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Potato with Colored Flesh Valuable and Attractive to the Consumer

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ABSTRACT

The purpose of this paper was to determine the vitamin C content and the selected consumption features (tastiness and cooking type) in edible potato tubers with colored flesh. The research material consisted of tubers of eight edible potato cultivars collected from a field experiment conducted in 2021 and 2022 at the Agricultural Experimental Station in Zawady of Siedlce University of Natural Sciences and Humanities (52°03'N; 22°33'E). The following cultivars were grown: two cultivars with red flesh – Rote Emma and Herbie 26, five cultivars with purple flesh – Blaue Annelise, Provita, Salad Blue, Vitelotte and Bora Valley, as well as one traditional cultivar, light yellow fleshed – Eurostar. The cultivar features of the potato tubers significantly modified the content of vitamin C and they determined cooking properties of the potato. The cultivars with red and purple flesh accumulated more vitamin C than the traditional cultivar. The cultivar Rote Emma and Salad Blue had the best tastiness, while the cultivar Herbie 26 and Bora Valley proved to be the least tasty. The red and purple-fleshed cultivars were dominated by the salad cooking type A and they differed significantly from the traditional cultivar Eurostar. Potato tubers with colored flesh are a valuable and attractive offer to the consumer.

Keywords: colored potato cultivars; vitamin C; sensory features.

INTRODUCTION

Globally, the potato (*Solanum tuberosum* L.) is considered as one of the most important crops for consumption. In the second half of the 19th century, both in Europe and in other parts of the world, the potato gained recognition and became the diet's basic component of millions of inhabitants [Zarzecka, 2009; Priedniece et al., 2017; Beals, 2019; Zarzecka, 2022]. Among the most important components of the potato tuber there are antioxidants, such as polyphenols, anthocyanins, ascorbic acid, which neutralize free radicals and reduce the incidence of certain cancers, osteoporosis and diabetes [Silveira et al., 2017; Dereje and Chibuzo, 2021; Pino and Vergara, 2021]. In Europe, the information about the cultivation of colored potatoes, also known as truffles, originating from France, dates back to the 19th century. They were brought to Poland in the mid-1970s, but did not gain approval. In 2021, the first and only domestic Provita cultivar with colored purple flesh was registered in Poland. Tubers with purple or red flesh can be found on all continents, but in Europe they are grown in small areas and most people do not know them. In recent years, colored (yellow, red and purple) potatoes have attracted the attention of researchers and consumers in view of their antioxidant activity, taste and appearance [Jariene et al., 2015]. According to Vaitkevičienė et al. [2019] the interest in cultivars with colored flesh is growing, especially among the proponents of healthy eating. For the consumer, the morphological features, which determine the attractive appearance of the tubers, as well as the cooking ones, particularly non-darkening of raw and cooked flesh, low tendency to overcook, and suitability for making preparations, are very

important [Zgórska, 2013]. The aim of this paper was to compare the vitamin C content as well as evaluate the tastiness and the cooking type of seven cultivars of edible potato with colored flesh: Rote Emma, Herbie 26, Blaue Annelise, Provita, Salad Blue, Vitelotte and Bora Valley in relation to the traditional cultivar with light yellow flesh color – Eurostar. The research hypothesis was adopted that the potato cultivars with red and purple flesh may be richer in vitamin C than the traditional cultivar and they have good sensory features.

MATERIAL AND METHODS

The material for the study consisted of tubers of eight edible potato cultivars was collected from the two-year field experiment conducted in 2021 and 2022 at the Agricultural Experimental Station in Zawady of Siedlce University of Natural Sciences and Humanities (52°03'N; 22°33'E). The experiment was set up using the randomized block method in three replicates. The experiment was one-factor: eight cultivars of edible potato with different flesh and skin color, with different earliness groups and with different country of origin:

1. Eurostar – a medium late cultivar, Dutch, light yellow color of flesh and skin,
2. Rote Emma – an early cultivar, German, red color of flesh and skin,
3. Herbie 26 – a medium-late, Czech Republic cultivar with red flesh and skin color,
4. Blaue Annelise – a medium-early cultivar, German, with purple flesh and skin color,
5. Provita – an early cultivar, Polish, with purple flesh and skin,
6. Salad Blue – a medium-early cultivar from the United Kingdom with purple flesh and dark blue skin,
7. Vitelotte – a medium-late cultivar from Peru with purple flesh and skin color,
8. Bora Valley – Korean medium-late cultivar, with purple flesh and skin color.

The plot size for planting and harvesting potato tubers was 12.96 m^2 (4.8×2.70 m). The experiment was conducted on a medium soil with a granulometric composition of sandy loam, acidic to slightly acidic, with a pH of 1 mol KCl = 5.48–5.62, of medium to high abundance in bioavailable forms of P, K and Mg. For the experiment, classical tillage was carried out, including plowing, harrowing, pre-winter plowing (in autumn) and harrowing, cultivating and harrowing (in spring). The forecrop for the potato was winter triticale. In fall, manure was applied at a dose of 25,0 $t \cdot ha^{-1}$ and mineral fertilization of phosphorus and potassium (100.0 kg $P_2O_5 \cdot ha^{-1}$ i 150.0 kg $K_2O \cdot ha^{-1}$). Mineral fertilization in the experiment was 350 $kg \cdot ha^{-1}$ (N:P:K = 1.0:1.0:1.5). Nitrogen fertilization at a dose of 100.0 kg $N \cdot ha^{-1}$ was applied in spring. To destroy weeds about 7-10 days before the emergence of potato plants, Bandur 600 SC herbicide was used (aclonifene 600 $g \cdot dm^3$) at a dose 2.5 $dm^3 \cdot ha^{-1}$. Two insecticides were used against potato beetle – Decis Mega 50 EW (deltamethrin 60 $g \cdot dm^3$) and Coragen 200 SC (chlorantraniliprole 200 $g \cdot dm^3$). Three fungicides were applied against potato blight: Infinito 687.5 SC (propamocarb hydrochloride 625 $g \cdot dm^3$ and fluopicolide 62,5 $g \cdot dm^3$), Cabrio Duo 112 EC (dimetomorph 72 $g \cdot dm^3$ and pyraclostrobine 40 $g \cdot dm^3$) and Carial Star 500 SC (mandiopropamide 250 $g \cdot dm^3$ and difenoconazole 250 $g \cdot dm^3$). Selection of plant protection products was in accordance with the recommendations of the Institute of Plant Protection - National Research Institute. Harvesting of potato cultivar tubers was carried out in the first and the second decade of September.

The vitamin C content of fresh tubers was determined using the Tilmans method according to Pijanowski modification [Gawliński et al., 1991]. This method involves extracting a sample of potato tubers with oxalic acid and titrating with oxalic acid, then titrating the resulting filtrate with 2.6-dichlorophenol-indophenol. The vitamin C content was expressed as the ascorbic acid content in the $mg \cdot kg^{-1}$of fresh matter. The sensory evaluation of the tubers (organoleptic features, also known as cooking ones) was carried out by a team of four people (tested for sensory predisposition) 7-10 days after harvesting [Roztropowicz et al., 1999]. The tastiness was determined after cooking the tubers on a scale of 1–9, in which 9 means excellent taste, 8 – very good taste, 7 – definitely good taste, 6 – quite good taste, 5 – moderately good taste, 4 – mediocre taste, and 3, 2, 1 – bad taste, not for consumption. The odor was also taken into account in determining this feature [Roztropowicz et al., 1999]. The cooking type of cooked tuber flesh was marked on a scale of 1-4, in which: 1 – type A –salad potatoes, 2 – type B –versatile usable potatoes, AB –salad potatoes for versatile use, BC –versatile potatoes with mealy flesh, 3 – type C – potatoes with mealy flesh, 4 – type D – potatoes with very mealy flesh [Nowacki, 2021].

When analyzing the weather conditions during the conducting of the experiment, it should be noted that in the first and second growing seasons, the average magnitudes of both, air temperature and precipitation, were at similar levels (Fig. 1–2). The distribution of air temperature by month, with the exception of July and August, was similar in both production seasons. July in 2021 was as much as 3.4°C warmer than in 2022, while August was, conversely, 3.9°C cooler than the 2022 value. The temperatures in July 2022 were similar to the multi-year mean. It should be added that tuberization and nutrient accumulation in the tuber occur in July and August.

Comparing the distribution of precipitation during the potato growing season, it was observed that it was uneven, especially in the months of July, August and September. The year 2021 was characterized by a more favorable distribution of precipitation during the growing season, and its sum was similar to the values of the multi-year period. The results obtained were statistically processed using analysis of variance, and the smallest significant difference was calculated using Tukey test at the level of $p \leq 0.05$ [Trętowski and Wójcik, 1991].

RESULTS AND DISCUSSION

The vitamin C content of the potato tuber is affected by various factors, such as cultivar, agrotechnical treatments and weather conditions [Kołodziejczyk, 2014; Barbaś and Sawicka, 2015; Jarienė, 2015]. The conducted research showed that the content of vitamin C in the potatoes grown in 2021 depended significantly on the cultivar (Fig. 3). The purple variety Bora Valley

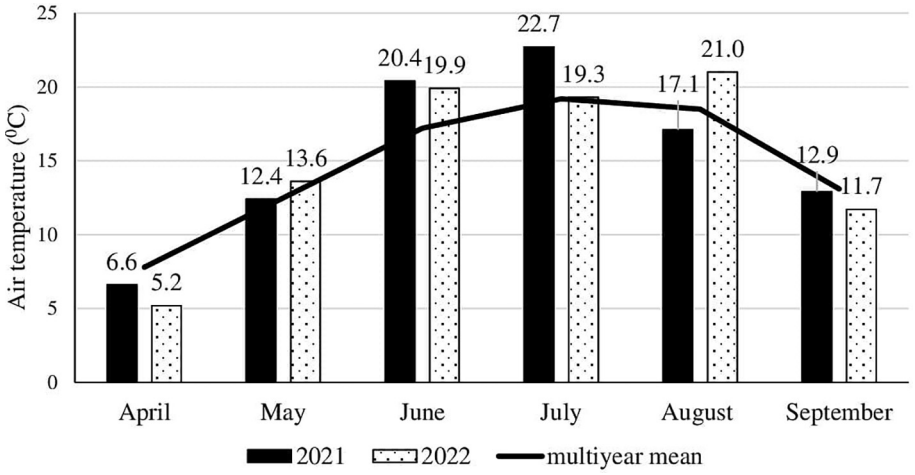

Figure 1. Air temperature (°C) during vegetation seasons in the years of research

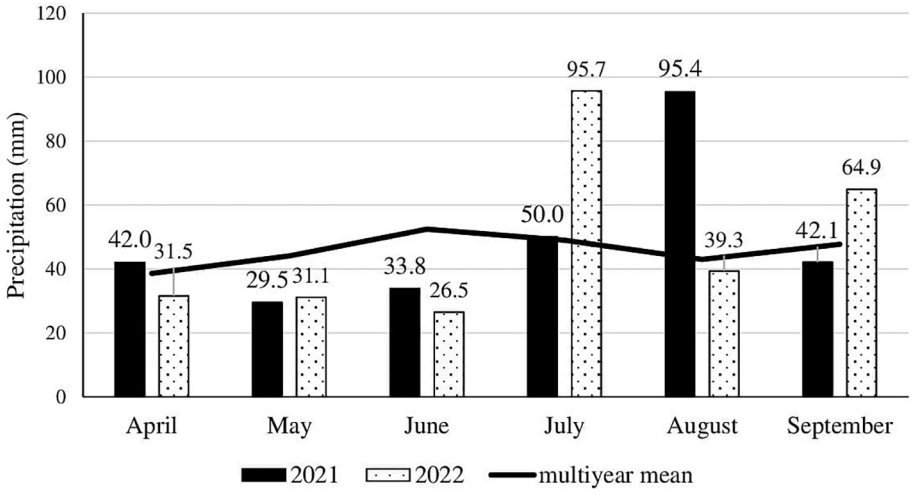

Figure 2. Precipitation (mm) during vegetation seasons in the years of research

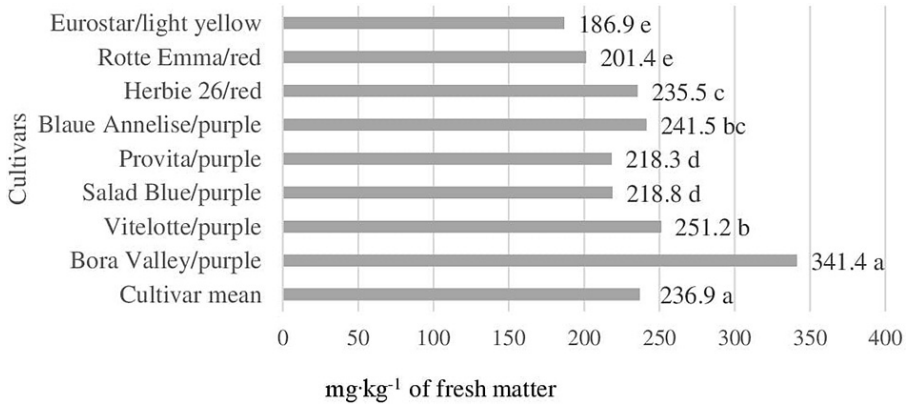

Figure 3. Vitamin C content (mg·kg^{-1}) of fresh matter in 2021; a, b, c, d, e – significance at the level p ≤0.05; those marked with the same letter do not differ significantly

had the highest content of the vitamin C (341.4 mg·kg^{-1} of fresh matter), and the smallest one was found in cultivar Eurostar, with light yellow flesh (186.9 mg·kg^{-1} of fresh matter). The cultivars: Vitelotte and Blaue Annelise, as well as Provita and Salad Blue formed homogeneous groups, but differed significantly from each other. The cultivar Eurostar, in terms of the analyzed feature, was not significantly different from only one cultivar – Rote Emma. The influence of the cultivar factor on the concentration of vitamin C was reported by Hamouz et al. [2011, 2018], Grudzińska et al. [2016], Silveira et al. [2017] and Zarzecka et al. [2021]. Moreover, Hamouz et al. [2018] said that for the potato tubers with purple and red flesh, there is not enough knowledge of the factors affecting the vitamin C content.

The chemical analyses and the statistical calculations, which were conducted in the second year of the study showed that the concentration of vitamin C in the tubers depended on the cultivar (Fig. 4). The red and purple-fleshed cultivars (with the exception of Rote Emma) accumulated significantly more vitamin C than the cultivar with light yellow flesh (Eurostar). The homogeneous group in terms of this feature was formed by the Vitelotte (the highest content), Provita and Herbie 26 varieties, as well as Salad Blue and Blaue Annelise, and Eurostar and Rote Emma cultivars. The vitamin C content depended significantly on the weather conditions in the years of research ($LSD_{0.05} = 3.3$). The synthesis from two years of study showed a significant interaction of cultivars with years ($LSD_{0.05} = 12.7$). The differences in the vitamin C content of the tubers may have been due to higher precipitation in July 2022 and lower air temperature compared to 2021. Also, Hamouz et al. [2011, 2018] showed that more vitamin C was accumulated by tubers under the conditions of a warmer and less wet region, and that the cultivars

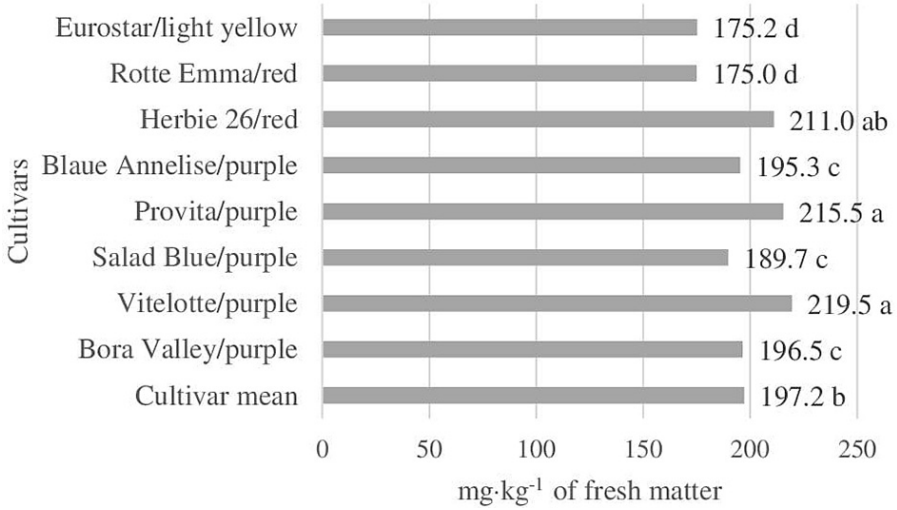

Figure 4. Vitamin C content (mg·kg^{-1}) of fresh matter in 2022; explanations – see Figure 3

with purple flesh had more of this component than red and white cultivars. The effect of weather conditions on the vitamin C content was also found by Trawczynski [2020] and Zarzecka et al. [2021]. The vitamin C content of the cultivars registered in Poland ranges from 115 to 257 mg·kg^{-1} of fresh matter, but most cultivars are below 200 mg·kg^{-1} [Nowacki, 2021]. The cultivars with colored flesh in the experiment accumulated more vitamin C and its amount depended significantly on weather conditions. In Poland, potato tubers provide a mean of about 37% of the total amount of vitamin C, while fruits provide 31% and vegetables 28%, so it is an essential component for the human body [Krzewińska and Michałowska, 2014].

Usually, the consumers choose domestic cultivars and mainly pay attention to the external appearance of the tubers and to the consumption features (the cooking type, the tastiness) [Mozolewski et al., 2014]. The statistical analysis showed that in 2021 the cultivars differed significantly in terms of tastiness (Fig. 5). The best tastiness was marked by the purple cultivar Salad Blue (9 degrees on a scale of 1-9), and the least tasty were Provita and Bora Valley (5 degrees on a scale of 1–9). The first homogeneous group, in terms of this feature was formed by: Eurostar, Rote Emma, Blaue Annelise, Salad Blue and Vitelotee, and the second one: Herbie 26, Provita and Bora Valley.

In 2022, the most delicious cultivar was the red one Rote Emma (9 degrees on a scale of 1-9), and the least tasty was cultivar Herbie 26 (3.67 degrees on a scale of 1–9) (Fig. 6).The statistical analysis showed that Rote Emma, Provita and Salad Blue cultivars formed a homogeneous group in terms of the feature. The second homogeneous group was formed by the following cultivars: Eurostar, Blaue Annelise and Bora Valley.

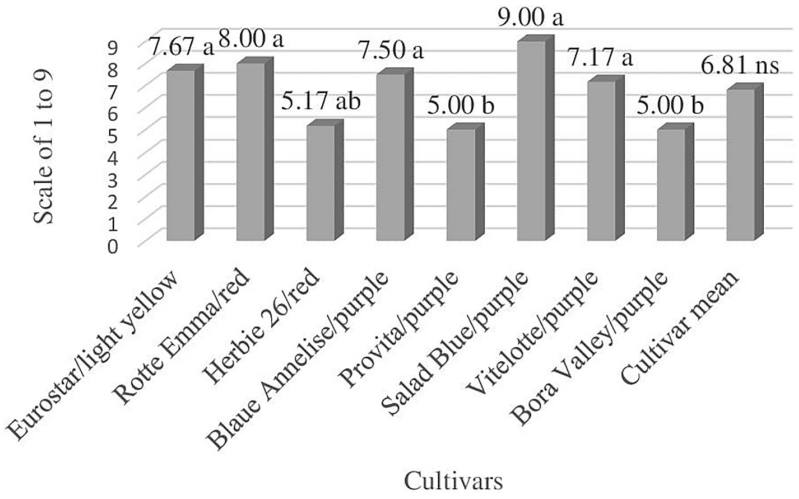

Figure 5. Potato tastiness on scale of 1 to 9 in 2021; explanations – see Figure 3; ns – not significant

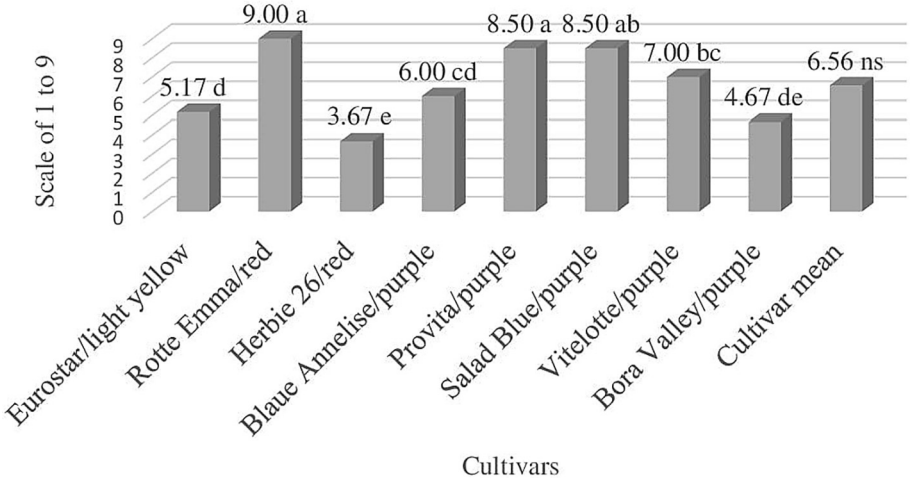

Figure 6. Potato tastiness on scale of 1 to 9 in 2022; explanations – see Figure 3; ns – not significant

Table 1. Cooking type of cultivars in 2021 and 2022 (scale 1–4)

Cultivars	Years			
	2021		2022	
	Results	Cooking type	Results	Cooking type
Eurostar	2.33a	B	2.50a	BC
Rotte Emma	1.00b	A	1.67b	AB
Herbie 26	1.33ab	A	1.33b	A
Blaue Annelise	1.33ab	A	1.17b	A
Provita	1.00b	A	1.33b	A
Salad Blue	1.00b	A	1.83ab	AB
Vitelotte	1.33ab	A	1.33b	A
Bora Valley	1.00b	A	1.00b	A
Cultivar mean	1.29ns	A	1.52ns	AB

Note: cooking type: A – potatoes salad, B – potatoes versatile usable, AB – potatoes salad for versatile use, BC – potatoes versatile to floury flesh; explanations of lettering a, b and ab – see Figure 3; ns – not significance.

The significant changes in the tastiness of potato cultivars were shown by Bienia et al. [2020] and Silveira et al. [2020]. Bienia et al. [2020] found that the Jelly cultivar had the best tastiness and odor and was the least mealy, while the Agnes and Viviana cultivars had the worst tastiness and their flesh was the mealiest. Better tastiness was exhibited by the potato tubers harvested in the warmer and less humid 2021 than in the 2022 growing season, but statistical differences between years were not statistically confirmed. Also, Krochmal-Marczak et al. [2016] and Bienia et al. [2020] showed that the tubers harvested in a warm and average year in terms of humidity had the best tastiness, and the worst in the wet season.

The cooking type is also an important feature of the potato's consumption value. In the first year of the study, all cultivars with red and purple flesh were classified as type A – salad, and only the Eurostar cultivar as type B – versatile usable (Table 1). The statistical analysis showed that the light yellow-fleshed Eurostar cultivar was significantly different from the red and purple cultivars: Rote Emme, Provita, Salad Blue and Bora Valley, but the listed colored cultivars did not differ from each other. In the second year of the study, the cooking type of the evaluated cultivars varied more and intermediate consumption types were recorded for the Eurostar (BC), Rote Emma and Salad Blue (AB) cultivars. The significant differences were found between the light yellow cultivar (Eurostar) and the red and purple cultivars (with the exception of Salad Blue). The traditional cultivar was the only one characterized by BC type. In the case of five cultivars (Herbie 26, Blaue Annelise, Provita, Vitelotte and Bora Valley), the results from the first year of the study were confirmed – the cultivars were in the salad type (A). Cultivar differences in cooking type confirmed by Bienia et al. [2020] and Silveira et al. [2020].

CONCLUSIONS

The vitamin C content of the cultivars with red and purple flesh was higher than in the traditional cultivar, light yellow-fleshed Eurostar, which allows concluding that these cultivars are more valuable to the consumer. The evaluated potato cultivars differed significantly in terms of tastiness, but it should be emphasized that it is a subjective feature. The red and purple flesh cultivars were dominated by salad cooking type – A and they were differed significantly from the traditional cultivar. The consumption features of the potato are important for the consumer of the 21st century, as the consumption of processed potatoes in Poland and Europe, compared to the unprocessed tubers, is annually increasing. *Solanum tuberosum* tubers with red and purple flesh should be seen as an attractive and valuable proposition on the edible potato market.

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