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CHANGES OF VITAMIN C CONTENT IN CELERY AND PARSLEY HERB AFTER PROCESSING

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ABSTRACT
Humans and other primates have lost the ability to synthesize vitamin C and therefore the only source is diet. Vitamin C or ascorbic acid has labile nature, it is removed or destroyed in specific degree immediately after harvest, but storage and post – harvest processing also contribute to its degradation. The aim of work was to determine the vitamin C content in the herb of selected celery and parsley varieties in dependence on chosen postharvest processing and to compare it with fresh herb. There were chosen five bulb forms varieties of celery (*Apium graveolens*) – Makara, Ilonaa, Hegy Köi, Talar and Diamant. In case of parsley (*Petroselinum crispum*) there were evaluated one variety of curly parsley, one variety of herb parsley – Petra, and five varieties of root parsley – Lenka, Eagle, Ginate D´Italia, Titana and Arat. Every variety was harvested in three terms, followed by vitamin C content estimation in fresh herb, after drying and after freezing. The content of vitamin C was estimated by HPLC method by the help of liquid chromatograph with UV detector. There was found the significant difference in content of vitamin C in parsley as well as in celery when comparing the fresh herb with herbs after post – harvest processes – drying (by air circulation in laboratory hall) and freezing. After processing of herbs in both observed species the vitamin C content decreased, in case of freezing it was about 65% (celery) and 61% (parsley), after drying about 86% (celery) and 82% (parsley) in comparison with fresh herb. The effect of processing played more important role in influencing of vitamin C content than variety in case of both selected species. For using of celery and parsley not only as culinary herb, but as a notable source of ascorbic acid it is the most important fresh herb intake.

Keywords: parsley; celery; ascorbic acid; freezing; drying

INTRODUCTION
Vitamin C, also known as ascorbic acid, L-ascorbic acid or L-ascorbate, is the most important vitamin for human nutrition that is supplied by fruits and vegetables. Actually, vitamin C is almost a generic name for all compounds that exhibit the same biologic activity as ascorbic acid **Stan et al. (2014)**. Although there are many functions of vitamin C, his role in health is discussed mostly in relation to its role as an antioxidant and its effects on cancer, blood pressure, immunity, drug metabolism and urinary excretion of hydroxyproline **Barrita et al. (2013)**. Vitamin C reinforced the immune system, supports digestion and stimulates appetite. It stimulates liver function and helps with the gout. It neutralizes harmful substances from cigarette smoke **Juríková et al. (2013)**. It can act as an anti-carcinogen and reduces the risk of cardiovascular diseases **Šlosár et al. (2008)**. Due to hypovitaminosis the fatigue starts and the resistance to infection decreases. Critical periods are particularly in the end of winter and spring period when the intake of ascorbic acid from natural sources is small **Keresteš (2011)**.

Humans and other primates have lost the ability to synthesize vitamin C as a result of a mutation in the gene coding for L-gulonolactone oxidase, thus vitamin C must be obtained through the diet **Carr et al. (1999)**. In addition, it is well known that AA content declines during storage, especially in thermally treated foods, with the consequent formation of non-enzymatic browning compounds, which serve as indicators of organoleptic quality loss of the product **Uddin et al. (2002)**. Amounts of nutrients are removed or destroyed by storage of raw materials or technological processing (drying, grinding) **Leahu et al. (2013)**. The lowest ascorbic acid value was found after convective drying, followed by vacuum drying and microwave drying. With convective drying, the appearance values of the dried parsley decreased when the drying period was extended **Akbudak et al. (2011)**. Vitamin losses are also caused by sunlight. Vegetables loses during a short staying in the sun even 50% of vitamin C. In the shadow, it loses only 15% during the same period **Jedlička (2012)**. Due to the labile nature of vitamin C, extraction procedures are designed to avoid the loss of vitamin **Odriozola et al. (2007)**.

Efficient sources of ascorbic acid are parsley (*Petroselinum crispum*) and celery (*Apium graveolens*), both from family Apiaceae, which are ranged between vegetables as well as culinary herbs, in dependence on variety, with wide spectrum of using. Besides vitamin C they are rich in other antioxidants, essential vitamins, elements like iron, calcium, potassium, phosphorus, magnesium, sulfur, crystal and also in volatile and fixid oils (lipids). In Apiaceae petroselinic acid is the major fatty acid **Shams et al. (2015)**. For their specific taste and smell, mainly due to volatile oils they are worldwide used as culinary herbs as well. Celery plays a role in prevention of cardiovascular disease, lowering blood glucose and serum lipid, decrease blood pressure and strengthener the heart. This herb has anti- bacterial, anti-fungal and anti-inflammatory effects. Also, a powerful antioxidant property has been attributed to compounds such asapigenin, apiein, vitamins A and C **Kooti et al. (2014)**.

Parsley with high iron content protects against to anaemia. Parsley has been reported to have possible medicinal attributes as an antioxidative, antimicrobial, anticoagulant, antihyperlipidemic and antihepatotoxic **Yanardag et al. (2003)**. It is a useful source of calcium. It has a diuretic effect; it is used in diseases like the kidneys, bladder infections, urinary and kidney stones, inflammation of the prostate and intestinal colic **Juríková et al. (2012)**. In Slovakia and Central Europe, it is primarily grown as root parsley, in lower extent as leaf parsley. Especially in case of leaf type there was bred several forms with variously divided and curly leafs **(Kóňa, 2006; Uher et al., 2009)**.

The aim of the work was to determine the vitamin C content in the herb of selected celery and parsley varieties in dependence on postharvest processing.

MATERIAL AND METHODOLOGY

The project was led on the land of the Slovak Agricultural University in the Department of Vegetables-Production. Celery was sowing in greenhouse, because of its requirements to warm conditions. Sowing was realised on 14th of February, 2013 and it was replanted in to rooting boxes on 21st of March, 2013, followed by planting out in to prepared soil on 7th of May, 2013. The plant spacing was 40 x 30 cm, 9 pieces in row, three rows for each observed variety. Parsley was sowing directly into the soil of 18th of April, 2013, in two rows for each variety.

There were used five bulb forms varieties of celery (Apium graveolens) – Makara, Ilonaa, Hegy Köi, Talar and Diamant. In case of parsley (Petroselinum crispum) there were evaluated one variety of curly parsley, one variety of herb parsley – Petra, and five varieties of root parsley – Lenkab, Eagle, Ginate D´Italia, Titana and Arat.
The trail consists from three variants:

- Analyses in fresh herb,
- Analyses in dried herb
- Analyses in frozen herb

In every variant, there were done three terms of harvest - a first one, second and third harvest. After harvesting of the plants vitamin C was determined in the laboratory of the Department of Vegetables - Production (Horticulture and Landscape Engineering Faculty). In case of fresh herb the analysis were done immediately after harvest, in dried herbs the sample was analysed one month after harvest in average (after drying by air circulation in laboratory hall of department) and in case of frozen herbs after three months of freezing. Terms of harvesting and terms of evaluations in laboratory after processing are figured in (Table 1). Both species were analysed at the same time.

The content of vitamin C estimation

HPLC method of vitamin C content estimation **Stan et al. (2014)** was used by the help of liquid chromatograph with UV detector, for separation was used RP C18 column, mobile phase was methanol : water (5:95, v/v), UV detection was adjusted to 258 nm (HPLC fy. VARIAN).

Statistical analyses

The obtained data were processed into tables in Microsoft Office Excel 2007. Then analysis of variance (ANOVA) were used by the help of the LSD test (significance level $\alpha = 0.05$) for statistical analyses in the program Statgraphic Centurion XVII (StatPointInc. USA).

RESULTS AND DISCUSSION

The value of vitamin C content in celery ranged in interval from 45.73 ±5.47 mg.100 g^{-1} (variety Diamant) to 56.79 ±8.72 mg.100 g^{-1} (variety Hegy Köi) in case of fresh herb, from 17.38 ±1.47 mg.100 g^{-1} (Talar) to 20.34 ±3.51 mg.100 g^{-1} (Hegy Köi) in case of frozen herb and from 5.82 ±1.46 mg.100 g^{-1} (Talar) to 9.06 ±1.85 mg.100 g^{-1} (Hegy Köi). Variety Hegy Köi reached the highest values in case of all evaluated thermal processes, but from the point of view of variety impact on vitamin C content, the varieties created almost homogenous group expect of statistical significant differences between couples of varieties Diamant - Hegy Köi and Hegy Köi – Talar according to used statistical analyses (Table 2).

Jedlička (2012) features the average values of vitamin C content in fresh herb of celery equal to 3.1 mg.100 g^{-1}. The values in case of all our varieties are higher. On the other hand, in comparison with the results of **Kóňa (2006)** there were found lower values, as he features average values of vitamin C in celery herbs 88.96 mg.100 g^{-1}, whereby the maximal values reached 142.00 mg.100 g^{-1}, minimal values 27.92 mg.100 g^{-1}. It corresponds with the results of **Kopec (2010)** with the average values for celery equal to 89.00 mg.100 g^{-1}.

Table 1 Dates of vitamin C content analyses in chosen varieties of celery and parsley.

Date of herb harvest	4th July 2013	19th August 2013	20th September 2013
Drying of herb until	26th July 2013	9th September 2013	14th October 2013
Freezing of herb until	24th October 2013	12th December 2013	8th January 2014

Figure 1 Parsley tops ready for drying.

Figure 2 Celery tops ready for drying.

When evaluating impact of thermal process on vitamin C content (Figure 3), there were high significant differences in case of all observed variants. In fresh herb the values were the highest, and then there was rapid decreasing in frozen herb variant, the lowest values were found in third variant – dried herb. It is in accordance with the results of **Roslon et al. (2010)**, where they tested leaves from two cultivar varieties of celery: 'Safir' – a leaf variety and 'Jabłkowy' – a celeriac variety. Fresh leaves contained on average 104.90 mg.100 g^{-1} of vitamin C. Freezing and drying caused decreasing content of vitamin C in investigated raw material.

The content of vitamin C in fresh herb of parsley reached values from 197.14 ±25.55 mg.100 g^{-1} (Eagle) to 170.43 ±19.05 mg.100 g^{-1} (Ginate D´Italia) as it is mentioned in Table 3. When comparing to **Kóňa (2006)**, our results are similar to average values of vitamin C content in parsley fresh herb, as he mentions 179.33 mg.100 g^{-1} in average, 340.00 mg.100 g^{-1} for maximal values and 150.00 mg.100 g^{-1} for minimal values. According to **Kopec (2010)** average vitamin C content was 136.90 mg.100 g^{-1}, which is lower than our results. In generally parsley herb belongs to sources with the highest content of vitamin C in vegetables. It is obvious as well from our results (Figure 3) in comparison of average values both observed crops, in all three variants. In **Matějková et al. (2010)** the vitamin C content was the highest by parsley leaves (1692 $mg.kg^{-1}$), parsley contained high vitamin C amounts also in root (515 $mg.kg^{-1}$). Chrysanthemum, mustard and mizuna also showed high ascorbic acid content according to **Kudrnáčová et al. (2015)** where they proved them to be another important source of vitamin C. Ascorbic acid content detected in their spring varieties ranged from 1890 to almost 3000 $mg.kg^{-1}$. The influence of variety on vitamin C content is figured in table 3, whereby there was found significant differences between varieties according to used statistical analyzes. Varieties Eagle and Arat reached significantly the highest values. Similarly, then in case of celery, there was found the significant difference in content of vitamin C in fresh herb and then in herbs after following post – harvest processes – drying and freezing. As it is represented in Figure 3, the highest values were found in case of fresh herb variant, following by frozen variant and the drying looks like the worse choice for vitamin C content preservation. It corresponds with results of **Leahu et al. (2013)** where the greatest values of acid ascorbic concentration were registered in the fresh parsley 347.60 ±6.2 $mg.100g^{-1}$. The greatest reduction in the content of ascorbic acid was in the dried dill samples (89.33%), followed by parsley (75.41%). Freezing of plants was decreasing the vitamin C content, but drying and higher temperatures have higher influence on the degradation of vitamin C in comparison to control. According to **Garba et al. (2014)** it was found that total vitamin C, was higher at lower drying temperature of 40 ˚C as expected. As the drying air temperature increases from 40 – 60 ˚C, decreased in ascorbic acid was observed. Similarly, there was observed the effect of temperature and storage period on the preservation of vitamin C, thiamine and riboflavin in leaves and whole plants (leaves with petioles and stems) of dill by **Lisiewska et al. (2003)**. In dill, the treatment of blanching affected a decrease in the level of vitamin C by 35 – 48%. The losses affected by blanching in the content of vitamin C in leafy vegetables ranged from 47% even to 80%. The content of vitamin C depends as well on the term of storage, even in refrigerator. **Howard et al. (1999)** showed a linear decrease in vitamin C content during refrigerated storage of vegetables.

After processing of herbs in both observed species the vitamin C content decreased in comparison with fresh herb, in case of freezing it was about 65% (celery) and 61% (parsley), after drying about 86% (celery) and 82% (parsley). Influence of the processing on AA content was observed in study of **Mareček et al. (2016)**, where they determined primary and secondary metabolites (including AA) in selected varieties of potatoes. The highest content was in the fresh tubers, whilst heat treatment reduces AA amount. Among the assessed cultivars the highest content showed tubers of variety Red Anna with purple skin (73.72 $mg.kg^{-1}$). Conversely, variety Picasso reached its lowest value (35.02 $mg.kg^{-1}$). The amount of vitamin C decreases due to storage conditions. From results presented

Table 2 Vitamin C content in celery (*Apium graveolens*) in dependence on variety and thermal processing*.

celery (*Apium graveolens*)			
Variety	**fresh herb** mg.100 g^{-1}	**frozen herb** mg.100 g^{-1}	**dried herb** mg.100 g^{-1}
Makar[ab]	54.24 ±8.30	18.39 ±3.04	7.11 ±1.68
Ilona[ab]	49.48 ±5.47	17.87 ±4.37	8.20 ±1.85
Hegy Köi[b]	56.79 ±8.72	20.34 ±3.51	9.06 ±1.85
Talar[a]	47.67 ±3.28	17.38 ±1.47	5.82 ±1.46
Diamant[a]	45.73±5.47	16.06 ±3.36	6.51 ±1.36

Note: *Means ± standard deviation. Different lowercase letters in column with names of varieties marks significant differences at p <0.05 by LSD in ANOVA (Statgraphic).

Table 3 Vitamin C content in parsley (*Petroselinum crispum*) in dependence on variety and thermal processing*.

parsley (*Petroselinum crispum*)			
Variety	**fresh herb** mg.100 g^{-1}	**frozen herb** mg.100 g^{-1}	**dried herb** mg.100 g^{-1}
Curly Parsley / CP[ab]	171.90 ±23.26	63.98 ±15.25	31.50 ±6.50
Petra[ab]	172.63 ±8.52	62.23 ±8.568	30.09 ±5.98
Lenka[bc]	183.84 ±16.31	76.63 ±12.87	34.18 ±8.03
Eagle[c]	197.14 ±25.55	80.82 ±15.69	36.63 ±9.04
Ginate D´Italia[a]	170.43 ±19.05	59.56 ±9.27	28.42 ±6.43
Titan[ab]	171.50 ±13.30	66.42 ±12.09	28.42 ±5.74
Arat[c]	194.91 ±16.06	81.94 ±13.36	36.54 ±7.79

Note: *Means± standard deviation. Different lowercase letters in column with names of varieties marks significant differences at p <0.05 by LSD in ANOVA (Statgraphic).

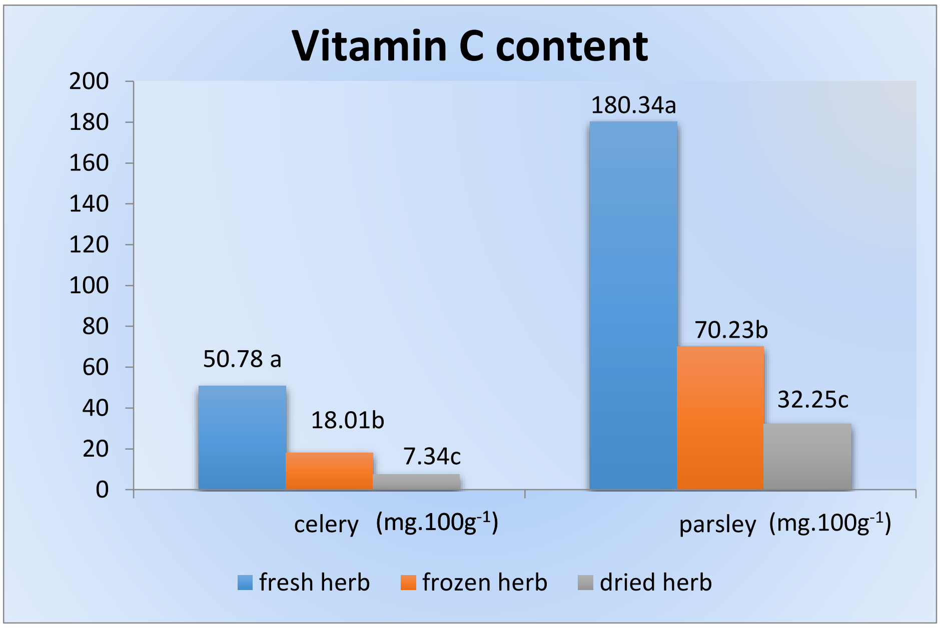

Figure 3 Graphical representation of statistical analysis of vitamin C content in celery and parsley herb depending on the observed variant. Note: *Different lowercase letters in graphs marks significant differences at p <0.05 by LSD in ANOVA (Statgraphic).

by **Matějková et al. (2014)** where they analysed variety, growing site, year and storage influence on the ascorbic acid content by selected vegetables there was noted statistically significant decrease of vitamin C after 30-days storage. The losses of vitamin C were highest in carrot (45%), followed by parsley (25%), garlic (24%) and onion (22%).

CONCLUSION

The submitted work was oriented to determination of vitamin C content in herb of selected celery and parsley varieties in dependence on postharvest processing. There were chosen 5 celery and 7 parsley varieties to evaluation. Every variety was harvested in three terms, followed by vitamin C content estimation in fresh herb, after drying and after freezing. Freezing of plants was decreasing the vitamin C content, but higher influence on the degradation of vitamin C has drying, which was confirmed by statistical analyses. In fresh herb the values were the highest 180.30 $mg.100g^{-1}$ for parsley and 50.78 $mg.100g^{-1}$ for celery, and then there was rapid decreasing in frozen herb variant to 70.23 $mg.100g^{-1}$ (parsley) and to 18.01 $mg.100g^{-1}$ (celery), followed by the lowest values in third variant – dried herb with the values 32.25 $mg.100g^{-1}$ (parsley) and 7.34 $mg.100g^{-1}$ (celery). The influence of variety on vitamin C content was confirmed only in some cases, the effect of processing plays significantly more important role in quantity of ascorbic acid in both selected species. Their fresh herb is notable source of tested antioxidant, very popular as culinary herb for its aromatic profile, but with additional value of medicinal effects.

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