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THE INFLUENCE OF RED BEET VARIETIES AND CULTIVATION ON THEIR BIOCHEMICAL AND SENSORY PROFILE

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ABSTRACT

Modern pharmacology shows that beetroot extracts exhibit antihypertensive and hypoglycaemic activity as well as excellent antioxidant activity. The promising results of the phytochemicals contained in the extracts suggest the opportunity for their use in functional foods.This study aimed to evaluate the biochemical profile (total ash and crude protein content, total polyphenols and betalains content) and sensory properties (5 points hedonic scale) of beetroot varieties from bio-B (B Taunus, B Boro, B Gesche) and traditional production-TP (TP Taunus, TP Boro, TP Rocket). The beetroots were obtained from a private producer from Austria.
The crude protein content in evaluated red beetroots ranged from 1.54 % (B Taunus) to 5.32 % of fresh weight (TP Boro). The ash content range was 0.53 % (TP Rocket and TP Boro) to 0.63 % of fresh weight (TP Taunus). The total polyphenol content was the highest in sample of B Taunus – 3.29 mg GAE kg^{-1} of fresh weight (GAE – gallic acid equivalent). Betalains were determined separately as the red – violet betacyanins and the yellow betaxanthins. The concentration of betacyanins ranged from 5.7 mg.kg^{-1} (TP Boro) to 8.07 mg.kg^{-1} of fresh weight (B Gesche), while that of betaxanthins – from 2.77 mg.kg^{-1} (TP Boro) to 5.39 mg.kg^{-1} of fresh weight (B Gesche). Sensory properties (appearance, color, consistency, aroma, taste) of all the beetroot varieties were evaluated overall as good with the best score in a taste and overall appearance noted for TP Boro. The results improve our knowledge on beetroot as a valuable vegetable and indicate that further studies on the properties of different varieties of red beet are justified.

Keywords: *Beta* sp., traditional cultivation, organic cultivation, sensory features, biochemical profile

INTRODUCTION

Beetroot is considered a health promoting plant because of the presence of valuable components. These include macronutrients, such as sugars, fats, proteins, as well as micronutrients – as vitamins, mineral compounds (including potassium, sodium, phosphorus, calcium, magnesium, copper, iron, and manganese), polyphenols, flavonoids, carotenoids, nitrates, ascorbic acid and betalains. All these compounds have nutritional values important in a healthy diet **(Chhikara *et al.* 2019)**. Betalains are water-soluble and occur in two forms – betacyanin (red-violet pigment) and betaxanthin (yellow-orange pigment). They serve as popular food colorants owing to their safety and the lack of toxic or carcinogenic properties **(Waldin, 2016)**. Beet processing and consumption are increasing more and more as a result of its recognition as an important source of natural antioxidants **(Georgiev *et al.* 2010; Chhikara *et al.* 2019). Preczenhak *et al.* (2018)** claim that the nutritional value of beet is MAINLY related to its content of vitamins, mineral compounds and bioactive substances. This vegetable is ranked as one of the 10 most effective vegetables because it has optimal nutritional and total phenol content **(Mandžuková, 2014)**. Dry matter amounts to 12-20 % of beetroot, and includes 4-12 % sugar, 2 % protein, and 0.1 % fat. Dietary fiber, mineral compounds, phenolic acids, including *p*-coumaric, protocatechuic, ferulic, vanillic, *p*-hydroxybenzoic constitute 0.8 % **(Janiszewska, 2014)**.

Beetroot is also referred to as a super food because of its beneficial effect on blood diseases such as anemia or leukemia. It is a source of iron, the deficit of which occurs in an organism that suffers from anemia or a general immune deficiency. The components of beetroot, such as folic acid and group B vitamins, affect mental state, potassium improves the function of heart, while fibre is essential for the correct activity of intestines and facilitates the removal of harmful substances from the body. Beetroot also has a positive impact on digestion, the activity of liver, blood circulation, and blood pressure **(Mandžuková, 2014)**. **Nagy (2013)** claims that it helps in the course of influenza infections and promotes detoxification**. Čumak (2018)** states it is commonly used in the prevention of avitaminoses and indicates the recommended amounts beetroot in diet based on scientific data (6 kg of fresh and 16 kg of boiled beetroot, annually). According to another source, patients suffering from cancer are recommended to consume 0.5 kg of the vegetable or drink 200 ml of beetroot juice per day **(Ritz *et al.* 2019).** The consumption of fermented beetroot juice was found to cause beneficial changes in the activity of microbial enzymes (*β*-glucuronidase, *β*-glucosidase and *α*-glucosidase), stabilise the microflora of the large intestine and substantially inhibit the growth of pathogenic microflora (*Escherichia coli, Enterococcus sp., Clostridium sp*.), and result in a 40 % increase of amount of short-chain fatty acids **(Klewicka *et al*., 2012)**. **Ritz *et al.* (2019)** concluded that the ingestion of the juice from red beet was associated with reduced symptoms of common cold with the strongest effect observed among patients with asthma. The reduced incidence of symptoms was correlated to higher concentration of exhaled NO. **Calvo *et al.* (2018)** pointed out that previous studies have provided compelling evidence that the ingestion of beetroot offers beneficial physiological effects manifesting in improved clinical outcomes of several pathological states such as hypertension, atherosclerosis, and *diabetes mellitus* type II and dementia. **Briggsová (2009)** mentions that beetroot has a beneficial effect on arteriosclerosis, specifically its component – vitamin E. Vitamin E, classified as an antioxidant, and prevents free radicals from oxidizing cholesterol. **Tran *et al.* (2017)** quotes that betalain pigments have several important biological properties, including antiradical, antioxidant, anti-inflammatory, hepatoprotective, and antitumor activities, and cytotoxicity towards human lung cancer. According to **Preczenhak *et al.* (2018)**, betalains are responsible for neutralizing oxidative stress because they can modulate the imbalance between oxidizing species and the antioxidant defence system. **Mroczek *et al.* (2019)** noted the hepatoprotective effect of extracts from red beet against ethanol-mediated hepatotoxicity. Betalains are present in red beet in significant amounts. Nonetheless, they are prone to degradation by extreme pH, oxygen, metal ions, improper water activity, exposure to light, and enzymatic activity. Thus, technological processing has a negative impact on their content **(Sawicki and Wiczkowski, 2018)**. According to **Chranioti *et al.* (2015)**, the use of betalains in food is limited mainly by their poor stability when exposed to heat and light. **Janiszewska (2014)** claimed that natural pigments are also affected by ultraviolet and gamma radiation.

According to **Wong (2016),** the earthy taste resulting from the presence of geosmin and easily perceived by consumers is a disadvantage of beetroot which may limit its consumption and cultivation. It is proven that up to six times more of this substance is found in the skin of beetroot than in its core. Geosmin is the substance released from soil after rain, and its amount in beets is genetically determined. For this reason, there is a classification of varieties according to the Richter scale of earthiness (**Waldin, 2016).** Red beet is preferred as a raw material for food industry used in the manufacture of food colorants found in food products such as ice cream, yogurts, and other products. Beetroot extract is also used to improve redness in tomato pastes, soups, sauces, desserts, jams, jellies, confectionery, and breakfast cereals **(Chhikara *et al*., 2019).**

The aim of this study was to determine the phytochemical and sensory profiles of beetroot varieties from bio- (designated by the letter B: B Taunus, B Boro, B Gesche) and traditional production (designated by the letters TP: TP Taunus, TP Boro, TP Rocket) obtained from a private producer from Austria.

MATERIAL AND METHODS

Biological material

The tested red beet varieties Taunus, Boro, Gesche and Rocket (Fig. 1) were obtained from a private producer from Austria. In a single field measuring roughly 15 m by 30 m, all the beets cultivated for this study were planted on May 6, 2020, in Hargelsberg, Upper Austria (latitude: 48.15°N, longitude: 14.42°E, altitude: 324 m). This northern part of Austria is primarily characterized by an Atlantic maritime climate with low pressure fronts, pleasant air from the Gulf Stream, and precipitation (approximately 900 mm total annual precipitation; mean annual air temperature of 9 °C). On a total of 12 m^2, each beetroot cultivar was sown in conventional rows. The soil had a pH of 6.8, a humus content of 2%, and a soil value of 42. It was classified as heavy to clayey loam. Following sowing, a manuring treatment using a nitrate-phosphate-potassium (N-P-K) fertilizer was applied (84 kg nitrogen, 26.2 kg phosphate, and 100 kg potassium per hectare; N-P-K ratio of 14:10:20; 600 kg per hectare). There was no more fertilizer added. For varieties from bio production the conditions were the same, but instead the commercial fertilizer was used stable manure (5 kg for m^2). On September 1, 2020, ripe beetroots were manually collected, washed with water, sliced (root and nodality), and kept in storage at 2–8 °C for a five days before analysis. From all varieties 2 kg of samples were used for analysis.

Taunus variety is the most famous of the cylindrical or elongated varieties and, because of its shape, is easy to peel, cook, and cut into equal pieces. It has dark purple flesh and is resistant to cracking. This variety is sown in April-May and ripens in 130 days, it is easy to grow because the roots come out of the ground when they are harvest-ready. The average root length, thickness, and plant height are 13 cm, 4 cm 30 cm, respectively.

Boro variety belongs to the round red varieties, it has a typical dark red colour with minimal division into zones and is characterised by an especially sweet and delicate taste. It is fast ripening and strongly resistant to fading caused by stress factors such as heat, drought, frost. It shows excellent disease resistance. *Boro* variety is sown from March to June and matures in 115 days.

Gesche variety is round with smooth skin and a dark red colour, it has very good durability which makes it especially suited to storage. The taste of this variety is sweet and pleasant. It is sown in from April to July.

Rocket is a cylindrical, oblong-shaped, and semi-early variety with a low to medium-high head and a smooth root. The length is 15-20 cm, the flesh is dark red with fine rings.

Figure 1 Red beet varieties used for evaluation (1a – bio variety Gesche, 1b – Rocket variety from traditional production, 1c – Boro variety from traditional production, 1d – Taunus variety from traditional production) (foto: Granátová)

Total crude protein and ash content

The ash and crude protein were determined following the standard AACC method 08 – 01 (AACC 1996). Nitrogen content was measured by the semi micro-Kjeldahl method. Nitrogen was converted to protein using the conventional factor of 6.25. Analysis were realised in triplicate.

Preparation of extracts

One gram of homogenised sample (IKA, A10, Germany, Mesh 8) was extracted with 20 mL of 80 % ethanol for 2 hours. After centrifugation at 3000 g (Himac CT 6E, Hitachi Ltd., Japan) for 20 min, the supernatant was used for total polyphenols determination.

Total polyphenol content

Total polyphenol content of the samples was measured spectrophotometrically, using the modified Folin-Ciocalteu method as described **Singleton *et al*., (1965)**. Sample extract (0.1 mL) was mixed with 0.1 mL of the Folin-Ciocalteau reagent and 1 mL of 20 % sodium carbonate. Absorbance was measured at 700 nm using BioTek Microplate Reader (ELx800). The total polyphenol content was expressed as mg gallic acid equivalent (GAE) per g of fresh matter. Analysis were realised in triplicate.

Total betalains content (betacyanins and betaxanthins)

The total betalains content of the beet extracts was determined using a spectrophotometric method based on absorbance measurement at two different wavelengths, respectively 480 nm for betaxanthins and 537 nm for betacyanins. The total betaxanthins and betacyanins content was expressed in mg.kg^{-1} fresh weight and was calculated according to a formula as described by **Castellar *et al.* (2003)** with slight modifications.

$$TBC\ [mg.kg^{-1}] = (AxDFxMWx1000/\varepsilon x1)$$

where A is the maximum absorption value at 537 nm for betacyanins and 480 nm for betaxanthins; DF is the dilution factor; MW is the molecular weight of betalains – betacyanins (550 g.mol^{-1}), betaxanthins (308 g.mol^{-}) ; ε is the the extinction coefficient of betalain; ε of 60,000 L.mol.cmi^{-1} in H_2O were applied to quantify betacyanins, and the quantitative equivalents of major betaxanthins were determined by applying the average molar extinction coefficient (ε) 48,000 L.mol.cm^{-1} in H_2O. Analysis were realised in triplicate.

Sensory characteristic

Sensory properties of the fresh red beet varieties were determined by a sensory panel consisting of 25 evaluators (10 women and 15 men age from 25 to 65 years). The panellists were asked to evaluate the appearance, colour, consistency, aroma, taste. A 5 – point hedonic scale was used to rate the samples, with scores ranging from 5 (like extremely) to 1 (dislike extremely) for each characteristic. A 5 points – meets all evaluation criteria without errors, quality is satisfactory – high; 4 points – meets almost all evaluation features without error, the quality is satisfactory – very good; 3 points – meets the evaluation criteria with minor errors, the quality is satisfactory – only average; 2 points – meets the evaluation criteria, but there are noticeable deficiencies, the quality is still satisfactory – but very weak; 1 point – does not meet the evaluation criteria, there are serious deficiencies, quality is unsatisfactory. Analysis were realised in triplicate.

Statistical analysis

All experiments were carried out in triplicate and the results reported are mean values of these replicates with standard deviation. The experimental data were subjected to the analysis of variance (Duncan's test), at a confidence level of 0.05, using SAS 2009 software.

RESULTS AND DISCUSSION

Total crude protein and ash content

The total crude protein in the samples ranged from 1.54 to 5.32 % (Tab. 1). The lowest content was determined in the sample of B Taunus, and the highest – in the TP Boro. **Petek *et al*. (2012)** investigated the effect of different modes of organic and mineral fertilization on the content of nitrogen and crude protein in the edible part of the common beet (*Beta vulgaris* var. *Conditiva)*. The test was carried out in a hilly terrain with several types of fertilization, including stable manure and NPK fertilizer. The highest levels of nitrogen (2.41 g in 1 kg of fresh weight) and crude protein (15.07 g in 1 kg of fresh weight) were observed in red beet fertilised with 1,000 kg ha^{-1} of NPK fertilizer. The lowest crude protein content was determined when the fertilization was performed with stable manure. The authors also state that the nitrogen and crude protein contents were higher in stored than in freshly harvested beetroots, by 14% on an average. They attribute this to water losses during storage which may increase the nutritional quality of beetroot as a functional food. In our study more crude protein was determined in the samples obtained from traditional agriculture, where mainly NPK fertilizers are used. **Wang *et al*. (2008)** stated that nitrogen fertilization leads to increased content of acids, sugars, nitrates and carotenes, and reduced content of vitamin C, calcium, magnesium and soluble sugars. Beetroot contains a significant amount of both essential and non-essential amino acids. The most represented essential amino acids are leucine (0.068 g per 100 g), lysine (0.058 g per 100 g), valine (0.056 g per 100 g), and – further with decreasing abundance – isoleucine, threonine, phenylalanine, histidine, tryptophan, methionine . Among the non-essential amino acids, glutamic acid (0.428 g per 100 g), aspartic acid, alanine, and serine are predominant (**Chhikara *et al*., 2019).**

Table 1 The results of total crude protein and ash content in fresh matter of analysed red beet varieties

Sample	Ash [%]	Crude protein [%]
B Taunus	0.63 ±0.02^{b}	1.54 ±0.18^{d}
B Boro	0.58 ±0.01^{c}	2.09 ±0.01^{c}
B Gesche	0.66 ±0.01^{a}	2.36 ±0.01^{b}
TP Rocket	0.53 ±0.01^{d}	2.35 ±0.01^{b}
TP Boro	0.53 ±0.01^{d}	5.32 ±0.01^{a}
TP Taunus	0.63 ±0.01^{b}	1.66 ±0.01^{d}

mean ±standard deviation; different letters in a line denote mean values that statistically differ one from another $p < 0.05$; B – bio production; TP – traditional production

The total ash content was the highest in sample B-Gesche and the lowest in samples TP Rocket and TP Boro (Tab. 1). This parameter does not depend only on the variety, but also on the conditions and location of cultivation. The concentration of heavy metals is influenced by the type of soil, and it is necessary to monitor their content. **Mzini and Winter, (2015)** determined the content of zinc, copper, iron, manganese, mercury, lead, nickel, and chromium in beetroot. They found that the content of these metals is affected by the quality of the irrigation water. The authors used drinking water, diluted sewage water and sewage water to irritate the plants. Beetroot irrigated with sewage water showed significantly higher levels of zinc, while irrigation with diluted sewage water had no effect on the content of heavy metals in beets. Concentrations of iron, manganese and of cadmium were observed to be significantly higher with sewage water irrigation that with irrigation with drinking water. **Jorhem *et al.* (2008)** investigated the utilization of lead by vegetables cultivated in contaminated soil. The vegetables were then combusted at 450 °C and analysed for the presence of lead using graphite furnace background-corrected atomic absorption spectrophotometry. The level of lead in these vegetables ranged from <0.004 to 2.7 mg.kg^{-1} fresh weight, with a range of 0.004 to 0.18 mg.kg^{1} determined for 11 samples of beetroot$^{\cdot}$ In general, the authors concluded that soil contamination has influence on lead levels in vegetables grown in it, and also that pH plays a role in the uptake of lead. The minerals most represented in beetroot are potassium, sodium, and phosphorus with their respective contents determined as 305 mg, 77 mg, and 38 mg per 100 g **(Chhikara *et al.* 2019).**

Total polyphenol content

The content of total polyphenols in the tested samples ranged from 2.30 to 3.29 mg GAE.g^{-1} (Tab. 2). The highest value was found in the B-Taunus sample. **Carrillo *et al.* (2019)** compared the content of phenolic compounds in organic and conventionally cultivated beetroot. The results of quantification with the Folin – Ciocalteu method showed that the total content of polyphenols in beetroot from traditional production ranged between 5644 and 11659 mg kg^{-1} (variety Belushi and Boro) and that their content in the samples from organic production was 37 % higher on average. The effect of the production system on the total polyphenol content was found to depend on the variety. The referenced study was focused on verifying whether or not nutritional differences can be demonstrated between beetroot labelled as bio/organic or traditional/conventional, and its results regarding higher content of phenolics in organic-labelled vegetables resemble our findings. **Calvo *et al*. (2018)** determined the total content of polyphenols in extracts from red beet leaf and root obtained with different extraction solvents – water, ethanol and methanol. They found that the extracts from leaves are 1.5 to 2.5 times richer in polyphenols in comparison with root extracts. Moreover, the content of polyphenols in the leaf extracts was dependent on the solvent used with the following trend observed: ethanol > methanol = water (~ 0.55, ~ 0.43, ~0.42 GAE g.L^{-1}, respectively). In the case of root extracts the trend was altered however to: ethanol = methanol > water (~0.32, ~0.28, ~0.17 GAE g.L^{-1}, respectively). In their comprehensive review, **Hogervorst–Cvejic *et al*. (2017)** polyphenols of food products and their biological benefits with the emphasis on their role in the prevention of several chronic non-infectious diseases such as cardiovascular diseases, cancer, and diabetes. These diseases are among the leading causes of death today which suggests that phenolic compounds are still going to be a subject of scientific interest for years to come. In addition to the well-known antioxidant properties of polyphenols, it is clear that their biological activity is the result of various others complex mechanisms.

Table 2 The results of total polyphenols in fresh matter of analysed red beet varieties

Sample	Polyphenols [mg GAE.g^{-1}]
B Taunus	3.29 ±0.03^{a}
B Boro	2.71 ±0.02^{d}
B Gesche	3.18 ±0.01^{b}
TP Rocket	2.41 ±0.01^{e}
TP Boro	2.30 ±0.01^{f}
TP Taunus	2.95 ±0.02^{c}

mean ±standard deviation; different letters in a column denote mean values that statistically differ one from another $p < 0.05$; B – bio production; TP – traditional production; GAE – gallic acid equivalent

Total betalains content (betacyanins and betaxanthins)

Betalains are natural pigments present in tubers, flowers, and fruits. They find use in the food industry because of their functional properties and safety of consumption. The concentration of betacyanins , typical red colorants, and betaxanthins, yellow colorants, in the analysed beetroot samples ranged from 5.70 to 8.07 mg kg^{-1} and from 2.77 to 5.39 mg.kg^{-1}, respectively (Tab. 3). The highest amount of both betalains was observed in the B Gesche sample. **Niziol-Lukaszewska and Gawęda (2015)** evaluated the quality of 15 cultivars of red beets, Boro among them, during four consecutive growing seasons. The weight, diameter of the roots, antioxidant activity, and content of dry matter, soluble sugars, betanin and vulgaxanthin were evaluated in the roots. The average content of betalain in this study for the Boro variety was 2.27 mg g^{-1}. **Sawicki and Wiczkowski (2018)** determined the total content of betalains in products from red beet (solid materials). The results varied between 0.76 and 14.23mg g^{-1}. Betacyanins and betaxanthins in the concentration ranges of 0.75 – 12.68 mg g^{-1} and 0.01– 2.20 mg g^{-1} were found. Total content of betalains in whole roots was 8.65 ±0.08 mg g^{-1}. **Aztatzi-Rugerio *et al.* (2019)** employed UV-VIS spectrophotometry to study thermal degradation of betanin at 75 °C and different treatment times. The absorption at 538 nm, associated with the presence of betanin, was found to decrease homogeneously with the heating time (from 0.850 to 0.466 in 120 min). The results indicate a reduction of betanin concentration which resulted from thermal degradation of this molecule. A more in-depth analysis proved the degradation to occur mostly – mostly through decarboxylation **Chhikara *et al*. (2019)** analyzed the betalain content of extracts in hairy root cultures and intact *Beta vulgaris* cv. *Detroit* dark red plant. The plant extract contained 39.76 ±0.98 mg.g^{-1} of dry matter of betalains (20.75 mg.g^{-1} betacyanins and 19.01 mg.g^{-1} betaxanthins), while the hairy root extract contained 47.11 mg.g^{-1} of dry matter of betalains (16.33 mg.g^{-1} betacyanin and 30.78 mg.g^{-1} of betaxanthin). Betalains form up to 70-100 % of the total phenolics of beets (approximately 60 % betacyanins and 40 % betaxanthins) **(Wruss *et al*., 2015)**.

Red beetroot is a rich source betalain pigments. Betalains are nitrogen compounds soluble in water that can scavenge free radicals, they can be considered nitrogenous anthocyanins (**Ivanišová, 2014**). The antioxidant properties of betalains are partly attributed to the phenolic group of the glucoside and partly to cyclic amine group of betalamic acid, which groups act as hydrogen donors. In addition, betalains are reported to have other biological effects including anti-inflammatory, hepatoprotective and antitumor, chemopreventive anti-cancer properties, and thus demonstrate health-promoting potential. Extracts from beetroot containing betalain are used in the food industry as natural colorants for different foods and beverages **(Račkauskiene *et al*., 2015)**. Owing to their strong antioxidant potential, betalains have intense antibacterial and antiviral activity and therefore can be considered as a cancer prevention factor. They show high sensitivity to light, heat and oxygen **(Nistor *et* al., 2017)**. The amount of red pigment in beetroot is influenced by several factors such as: species, variety, cultivation area, ripening period, agricultural technology, and the type of fertilizer used. Betalains primarily need nitrogenous substances for synthesis (because they contain nitrogen in their structure). It is therefore essential that a fertilizers with enough nitrogen is supplied in organic as well as traditional agriculture.

Table 3 The content of betalains (betacyanins and betaxanthins**)** in fresh matter of analysed red beet varieties

Sample	Betacyanins [mg.kg^{-1}]	Betaxanthins [mg.kg^{-1}]
B Taunus	5.93 ±0.02^{e}	3.22 ±0.09^{d}
B Boro	6.50 ±0.02^{d}	2.89 ±0.06^{e}
B Gesche	8.07 ±0.05^{a}	5.39 ±0.01^{a}
TP Rocket	7.42 ±0.04^{b}	4.52 ±0.03^{b}
TP Boro	5.70 ±0.02^{f}	2.77 ±0.01^{f}
TP Taunus	6.93 ±0.02^{c}	3.95 ±0.04^{c}

mean ±standard deviation; different letters in a column denote mean values that statistically differ one from another $p < 0.05$; B – bio production; TP – traditional production

Sensory characteristic

The TP Boro sample (traditional agriculture) was evaluated as a best sample with a result of 25.89 points (Tab. 4). The appearance, shape, colour and taste were rated the best and achieved an average value of 4.67 out of a possible 5 points. The appearance and shape were regular and round. The colour was interesting because it was consisted of alternating paler and darker shades of red. The smell was typically earthy, and the consistency was very hard. The second best-rated sample was of the same variety but obtained from bio agriculture, it received 24.78 points. This sample had a pleasantly sweet taste, and the earthiness was not immediately perceivable. The shape was round and the alternating colour pattern was also noticeable in the cross section. Unlike the variety from traditional cultivation, it was less hard. The third highest score was assigned to the sample B Gesche (23.17 points). The shape of this variety was also round, the colour was soft red alternating with paler shades. The aroma was more pronounced, and the taste was sweet, pleasant at certain moments gently hot. There was no earthiness either in the taste or in the aroma. Taunus variety from bio production was evaluated at 22.89 points and achieved the highest results in the shape and colour. The shape was described as oval, regular and the colour was deep red to burgundy with pale areas. Rated the weakest was its smell which appeared to be very weak or non-existent. Its consistency was semi-hard to hard, and the taste was described as earthy with a faint hint of bitterness. The other two samples scored below 20 points, both were products of traditional agriculture, oval in shape, odourless, of a deep red colour with transitions to paler shades. They had a harder consistency and a sweeter taste with earthy notes. The roots of Taunus variety was drier, very hard and scored 19.38 points. The Rocket variety finished last, rated at 18.89 points. **Bach *et al.* (2014)** evaluated the sensory properties in five red beet varieties in the aspect of their suitability for consumption in either raw, cooked, or fried form. The authors performed sensory evaluation using descriptive sensory analysis and consumer tests which showed differences between raw red (Taunus, Rocket and Pablo), white striped pink (Chioggia), and yellow (Burpee's Golden) varieties. Adequacy of raw beets was associated with a high sensory score of beet taste, crispness and juiciness and a low bitterness score. Out of 23 evaluated sensory descriptors, only 8 showed significant differences between the samples of the tested varieties. It was stated that raw beetroot has a delicious flavour and pungent aroma. The results of the descriptive sensory analysis of raw and cooked beetroot were recorded on a scale from 0 (low intensity) up to 15 (high intensity). With regard to the evaluation of the aroma of raw beetroots, there were no significant differences between the samples of the tested varieties. All of them were assigned low scores, suggesting a very delicate aroma. With respect to flavour, 2 light-coloured varieties (Chioggia and Burpee's Golden) differed from the red varieties (Taunus, Rocket and Pablo) – they were assigned higher scores for pungent, soapy and horseradish flavours as well as bitterness and astringency. Rocket, Pablo and Burpee's Golden were rated sweeter than Chioggia and Taunus. Consumers evaluated the sensory properties of color, taste and texture in three culinary preparations. In the raw and fried forms, beetroot flavour was rated highest in Pablo and the lowest in Chioggia. Pablo was also rated as the least hot and had the lowest score for the delicious taste when raw. Rocket and Pablo were rated juicier than Chioggia and Burpee's Golden. Overall, the pink Chioggia was paler and less bright red than the dark red Taunus, Rocket and Pablo. The red colour of the beet comes from betacyanins, the yellow – from betaxanthins. White colour is a result of the to the absence of betalains. **Vallespir *et al*. (2019)** evaluated 10 beetroot varieties in terms of size, shape uniformity and external appearance. One beet from each variety was evaluated for the content of soluble solids and taste whan raw by 2 evaluators. Taunus was the best variety among the cylindrically shaped varieties. Cylindrical varieties cooked more evenly than the spherical varieties. Their other advantage is more even slice dimensions. The Taunus variety was evaluated in the study using a 5-point scale. This variety received 5 for overall appearance, 4.5 points for external appearance, and 3.3 points for taste when raw. Part of the assessment was also focused on shape where a 10-point scale was used. Samples of Taunus variety received 8.8 points. The referenced study used the same method of sensory rating of appearance and taste which makes the results comparable to our values. In our case, beetroots of the Taunus variety both bio and traditional production received 3.33 points and 3 points for taste, respectively.

Table 4 The results of sensory evaluation of the analysed red beet varieties

Sample	Sensory characteristics [total points]
B Taunus	22.89 ±0.19^{c}
B Boro	24.78 ±0.39^{b}
B Gesche	23.17 ±0.04^{c}
TP Rocket	18.89 ±0.19^{e}
TP Boro	24.89 ±0.19^{a}
TP Taunus	19.39 ±0.12^{d}

mean ±standard deviation; different letters in a column denote mean values that statistically differ one from another $p < 0.05$; B – bio production; TP – traditional production

CONCLUSION

The majority of the positive effects of beetroot result from the pigments it contains and which have anti-inflammatory, antioxidant, or anti-tumor properties. In this study, beetroots of the Boro variety from traditional production have shown to have the highest content of crude protein (5.32 %). This variety was also evaluated as the best regarding its sensory properties (24.89 points). The variety Gesche from bio production was determined to be the richest in betalains (7.42 mg kg^{-1} betacynins and 5.39 mg kg^{-1} betaxanthins, fresh matter). It was also found to contain the total ash. Beetroots of the Taunus variety bio production had the highest total content of polyphenols. Concluding, it can be stated that, based on our findings, the best beetroots from traditional production were of the Boro variety and from bio production – the ones of the Gesche variety. Nonetheless, future studies necessary to further investigate the potential of beetroot both as raw material and consumer product, and to reduce the possible risks (heavy metals, residues of pesticides and herbicides) associated with its presence in human diet. Biologically active compounds as well as nutritive parameters were generally higher in variety from bio production. Red beet from organic production is currently the subject of great interest for food manufacturers and consumers, especially for the production of food with added value. However, further joint research is also needed between individual countries in order to increase the range of varieties as well as competitiveness.

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