Original research article

PUMPKIN (*Cucurbita maxima* Duch.) FRUIT YIELD AND NUTRITIONAL QUALITY

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SUMMARY

In addition to stable and high fruit yields, traits related to nutritional quality play a significant role in placing pumpkins on the market. The paper analyzes traits related to nutritional quality (fruit flesh dry weight, total sugars and carotenoids content, and pH) together with traits of agronomic importance (number of fruits per plant, fruit weight, and yield per plant) in seven pumpkin (*Cucurbita maxima* Duch.) accessions, grown at the same locality (Bački Petrovac) during three consecutive seasons (2016, 2017, and 2018). We observed significant differences among the accessions regards all the investigated traits, except for pH. Adverse effects of the environmental factors, primarily those related to high and extremely high air temperatures, were observed for total carotenoids and sugars content, and for fruit weight and yield. Accessions B2398 and A2620 -2 had the best values of the examined parameters and therefore should be used for breeding pumpkins of high yield and quality.

KEYWORDS: carotenoids, environmental conditions, fruit yield, high temperature, pumpkin, sugar content

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INTRODUCTION

Pumpkin (*Cucurbita maxima* Duch.) is an economically important species of the *Cucurbita* genus. Unlike oil pumpkin (*Cucurbita pepo* L.) which is grown for its oil-rich seeds, this plant is commercially grown for its fruit, which flesh is nutritionally valuable, yet low in calories. Pumpkin nutritional quality is primarily due to carotenoids which upon consumption convert into vitamin A. On the other hand, the taste depends on the content and ratio of several biochemical components, where sugars and acidity have special importance. The fruit flesh has a beneficial effect on the human digestive tract and there is an extremely low risk of allergy to pumpkins. Due to the increase in production areas and improvements in cultivation practices and breeding, the production of pumpkins and gourds worldwide is on the rise and amounts to approximately 25 million tons per year. Both yield and quality depend on plant genetic characteristics and growing conditions. Choice of plant variety and agricultural practices, i.e. nutrition, watering, weed control, etc. can be fully controlled by the producers. On the other hand, environmental factors, such as high air temperatures, late spring frosts, or flooding cannot be controlled and may adversely affect the crops (Conti et al., 2015; Abbas et al., 2020; FAO, 2020; Meléndez-Martínez et al., 2021).

This study was undertaken to investigate the relationships among pumpkin traits related to nutritional quality and traits of agronomic importance. In addition, the effects of high air temperatures during fruit formation and ripening have been investigated. The accessions with the best quality and yield traits have been identified.

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MATERIAL AND METHODS

The plant material used in this study consisted of seven *Cucurbita maxima* Duch. accessions chosen from the breeding collection of the Institute of Field and Vegetable Crops, National Institute of the Republic of Serbia, Novi Sad. The accessions (B2398, B2432, B1433, A2620-1, A2620-2, A2335, and B673-1) are populations collected in the territory of Serbia. All of them are with fruits of the same type; circular or broadly elliptic, medium-sized, and

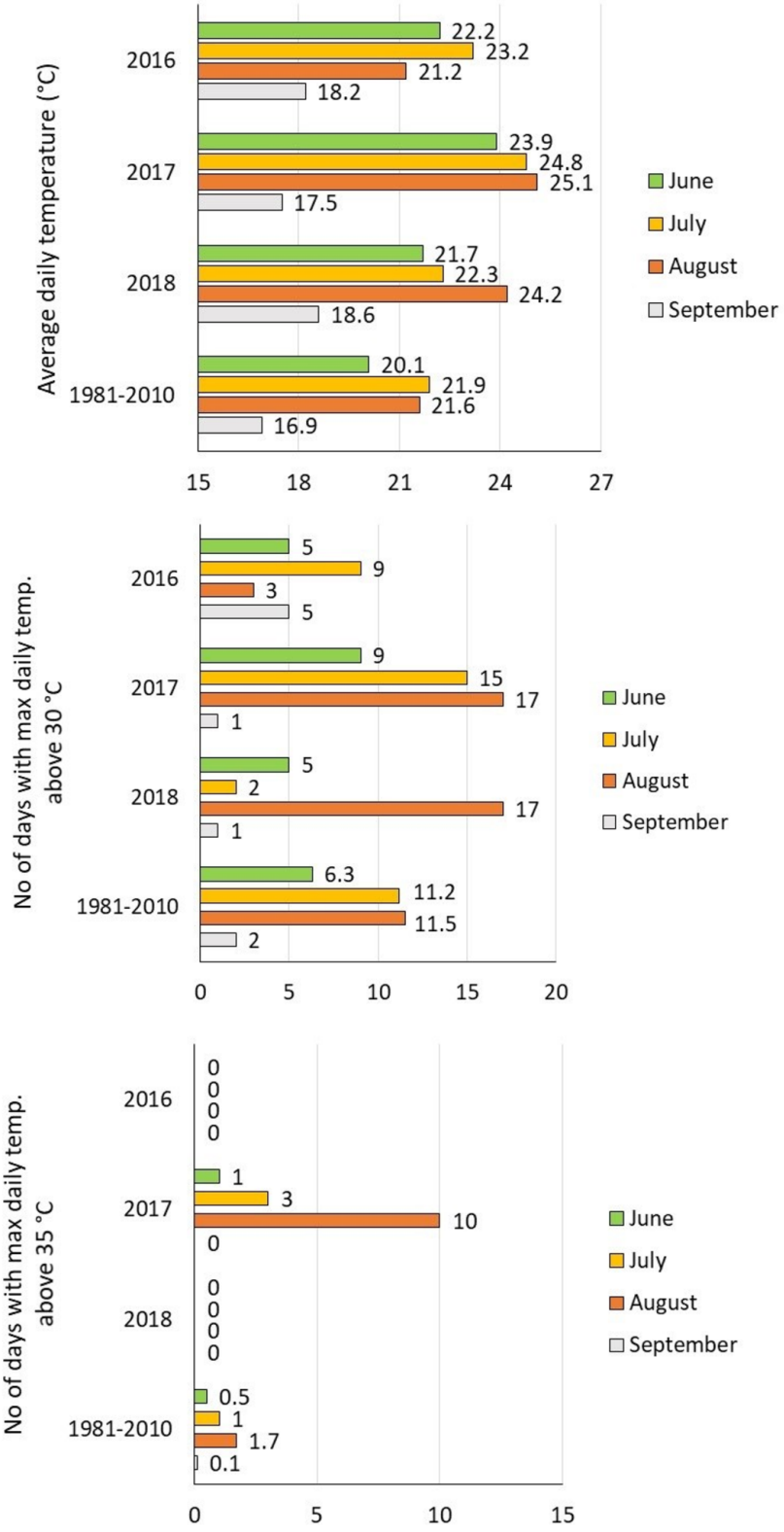

Figure 1. Air temperatures during pumpkin fruit set and ripening

grey. The three-year (2016, 2017, and 2018) trial was set at the experimental field of the Institute, Bački Petrovac location, according to random block system, replicated three times. The main plot consisted of a row with five plants spaced 2 m apart. The distance between the rows was 5 m. The usual agricultural procedures were applied. Sowing was done in the first decade of May, and the fruits were harvested in the phase of full maturity, at the end of October.

Data concerning air temperatures during the pumpkin fruit set and ripening (June-September) were collected from the meteorological station located near the experimental field and are shown in Figure 1. Since irrigation was carried out as needed, precipitation data are not shown.

Pumpkin flesh dry weight (%), total sugars (mg/g fresh weight) and carotenoids content (mg/kg fresh weight), and pH were analyzed. Total sugars content was determined by a standard method modified according to Albalasmeh et al. (2013). Carotenoids contents were determined according to the method described by Wellburn (1994). Fresh plant material (0.2 g) was homogenised with 80% acetone (10 ml) using cooled mortar and pestle. After extraction and centrifugation (10 min, at 4350xg), absorbances were recorded for supernatants at 470, 646 and 663 nm. Carotenoids contents were calculated from equations described in the applied method.The data on the traits of agronomic importance: number of fruits per plant, fruit weight (kg), and yield per plant (kg) were collected at harvest.

Data were processed by analysis of variance and the least significant difference test, 0.05 probability level, was used for comparisons of means among the accessions and the environments. Basic statistical parameters (average values, coefficients of variation) were calculated for the examined traits.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the pumpkin accessions included in the study, regarding all investigated traits, except pH (Table 1). The measured values of the nutritional quality traits were in the range reported by Murkovic et al., 2002; Azevedo-Meleiro & Rodriguez-Amaya, 2007; Itle & Kabelka, 2009; Kim et al., 2012 and Graça Dias et al., 2018. Total carotenoids content and fruit yield per plant varied the most, followed by

Table 1. Pumpkin traits related to nutritional quality and traits of agronomic importance, differences among the accessions, average for three seasons (2016, 2017, and 2018)

Accession	Dry weight (%)	Total sugars content (mg/g)	Total carotenoids content (mg/kg)	pH	No of fruits per plant	Fruit weight (kg)	Yield per plant (kg)
B2398	13.8	44.6	67.8	7.3	2.4	7.7	19.2
B2432	9.6	27.4	50.4	7.1	1.7	8.5	13.4
B1433	18.2	34.5	12.7	7.0	1.4	4.8	6.7
A2620-1	7.4	25.1	54.5	7.2	1.4	6.2	9.2
A2620-2	8.2	33.8	88.2	7.2	2.9	10.0	26.6
A2335	14.2	37.9	19.4	7.2	2.3	4.8	11.3
B673-1	8.0	18.2	52.4	6.8	1.7	12.4	20.2
Average	11.4	31.6	49.3	7.1	2.0	7.8	15.2
CV (%)	36.3	27.7	53.2	2.1	28.9	35.8	46.3
LSD 0.05	4.1	6.1	6.3	0.5	0.6	2.5	4.3

fruit flesh dry weight and fruit weight. Five out of seven accessions had total carotenoids content higher than 20 mg/kg, which is very high according to the scale suggested for particular foods by Briton & Khachik (2009). According to the same scale, the remaining two accessions were high in carotenoids. This result implies that all analyzed pumpkins are of high nutritional quality, and the differences between the accessions are not of great practical importance if the food is consumed fresh. However, when pumpkin is a raw material for processed food, six to seven times higher carotenoid content determined by A2620-2 compared to B1433 becomes important, because it certainly affects the quality of the final product and the amount of raw material required for the process.

On average for the three seasons and taking into account all the investigated traits, the best performing were B2398 and A2620-2. Therefore those accessions should be included

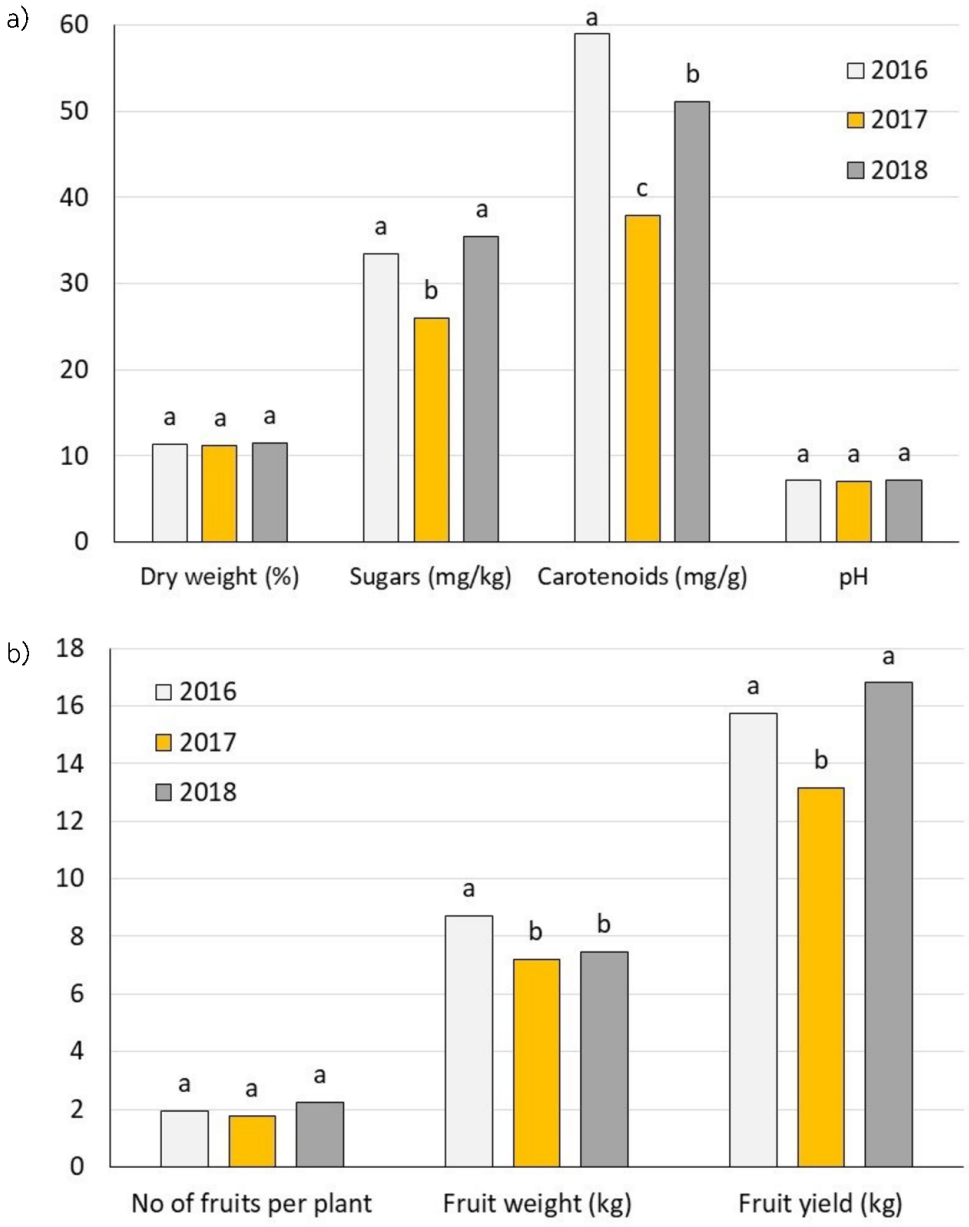

Figure 2. Pumpkin traits related to nutritional quality (a) and traits of agronomic importance (b), differences among growing seasons. The bars marked with the same letter do not differ at the 0.05 level of probability, according to the LSD test

in breeding programs aimed at improving pumpkin nutritional quality.

The average values for the nutritional quality and agronomic traits calculated for individual seasons are shown in Figure 2. Since the plants were irrigated as needed and did not suffer from drought or from diseases that could cause significant losses of yield and quality, the observed differences are primarily attributed to differences in air temperatures among the seasons and discussed as such.

Dry weight and pH values did not differ significantly among the growing seasons. However total sugars and carotenoids contents were the lowest in 2017, implying the adverse effect of high (> 30 °C) and particularly extremely high (> 35 °C) air temperatures on pumpkin flesh quality traits. There were a total of 14 days with the maximum daily air temperature higher than 35 °C during the 2017 season. The multi-year average for the period is 3.3 days, and there were no such days in the 2016 and 2018 seasons (Figure 1). The effect was most pronounced in carotenoids; the content determined for samples from 2017 was approximately 35% lower in comparison to the samples from the temperate 2016 season when the values were at maximum. Pumpkin flesh carotenoid content from 2018 was also significantly lower (approx. 13%) compared to 2016. According to Lester (2006), carotenoid biosynthesis is inhibited or promoted by a certain environmental temperature range, which is crop-dependent. Further research is needed to determine the optimal temperature range for carotenoid synthesis and accumulation in pumpkins, and to investigate if the differences among genotypes can be successfully exploited in breeding programs. As observed for carotenoids, the sugar content was the lowest in the 2017 season. The value was the highest in 2018, which was generally warm, yet without extremely high maximum daily temperatures. The results suggest high yet not extremely high air temperatures as favorable for sugar accumulation in pumpkin fruits.

There were no significant differences among the seasons in the number of fruits per plant, though the highest value was noted for 2018, when pumpkins yielded the best. On the other hand, fruit weight was the highest in temperate 2016, and significantly lower in the other seasons. Although significant, the differences among seasons, i.e. daily temperatures, were generally less pronounced for traits of agronomic importance compared to traits related to nutritional quality.

CONCLUSION

Significant differences were found among the seven pumpkin accessions in terms of all traits related to nutritional quality and traits of agronomic importance, except for the pH of the fruit flesh. The adverse effect of high and extremely high air temperatures was most pronounced for the content of total carotenoids and sugars, as well as to a lesser extent for fruit weight and yield. Accessions B2398 and A2620 -2 should be included as parents in breeding programs aimed to improve pumpkin nutritional quality and yield.

REFERENCES

Abbas, H.M.K., Huang, H.-X., Huang, W.-J., Xue, S.-D., Yan, S. -J., Wu, T.-Q., Li, J.-X., & Zhong, Y.-J. (2020). Evaluation of metabolites and antioxidant activity in pumpkin species. *Natural Product Communications, 15*(4), 1-11. doi:10.1177/1934578X20920983

Albalasmeh, A.A., Berhe, A.A., & Ghezzehei, T.A. (2013). A new method for rapid determination of carbohydrate and total carbon concentrations using UV spectrophotometry. *Carbohydrate Polymers, 97*(2), 253-261. doi:10.1016/j.carbpol.2013.04.072

Azevedo-Meleiro, C.H., & Rodriguez-Amaya, D.B. (2007). Qualitative and quantitative differences in carotenoid composition among *Cucurbita moschata, Cucurbita maxima,* and *Cucurbita pepo. Journal of Agricultural and Food Chemistry, 55*(10), 4027-4033. doi:10.1021/jf063413d

Britton, G., & Khachik, F. (2009). Carotenoids in food. In Britton G., Liaaen-Jensen S., Pfander H. (Eds.), Carotenoids, Vol. 5. Basel, Boston, Berlin: Birkhauser Verlag.

Conti, S., Villari, G., Amico, E., & Caruso, G. (2015). Effects of production system and transplanting time on yield, quality and antioxidant content of organic winter squash (*Cucurbita moschata* Duch.). *Scientia Horticulturae, 183*, 136-143. doi:10.1016/j.scienta.2014.12.003

Graça Dias, M., Olmedilla-Alonso, B., Hornero-Méndez, D., Mercadante, A.Z., Osorio, C., Vargas-Murga, L., & Meléndez-Martínez, A.J. (2018). Comprehensive database of carotenoid contents in Ibero-American foods. A valuable tool in the context of functional foods

and the establishment of recommended intakes of bioactives. *Journal of Agricultural and Food Chemistry, 66*(20), 5055-5107. doi:10.1021/acs.jafc.7b06148

FAO (2020). Food and Agriculture Organization of the United Nations, FAOSTAT Database. Retrieved from http://www.fao.org/faostat/en/#data/QC (11/30/2020)

Itle, R.A., & Kabelka, E.A. (2009). Correlation between L*a*b* color space values and carotenoid content in pumpkins and squash (*Cucurbita* spp.). *HortScience, 44* (3), 633-637. doi:10.21273/HORTSCI.44.3.633

Kim, M.Y., Kim, E.J., Kim, Y.N., Choi, C., & Lee, B.H. (2012). Comparison of the chemical compositions and nutritive values of various pumpkin (*Cucurbitaceae*) species and parts. *Nutrition Research and Practice, 6*(1), 21-27. doi:10.4162/nrp.2012.6.1.21

Lester, G.E. (2006). Environmental regulation of human health nutrients (ascorbic acid, β-carotene, and folic acid) in fruits and vegetables. *HortScience, 41*(1), 59-64. doi:10.21273/ HORTSCI.41.1.59

Meléndez-Martínez, A.J., Mandić, A.I., Bantis, F., Böhm, V., Borge, G.I.A., Brnčić, M., Bysted, A., Cano, M.P., Dias, M.G., Elgersma, A., Fikselová, M., García-Alonso, J., Giuffrida, D., Gonçalves, V.S.S., Hornero-Méndez, D., Kljak, K., Lavelli, V., Manganaris, G.A., Mapelli-Brahm, P., Marounek, M., Olmedilla-Alonso, B., Periago-Castón, M.J., Pintea, A., Sheehan, J.J., Šaponjac, V.T., Valšíková-Frey, M., Van Meulebroek, L. & O'Brien, N. (2021). A comprehensive review on carotenoids in foods and feeds: *status quo*, applications, patents, and research needs. *Critical Reviews in Food Science and Nutrition*, doi:10.1080/10408398.2020.1867959

Murkovic, M., Mülleder, U. & Neunteufl, H. (2002). Carotenoid content in different varieties of pumpkins. *Journal of Food Composition and Analysis, 15*(6), 633-638. doi:10.1006/ jfca.2002.1052

Wellburn, A.R. (1994). The spectral determination of chlorophylls a and b, as well as total carotenoids, using various solvents with spectrophotometers of different resolution. *Journal of Plant Physiology, 144*(3), 307-313. doi:10.1016/S0176-1617(11)81192-2

SAŽETAK

PRINOS I NUTRITIVNI KVALITET PLODA BUNDEVE (*Cucurbita maxima* Duch.)

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Pored stabilnih i visokih prinosa, značajnu ulogu u plasiranju bundeve na tržište imaju osobine vezane za nutritivni kvalitet. U radu su analizirane osobine koje se odnose na nutritivni kvalitet (suva masa mesa ploda, sadržaj ukupnih šećera i karotenoida, pH vrednost) zajedno sa osobinama od agronomskog značaja (broj plodova po biljci, masa ploda i prinos po biljci) kod sedam akcesija bundeve (*Cucurbita makima* Duch.), gajenih na lokalitetu Bački Petrovac tokom tri uzastopne sezone (2016, 2017. i 2018.). Primećene su značajne razlike među akcesijama u pogledu svih ispitivanih osobina, osim pH vrednosti. Nepovoljni efekti sredine, pre svega oni koji se odnose na visoke i ekstremno visoke temperature vazduha, uočeni su kod sadržaja ukupnih karotenoida i šećera, kao i kod mase i prinosa ploda. Najviše vrednosti ispitivanih parametara imale su akcesije B2398 i A2620-2 i stoga bi ih trebalo koristiti za oplemenjivanje bundeve visokog prinosa i kvaliteta.

Ključne reči: bundeva, karotenoidi, prinos ploda, sadržaj šećera, uslovi sredine, visoke temperature

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