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PHYSICO-CHEMICAL CHARACTERISTICS OF PUMPKIN FRUITS (*CUCURBITA MAXIMA* DUCH.) CULTIVATED ON SANDY SOILS AT SCDCPN DĂBULENI

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Abstract

The edible pumpkin is grown for its fruits, which can be consumed riped, boiled, or candied. In Romania, the pumpkin culture has recently started attracting the growers attention. In this context, at the Dăbuleni research station, six pumpkins (three cultivars `Marele alb`, `Coroana Prinţului`, `Tudor`, and three genotypes D19, P1, P2) were studied to analyze their nutritional potential. Observations regarding the physical characteristics of the fruits (height, diameter, and weight of the fruit, diameter of the fruit cavity, shape index, and pulp thickness) were analyzed, as well as observations regarding the food quality (soluble dry matter, total dry matter, malic acid, carbohydrates, vitamin C). The thickness of the fruit pulp varied between 3.30 cm for `Tudor` and 4.50 cm for the `Coroana Prinţului` cultivars, and the fruit weight varied between 3.16 kg (P2) and 8.20 kg for the `Marele Alb`. A content in soluble dry matter of more than 11% was presented at the `Marele alb`, P2, and D19.

Key words*: pumpkin, morphometric characteristics, biochemical characteristics, sandy soils.*

INTRODUCTION

Cucurbita maxima is an annual species of the *Cucurbita* genus from the *Cucurbitaceae* family, which grows as a bush or creeps on the ground, its fruits being an important, but still underestimated, raw material, which can be processed in the form of natural juices, creams, jams, marmalades, or consumed as dry or candied snacks (Niewczas et al., 2014). Pumpkin was included in the category of useful vegetables due to its rich content of phenols, flavonoids, vitamins (carotene, vitamin A, α-tocopherol and vitamin C), amino acids and carbohydrates, thus showing great importance for human nutrition and economy (Zhang et al., 2000; 2002; Wang et al., 2002; Dinu et al., 2016; Whitaker and Davis, 1962; Robinson and Decker-Walters, 1997; Kulkarni and Joshi, 2013; Ping et al., 2002).

The numerical growth of the population together with the unpredictable climate changes and the decrease in soil fertility, have forced the exploration of alternative underutilized flora, while there is also a great opportunity for economic growth in the agricultural system by introducing underutilized products to the market (Sharma & Ramana Rao, 2013). Because pumpkin cultivars differ in terms of nutritional values, producers and researchers are searching for the most valuable and nutritionally appropriate genotypes (Dinu et al., 2016). There are few scientific studies on the physiological, chemical, physicochemical, nutritional, functional and technological characteristics of pumpkin. Most researchers agree with the need for a greater number of investigations, in order to better capitalize on the pumpkin culture (Ahmad and Khan, 2019).

MATERIALS AND METHODS

The experiment was located on the sandy soils of the Dăbuleni RDSPCS (Research-Development Station for Plant Culture on Sands) from the south of Oltenia, and for its establishment, the randomized block method was used.

The plant material used to establish the experience in the two years of study 2021-2022 was represented by six pumpkin cultivars 'Marele alb', 'Coroana prinţului', 'Tudor', D19, P1 and P2.

The physical properties of the fruits, determined in the two years, were represented by the height and diameter of the fruits (cm),

the diameter of the fruit cavity (cm), the shape index, fruit weight (kg) and pulp thickness (cm), according to the methodology described by Ionică (2014). The chemical properties of pumpkin fruits were determined according to the methodology described by Croitoru (2021). Soluble dry matter (SUS) was determined by the refractometric method, the results being expressed as percentages (%). To determine the content of total dry matter (SUT), the gravimetric method was applied based on the removal of water by evapotranspiration from the average analytical sample used, keeping it in the oven at a temperature between 85-105°C. The results were expressed as a percentage of total dry matter (%).

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

Carbohydrates were determined according to the Fehling Soxhelt method described by Croitoru (2021), the result being expressed in percentages. The pH of pumpkin fruits was determined according to the method described by Rangana (1977), mentioned by Sharma and Rao (2013).

The obtained data were processed statistically, using the statistical analysis program (StatPoint Technologies, Warrenton, VA, USA). Relationships between fruit physical characteristics were quantified using correlations.

RESULTS AND DISCUSSIONS

Analyzing the results from Table 1, it can be seen that there are differences between the two years of study, both from a thermal and hydrological point of view. These differences influenced the morphological characteristics and biochemical composition of pumpkin fruits to a certain extent. During the two years of the study, the temperatures recorded during the May-August vegetation period were higher than the multiannual average. From the point of view of the amount of precipitation in 2021, the months of May and June recorded amounts of 55 mm and 53 mm, respectively, much lower than those of April and June 2022 when precipitation was recorded in the amount of 73.6 mm and 67.4 mm, respectively. In the two years analyzed, it can be observed that the month of July was the driest, with the amount of precipitation being between 15 mm (2022) and 16.8 mm (2021).

Table 1. Average air temperature and amount of precipitation during the pumpkin growing season

Month	Temperature (°C)			Rainfall (mm)		
	2021	2022	1956-2022*	2021	2022	1956-2022*
April	9.72	11.70	11.88	30.6	73.6	46.97
May	17.6	18.3	16.95	55	38.4	62.39
June	21.7	22.9	21.55	53	67.4	69.83
July	25.7	25.2	23.29	16.8	15	54
August	24.5	25.1	22.66	9.00	49.4	36.76

Table 2 shows the results obtained in 2021 regarding the main biometric characteristics of pumpkin fruits. In this year, the pumpkin fruits showed an average height that varied between 31.10 cm for the 'Tudor' cultivar and 9.30 cm for the fruits of the D19 genotype. The diameter of the fruits showed an average value between 26.60 cm for the 'Marele alb' and 11.50 cm for the 'Tudor' cultivar. Regarding the diameter of the cavity of the analyzed fruits, during 2021, recorded values varied between 22.50 cm for the fruits of 'Marele alb' cultivar and 6.10 cm for the fruits of the 'Coroana prințului'. The shape index presented average values that varied between 0.43 cm for the D19 genotype and 2.76 cm for the 'Tudor'.

An important characteristic analyzed for pumpkin fruits is their weight, which recorded in 2021 the highest prediction of 8.20 kg for the 'Marele alb' cultivar, with variation limits between 5.00 kg and 11.30 kg, and the lowest weight of 3.16 kg in the P2 genotype with variation limits between 2.40 and 4.40 kg. Ahmed (2017) reported for the analyzed cultivars an average fruit weight that varied between 1.41 kg and 5.78 kg, lower than those recorded in the present study.

The pulp thickness of the analyzed pumpkin fruits varied between 4.50 cm in the 'Coroana prințului' cultivar and 3.52 cm in the fruits of the P2 genotype. In the specialized literature, Niewczas et al. (2014) reported for the cultivars analyzed values that confirm the results

obtained in the present study, respectively a height of the fruits between 10.06 cm and 29.90 cm, the diameter of the fruits between 17.20 cm and 28.20 cm and a pulp thickness between 3.00 cm and 4.60 cm. Analyzing the data from Table 2, it appears that in 2021 the 'Marele alb' cultivar stood out with the highest average values obtained for fruit diameter and fruit weight, and for the thickness of the flesh of the pumpkin fruits, the 'Coroana prințului' cultivar stood out.

Table 2. Biometric characteristics of fruits from pumpkin fruits studied in 2021

Cultivar/ Genotype	Statistical analysis	Fruit height (cm)	Fruit diameter (cm)	Cavity diameter (cm)	Shape index (cm)	Fruit weight (kg)	Pulp thickness (cm)
'Marele alb'	Mean ± SD	27 .00 ± 2.92	26.60 ± 4.28	22.50 ± 3.99	1.02 ± 0.10	8.20 ± 2.76	4.30 ± 0.67
	Variation limits	23.00 – 30.00	23.00 – 33.00	19.00 – 28.00	0.88 – 1.17	5.00 – 11.30	3.50 – 5.00
	CV%	10.80	16.08	17.91	10.06	33.69	15.6
'Coroana prințului'	Mean ± SD	22.50 ± 1.12	10.60 ± 1.08	6.10 ± 1.02	2.15 ± 0.29	3.50 ± 0.40	4.50 ± 0.61
	Variation limits	21.00 – 24.00	9.00 – 12.00	4.50 – 7.00	1.75 – 2.56	3.00 – 4.00	3.50 – 5.00
	CV%	4.97	10.23	16.8	13.36	11.43	13.61
'Tudor'	Mean ± SD	31.10 ± 2.90	11.50 ± 2.24	7.90 ± 2.07	2.76 ± 0.42	6.56 ± 1.27	3.60 ± 0.26
	Variation limits	26.50 – 34.00	9.00 – 15.00	5.50 – 11.00	2.10 – 3.24	4.40 – 7.60	3.30 – 4.00
	CV%	9.33	19.44	26.23	15.13	19.36	7.35
D19	Mean ± SD	9.30 ± 0.76	21.80 ± 1.04	18.20 ± 1.04	0.43 ± 0.03	3.28 ± 0.26	3.60 ± 0.55
	Variation limits	8.50 – 10.00	21.00 – 23.50	17.50 – 20.00	0.39 – 0.48	2.50 – 4.00	3.00 – 4.50
	CV%	8.15	4.76	5.7	8.1	17.96	15.21
P1	Mean ± SD	26.61 ± 2.52	21.82 ± 3.55	17.78 ± 2.95	1.24 ± 0.18	7.74 ± 2.15	4.04 ± 0.74
	Variation limits	23.00 – 29.50	19.50 – 28.00	15.80 – 23.00	1.00 – 1.51	5.00 – 10.80	3.00 – 5.00
	CV%	9.48	16.29	16.59	14.93	27.8	18.9
P2	Mean ± SD	18.00 ± 5.18	16.60 ± 4.38	13.08 ± 4.40	1.20 ± 0.62	3.16 ± 0.89	3.52 ± 0.89
	Variation limits	10.50 – 25.00	12.00 – 21.50	8.30 – 17.90	0.54 – 2.08	2.40 – 4.40	3.00 – 3.80
	CV%	28.8	26.38	33.68	23.2	28.18	8.85

SD = standard deviation; CV = coefficient of variability

Table 3. Biometric characteristics of pumpkin fruits studied in 2022

Cultivar / Genotype	Statistical analysis	Fruit height (cm)	Fruit diameter (cm)	Cavity diameter (cm)	Shape index (cm)	Fruit weight (kg)	Pulp thickness (cm)
'Marele alb'	Mean ± SD	30.4 ± 5.09	24.48 ± 2.33	16.31 ± 2.32	1.25 ± 0.25	8.16 ± 2.05	4.34 ± 0.57
	Variation limits	25.70 – 38.00	21.60 -27.20	14.00 – 19.50	0.94 – 1.46	6.19 – 11.58	3.50 – 5.00
	CV%	16.75	9.54	14.26	19.68	25.14	13.1
'Coroana prințului'	Mean ± SD	10.80 ± 1.52	25.44 ± 2.40	16.70 ± 2.25	0.43 ± 0.05	4.78 ± 1.41	4.60 ± 1.29
	Variation limits	9.00 – 13.00	22.40 – 28.50	13.50 – 19.00	0.35 – 0.48	2.94 – 6.42	3.00 – 6.50
	CV%	14.12	9.45	13.45	11.91	29.4	28.14
'Tudor'	Mean ± SD	13.60 ± 1.50	28.84 ± 2.96	21.24 – 3.37	0.48 ± 0.08	6.57 ± 1.15	4.34 ± 0.21
	Variation limits	11.60 - 15.60	25.60 - 32.20	18.00 – 25.00	0.36 – 0.59	4.90 – 7.74	4.10 – 4.60
	CV%	11	10.25	15.88	17.65	17.55	4.78
D19	Mean ± SD	8.80 ± 0.63	23.30 ± 2.78	15.82 ± 2.45	0.38 ± 0.03	3.78 ± 1.47	3.40 ± 0.96
	Variation limits	8.00 – 9.70	21.00 – 28.00	12.50 – 19.30	0.34 – 0.42	2.86 – 6.33	2.50 – 5.00
	CV%	7.14	11.93	15.51	8.98	38.99	28.29
P1	Mean ± SD	18.48 ± 3.16	25.96 ± 2.51	18.56 ± 2.55	0.71 ± 0.11	5.84 ± 1.39	3.58 ± 0.56
	Variation limits	16.00 – 23.02	22.50 – 29.00	16.30 – 22.50	0.59 – 0.84	3.94 – 7.49	3.00 – 4.20
	CV%	17.09	9.66	13.76	15.47	23.79	15.6
P2	Mean ± SD	20.74 ± 6.96	29.60 ± 2.06	21.50 ± 3.06	0.71 ± 0.25	8.77 ± 1.86	3.96 ± 0.99
	Variation limits	15.50 – 31.00	27.50 – 33.00	17.50 – 25.50	0.47 – 1.05	6.69 – 10.79	2.50 – 5.00
	CV%	33.57	6.97	1423	34.92	21.24	24.91

SD = standard deviation; CV = coefficient of variability

In the year 2022, it can be observed, analyzing the results in Table 3, that the highest average values were obtained by the 'Marele alb' cultivar, for the height and shape index of the fruits respectively 30.40 cm and an index of 1.25. For the pulp thickness, the 'Coroana prințului' cultivar stood out with an average value of 4.60 cm, and the genotype P2 for the highest average values of the respective fruit diameter of 29.60 cm and an average fruit

weight of 8.77 kg. The lowest average values recorded in 2022 for all analyzed biometric characteristics were quantified by the fruits of D19 genotype.

The data obtained in 2022, in the present study, are consistent with those reported in the literature by Ferriol et al. (2004), respectively an average weight between 1.5 kg and 18.7 kg, a diameter with values between 13.6 cm and 43.5 cm and a thickness of the pulp that varied between 1.6 cm and 5.5 cm. Ahmed et al., (2017) reported a diameter of the fruit cavity between14.04 cm and 25.44 cm for the studied cultivars. The relationships between the biometric characteristics of the fruits were examined with the help of correlations and the results are presented in Table 4. In the year 2021, high positive correlations were calculated between the height of the fruit and the shape index (r = 0.69), and between height and weight fruit (r = 0.72). A positive correlation was also calculated between fruit diameter and weight (r = 0.50) and between fruit cavity weight and diameter (r = 0.47).

In 2022 high positive correlations were calculated between height and fruit shape index (r = 0.97), fruit height and weight (r = 0.71), fruit diameter and weight (r = 0.69), and between the weight of the fruit and the diameter of its cavity (r = 0.56).

Analyzing the correlations between the biometric characteristics regarding the thickness of the pulp, it was observed that it is influenced by the weight of the fruit, recording correlation values between r = 0.35 in 2021 and r = 0.32 in 2022.

Table 4. Correlations between the characteristics of pumpkin fruits analyzed in the two years (2021-2022)

Characteristics	Fruit height (cm)		Fruit diameter (cm)		Cavity diameter (cm)		Shape index (cm)		Fruit weight (kg)		Pulp thickness (cm)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Fruit height (cm)	1.00	1.00										
Fruit diameter (cm)	-0.16	0.05	1.00	1.00								
Cavity diameter (cm)	-0.18	0.01	1.00	0.91	1.00	1.00						
Shape index (cm)	0.69	0.97	-0.79	-0.18	-0.81	-0.20	1.00	1.00				
Fruit weight (kg)	0.72	0.71	0.50	0.69	0.47	0.56	0.10	0.53	1.00	1.00		
Pulp thickness (cm)	0.24	0.13	0.18	0.21	0.08	-0.07	0.02	0.09	0.35	0.32	1.00	1.00

Pumpkin genotypes differ in color, size and shape, showing a hard rind with thick, edible flesh around the seed cavity (Hosen et al., 2021). Morphological characterization is essential in elucidating the genetic relationships between different groups of *Cucurbita* species (Barzegar et al., 2013). Fruit shape morphology is one of the most diverse traits and depends on geographic origin (i.e., adaptation to environmental factors), cultural traditions, culinary attributes, and market characteristics and requirements (Staub et al., 2000).

According to the data in Table 5, the pumpkin genotypes studied at Dăbuleni RDSPCS in the two years, presented a round fruit shape, slightly elongated at 'Marele alb' cv. and P1, elongated at 'Coroana prințului' cv., 'Tudor' cv. and P2, and at D19 a flattened shape. Regarding the size of the fruits, they presented large (> 4 kg) and very large (> 6 kg) fruits, this classification being made according to the scale used by Abdein in 2018.

Table 5. Classification of pumpkin fruits in the genotypes studied, according to shape, size, peel and pulp color

Cultivar/ Genotype	The shape of fruits	The size of fruits*	The skin color of the fruit	The color of the fruit pulp
'Marele alb'	Round, slightly elongated	Extra large	White-grey	Yellow
'Coroana prințului'	Elongate	Large	Dark green	Orange
'Tudor'	Elongate	Large	Light greens	Orange
D19	Flattened	Medium	White-reddish	Orange
P1	Round, slightly elongated	Extra large	Dark green	Yellow
P2	Elongate	Large	Light green	Orange

*small (< 2 kg), medium (2-4 kg), large (> 4 kg), extra-large (> 6 kg)

The color of the skin varied from shades of white-gray to 'Marele alb' cv., red-white in D19, light green in 'Tudor' cv. and dark green in the rest of the genotypes. As for the color of the fruit pulp, it varied between yellow ('Marele

alb' and P1) and orange in the rest of the analyzed genotypes.

The sensory qualities of the products, which determine their value from the point of view of consumers, are represented by the content of sugar, organic acids, phenolic compounds, volatile substances, etc. In this sense, the main chemical properties of pumpkin fruits were analyzed in 2022, the results being presented in Table 6. Soluble dry matter (SUS, %) varied between 12.60% in genotype D19 followed by P2 with 12.00%, and 6.40% in genotype P1. Total dry matter content (SUT, %) showed values between 17.40% at P2 and 10.00% at D19. The highest value of titratable acidity (TA) of 0.26 g malic acid/100 g substance was recorded in 'Tudor' cv. and the lowest in D19 genotype, respectively 0.12 g malic acid/100 g substance. Vitamin C had values between 13.20 mg/100 g fresh substance in D19 genotype and 23.70 mg/100 g fresh substance in P1 genotype.

Regarding the carbohydrate content, it varied between 5.51% in P1 and 17.21% in P2 genotype. The pH of the pumpkin fruits recorded for the analyzed genotypes, had values that varied between 5.90 for P1 and 6.20 for D19 genotype. The results obtained are in accordance with the specialized literature, but lower than those reported by Sharma and Rao (2013), respectively a pH with values between 5.66 and 6.72, a titratable acidity with a value of 0.38% and a vitamin C content that varied between 4.3 mg and 15 mg/100 g of fresh substance. Regarding the content of soluble dry matter, the results obtained are higher than those reported by Javaherashti et al. (2012) respectively a content with values between 6.83% and 8.47%, and consistent with those reported by Dinu et al. (2016), respectively values between 12.60% and 5.51%. Regarding the total content of dry matter, Dinu et al. (2016) reported values between 7.53% and 12.42% lower than those recorded in the studied cultivars. Zinash et al. (2013) recorded in the analyzed pumpkin fruits a total content of dry matter with values between 6.00% and 11.00%, which confirms the results obtained in the present study. Selvi et al. (2012) reported for the cultivars analyzed a carbohydrate content with average values between 0.73 g and 2.95 g/100 g substance. The modification of the pH of the pulp of pumpkin fruits influences the activity of enzymes during the ripening period, and the antioxidant system, subsequently affecting their sensory quality (McCollum et al., 1988).

Table 6. Chemical properties of pumpkin fruits analyzed in 2022

Cultivar/ Genotype	SUS (%)	SUT (%)	TA (g malic acid/ 100 g subst)	Vit C (mg/ 100 g)	Carbohydrates (%)	pH
'Marele Alb'	11.0	10.3	0.16	16.70	8.43	5.98
'Coroana prințului'	9.8	15.0	0.18	21.20	10.84	6.05
'Tudor'	8.0	14.1	0.26	18.40	9.46	6.08
D 19	12.6	10.0	0.12	13.20	6.88	6.20
P1	6.4	16.0	0.16	23.70	5.51	5.90
P2	12.0	17.4	0.16	20.20	17.21	6.11

*SUT = total dry substance; SUS = total soluble substance; TA = titratable acidity; Vit C = vitamin C.

CONCLUSIONS

Following the study, the 'Marele alb' cultivar stood out for the height, diameter, weight and diameter of the fruit cavity, and the 'Coroana prințului' cultivar stood out for the pulp thickness.

The D19 genotype is also notable for its very sweet taste with a content of 12.60% dry matter.

The present study provides information about less used agricultural products, allowing us to make better use of this category of nutritionally rich products.

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