	41.05	9.40	12.00	21.40
Red mulberry	126.75	11.25	8.88	93.00	22.25	115.25
Black mulberry	18.00	0.00	0.00	18.00	0.00	18.00

Conclusion

The fruits of mulberry species, particularly white and red mulberry fruits, are very rich in sugar content which means energy for the human body. Literature does not provide much information on the products made from mulberry fruits and this subject has been poorly studied. The black mulberry fruits have antioxidant and antiseptic ingredients, and are commonly used for soar throat and are also effective against anemia. The products made from mulberry fruits include high sugar and nutrition contents, such as pekmez, pestil and kome, that are candidates as alternatives to other energy sources. These products have been used for centuries as traditional recipes to enhance endurance, maintain mental alertness, improve performance and strengthen the human body. This basic research will take part among the few studies on the determination of mulberry fruit characteristics in scientific literature and will shed light on further researches.

Further researches will unveil other benefits of these fruits and introduce the products to the world.

REFERENCES

1. Y. Huo, Mulberry Cultivation and Utilization in China, FAO Animal Production and Health Paper, 2002, p. 11 (2000).
2. R.A. Read and R.L. Barnes, *Morus L. Mulberry in Seeds of Woody Plants in the USA*. C.S. Schopmeyer, Tech. Coord. U.S. Department of Agriculture (1974).
3. I.N. Lamson, *Morus rubra L. Red Mulberry*, in: Russel M. Burns and Barbara H. Honkala (Tech. Coordinators), *Silvics of North America*, Vol. 2, *Hardwoods Agricult. Handbook*, 654, Washington, US Depart. of Agricult. Forest Service, pp. 470–473 (1990).
4. E. Bellini, E. Giordani and J.P. Roger, *Informatore Agrario*, **56**, 89 (2000).
5. K. Browicz, *Fragmenta Floristica et Geobotanica*, **45**, 273 (2000).
6. H. Lale, A Research on Pomological, Phenological and Fruit Quality Characters of Some Mulberry Cultivars in Turkey, Master Thesis, Science Institute of Ege University (1992) (unpublished).
7. J.L. Hartwell, *Lloydia*, 30 (1971).
8. C.F. Reed, Information Summaries on 1000 Economic Plants, Horticulture Handbook 450, Washington DC, pp. 544–547 (1976).
9. J.A. Duke and K.K. Wain, Medicinal Plants of the World (Computer Index with more than 85,000 entries), 3 Vol. (1981).
10. J.D. Martin, G.L. Rodrigo, J.H. Cordero, E.D. Diaz and C.D. Romero, *Food Technol Biotechnol.*, **41**, 173 (2003).
11. Anonymous, Agricultural Construction and Production, National Statistical Institute (DIE), Ankara, Turkey (2000).
12. Y. Elmaci and T. Altug, *J. Sci. Food Agriculture*, **82**, 632 (2002).
13. S. Guven and M. Basaran, *Tarimsal Arastirma Dergisi (Turkish)*, **1**, 108 (1979).
14. Z.X. Wu, L.J. Zhu, W.L. Hong and Z.D. Sheng, Guihuami: a New Mulberry Selection, *China Fruits*, **6**, 55 (2002).
15. M.M. Aslan, The Selection of Promising Mulberry Types from Some Counties of Malatya, Elazig, Erzincan and Tunceli in Turkey, M.Sc. Thesis, Science Institute of Cukurova University, (1998) (unpublished).
16. I. Cam, Studies on Some Phenological Characteristics and Selection of Mulberries which Grow in Edremit and Gevas Regions of Turkey, M.Sc. Thesis, Science Institute of Yuzuncu Yil University (2000) (unpublished).
17. D. Gerasopoulos and G. Stavroulakis, *J. Sci. Food Agric.*, **73**, 261 (1997).
18. J.R. Barbour, R.A. Read and R.L. Barnes, *Morus L. (Mulberry)*, *Woody Plant Seed Manual* (online /<http://wpsm.net/>), pp. 1–10 (2002).
19. W.H. Griggs, and B.T. Iwakiri, *J. Hort. Sci.*, **48**, 83 (1973).