

### 1. Physico-chemical characteristics of fresh mulberry fruits

As mentioned in Table 1, Black mulberry (*Morus nigra*) fruits were distinguished by a characteristic dark purple color, typical of mature fruits of this species.<sup>27</sup> This is referenced as one of the distinguishing features in separating *M. nigra* from white and red forms. Average fruit length was  $24 \pm 1.6$  mm, and width was  $14.9 \pm 0.64$  mm. These measurements fall in the range of fruit lengths of 17.39–27.01 mm and widths of 10.89–17.91 mm, as reported by Gozlekci et al. (2014) for various genotypes of *Morus nigra* in Turkey.<sup>28</sup> The fruit weight for this study was  $2.7 \pm 0.36$  g, which agrees closely with studies by Hosseini et al. (2018), who recorded a mean fruit weight of range 1.79–5.69 g for *M. nigra*.<sup>29</sup> Jalikop et al. (2011) also reported a weight range of 0.56–4.01 g for ten mulberry accessions.<sup>30</sup> Such differences are primarily due to genetic and environmental differences. Peduncle length ranged between  $38.1 \pm 2$  mm, which align with the findings of Ercisli and Orhan (2007), that black mulberry fruits have peduncles measuring from 37.7 to 55.9 mm.<sup>31</sup> The edible portion was determined to be  $83.6 \pm 1.36\%$ , which is lower but in agreement with the high edible fractions of 95% to 99% reported by Skender (2019) and Gozlekci (2014) for mulberry fruits.<sup>32,28</sup> This study provides reliability for the value determined for the mulberry characteristics.

The TSS was  $16.8 \pm 0.9^\circ$ Brix, which is in accordance with the study of of.<sup>33</sup>, who quoted TSS between 15.65% and 22.10% in black mulberry cultivars. The titratable acidity was  $1.62 \pm 0.07$  g/100g, which is in agreement with the study of of.<sup>34</sup>, who quoted 1.621 to 2.816 g/100g in black mulberries. The pH was  $4.76 \pm 0.15$ , which align with similar study where pH was found between 3.37–5.33 and 4.00–6.70 in different mulberry species.<sup>35,36</sup> Ascorbic acid was found to be  $32.6 \pm 0.9$  mg/100g mg/100g, which is similar to that obtained by Krishna et al. (2018), where ascorbic acid ranged between 6.71 to 27.48 mg/100g FW.<sup>37</sup> TPC was recorded as  $350.8 \pm 1.2$  mg GAE/100g, which is similar to the results obtained by Farahni et al. (2019) i.e., 134.73 to 922.64 mg/100g FW, and by Liang et al. (2012) which ranged between 189.67 to 246 mg/100g.<sup>36,35</sup> The TFC ranged between  $390 \pm 0.9$  mg RE/100g and  $49.2 \pm 0.76$  mg QE/100g. Similar results were obtained by the Liang et al. (2012) and Butkhup et al. (2013), where values ranged between 64.55 to 211.01 mg CE/100g and 40.94 and 191.65 mf/100g, respectively.<sup>35,38</sup> The total anthocyanin content was calculated as  $281.6 \pm 0.83$  mg/100g which fall in the range (52.62 to 475.65 mg/100g) reported by Hosseini et al. (2018).<sup>29</sup> Antioxidant activity was measured as 68%, which was much higher as compared to 47.94 % determined by khatri et al. (2024) in black mulberries.<sup>39</sup> The chemical characteristics of mulberry fruit are mentioned in Table 1

**Table S1** Physico-chemical characteristics of fresh mulberry fruit

Parameters	Values (Mean $\pm$ SD)
<b>Physical parameters</b>	
Visual color	Dark purple
Length(mm)	24 $\pm$ 1.60
Width(mm)	14.9 $\pm$ 0.64
Weight(g)	2.7 $\pm$ 0.36
Edible portion (%)	83.6 $\pm$ 1.36
Seed (%)	17.5 $\pm$ 1.36

Peduncle length(mm)	38.1±2.04
<b>Chemical parameters</b>	
TSS(B <sup>0</sup> )	16.8±0.90
Titratable acidity(g/100g)	1.62±0.07
pH	4.76±0.15
Vitamin C (mg/100g)	32.60±0.92
Total phenol (mg GAE/100g)	350.8±1.2
Total flavonoids (mg RE/100g)	390±0.90
Total flavonoids (mg QE/100g)	49.20±0.76
Total anthocyanin (mg/100g)	281.60±0.83
Antioxidant activity (%)	68±0.46

The results are presented as mean of triplicates ± standard deviation (SD).

**Table S2** Chemical characteristics of foam mat dried mulberry juice powder

Treatment	Ascorbic acid(mg/100g)	Total Phenol(mg GAE/100g)	Total Flavonoid(mg QE/100g)	Total flavonoid(mg RE/100g)	Total Anthocyanin Content(mg/100g)	Antioxidant activity(%)
T <sub>1</sub>	12.26±0.46 <sup>d</sup>	180.63±0.56 <sup>a</sup>	363.60±0.53 <sup>a</sup>	57.97±0.65 <sup>a</sup>	100.23±0.41 <sup>cd</sup>	65.53±0.83 <sup>a</sup>
T <sub>2</sub>	13.73±0.64 <sup>cd</sup>	164.76±0.68 <sup>ab</sup>	345.70±0.65 <sup>abcd</sup>	49.30±0.26 <sup>bc</sup>	98.13±0.52 <sup>bc</sup>	51±0.77 <sup>bc</sup>
T <sub>3</sub>	20.83±0.76 <sup>bc</sup>	127.96±0.41 <sup>cd</sup>	337.53±0.61 <sup>cde</sup>	45.53±0.55 <sup>c</sup>	131±0.8 <sup>bc</sup>	48.20±0.69 <sup>cd</sup>
T <sub>4</sub>	24±0.28 <sup>a</sup>	101.63±0.55 <sup>de</sup>	331.33±0.36 <sup>def</sup>	34.67±0.49 <sup>de</sup>	181.23±0.40 <sup>ab</sup>	37.51±0.32 <sup>de</sup>
T <sub>5</sub>	28.16±0.28 <sup>a</sup>	94.70±0.52 <sup>e</sup>	285.86±0.80 <sup>gh</sup>	24.07±0.46 <sup>f</sup>	202.16±0.28 <sup>a</sup>	32.20±0.41 <sup>e</sup>
T <sub>6</sub>	10±0.70 <sup>d</sup>	158.40±0.45 <sup>ab</sup>	350.33±0.49 <sup>abc</sup>	49.76±0.25 <sup>bc</sup>	98.13±0.15 <sup>d</sup>	55.66±0.80 <sup>bc</sup>
T <sub>7</sub>	13.66±0.57 <sup>cd</sup>	138.36±0.40 <sup>bc</sup>	323.56±0.40 <sup>def</sup>	39.50±0.62 <sup>cd</sup>	102.36±0.28 <sup>cd</sup>	48.06±0.60 <sup>cd</sup>
T <sub>8</sub>	15.66±0.56 <sup>cd</sup>	110.96±0.98 <sup>de</sup>	298.63±0.55 <sup>fg</sup>	29.53±0.30 <sup>ef</sup>	133.16±0.28 <sup>bc</sup>	46.16±0.40 <sup>cd</sup>
T <sub>9</sub>	21.33±0.86 <sup>ab</sup>	82.60±0.65 <sup>ef</sup>	283.90±0.36 <sup>h</sup>	24.5±0.25 <sup>f</sup>	160.80±0.75 <sup>b</sup>	36.75±0.90 <sup>de</sup>
T <sub>10</sub>	22.56±0.76 <sup>ab</sup>	69.83±0.45 <sup>f</sup>	254.76±0.60 <sup>i</sup>	21±0.40 <sup>g</sup>	190.03±0.80 <sup>a</sup>	32.70±0.40 <sup>e</sup>
T <sub>11</sub>	10.83±0.70 <sup>d</sup>	161.78±0.36 <sup>ab</sup>	355.50±0.62 <sup>ab</sup>	52.38±0.54 <sup>ab</sup>	96.16±0.28 <sup>d</sup>	64.66±0.57 <sup>a</sup>
T <sub>12</sub>	12.33±0.45 <sup>d</sup>	145.86±0.15 <sup>bc</sup>	341.76±0.75 <sup>bcde</sup>	47.93±0.30 <sup>bc</sup>	97.50±0.50 <sup>d</sup>	57.93±0.05 <sup>ab</sup>
T <sub>13</sub>	15.66±0.65 <sup>cd</sup>	115.66±0.41 <sup>d</sup>	309.50±0.43 <sup>ef</sup>	34.70±0.52 <sup>de</sup>	135.36±0.40 <sup>bc</sup>	49.10±0.26 <sup>cd</sup>
T <sub>14</sub>	20.33±0.57 <sup>bc</sup>	86.66±0.76 <sup>ef</sup>	288.66±0.65 <sup>gh</sup>	29.23±0.8 <sup>ef</sup>	149.63 ±0.40 <sup>b</sup>	43.53±0.47 <sup>d</sup>
T <sub>15</sub>	24.33±0.8 <sup>a</sup>	73.93±0.40 <sup>f</sup>	281.47±0.44 <sup>h</sup>	22.20±0.43 <sup>g</sup>	192.10±0.65 <sup>a</sup>	43.23±0.25 <sup>d</sup>

WPI : Whey protein isolate; SPI: Soya protein isolate;(WPI:M -Whey Protein Isolate : Maltodextrin in ratio 1:1),T<sub>1</sub>=2g/100ml

WPI,T<sub>2</sub>=4g/100ml WPI,T<sub>3</sub>=6g/100ml WPI,T<sub>4</sub>=8g/100ml WPI,T<sub>5</sub>=10g/100ml WPI, T<sub>6</sub>=2g/100ml SPI,T<sub>7</sub>=4g/100ml SPI,T<sub>8</sub>=6g/100ml

SPI,T<sub>9</sub>=8g/100ml SPI,T<sub>10</sub>=10g/100ml SPI, WPI:M T<sub>11</sub>=2g/100ml WPI:M,T<sub>12</sub>=4g/100ml WPI:M ,T<sub>13</sub>=6g/100ml WPI:M,T<sub>14</sub>=8g/100ml

WPI:M,T<sub>15</sub>=10g/100ml WPI:M.

**Table S3.** FTIR characteristics of foam mat dried mulberry (T<sub>2</sub>)

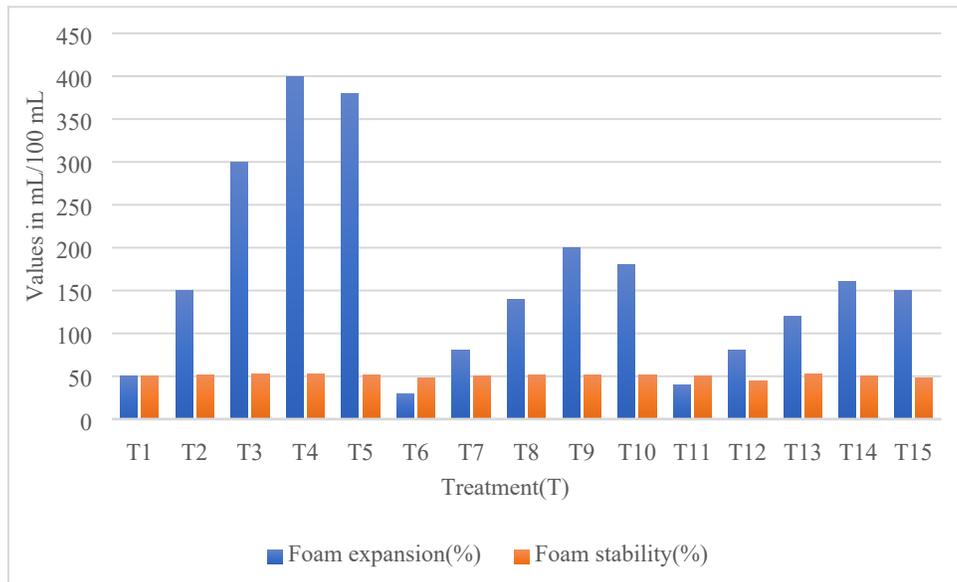
Sample	Wave Number (cm <sup>-1</sup> )	Transmittance (%)	Peak Type	Type of Bond	Type of Vibration	Functional Group
T <sub>2</sub>	3279.92	66.50%	Medium	O-H	Stretching	Alcohol and Phenols
	2923.68	75.80%	Medium	C-H	Stretching	Methyl/Methylene
	1626.90	68.40%	Strong	C=O	Stretching	Carbonyl compound, Phenols
	1403.26	71.20%	Medium	C-H	Bending	Methyl/Methylene
	1241.24	75.30%	Medium	C-N	Stretching	Proteins
	1051.47	52.20%	Strong	C-H or C-O	Bending / Stretching	Methyl/Methylene compounds
	1002.84	56.80%	Moderate	C-H or C-O	Bending / Stretching	Proteins
	865.98	77.30%	Weak	C-H	Bending	Methyl/Methylene compounds
	817.06	78.20%	Weak	C-H	Bending	Benzene
	777.32	78.90%	Weak	C-H	Bending	Mono-substituted benzene ring
	585.65	81.00%	Weak	P-O	Bending	Anthocyanin
	516.14	82.60%	Weak	S=O	Bending	Sulfonic acid, sulfonate
T <sub>6</sub>	3294.39	54.8%	Medium	O-H	Stretching	Alcohol and Phenol
	2922.90	66.70%	Medium	C-H	Stretching	Methyl/Methylene
	1613.93	83.35%	Medium	C=O	Stretching	Carbonyl compound, Phenols
	1404.32	83.91%	Medium	C-H	Bending	Methyl/Methylene
	1249.93	82.55%	Medium	C-H	Bending	Proteins
	1051.23	31.72%	Strong	C-H or C-O	Bending /Stretching	Phenolic compounds
	1025.84	32.60%	Strong	C-H or C-O	Bending /Stretching	Phenolic compounds
	865.96	93.12%	Weak	C-H	Stretching	Carbohydrates
	817.13	92.75%	Weak	C-H	Stretching	Benzene
	777.17	93.44%	Weak	C-H	Bending	Benzene
	586.81	83.89%	Medium	P=O	Bending	Anthocyanin
	517.83	84.98%	Medium	S=O	Bending	Sulfonic acid, sulfate and Sulfonate
	424.06	95.47%	Weak	C=C	Bending	Aromatic compound

**Table S4.** EDS elemental spectrum of various identified elements in foam mat dried mulberry powder

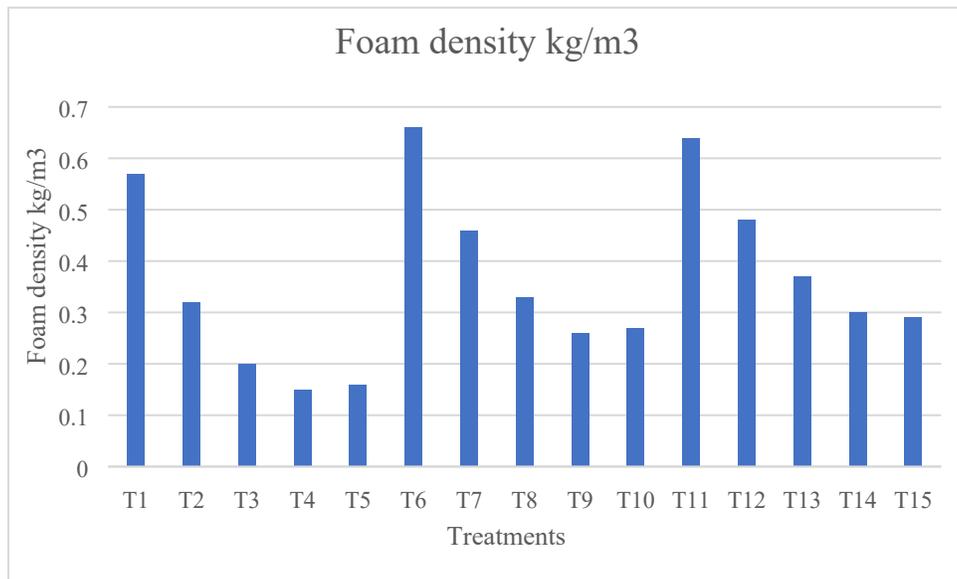
Sample	Element	Weight(%)	Atomic (%)
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WPI(T <sub>2</sub> )	Carbon	51.46	59.64
	Nitrogen	6.82	6.78
	Oxygen	36.49	31.75
	Sodium	0.27	0.16
	magnesium	0.30	0.17
	Potassium	3.05	1.09
	Calcium	0.48	0.17
	copper	1.14	0.25
SPI(T <sub>6</sub> )	Carbon	51.88	59.30
	Nitrogen	9.25	9.06
	Oxygen	35.72	30.65
	magnesium	0.21	0.12
	Potassium	1.72	0.60
	copper	1.22	0.26

Whey Protein Isolate (WPI)(T<sub>2</sub>):2g/100mL ,Soya Protein Isolate(SPI)(T<sub>6</sub>):2g/100mL



(a)



(b)

Figure S1 (a-b): Foaming properties of mulberry fruit juice ( $p < 0.005$ )