Thesis of Doctoral (PhD) Dissertation

EVALUATION OF IMPORTANT QUALITY PARAMETERS OF DIFFERENT BEETROOT GENOTYPES AND THEIR POSSIBLE ROLE IN PROCESSING

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1. BACKGROUND AND OBJECTIVES OF THE DOCTORAL DISSERTATION

The beetroot is well known and cultivated vegetable all around the world, which can be consumed either fresh or in processed form. Although it has been cultivated from a long time, it has only started to be consumed in significant quantities in recent decades, after researchers have shown its significant antioxidant effect, mainly due to its pigments.

The pigments of beetroot belong to the group of betalains, which gives an excellent alternative instead of the synthetic colorants (E123) (*Henry*, 1996). From the 1970's on, the breeding was aimed specifically at the amount and composition of beetroot pigments (*Baranski* et al., 2016).

At present, the most common forms of processing beetroot are canning, juice and powder production. The latter processing provides natural colorant (labeled as E162) to the food industry, the pharmaceutical (nutritional supplement products) and cosmetics industry. In Hungary the beetroot is mainly grown for canning purposes, but nowadays the demand for juice production, chips production and consumption of fresh beets has increased.

There is an increasing interest for the beetroot, however, the growing area is still between 300 and 400 hectares, with 8 to 10 thousand tons of yield per year (*Hraskó – Tóthné Taskovics*, 2011; AKI, 2017; NAIK, 2019).

The range of beetroot product is much wider abroad, for this, the volume of production is more significant. Europe provides the vast majority of the production, mainly France, Germany, Ukraine, Poland and the United Kingdom produce more millions of tons per year. In Poland, for example, beetroot is one of the most popular vegetables, from which many traditional dishes are made. In addition to Europe (158 million tons) (*Neelwarne*, 2013), the United States (28 million tons) and Russia also produce significant quantities, the latter producing approximately 33 million tons per year, according to FAO 2014 data (*Chhikara* et al., 2019).

The produced beetroot will be bunched fresh market goods (UK) or processed product such as pre-cooked vacuum packed beetroot, canned baby beetroot or fermented beetroot juice (Poland). It is also a popular soup ingredient (Ukraine), however, it is consumed roasted and steamed (United States) as well. The list of beet-colored foods is long, including coloring of ice creams, yoghurts, sweets, tomato sauces and jams, and serves as a natural colorant for marinated meats.

In addition to the root, the beetroot leaves are also an excellent source of minerals and are grown in many countries for their leaves, which are used to make salad mixes.

Beetroot (both root and leaf), in addition to its mineral content, is an important source of vitamins (B and C) for the human organism.

Beetroot leaves were used by the ancient Romans to relieve fever. According to Greek legends, Aphrodite regularly consumed beetroot for beauty and Hippocrates found the leaves suitable for curing wounds. In the Middle Ages it was used mainly for hematopoietic problems (*Bryan – Pierini*, 2013).

There has been a renewed interest in recent decades, as the positive effects of beetroot juice on sport performances have been pointed out (*Bailey* et al., 2010).

Ferenczi (1970) was the first who pinpointed to the anticarcinogenic effect of beetroot juice during his work life (*Fehérvári-Póczik*, 2006), which is due to the antioxidant effect of the pigments (*Kanner* et al., 2001). The promising results of their bioactive compounds in health protection give the opportunity for their use in functional foods (*Babarykin* et al., 2019).

Based on the above, it is important to promote the growing and consumption of beetroot in Hungary as well.

Mainly information about bioactive compounds of processed beetroot can be found, however, there is little information on the varieties. It makes comparison of own data more difficult and, on the other hand, points to the necessity for testing varieties (both morphologically and analytically), therefore, the cultivation can be made with genotypes appropriate for the purpose of the growing.

The aim of our experiment was to investigate the morphological characteristics and bioactive compounds of beetroot cultivars, hybrids and a heirloom variety on lowland chernozem soil in second cultivation. In addition, our aim was to highlight the differences between genotypes, therefore, sensory evaluation was carried out.

The genetic background of genotypes strongly determines the amount of bioactive compounds that are further modified by the year effect. Thus, the aim of the experiment was to examine these and based on it, recommendation can be made for their use in the food industry.

2. MATERIAL AND METHOD

2.1. The location, time of experiment and the evaluated genotypes

The open field experiments were conducted at the University of Debrecen, Farm and Regional Research Institute, Botanical and Exhibition Garden, between 2015 and 2017 with different beetroot varieties (Table 1). The experiment was performed with 9 beetroot varieties (open pollinated), where 6 of them were spherical and 3 of them were cylindrical. Moreover, 3 hybrids and one heirloom genotype were evaluated on lowland chernozem soil.

In 2015 the experiment was carried out with 6 varieties, then new beetroot genotypes were involved from 2016. It was the second year of the experiment, when it was concluded, that some of them are not perspective genotypes, therefore these varieties were not used in the next year. In this way, 10 genotypes were evaluated in 2017.

The experiment was randomized with 3 repetitions per genotype.

Table 1. The evaluated beetroot genotypes in the experiment (Debrecen, 2015-2017)

	Variety/ hybrid	**Breeder/ Distributor**	**Origin**	**Root type**	**2015**	**2016**	**2017**
1	***Bonel***	Nickerson Zwaan	NL	spherical	X	X	X
2	***Libero***	Rijk Zwaan	NL	spherical	X	X	X
3	***Cylindra***	Rédei Kertimag Ltd.	HU	cylindrical	X	X	X
4	***Rubin***	ZKI Ltd.	HU	spherical	X	X	–
5	***Detroit 2***	Rédei Kertimag Ltd.	HU	spherical	X	X	–
6	***Chioggia***	ZKI Ltd.	HU	spherical	X	X	–
7	***Larka***	Rijk Zwaan	NL	spherical	–	X	X
8	***Akela***	Rijk Zwaan	NL	spherical	–	X	X
9	***Belushi F_1***	Rijk Zwaan	NL	spherical	–	X	X
10	***Zeppo F_1***	Rijk Zwaan	NL	spherical	–	X	X
11	***Camaro F_1***	Vilmorin	FR	spherical	–	X	X
12	***Carillon***	Rijk Zwaan	NL	cylindrical	–	X	X
13	***Lomako***	Rijk Zwaan	NL	cylindrical	–	X	X

2.2. Soil characteristics of the experimental area

The experiment was carried out on lowland chernozem soil with different plots per year. The soil sample was analyzed by the Agricultural Laboratory Centre, University of Debrecen.

The results showed that based on the pH, total water-soluble salt, humus and available nutrients, the experimental area has excellent values for beetroot production.

2.3. Climatic characteristics of the experimental area

The daily temperature and the natural precipitation were measured during the vegetation period in all experimental years (Fig. 1).

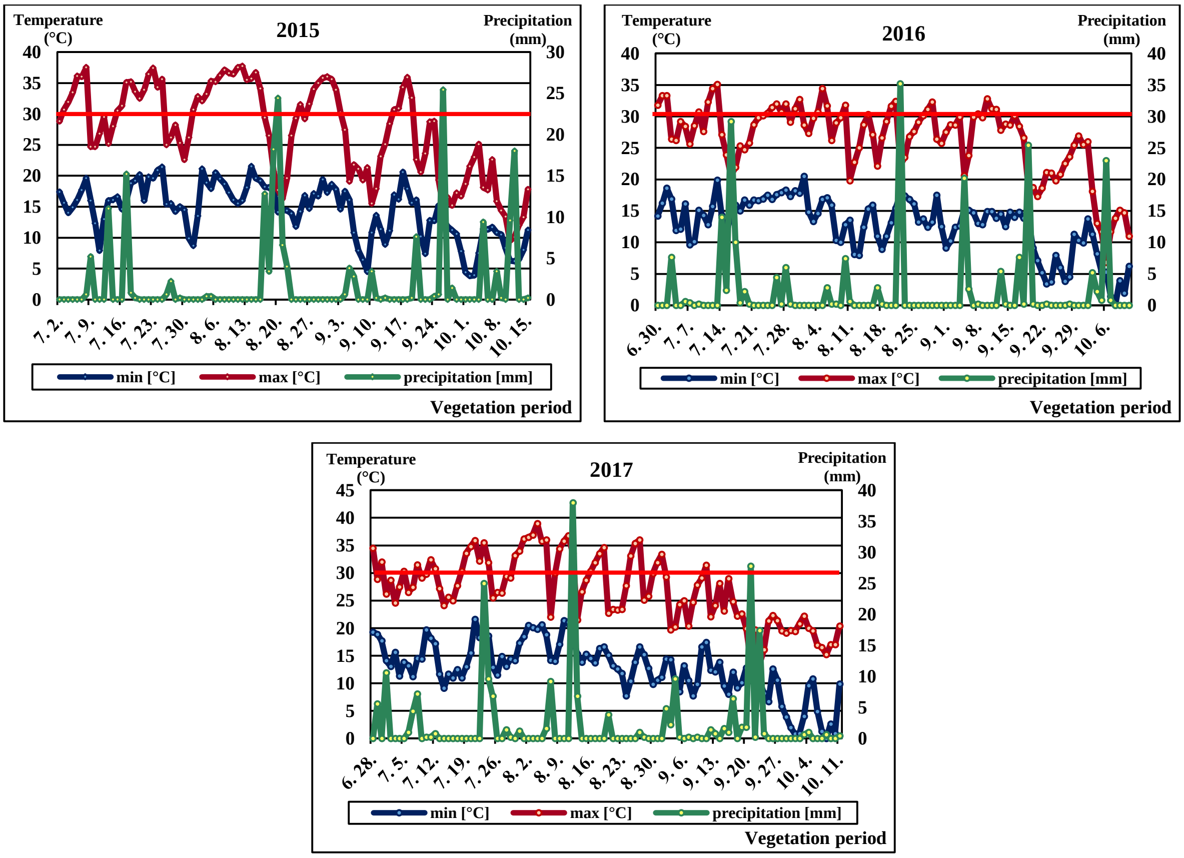

Figure 1. Daily minimum and maximum temperature (°C) and precipitation (mm) during the vegetation period (Debrecen, 2015-2017)

Source: Agrometeorological and Agro-ecological Monitoring Centre, Institutes for Agricultural Research and Educational Farm, Farm and Regional Research Institute, University of Debrecen.

It can be stated that in 2015 there was an extremely hot, dry summer, with the maximum temperature reaching or exceeding 30 °C several times (for a total of 44 days).

It was followed by a significant temperature decrease in August (16.3 °C daily maximum), when the amount of natural precipitation was 24 mm, which was not sufficient until the end of September, therefore, it was completed with drip irrigation for the proper development (30 mm occasionally) 2-3 times a week.

In 2016 and 2017 the temperature was moderate with no high fluctuation, and with more natural precipitation compared to the previous year (2015), and in these years, the minimum temperature dropped to 0 °C in early October.

In 2016 the maximum temperature during the growing season was 30 °C on 31 days, of which 1 day it reached the 35 °C, while in 2017 the temperature was above 35 °C on 12 days. The beetroot is a cold tolerant plant (16-19 °C), therefore, temperature constantly above 30 °C can be unfavorable for its development (*Nizioł-Łukaszewska – Gawęda*, 2014).

As a result, among the three years, 2015 was less favorable for beetroot cultivation.

2.4. The experimental background

The sowing dates were 2 of July 2015, 30 of June 2016 and 28 of July 2017. The size of one plot was 5 m x 0.4 m in all years, which was randomized with 3 repetitions per genotype.

In selecting the plot, the previous crop, the soil and other conditions for the beetroot cultivation were taken into consideration. During the growing season, proper plant care and weed control was carried out.

The thinning (spacing) was done at the stage of 2 to 4 leaves, with a 5 to 7 cm space between the plants. Regarding to plant protection, they were protected against fungal disease, flea and aphid in all years.

The samples were prepared on 15 of October 2015, 11 of October 2016 and 2017.

2.5. Morphological and sensory evaluations

After harvesting, the roots were cleansed from contamination, then the following **morphological parameters** were examined:

- Leaf length (cm)
- Leaf weight (g)
- Root weight (g)
- Root length (cm)
- Root diameter (cm)

The **sensory evaluation** was carried out with 5 to 6 participants, mostly women of ages between 20 to 50. The following properties were evaluated (Table 2):

- Inner color intensity* (1 – light red ... 5 – dark red)
- Presence of white ring* (1 – with white ring ... 3 – uniform inner color)
- Taste (1 – strong earthy taste, sour aftertaste ... 5 – sweet, without earthy taste)

** In case of* Chioggia *these parameters are not relevant due to its genetic background (intensive white rings).*

Table 2. Parameters of the sensory evaluation (*Takács-Hájos – Rubóczki*, 2012)

Sensory evaluation	**Inner color (1-5)**	**White ring (1-3)**	**Taste (1-5)**
Scores*	5 – dark red ⇧ 1 – light red	3 – uniform inner color  ⇧  1 – with white ring	5 – sweet, without earthy taste ⇧ 1 – strong earthy taste, sour aftertaste

**The higher score indicates better quality.*

2.6. Laboratory measurements

Regarding to measurements, they were performed at the Agricultural Laboratory Centre, University of Debrecen and were the following.

Total dry matter content (%)

Total dry matter content was determined by drying on 105 °C according to MSZ-08-1783-1:1983 chapter 2 protocol.

Water soluble solids content (Brix%)

The water soluble solids content was measured with a digital refractometer (PAL-1, Atago, Japan).

Betanin and vulgaxanthin content (mg/100 g)

The color content was determined according to *Nilsson's* (1970) method. The yellow pigment (λ=476 nm) and the red pigment (λ=538 nm) were measured by spectrophotometer (Lambda 25 UV/Vis, PerkinElmer, USA) with a correction value of λ=600 nm. The results were expressed as mg per 100 g fresh weight.

Total polyphenol content (mg GAE/100 g)

The phenolic compounds were measured with a colorimetric method (λ=760 nm) applying *Folin-Ciocalteu* reagent and using spectrophotometer (Lambda 25 UV/Vis, PerkinElmer, USA) (*Meda* et al., 2005). The results were expressed in mg gallic acid equivalent (GAE) per 100 g fresh weight.

Flavonoid content (mg CE/100 g)

The flavonoids were measured with a colorimetric method by *Kim et al.* (2003) using spectrophotometer (Lambda 25 UV/Vis, PerkinElmer, USA). The results (λ=510 nm) were expressed in mg catechin equivalent (CE) per 100 g fresh weight.

Nitrate content (mg/kg)

Nitrate content was measured with CONTIFLOW method (FIAstar 5000 Analyzer, Foss, Denmark) where the values were read between λ=520 and λ=540 nm (*Abrankó* et al., 2011) by MSZ EN 12014-7:1999 chapter 6 protocol. The nitrate content expressed as nitrate ion was expressed in mg/kg fresh weight.

2.7. Statistical analysis

Variance analysis (ANOVA) was performed by XLSTAT in Microsoft Excel 2013 program where statistical differences were determined at the level of $\alpha = 0.05$. Furthermore, Duncan multiple comparison test and LSD was applied as a post ANOVA test. The results were expressed as mean ± standard deviation (*Huzsvai*, 2012; *Berzsenyi*, 2015).

Pearson's correlation matrix was used to determine the relationship between the different parameters ($p = 0.05$).

3. RESULTS

Morphological parameters

Morphological measurements were carried out to determine the length and weight of the foliage of the genotypes and the weight of the root. In addition, shape index was calculated from the ratio of the length and diameter of the root. These parameters can determine the possibility of the cultivation of the variety or can give recommendations for its use. The morphological properties of the examined genotypes are shown in *Table 3* as the mean of the years.

Beetroot genotypes with fast growth, smaller foliage and intense root thickness are preferred to grow for fresh consumption. In our experiment, the spherical type *Larka* and *Akela* varieties showed the best values for the development of foliage and root.

Table 3. Morphological properties of beetroot genotypes in the mean of the years (Debrecen, 2015-2017)

Parameter	**Leaf length**	**Leaf weight**	**Root weight**	**Shape index**
Unit / genotype	**(cm)**	**(g)**	**(g)**	**(length/ diameter)**
Bonel	39.53	81.13	213.20	1.29
Libero	39.80	68.80	210.13	1.10
Cylindra*	38.67	70.40	237.93	3.24
Rubin	42.80	133.30	293.00	1.17
Detroit 2	42.00	120.90	273.10	1.23
Chioggia	51.00	139.70	240.50	0.81
Larka	37.10	50.40	232.30	0.99
Akela	38.95	58.00	232.50	1.06
Belushi F_1	41.00	75.00	290.10	1.14
Zeppo F_1	37.90	54.00	254.30	0.99
Camaro F_1	43.00	72.70	249.60	1.14
Carillon*	37.90	57.20	267.10	3.40
Lomako*	34.10	28.40	162.00	3.65

* cylindrical genotype

It can be stated that in the case of *Bonel* and *Libero* genotypes the expected round shape was not always fulfilled, however, the smaller foliage and the intense root thickening allows the cultivation of beets for fresh consumption.

Of the cylindrical genotypes, the *Carillon* genotype showed a favorable foliage-root ratio, which can be excellent for the preparation of sliced products. The foliage-root ratio of the *Lomako* genotype also developed favorably, except of the root weight which was much less, which allows only smaller slices to process.

In the case of hybrids, the *Zeppo* F_1 value was the best for all morphological parameters.

In our experiment, the *Rubin* and *Detroit 2* spherical types were not promising varieties, therefore the cultivation of these genotypes is recommended mainly for home garden production.

Significant leaf weight was found for the *Chioggia* genotype and a flat root shape was obtained for the shape index.

Bioactive compounds

Beetroot can be grown for fresh consumption or as a raw material for canning. The two different goals require different quality. Morphological characteristics (proper root shape, thin bottom root) are important for fresh consumption, in addition to the uniform, intense red color, the higher water soluble solids (sweet taste) and the moderate presence of species-specific earthy taste.

In contrast, for canning purposes, besides the color content, water soluble solids content is also important, since in certain processing methods (dried products), the higher carbohydrate content interferes (causes browning), which degrades the color of the product. In addition to morphological parameters, the amount of bioactive compounds plays an important role in the selection of the variety. The values of the evaluated compounds in the mean of the years are presented in *Table 4*.

It can be stated that among the spherical genotypes, *Bonel* and *Akela* showed excellent quality in the mean of the years. Furthermore, the *Larka* genotype showed very good values in most of the bioactive compounds. These varieties can be excellent raw materials for fresh salad mixes due to their high bioactive compounds content.

Table 4. Bioactive compound content of beetroot genotypes in the mean of the years (Debrecen, 2015-2017)

Parameter	**Total DM**	**Water-soluble DM**	**Betanin**	**Vulga-xanthin**	**BC/ BX**	**Total polyph.**	**Flavo-noid**	**Nitrate**
Unit / genotype	**(%)**	**(Brix%)**	**(mg/100 g)**	**(mg/100 g)**	**-**	**(mg GAE /100 g)**	**(mg CE /100 g)**	**(mg/kg)**
Libero	7.85	7.64	23.75	24.12	1.02	97.93	19.19	1410
Cylindra*	11.42	8.87	26.44	30.77	1.01	115.51	23.07	1203
Rubin	10.76	8.98	21.37	15.94	1.33	78.05	10.44	-
Detroit 2	9.86	9.74	14.46	13.61	1.14	69.07	10.21	-
Chioggia	11.10	8.33	0.52	0.80	0.67	26.58	2.95	-
Bonel	11.06	9.17	24.79	32.12	0.77	141.75	31.63	978
Larka	8.40	7.70	27.72	29.46	0.97	105.40	21.62	1351
Akela	11.01	9.73	25.31	29.43	0.87	111.45	24.93	767
Belushi F_1	9.86	10.09	19.83	24.11	0.91	89.65	16.72	684
Zeppo F_1	10.35	9.19	23.21	29.49	0.82	108.65	19.95	767
Camaro F_1	10.74	8.65	25.08	27.85	0.97	110.50	21.75	839
Carillon*	11.55	8.57	31.61	32.86	1.00	119.25	24.65	1056
Lomako*	9.75	7.02	38.11	45.05	0.85	147.00	34.40	1899

* cylindrical genotype

Among the cylindrical types, the *Lomako* showed excellent values for betanin, vulgaxanthin, total polyphenol and flavonoid content, while the *Carillon* genotype contained more total solids, water soluble solids, and lower nitrate. Besides, it had an excellent BC/BX ratio. The *Lomako* genotype can be recommended for dried product production, due to that it has showed higher color content and lower water soluble solids content in the experiment.

In the case of hybrids, it can be stated that in most parameters *Camaro* F_1 showed better values, while the least amount of bioactive compounds was measured in the *Belushi* F_1 hybrid.

The *Chioggia* genotype as a special variety was investigated and it did not show high values for bioactive compounds, partly due to its genetic background. This white-red-striped genotype can play a major role in the preparation of cold dishes.

Correlation between the bioactive compounds

Researches have shown relationship between the main bioactive compounds of beetroot, which was analyzed in our experiment using Pearson's correlation matrix. The relationship between total dry matter, total polyphenol, flavonoid, betanin, vulgaxanthin, BC/BX and nitrate content among the different years were evaluated. Strong positive relationship was found between total polyphenol and flavonoids (r = 0.932; r = 0.953 and r = 0.917) in all experimental years. It can be explained by that the flavonoids are part of the phenolic compounds, therefore, their synthesis is related.

Similarly strong correlation was found between the two pigments (r = 0.975; r = 0.933 and r = 0.848), which can be due to that their biosynthesis starts from the same compound, the betalamic acid.

There is also a positive relationship between the two pigments, total polyphenol and flavonoids, but this varies significantly between years. Strong correlation was found in the first year of the experiment, when the correlations between total polyphenol and betanin and vulgaxanthin were r = 0.874 and r = 0.858, respectively.

Similarly, the relationship between flavonoid and pigments was observed (r = 0.779 and r = 0.827). In 2016 and 2017, this relationship was weaker (r = 0.405-0.680) between the amounts of these bioactive compounds. This is probably due to the different temperature values.

The beetroot belongs to the cold-tolerant plant species, therefore, lower temperatures (< 25 ° C) from the time of root thickening to harvesting favor the accumulation of bioactive compounds. In 2015, during the last third of vegetation, values above 35 °C were detected for 5 days, while in 2016 and 2017, values above 35 °C were limited to 0-2 days. This is probably the reason why we found a different relationship between the accumulation of pigments and other bioactive compounds.

Furthermore, it can be stated that there is a positive correlation between the pigments and the nitrate, thus, parallel to the amount of pigment, the amount of nitrate increases as well. In the year of 2017, a stronger correlation was observed between betanin, vulgaxanthin and nitrate (r = 0.837 and r = 0.826) than in 2016 (r = 0.603 and r = 0.560). This difference could be due to the changes in climatic factors.

Sensory evaluation

The sensory evaluation is important not only in the use of beet for fresh consumption, but also of processing. The mean values of the evaluated genotypes by the year are shown in *Table 5*.

Table 5. Sensory evaluation of beetroot genotypes in the mean of the years (Debrecen, 2015-2017)

Parameter	**Inner color**	**White ring**	**Taste**
Unit / genotype	**(1-5)**	**(1-3)**	**(1-5)**
Bonel	4.63	2.57	4.00
Libero	4.20	2.37	3.60
Cylindra*	4.00	2.30	3.83
Rubin	3.70	2.05	2.85
Detroit 2	3.80	2.05	3.60
Chioggia	-	-	1.90
Larka	4.20	2.25	3.55
Akela	4.50	2.55	4.00
Belushi F_1	3.70	2.15	3.30
Zeppo F_1	3.80	2.10	2.95
Camaro F_1	3.60	1.90	2.80
Carillon*	4.05	2.20	3.95
Lomako*	4.50	2.55	2.95

* cylindrical genotype

It can be stated that the spherical *Bonel* and *Akela* have excelled in all three parameters. The intense red color without white rings and the pleasant taste (sweet, without earthy taste) were fulfilled in these varieties.

In the case of cylindrical genotypes, the *Lomako* excelled in inner color while *Carillon* has showed the most pleasant taste.

Among the hybrids, *Belushi F_1* showed more favorable inner color intensity and uniformity, and this hybrid was less characterized by the presence of earthy aftertaste.

In the experiment, the *Chioggia* genotype did not show favorable taste.

Finally, it can be stated that there are significant differences between the genotypes both in morphological parameters and in bioactive compounds content, which is greatly influenced by the year effect.

4. NEW SCIENTIFIC RESULTS OF THE DISSERTATION

1.) Our experiment with 13 genotypes on lowland chernozem soil showed, that the red pigment (betanin) content of beetroot has correlation (r = 0.653) with the amount of total polyphenols.

2.) In our experiment, a strong positive relationship was found between total polyphenol and flavonoid content (r = 0.934). A similar correlation was found (r = 0.919) between the two pigments (betanin and vulgaxanthin).

3.) In our experiment, the genotypes with higher values (*Lomako*, *Bonel*) showed a total polyphenol content of 141-147 mg GAE / 100 g in the average of the years, which is higher than in the reported literature (around 100 mg GAE / 100 g).

4.) The amount of flavonoids in the best color intensity genotypes (*Lomako*, *Bonel*) ranged from 31 to 34 mg CE / 100 g. This relationship was also proved by the correlation between the flavonoids and the yellow pigments (r = 0.665).

5.) As a result, the pigment content of beetroot significantly determines its nutritional value.

5. PRACTICAL USE OF THE RESULTS

1.) It can be stated that among the varieties, the spherical genotype *Bonel*, *Akela* and *Larka* showed excellent quality in the mean of the years, which means they had dark red inner color without white ring and pleasant taste. Furthermore, these genotypes showed very good values in the morphological properties and in the bioactive compounds. These varieties can be excellent raw materials for fresh salad mixes due to their high bioactive compound content.

2.) In our experiments we have found that the inner color intensity of *Lomako* was outstanding, while *Carillon* genotype showed favorable taste and foliage-root ratio in the average of the years, therefore, they can be excellent for processing and for the preparation of sliced products.

3.) Our experiments have showed, that *Lomako* genotype can be recommended for dried product production as well, due to that it has showed higher color content and lower water soluble solids (sugar) content in the average of the years.

4.) In the case of raw material for beetroot juice production, the high pigment and sugar content, as well as the absence of earthy aftertaste, are important. We have found that under our circumstances, *Bonel* and *Akela* varieties were excellent in these properties.

5.) The *Chioggia* was evaluated as an heirloom genotype with pink and white rings. It was concluded, that these variety has much less pigment and sugar content compare to the other genotypes, however, it can be an excellent raw material for the preparation of cold dishes.

6.) Besides (open pollinated) varieties, hybrids are available for beetroot cultivation. In our experiment, 3 new hybrids were evaluated (*Belushi* F_1, *Zeppo* F_1, *Camaro* F_1), and it can be concluded that, the *Zeppo* F_1 was the best for all morphological parameters, while the highest amount of bioactive compound was measured in *Camaro* F_1. Furthermore, *Belushi* F_1 got favorable values at the sensory evaluation (inner color intensity and uniformity, moderate presence of earthy aftertaste) among the hybrids.

7.) In summary, it can be stated, that the examined hybrids showed lower values for inner quality and bioactive compound content (polyphenols, flavonoids) compared to most of the (open pollinated) varieties. Due to the lower inner quality and the significantly higher seed price, at present it is advisable to choose from conventional varieties for cultivation.

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7. PUBLICATIONS IN THE TOPIC OF THE DISSERTATION

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Registry number: DEENK/81/2020.PL
Subject: PhD Publikációs Lista

Candidate: Tímea Rubóczki
Neptun ID: HIWHZ3
Doctoral School: Kálmán Kerpely Doctoral School
MTMT ID: 10056789

List of publications related to the dissertation

Hungarian scientific articles in Hungarian journals (2)

1. **Rubóczki, T.**, Takácsné Hájos, M.: Cékla fajták gazdasági értékmérő tulajdonságainak értékelése.
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2. Raczkó, V., **Rubóczki, T.**, Borbélyné Varga, M., Takácsné Hájos, M.: Cékla (Beta vulgaris L. ssp. esculenta Gurke var. rubra L.) beltartalmi paramétereinek változása tárolás hatására.
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Foreign language scientific articles in Hungarian journals (5)

3. **Rubóczki, T.**, Takácsné Hájos, M.: Folic acid content of beetroot leaf and root by different growing stages and genotypes.
   Agrártud. Közl. 1. (2), 115-119, 2019. ISSN: 1587-1282.
   DOI: http://dx.doi.org/10.34101/actaagrar/2/3688

4. Takácsné Hájos, M., **Rubóczki, T.**: Evaluation of mineral element content of beetroot during the different stages of the growing season.
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Hungarian conference proceedings (2)

8. **Rubóczki, T.**, Takácsné Hájos, M.: Cékla termesztés jelentősége és jövedelmezősége.
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9. Takácsné Hájos, M., **Rubóczki, T.**: Különböző vetési időkből származó céklafajták minőségének alakulása és felhasználásának lehetőségei.
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10. Takácsné Hájos, M., **Rubóczki, T.**, Cottonaro, A.: Céklafajták ásványi elem tartalmának alakulása: A céklalevél értéke = Evaluation of mineral element content of beetroot varieties: The value of beetroot leaves.
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11. **Rubóczki, T.**, Kincses, S., Takácsné Hájos, M., Csubák, M.: Dudarit talajkondicionáló készítmény hatásának vizsgálata talaj-növény rendszerben.
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List of other publications

Hungarian scientific articles in Hungarian journals (1)

15. Takácsné Hájos, M., **Rubóczki, T.**, Takács, J.: Különleges paradicsomfajták összehasonlító vizsgálata.
Kertgazdaság. 48 (3), 14-26, 2016. ISSN: 1419-2713.

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18. Takácsné Hájos, M., **Rubóczki, T.**, Szabó, F. M., Kiss, A.: Effect of Environmentally Friendly Nutrition Supply on Stevia (Stevia rebaudiana B.) Production.
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19. Tóth, A. R., **Rubóczki, T.**, Takácsné Hájos, M.: Evaluation of industrial tomato genotypes in open-field production.
Acta Univ. Sapientiae. Agric. Environ. 11 (1), 109-116, 2019. ISSN: 2065-748X.
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21. Takácsné Hájos, M., Madar, Á., **Rubóczki, T.**, Homoki, D. Z., Stündl, L.: Különböző saláta fajták ásványielem tartalmának alakulása akvapóniás és hidropóniás termesztés mellett.
In: Alkalmazkodó vízgazdálkodás: Lehetőségek és kockázatok. Víztudományi Nemzetközi Konferencia. Konferencia kötet. Szerk.: Jakab Gusztáv, Tóth Attiláné, Csengeri Erzsébet, SZIE AGK Tessedik Campus, Szarvas, 197-203, 2018. ISBN: 9789632697369

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22. Takácsné Hájos, M., **Rubóczki, T.**: Édesburgonya fajták ásványielem-tartalmának alakulása.
In: 16. Magyar Magnézium Szimpózium : Program és összefoglalók, Magyar Kémikusok Egyesülete, Budapest, 11, 2019. ISBN: 9789639970960

23. **Rubóczki, T.**, Raczkó, V., Takácsné Hájos, M.: Levélzöldségek ásványielem-tartalmának alakulása = Changes in mineral contents of leaf vegetables.
In: 14. Magyar Magnézium Szimpózium : Program és összefoglalók, Magyar Kémikusok Egyesülete, Budapest, 55-56, 2015. ISBN: 9789639970540

24. Raczkó, V., Tóth, A. R., Ujlaki, G., **Rubóczki, T.**, Takácsné Hájos, M.: Magnézium lombtrágyázás hatása paradicsom (Lycopersicon lycopersicum L.) és sztívia (Stevia rebaudiana B.) gazdasági értékmérő tulajdonságaira = The effect of Mg-leaf fertilization on the economical parameters of tomato (Lycopersicon lycopersicum L.) and stevia (Stevia rebaudiana B.).
In: 14. Magyar Magnézium Szimpózium : Program és összefoglalók, Magyar Kémikusok Egyesülete, Budapest, 15-16, 2015. ISBN: 9789639970540

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25. Kovácsné, M. Á., Takácsné Hájos, M., **Rubóczki, T.**: Evaluation of different lettuce variaties by aquaponic and hydroponic technology.
In: Vth Horticulture and Landscape Planning Conference from Transylvania. Ed.: Benedek Klára, Sapientia Erdélyi Magyar Tudományegyetem, Marosvásárhely, 11, 2019.

26. Tóth, A. R., **Rubóczki, T.**, Takácsné Hájos, M.: Evaluation of industrial tomato genotypes on open field growing.
In: Vth Horticulture and Landscape Planning Conference from Transylvania. Ed.: Benedek Klára, Sapientia Erdélyi Magyar Tudományegyetem, Marosvásárhely, 21, 2019.

27. Tóth, A. R., Tóthné, B. A., **Rubóczki, T.**, Takácsné Hájos, M.: Rheological evaluation of industrial tomato in raw and processed condition.
In: Scientific researches in food production : Proceeding of abstracts, Debreceni Egyetemi Kiadó, Debrecen, 15, 2018.

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28. **Rubóczki, T.**, Takácsné Hájos, M.: Céklalevél mint lehetséges salátakeverék alapanyag.
Agrofórum. 30 (6), 144-146, 2019. ISSN: 1788-5884.

29. Takácsné Hájos, M., **Rubóczki, T.**: Édesburgonya fajták és hazai termesztésük lehetőségei.
Agrofórum. 30 (1), 36-39, 2019. ISSN: 1788-5884.

30. Takácsné Hájos, M., **Rubóczki, T.**: Kézimunkaerő-szükséglet csökkentésének lehetőségei a zöldségtermesztésben.
Agrofórum. 29 (1), 44-46, 2018. ISSN: 1788-5884.

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31. **Rubóczki, T.**, Takácsné Hájos, M.: Gyökérzöldségfélék termesztésének lehetőségei környezetkímélő módszerrel.
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32. Takácsné Hájos, M., **Rubóczki, T.**: Új lehetőségek a torma termesztésében.
Agrofórum. 28 (1), 16-19, 2017. ISSN: 1788-5884.

33. Takácsné Hájos, M., **Rubóczki, T.**: A palántanevelés kockázati tényezői.
Agrofórum. 27 (11), 92-97, 2016. ISSN: 1788-5884.

Total IF of journals (all publications): 0,624
Total IF of journals (publications related to the dissertation): 0

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

09 March, 2020