

PHYSICO-CHEMICAL CHARACTERISTICS OF WATERMELON FRUITS (*CITRULLUS LANATUS*) OF GENOTYPES CULTIVATED ON SANDY SOILS IN SOUTHWESTERN ROMANIA

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Abstract

The study was carried out during 2022-2024 within the experimental field of the Research - Development Station for Plant Culture on Sands Dăbuleni. The method used to set up the experiment was the randomized block. The material used to set up the experiment consisted of six watermelon genotypes: 'Dulce de Dăbuleni', 'Oltenia', 'De Dăbuleni', own creations of the Research - Development Station for Plant Culture on Sands Dăbuleni, and Burebista F1, Kratos F1, Fechete F1 of other origin. Physical characteristics such as length, diameter, and shape index of the fruits, quantitative characteristics such as fruit weight, fruit peel thickness and weight, core percentage, and also biochemical ones such as soluble dry matter content, total dry matter content, titratable acidity, vitamin C, and carbohydrates were evaluated. The weight of the fruits analyzed during the study period recorded average values that varied between 4.63 kg for Burebista F1(2024) and 9.32 kg for Fechete F1(2023). The soluble dry matter content varied between 10.00 and 11.80%, the highest average value being recorded for the Burebista F1 cultivar, respectively 11.00%.

Key words: watermelon, physicochemical characteristics, sandy soils.

INTRODUCTION

Watermelon (*Citrullus lanatus*) is a highly valued species due to its large, round, oval, or elongated fruits, rich in vitamins (Salk et al., 2008). Watermelon fruits are also an important source of nutrients, including lycopene, a carotenoid pigment with a special antioxidant role in the metabolism of the human body, protecting it against serious diseases such as cancer (Perkins-Veazie & Collins, 2004). Watermelons were first cultivated 5000 years ago in Egypt, often found in hieroglyphs and frescoes in ancient Egyptian tombs. In China, it was introduced in the 10th century, later making its way west to North America (Anonymus, 2014). Knowledge of the physicochemical characteristics of the fruits plays an important role in the sorting, classification, and handling process. The shape of the fruit plays an important role in determining the method of their valorization, either for retail sale or in the processing process in the form of different products (Bahansawy et al., 2004; Khater & Bahansawy, 2016; Dou et al., 2018). The accumulation of knowledge regarding the

physicochemical characteristics facilitates the use and evaluation of local watermelon cultivars studied in breeding programs (McGregor, 2012). Therefore, the present study aimed to analyze the physicochemical characteristics of the fruits of watermelon genotypes grown in the sandy soil area.

MATERIALS AND METHODS

The experiment was established in the period 2022-2024 on sandy soils in the research field of the Research - Development Station for Plant Culture on Sands Dăbuleni. The randomized block method was used with four repetitions.

The study material was represented by 6 watermelon genotypes: 'Dulce de Dăbuleni', 'Oltenia', 'De Dăbuleni', Burebista F1, Kratos F1, and Fechete F1, whose fruits were harvested at physiological maturity.

The determined physical characteristics were the length (cm), diameter (cm) and shape index of the fruits, as well as their quantitative characteristics, namely the weight of the fruits (kg), the thickness of the peel (cm) and the

percentage of the fruit core (%), according to the methodology described by Ionică M. E. (2014). Based on the results obtained in the three years of study, a classification of fruits by shape and size was performed.

The classification of fruits by size was performed according to the method described by Khater & Bhansawi in 2016 (< 5kg = small fruits; 5-8 kg = medium fruits; 8-11 kg = large fruits and > 11 kg = very large fruits), and the classification according to the shape index was performed according to the method described by Dou et al. in 2018 (< 1.8 = elongated shape; 1.4-1.6 = oval shape and between 1.0-1.10 = spherical shape).

The determination of the chemical properties of the fruits such as soluble dry matter content (%), total dry matter (%), carbohydrates (%), titratable acidity (g malic acid/ 100g fresh matter), and vitamin C (mg), was performed according to the methods described by Croitoru (2021).

The soluble dry matter (SUS) was determined by the refractometric method, the results being expressed in percentages (%). The determination of the total dry matter (SUT) content was carried out using the gravimetric method based on the removal of water by evapotranspiration from the average analytical sample used, keeping it in an oven at a temperature between 85-105°C, the results being expressed in percentages of total dry matter (%).

The determination of the titratable acidity (TA) was carried out according to the method described by Ionică (2014), the results being expressed in grams of malic acid/100 g of fresh substance. To determine the vitamin C content, the iodometric method described by Croitoru (2021) was used, which is based on the oxidation of ascorbic acid with excess iodine, the results being expressed in mg of ascorbic acid.

Carbohydrates were determined according to the Fehling Soxhelt method described by Croitoru (2021), with the results expressed in percentages.

Regarding the determination of plant productivity, at the end of the vegetation

period, the total production for each experimental variant was calculated, and the production was reported in tons/ha.

The data obtained were statistically processed using the statistical analysis program (Stat Point Technologies, Warrenton, VA, USA). The relationships between the physical characteristics of the fruits were quantified using correlations.

RESULTS AND DISCUSSIONS

The literature review states that the evaluation of physical characteristics, plant growth form, and leaf and fruit shape are useful indicators in determining genetic variation and in the selection process. From the analysis of the data in Tables 1 and 2, it appears that during the analyzed period, there was a high variability between the analyzed genotypes, depending on the climatic year.

Regarding the physical characteristics of the fruits during the analyzed period, the highest coefficient of variability (15.99%) was calculated for the length of the fruits ('Oltenia' in 2023).

The variation limits for fruit length were between 39.99 cm for 'De Dăbuleni' in 2022 and 20.90 cm for Burebista F1 in 2024. The lowest value of fruit diameter for the study period was recorded in 2024 for Burebista F1 (20.18 cm), and the highest value of 24.40 cm was also recorded in 2024 for the 'Oltenia' cultivar.

The results obtained are higher than those reported by Hakimi & El Madidi in 2015 for fruit length (31.70 cm) and diameter (23.20 cm).

From the point of view of the shape index, it presented the lowest value of 1.04 in 2024 for Burebista F1 and the highest of 1.97 in 2022 for 'De Dăbuleni'. In the literature, Tanaka & Mizutani (1995) reported lower shape index values for the analyzed cultivars than those in the present study, reporting an oval (if = 0.6) and spherical (if = 1.0) fruit shape.

Table 2 presents the results obtained regarding the main quantitative characteristics of watermelon fruits, such as weight, peel thickness, and fruit core percentage.

Table 1. Physical characteristics of the fruits of watermelon genotypes studied during 2022-2024

Genotype	Descriptive statistics	Morphological characteristics								
		Fruit length (cm)			Fruit diameter (cm)			FSI		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
'Dulce de Dăbuleni'	Mean±SD	29.66±0.91	25.78±2.22	22.40±0.89	22.50±0.77	22.56±1.39	21.10±1.14	1.19±0.03	1.14±0.06	1.06±0.05
	Variation limits	25.50/27.80	23.70/29.20	21.00/23.00	21.50/23.50	21.00/24.00	20.00/22.50	1.14/1.23	1.08/1.22	1.02/1.15
	CV%	3.41	8.63	3.99	3.43	6.18	5.40	2.60	5.08	4.69
'Oltenia'	Mean±SD	29.04±2.22	26.64±4.26	27.00±1.73	22.94±0.94	21.78±2.58	24.40±1.52	1.27±0.09	1.23±0.17	1.11±0.05
	Variation limits	26.5/32.5	20.50/31.50	24.00/28.00	22.00/24.50	17.80/24.50	22.00/26.00	1.17/1.41	1.07/1.51	1.04/1.17
	CV%	7.63	15.99	6.42	4.12	11.87	6.22	7.43	13.77	4.25
'De Dăbuleni'	Mean±SD	39.98±3.79	36.06±4.14	37.88±1.94	20.24±0.81	20.70±1.33	21.32±2.02	1.97±0.15	1.75±0.25	1.79±0.24
	Variation limits	34.50/44.50	30.00/41.00	36.20/40.50	19.00/21.20	19.40/22.80	19.30/24.50	1.73/2.10	1.46/2.10	1.49/2.10
	CV%	9.47	11.74	5.12	4.02	6.41	9.46	7.40	14.03	13.43
Burebista F1	Mean±SD	25.84±1.82	23.28±1.42	20.90±1.56	22.23±0.73	21.44±1.53	20.18±1.28	1.16±0.06	1.09±0.03	1.04±0.02
	Variation limits	23.00/27.2	21.40/25.40	18.50/22.50	21.60/23.50	19.20/23.40	18.50/21.50	1.06/1.23	1.04/1.11	1.00/1.05
	CV%	7.06	6.12	7.45	3.28	7.15	6.34	5.42	2.6	2.22
Kratos F1	Mean±SD	31.56±2.16	31.84±1.05	30.18±2.49	21.52±1.24	23.62±2.89	22.84±1.30	1.47±0.16	1.36±0.15	1.33±0.14
	Variation limits	28.50/33.60	30.50/33.00	26.00/32.50	19.50/22.80	20.10/28.10	21.00/24.20	1.28/1.72	1.12/1.52	1.16/1.55
	CV %	6.85	3.28	8.24	5.78	12.22	5.71	10.93	11.05	10.94
Fechețe F1	Mean±SD	25.04±1.68	26.58±1.52	22.36±2.09	21.86±1.02	23.86±1.77	21.70±1.52	1.15±0.06	1.13±0.12	1.03±0.07
	Variation limits	23.50/27.40	24.50/28.60	20.00/25.00	21.00/23.50	21.20/25.10	20.00/24.00	1.08/1.24	1.05/1.13	0.95/1.13
	CV%	6.71	5.73	9.33	4.68	7.49	7.02	5.27	11.03	6.81

Table 2. Quantitative characteristics of fruits in watermelon genotypes studied during 2022-2024

Genotype	Descriptive statistics	Morphological characteristics								
		Fruit weight (kg)			Peel thickness (cm)			Core percentage (%)		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
'Dulce de Dăbuleni'	Mean ± SD	7.18±0.49	6.91±1.37	5.24±0.73	1.2±0.19	1.10±0.26	1.60±0.22	42.72±1.36	53.66±5.11	55.85±3.96
	Variation limits	6.53/7.66	5.39/8.70	4.50/6.30	1.00/1.50	0.80/1.50	1.50/2.00	41.11/44.14	44.67/57.06	49.17/59.31
	CV %	6.79	19.83	13.88	15.03	24.05	13.98	3.17	9.52	7.09
'Oltenia'	Mean ± SD	8.68±1.28	7.09±1.76	8.88±1.34	1.48±0.15	1.42±0.23	1.40±0.42	58.24±3.97	59.57±4.19	59.39±6.94
	Variation limits	7.32/10.20	4.34/9.12	6.94/9.93	1.30/1.70	1.20/1.70	1.00/2.00	53.92/63.51	54.27/65.16	53.25/70.31
	CV %	14.71	24.88	15.12	10.02	16.05	29.88	6.82	7.04	11.68
'De Dăbuleni'	Mean ± SD	8.89±1.40	8.57±1.13	9.26±0.98	1.38±0.16	1.68±0.26	1.32±0.20	58.30±5.74	54.77±6.82	59.24±3.28
	Variation limits	7.17/10.39	7.08/10.18	8.51/10.99	1.20/1.60	1.40/2.00	1.00/1.50	51.38/66.56	42.77/59.24	54.67/62.63
	CV %	15.72	13.18	10.63	11.91	15.41	15.53	9.84	12.46	5.53
Burebista F1	Mean ± SD	6.80±0.63	6.00±0.98	4.63±0.89	1.50±0.07	1.14±0.24	1.44±0.58	58.73±5.06	61.23±10.56	59.29±4.99
	Variation limits	6.11/7.57	4.65/7.27	3.40/5.77	1.40/1.60	0.80/1.40	0.80/2.00	52.84/66.26	44.43/69.60	53.30/66.40
	CV %	9.2	16.33	19.26	4.71	21.13	40.07	8.61	17.25	8.42
Kratos F1	Mean ± SD	7.58±0.63	8.96±0.34	8.04±0.95	1.46±0.27	1.48±0.44	1.22±0.22	54.38±9.31	55.85±5.78	62.91±4.08
	Variation limits	7.07/8.67	8.56/9.40	6.72/9.17	1.00/1.70	0.90/2.00	1.00/1.50	40.99/66.28	49.55/64.23	55.75/65.76
	CV %	8.28	3.74	11.78	18.51	29.99	17.77	17.13	10.35	6.49
Fechețe F1	Mean ± SD	6.62±0.91	9.32±1.24	5.82±1.00	1.42±0.32	1.10±0.14	1.30±0.27	63.73±3.73	65.25±3.66	62.00±6.88
	Variation limits	5.62/8.09	7.62/11.05	5.25/7.60	1.00/1.80	1.00/1.30	1.00/1.50	60.27/67.96	59.87/70.15	53.14/70.85
	CV %	13.78	13.26	17.22	22.49	12.86	21.1	5.86	5.61	11.1

Fruit weight recorded values during the study period ranging from 4.63 kg in 2024 for Burebista F1 and 9.32 kg for Fechete F1 in 2023, followed by 'De Dăbuleni' with 9.26 kg in 2024.

The data obtained regarding fruit weight are consistent with those reported in the literature by Hakimi & El Madidi, respectively 8.3 kg, but lower than those reported by Frătuțu et al. (2024) of 12.55 kg. Regarding the thickness of the peel of the watermelon fruits analyzed, it presented values ranging between 1.10 cm for 'Dulce de Dăbuleni' and Fechete F1 in 2023, and the highest value of 1.68 cm was recorded for 'De Dăbuleni' also in 2023. The highest percentage of core (65.27%) was recorded in 2023 for Fechete F1, and the lowest (42.72%) for 'Dulce de Dăbuleni' in 2022. In the literature, Bahnasawy et al. (2004) mention that the thickness of the fruit peel is positively correlated with the increase in fruit weight. The data obtained by them regarding peel thickness and core percentage are higher (12.11-20.28 mm for peel thickness and 42.12-65.70% for core percentage) than those recorded in the present study.

The highest coefficient of variability for quantitative characteristics was calculated in 2024 at Burebista F1 for peel thickness, respectively 40.07%, and the lowest of 3.17% for core percentage at 'Dulce de Dăbuleni' in 2022.

To classify the fruits according to the shape index and fruit weight, the scale proposed by Khater & Bhansawi (2016) was used (Table 3). Analyzing the data in Table 3, we can see that depending on the average weight obtained by each cultivar during the study period, 3 of the 6 cultivars presented large fruits with a weight ranging between 8.15 kg (Kratos F1) and 8.91 kg ('De Dăbuleni'), and the other 3 presented medium-sized fruits, with values ranging between 5.81 kg (Burebista F1) and 7.25 kg (Fechete F1).

Regarding their shape, the 'De Dăbuleni' genotype presented elongated fruits with a shape index greater than 1.80. The cultivars Burebista F1 and Fechete F1 presented a spherical fruit shape (1.10) and the other 3 a spherical-oval shape with an index ranging between 1.13 ('Dulce de Dăbuleni') and 1.39

(Kratos F1). Dou et al. (2018) mention in their study that the shape of the watermelon fruits analyzed ranged between elongated (if > 1.8) and spherical (if $= 1.0-1.1$).

Table 3. Classification of fruits in the watermelon genotypes studied, depending on their shape index and weight

Genotype	Fruit weight*(kg)	Size	FSI*	Shape
'Dulce de Dăbuleni'	6.44	medium	1.13	spherical-oval
'Oltenia'	8.22	large	1.20	spherical-oval
'De Dăbuleni'	8.91	large	1.84	elongate
Burebista F1	5.81	medium	1.10	spherical
Kratos F1	8.15	large	1.39	spherical-oval
Fechete F1	7.25	medium	1.10	spherical

*The data represents the average of the 2022-2024

The chemical characteristics of the fruits (Table 4) showed that during the study period, the total dry matter (%) recorded the highest value of 12.11% in the 'De Dăbuleni' genotype and the lowest of 9.65% in 'Dulce de Dăbuleni'. The soluble dry matter (%) presented values ranging between 10.00% in 'Dulce de Dăbuleni' and 11.00% in Burebista F1. The titratable acidity content determined in the fruits analyzed during the study period ranged between 0.25 g malic acid/100 g fresh matter in 'Oltenia', and 0.37 g malic acid/100 g fresh matter in Burebista F1. The highest vitamin C content for the study period was recorded in Burebista F1 (17.11 mg) and the lowest in 'Dulce de Dăbuleni' (10.79 mg). In terms of carbohydrate content, Burebista F1 stood out with 9.86% and Kratos F1 with 8.59%. In the specialized literature, Victoire et al. (2023) reported lower values for the soluble dry matter content (7.06-7.89%) and total dry matter content (1.53-5.37%) for the analyzed cultivars than those obtained in the present study. The data obtained in the present study are higher than those reported by Bîrsoghe et al., 2024 in terms of vitamin C content (8.80-14.96 mg/100 g fresh matter), and relatively similar in terms of total dry matter content (8.5-14.38%) and soluble dry matter (9.00-12.20%).

Table 4. Chemical properties of fruits of watermelon genotypes studied during 2022-2024

Genotype	Descriptive statistics	SUS (%)	SUT (%)	TA g (malic ac/100 g FW)	Vit C (mg)	Carbohydrates (%)
'Dulce de Dăbuleni'	Mean $\pm$ SD	10.00 $\pm$ 0.40	9.65 $\pm$ 0.71	0.26 $\pm$ 0.01	10.79 $\pm$ 3.62	9.74 $\pm$ 4.65
	Variation limits	9.60 / 10.40	8.90 / 10.32	0.25 / 0.26	8.60 / 14.96	6.02 / 14.96
	CV (%)	4.00	7.40	2.25	33.52	47.76
'Oltenia'	Mean $\pm$ SD	10.10 $\pm$ 0.10	9.59 $\pm$ 0.07	0.25 $\pm$ 0.03	13.76 $\pm$ 0.49	8.81 $\pm$ 0.19
	Variation limits	10.00 / 10.20	9.52 / 9.65	0.23 / 0.28	13.20 / 14.08	8.60 / 8.94
	CV (%)	0.99	0.68	9.93	3.54	2.11
'De Dăbuleni'	Mean $\pm$ SD	10.80 $\pm$ 1.25	12.11 $\pm$ 2.00	0.30 $\pm$ 0.05	10.90 $\pm$ 2.15	9.27 $\pm$ 1.08
	Variation limits	9.80 / 12.20	10.61 / 14.38	0.24 / 0.33	8.94 / 13.20	8.43 / 10.49
	CV (%)	11.56	16.53	16.63	19.73	11.64
Burebista F1	Mean $\pm$ SD	11.00 $\pm$ 0.92	11.65 $\pm$ 0.65	0.37 $\pm$ 0.12	17.01 $\pm$ 3.97	9.86 $\pm$ 1.39
	Variation limits	10.00 / 11.80	11.09 / 12.36	0.28 / 0.51	13.20 / 21.12	8.60 / 11.35
	CV (%)	8.33	5.58	32.40	23.32	14.09
Kratos F1	Mean $\pm$ SD	10.47 $\pm$ 0.92	11.79 $\pm$ 0.75	0.27 $\pm$ 0.01	12.32 $\pm$ 3.84	8.59 $\pm$ 1.54
	Variation limits	9.40 / 11.00	11.34 / 12.66	0.26 / 0.28	7.92 / 14.96	6.81 / 9.49
	CV (%)	8.83	6.37	4.33	31.13	17.92
Fechete F1	Mean $\pm$ SD	10.63 $\pm$ 0.32	9.96 $\pm$ 2.23	0.30 $\pm$ 0.04	11.96 $\pm$ 1.98	9.51 $\pm$ 1.63
	Variation limits	10.40 / 11.00	7.40 / 11.49	0.26 / 0.33	9.68 / 13.20	8.25 / 11.35
	CV (%)	3.02	22.42	11.84	16.53	17.11

*The data represents the average of the 2022-2024

Table 5 presents the statistical calculation of the average production obtained by each cultivar during the study period of 2022-2024.

Table 5. Average watermelon production recorded during the period 2022-2024

Genotype	Average production (t/ha)	Relative production (%)	Difference (t/ha)	LSD*
'Dulce de Dăbuleni'	23.18	100	0.00	Control
'Oltenia'	23.52	101.46	0.34	NS
'De Dăbuleni'	32.65	138.82	9.47	NS
Burebista	43.97	134.69	20.79	***
Kratos	44.48	101.16	21.30	***
Fechete	47.86	107.59	24.68	***

LSD 5% = 10.55

LSD 1% = 14.46

LSD 0.1% = 19.69

LSD* - Least Significant Difference; NS - Not significant

Thus, according to the data, the highest production of 47.86 t/ha was recorded for Fechete F1 with a difference from the control of 24.68 t/ha, statistically ensured as very significant.

The lowest production of 23.18 t/ha was recorded for the control cultivar 'Dulce de Dăbuleni'. The results obtained are higher than those reported by Shrefler et al. (2015), respective productions ranging between 12 and 37 t/ha.

CONCLUSIONS

The observations and determinations obtained from the study carried out at the Research - Development Station for Plant Culture on

Sands Dăbuleni, during the period 2022-2024 allowed the evaluation of watermelon genotypes so that they could be used in breeding programs as future progenitors;

The recorded production and quality data will be used as criteria in choosing the watermelon genotypes cultivated on sandy soils in the southern part of the country.

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