Theses of doctoral (PhD) dissertation

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EXAMINATION OF DIFFERENT BEETROOT VARIETIES OF VALUABLE COMPONENT CONTENTS AND ITS CHANGES ON EFFECT OF DRYING

Theses of PhD dissertation

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1. INTRODUCTION AND OBJECTIVES

In the developed countries, a diet that is based on healthy materials, natural ingredients, free of artificial flavoring and coloring, is becoming increasingly important today. The variety diets has become increasingly important for people who follow a health-conscious lifestyle. Although the beetroot does not belong to the generally popular vegetables, due to its many positive nutritional and physiological properties, it is becoming increasingly common. In addition its significant potassium and magnesium content, it has low sodium concentration, which has a beneficial effect on the human body's ionic state. It contains betacianins which can reduce the oxidative stress and the harmful effects of free radicals, have antibacterial and antiviral properties, can inhibit the growth of cancer cells and participate in the prevention of cardiovascular disease. The plant itself can occur almost everywhere, because it is easy to grow and does not require extra care without the hoe work.

In my work three varieties of beetroot (*Beta vulgaris* L .: 'Alto F1', 'Cylindra', 'Detroit') were grown in untreated and treated soil with fertilizer for two years in the Szent István University, Faculty of Horticulture, Experimental Plant and Farm. The samples cultivated by me were the raw material for my experimental work.

Based on the above mentioned things, my objectives were:

- examining the intrinsic properties of three different beetroot varieties (*Beta vulgaris* L.:’Alto F1 ',' Cylindra ',' Detroit ') according to untreated or cultivated with fertilizers (chelating agent: ammonium nitrate, 27% nitrogen, 7% calcium oxide, 5% magnesium oxide) individuals,
- the isolation of the examined components in the three parts of the peeled beetroot (upper, middle and lower part) and peel part in order to define the distribution of some parameters within the beetroot, which information may be particular importance for medical use,
- comparison of different drying technologies (atmospheric, vacuum and microwave vacuum drying) for the beet varieties (*Beta Vulgaris* L.: Alto F1 ',' Cylindra ',' Detroit ') based on changes of their parameters, especially recognition of microwave vacuum drying method as a gentle dehydration method.

2. MATERIALS AND METHODS

2.1. Beetroot varieties included in the study

The three examined beetroot varieties ('Alto F1', 'Cylindra' and 'Detroit') were grown in 2014 and 2015 in treated soil with fertilizer (produced by Genesis) and untreated soil (control). After harvesting, cleaning and peeling, separeting treated and untreated samples the beetroot bodies were divided into three parts, so with the peel part in the four different parts the valuable component contents were determined. Therefore, the examined parts of the plant included the top (T), middle (M), end (E) and peel (H) parts of the beet root.

2.2. Test methods for raw samples

The **total dry matter content** was determined from three parallel prepared samples according to MSZ 4220: 1980. **Nitrite and nitrate content** measurements were performed on MERCK RQflex® plus Reflectoquant® instrument. For determination of colour content was used the method developed by STINTZING et al. (2005) and CASTELLAR et al. (2003). The light absorption of the samples was detected on 484 nm for **betaxantine** and on 535 nm for **betacyanin**. The **antioxidant capacity** of the samples was determined by the Ferric Reducing Ability of Plasma (FRAP) method developed by BENZIE and STRAIN (1966). Based on the method of SINGLETON and ROSSI (1965) **total polyphenol content** was examined. **Ascorbic acid content** was determined by high performance liquid chromatography (HPLC) (MAERE, 1988). Measurements were performed using a high performance liquid chromatography instrument produced by Shimadzu. The **mineral content** of the samples was determined with Perkin Elmer Optima 8000 ICP-OES. The sample preparation was done according to MSZ EN 13805: 2002 and the measurement was performed according to EPA Method 6010C: 2007. During the investigation the calcium, potassium, magnesium, sodium, copper, iron, manganese, phosphorus and zinc contents were determined.

2.3. Applied drying modes

The raw materials of drying process were 2 mm thick beetroot slices which was cut into 1*1 cm square pieces before drying in order to exclude the differences arising from the inhomogeneous product size when comparing the results. Table 1 contains the codes of different drying methods.

Table 1: **Applied drying modes**

Drying methods		**Codes**
Atmospheric drying (10 m/m%)		A60°C
Pre-drying (to 30 m / m%)	**Post-drying (10 m / m%)**	
60 min atmospheric drying at 60 °C	vacuum drying at 40°C	V40°C
60 min atmospheric drying at 60°C	vacuum drying at 50°C	V50°C
60 min atmospheric drying at 60°C	vacuum drying at 60 °C	V60°C
90 min atmospheric drying at 40°C	microwave vacuum drying s (10 min 300W+3 min 600W)	MV40°C
60 min atmospheric drying at 60°C	microwave vacuum drying (10 min 300W+3 min 600W)	MV60°C
45 min atmospheric drying at 80°C	microwave vacuum drying (10 min 300W+3 min 600W)	MV80°C

2.4. Examination of dried samples

During the analysis of the dried samples the color coordinates, betacianin, betaxanthin and total polyphenols contant antioxidant capacity and were determined, and the quantitative detection of some phenolic acids was performed in the microwave vacuum samples by HPLC (SZÉKELY et al., 2014).

The **texture measurement** of dried beetroots was realized with Brookfield LFRA Texture Analyzer, the data capture and the evaluation with Texture ProLite.

During the **sensory analysis** of beetroots, the critics had to evaluate the appearance of the dried products (max. 5 points), colour (max. 5 points), texture (max. 5 points) and taste (max. 5 points). As a continuation of sensory criticism, profile analysis was carried out to map the specificity of the processing of the three beetroot varieties as dehydrated samples.

2. RESULT AND DISCUSSION

3.1. Results of raw beetroot samples

Regards of the total dry matter content, the results show that the total dry matter content of the peel parts were always the highest (Fig. 1).

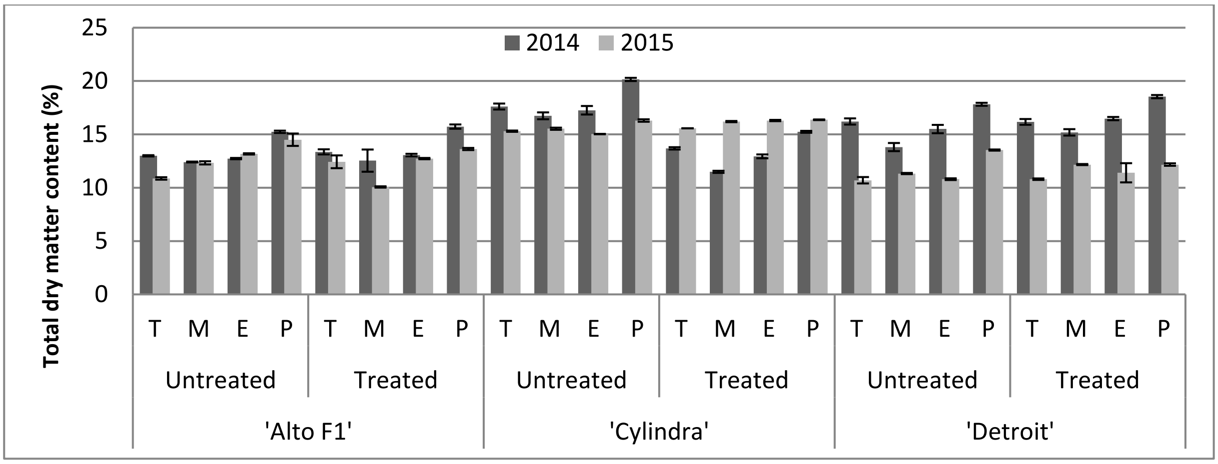

Figure 1: Total dry matter content of the examined beetroot varieties

On the basis of the betacianin content results (Fig. 2) it can be stated that the betacyanin content of the peel part was the highest for all samples in both years.

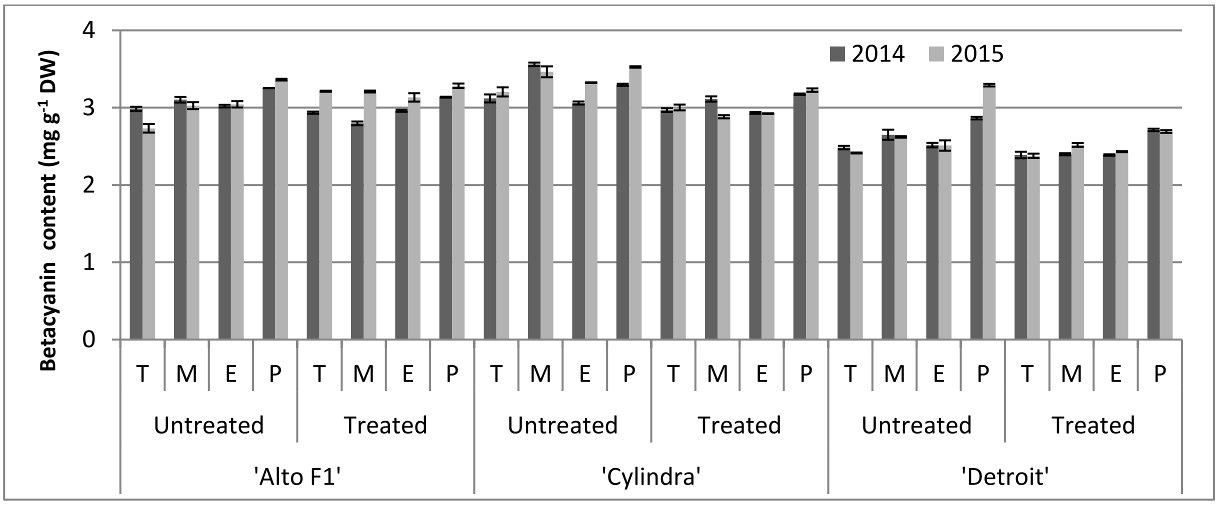

Figure 2: Betacyanin content of the examined beetroot varieties

In my experiments, in the majority of cases the betaxantin content of the three examined beetroot varieties were detected in the lowest amount in the peel (Fig. 3).

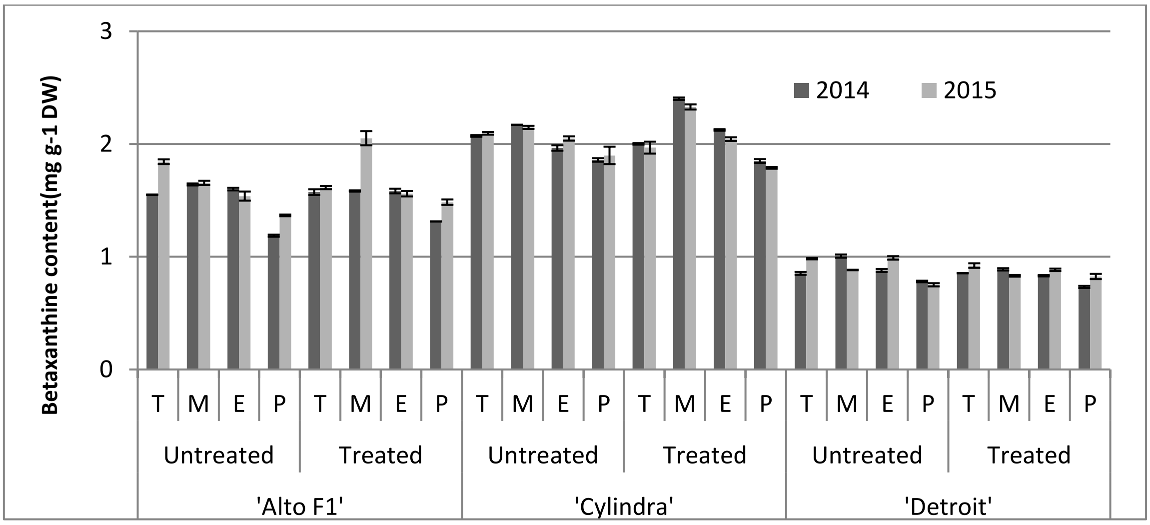

Figure 3: Betaxanthine content of the examined beetroot varietiesv

The antioxidant capacities of beetroots cultivated in 2015 were on average 60.9% higher than one of beetroot samples from the previous year. It can be seen on Fig. 4 that typically the top and the peel part had higher antioxidant capacity in case of samples cultivated in the 2014, whereas in case of the samples cultivated in the 2015 the antioxidant capacities of the peel parts were higher.

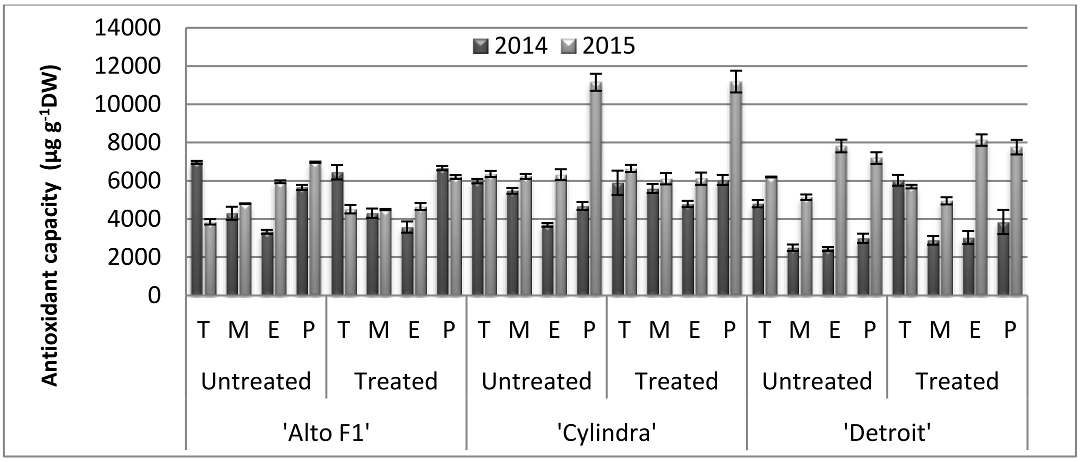

Figure 4: The antioxidant capacity of the invetigated beetroots

It can be observed that the top and peel part of the treated samples contained the highest amount of nitrite in all three beetroot varieties, relative to the middle and end parts of the beetroot (Fig. 5). The peel part of the untreated samples contained a lower concentration of nitrite than the treated samples. The average nitrite content of treated samples (150.64 mg l^{-1}) was 18.48% higher than the nitrite content of untreated samples (~127.14 mg l^{-1}).

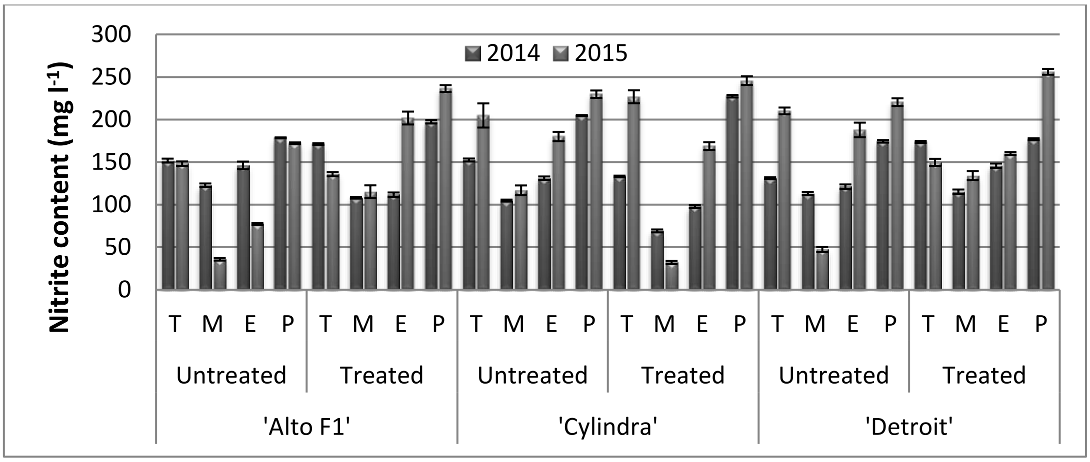

Figure 5: The nitrite content of the examined beetroot varieties

By comparing the average vitamin C content of the two vintage years, it can be stated that only average 2.39% higher values were detected in the samples cultivated in 2015. There were significant differences in the distribution of vitamin C content between the vintages, but in every case the untreated individuals had higher vitamin C content. For both years, the vitamin C contents of the 'Alto F1' beetroots were the lowest values (2014: 10 2.104 mg 100g^{-1} DW; 2015:~ 2.143 mg 100g^{-1} DW.). Analyzing the data of Fig. 6, it can be seen that the vitamin C contents of the peel parts were the highest for each sample, which were 2.99 ± 0.37 mg 100g^{-1} DW and 4.57 ± 0.43 mg 100g^{-1} DW in case of samples cultivated in 2014, furthermore 3.33 ± 0.45 mg 100g^{-1} DW, and 4.76 ± 0.10 mg 100g^{-1} DW in case of samples cultivated in 2015.

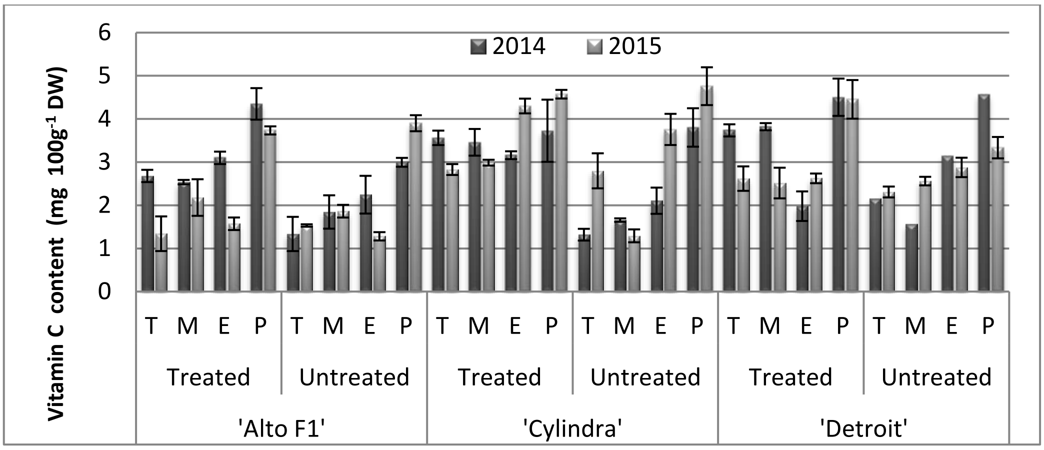

Figure 6: Vitamin C content of the examined beetroot varieties

During the investigation of mineral content the calcium, potassium, magnesium, sodium, copper, iron, manganese, phosphorus and zinc contents were determined in four different parts of the beetroots. In all three beetroot varieties, there was a significant difference between the years. Among the treated and untreated variants, ignoring the vintage effect for 'Alto F1' in Ca, Cu Fe contents, for 'Cylindra' in Ca, K, Mg, Na, Mn, P contents and for 'Detroit' in Ca, Mg, Mn, Na, Cu, Zn contents there were a significant differences. Calcium, manganese, and magnesium were mainly in the top and the peel parts, while the highest iron content was found in the peel pars in both years.

3.2. Test results of dried samples

Regarding the color characteristics of the pre-dried samples, the Cylindra variety preserved mostly the color characteristic of beetroot. Pre-drying at 60 °C proved the most suitable method for preserving as much as possible betacianin, betaxantine and antioxidant capacity values for all three beet varieties. In the analysis of total polyphenol content, there was no significant difference in pre-drying methods at different temperatures in the case of 'Alto F1'. For Cylindra the pre-drying at 60 °C and for 'Detroit' the pre-drying at 80 °C proved the most gentle method.

It can be seen on Fig. 7 the changes of betacyanin content of dried beetroots due to the drying. The 'Cylindra' variety had the highest initial betacyanin content (3.24 mg g^{-1} DW), which was reduced by an average of 61.39% due to drying, while for 'Alto F1' 52.45% and for 'Detroit', 79.46% lower betacyanin content was detected on average in the dried samples.

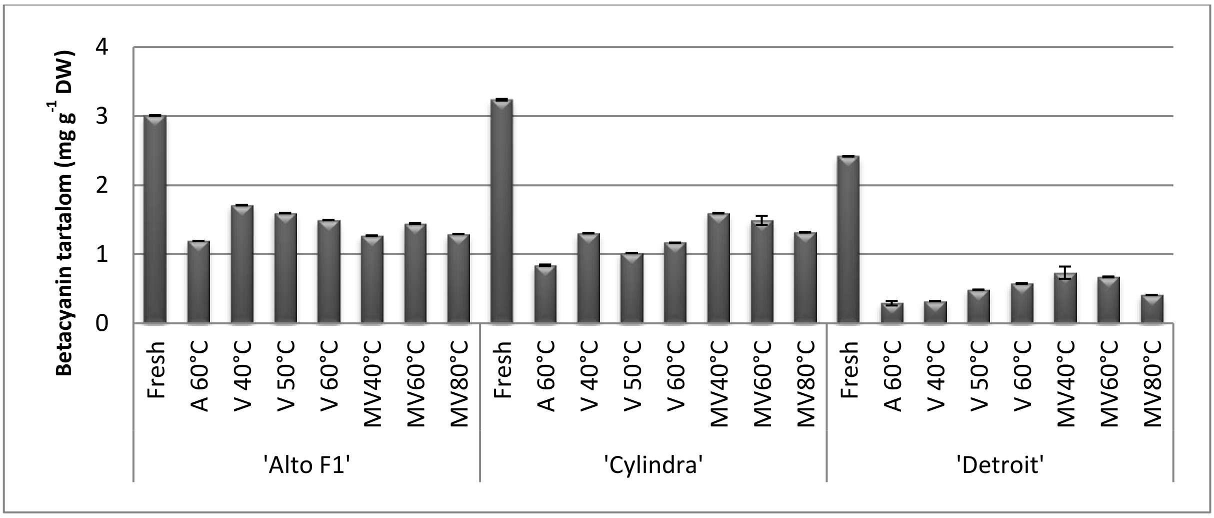

Figure 7: The betacyanin content of dried beetroots

For the analysis of betaxantine content (Fig. 8) the highest values were in 'Cylindra' samples after drying, in which the betaxanthine content reduced on average with 53.60%. Although the betaxantine content of the 'Detroit' samples decreased the lowest amount, representing an average reduction of 40.32%, while in the case of 'Alto F1' this decrease was 62.86%.

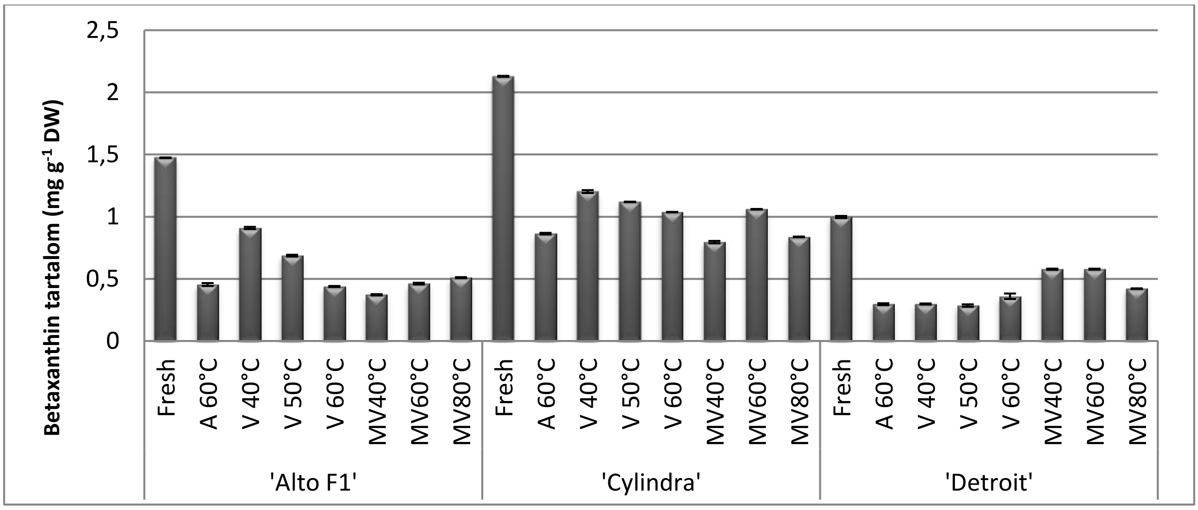

Figure 8: The betaxanthine content of dried beetroots

For Alto F1 and Cylindra, the antioxidant capacity (Fig. 9) was reduced by almost 80%, while the 'Detroit' variety showed a reduction only 78.04% on average after each drying.

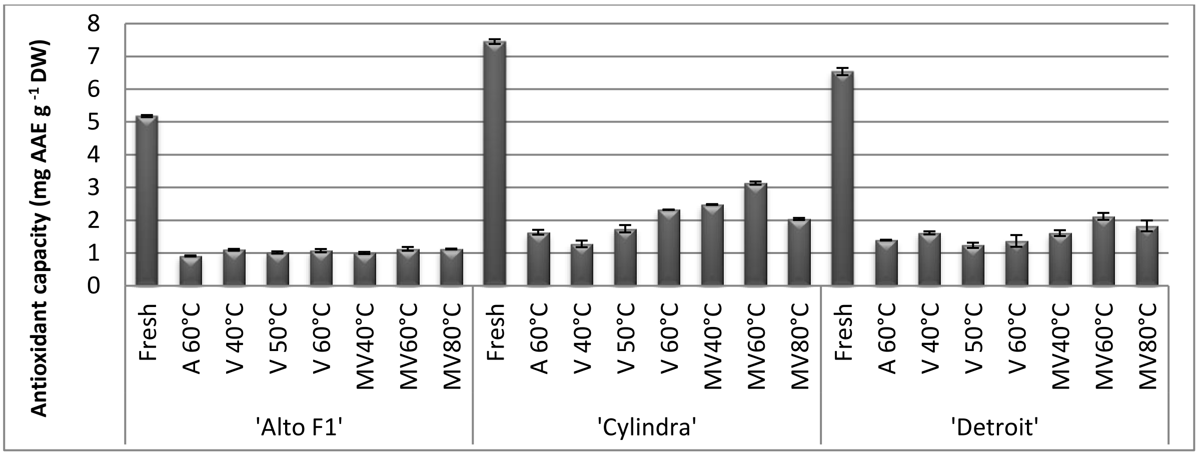

Figure 9: Antioxidant capacity of dried beetroot

Dried samples using the A60 °C method proved the hardness values in the case of 'Alto F1' and 'Cylindra', while the microwave vacuum dried samples had lower values for all investigated beetroot varieties (Fig. 10). Chewiness refers to the work required to crush the product, for which the microwave vacuum dried samples also had better values (Fig 11).

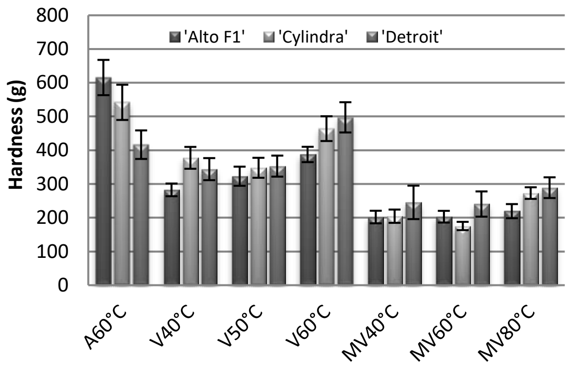

Figure 10: Hardness values of dried samples

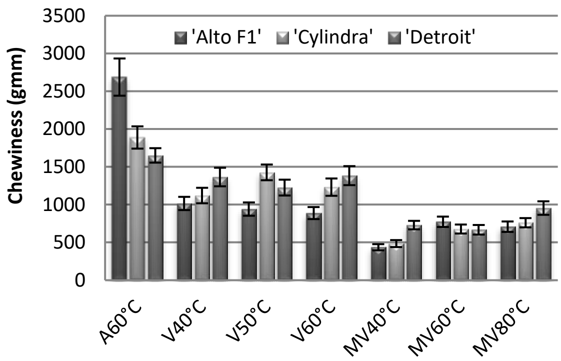

Figure 11: Chewiness values of dried samples

It can be seen that the organoleptic profile of 'Cylindra'and 'Detroit' is similar (Fig. 12). Really outstanding data were in the case of colour homogeneity, where the 'Alto F1' samples were clearly considered the most favourable. At the 0.01 level of confidence, there was a significant difference in colour homogeneity and crispness from the results of the statistical calculation, and at the 0.05 level of confidence between the hue, colour homogeneity, sweet scent, crispness and global taste intensity.

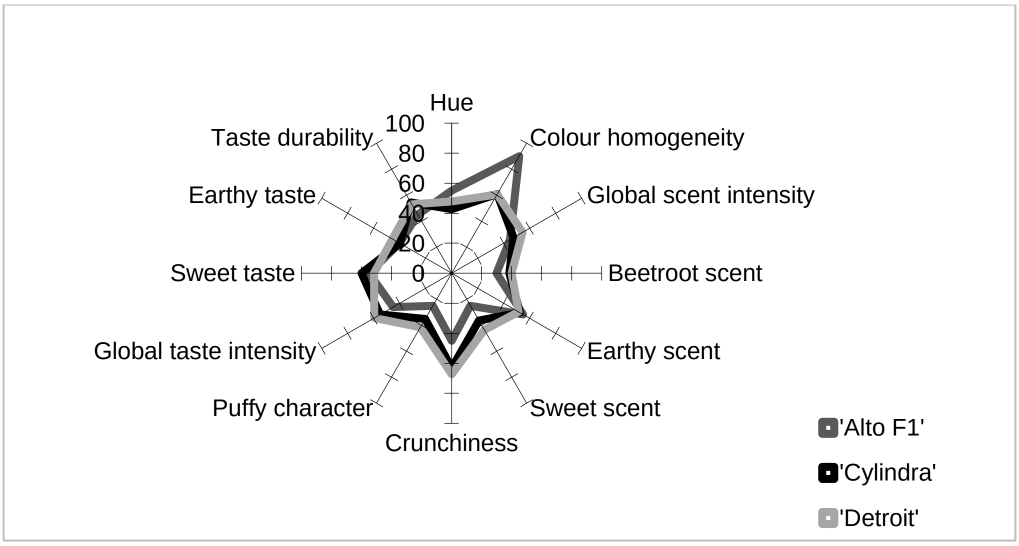

Figure 12: Sensory profile of microwave vacuum dried beetroot species

3.4. New scientific results

1. After the split into three parts of beetroot body applied firstly by me, examined some parts of the 'Alto F1', 'Cylindra' and 'Detroit' beetroot spieces it can be stated the peel parts have the lowest betaxantine content (0.73-1.90 mg / ml). In contrast, the content of betacyanin in the peel parts were partially enriched in the highest amount (2.69-3.53 mg g^{-1}). The peel parts have the highest antioxidant capacity (6197.73-11191.60 µg AAE g^{-1} DW). On the basis of the results of two consecutive years on the whole beetroot body, the betacyanin-betaxantine ratio was 61-74% betacyanine: 26-39% by the 'Alto F1', 'Cylindra' and 'Detroit' beetroot species.

2. In the case of 'Alto F1', 'Cylindra' and 'Detroit' beetroot cultivations, the fertilizer treatment increased the betacyanin, betaxantine content and antioxidant capacity of the samples, but the fertilizer treatment resulted enrichment in the nitrite content of the peel part (average 11.35%).

3. For the 'Alto F1', 'Cylindra' and 'Detroit' beet varieties, to the vacuum drying and the microwave vacuum drying between the pre-drying methods (40 °C, 60°C and 80 °C) required to achieve a moisture content of 30 m/m%, the pre-drying at 60 °C has proved the most suitable method based on the results of betacyanin, betaxantine content and antioxidant capacity.

4. In the case of the 'Alto F1', 'Cylindra' and 'Detroit' beetroot species, the vacuum drying and the microwave vacuum drying resulted lower degradation in betacyanin and betaxantine content compared to atmospheric drying. The microwave vacuum dried samples have special product characteristics that are favoured by sensory critics, and can be proven by texture measurement results, as they have lower hardness, cohesiveness, rubberiness, and chewiness values than atmospheric dehydrated or vacuum dried products.

5. CONCLUSIONS AND RECOMMENDATIONS

For the beetroot varieties grown by me, the analysis of betacyanin, betaxantin, total polyphenol content and antioxidant capacity values showed that there was a significant difference between the years. In all cases, the betacyanin content is partially accumulated in the peel parts, whereas in most cases the betaxanthine content was found in the smallest concentration in the peel parts. The evaluation of the antioxidant capacity and the total polyphenol content showed the tendency for the highest values to be detected in the top and the peel part.

The untreated samples had a lower nitrite and nitrate content for each beetroot varieties on average in both years, but the effect of treatment there was not a significant difference. The nitrite contents of the treated individuals were partly accumulated in the top and the peel part, whereas in the untreated samples of the peel part it was in much lower concentration.

In all cases, the largest amount of vitamin C was partially accumulated in the peel part between the examined parts. There was little discrepancy between the years, and the vitamin C content did not change significantly on the effect of the treatment.

Analyzing of the mineral content, it was found that calcium, manganese and magnesium were mainly accumulated in the highest amounts in the top and the peel part, while the highest iron content was found in the peel part in both years. Typically, the samples cultivated in 2014 had a higher mineral contents, except for the sodium and iron content, by which there was the opposite effect.

Some of the valuable components were enriched in the peel part, so it is important to consider and analyze further this feature especially for medical products.

Analyzing the dried beetroots according to their investigated parameters, in most cases the 'Cylindra' variety proved the most suitable for drying process, within this the MV60 °C drying method provided the most beneficial values.

Evaluating the results of the texture measurement, it can be clearly established that microwave vacuum dried samples compared to atmospheric and vacuum dried products had lower values of elasticity, chewiness, hardness and cohesion values.

Analyzing the results of the sensory criticism, it can be clearly stated that the microwave vacuum dried products were favored by the critics, and based on the profile analysis there were a significant differences between the hue, color homogeneity, sweet smell, taste intensity and crispness of the pieces among the microwave vacuum dried products of the three beetroot varieties which demonstrates the importance of variety choice to technological processes.

As a continuation of the theme, it is worth to include additional beetroot varieties in the experiments to give a more nuanced picture of the differences between varieties. It would also be useful to carry out the drying experiments with beetroots having a larger size.

Publications related to the dissertation

Journals with impact factor

Dóra Székely, Lilla Szalóki-Dorkó, Mónika Stéger-Máté, Beatrix Szabó-Nótin, Judit Ivanics, Judit Monspart-Sényi (2014) Distribution of antioxidant components in roots of different red beets (*Beta Vulgaris* L.) varieties. *Acta Alimentaria*, 23 (Suppl) p. 164-171.DOI: 10.1556/AAlim.43.2014.Suppl.23

Dóra Székely, Klaudia Vidák, Diána Furulyás, Ákos Ribárszki, Mónika Stéger-Máté (2019): Effect of drying methods on physicochemical parameters of different red beetroots (*Beta Vulgaris* L.) species. *Periodica Polytechnica Chemical Engineering*, DOI: 10.3311/PPch.13104 (Published online: 22 January 2019)

Journals without impact factor

Dóra Székely, Brigitta Illés, Mónika Stéger-Máté, Judit Monspart-Sényi (2016): Effect of drying methods for inner parameters of red beetroot (*Beta vulgaris* L.*) Acta Inuv. Sapientiae, Alimentaria,* 9, p. 80-68.

International conference full text

Dóra Székely, Peggi Steinbach, Mónika Stéger-Máté, Judit Monspart-Sényi (2015): Impact of growing conditions of red beetroots (*Beta Vulgaris* L.) for the nutritional charcteristics, Food Science Conference 2015 november 18-19, Corvinus University of Budapest, Proceeding cd, p. 284-251. ISBN 978-963-503-603-5

Dóra Székely, Lilla Dorkó, Mónika Stéger-Máté, Judit Ivanics, Judit Monspart-Sényi (2013): Comparison of morphological and inner content parameters of different beetroot (*Beta vulgaris* l.) varieties. Food Science Conference 2013, Budapesti Corvinus Egyetem, Élelmiszertudományi Kar, Darányi Program, Proceeding: Konferencia kiadvány p. 275-278.

International conference abstract

Dóra Székely, A. Bíró, M. Stéger-Máté, J. Monspart-Sényi (2016): Effect of drying methods for inner parameters of red beetroot *(Beta vulgaris)* International Conference on Science and Technique in the Agri-food Business, ICoSTAF, 2016. június 2.

Dóra Székely, Szabina Virágh, Zsuzsanna Jókai-Szatura, Mónika Stéger-Máté (2017): Investigation of magnesium content of different beetroot (*Beta vulgaris* L.) varieties according to the fertilizer. 15. Magyar Magnézium Szimpózium, 2017. április 18.

Citation

CHHIKARA, N., KUSHWAHA, K., SHARMA, P., GAT, Y., PANGHAL, A. (2019): Bioactive compounds of beetroot and utilization in food processing industry: A critical review. In: *Food Chemistry,* 272 192-200. p. DOI:10.1016/j.foodchem.2018.08.022