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DYNAMICS OF SELECTED BIOACTIVE SUBSTANCES CHANGES IN *CUCURBITA MOSCHATA* DUCH. EX POIR. AFTER STORAGE AND DIFFERENT METHODS OF TECHNOLOGICAL PROCESSING

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Abstract

ANDREJIOVÁ ALENA, HEGEDŰSOVÁ ALŽBETA, ŠLOSÁR MIROSLAV, BARÁTOVÁ SILVIA. 2016. Dynamics of Selected Bioactive Substances Changes in *Cucurbita Moschata* Duch. Ex Poir. After Storage and Different Methods of Technological Processing. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 64(2): 387–393.

The winter squash is an important source of antioxidants, especially carotenoids. The aim of submitted research work was to determine the effect of genotype, storage and different methods of technological processing (baking, boiling and sterilization) on the content of ascorbic acid and total carotenoids in fruits of winter squash (*Cucurbita moschata* Duch. ex Poir.). The small-plot field experiment was established at Slovak University of Agriculture in Nitra in 2013. Five cultivars of winter squash ('Liscia', 'Orange', 'Hannah', 'UG 205 F1' and 'Waltham') were examined in experiment. The total carotenoids content in the pulp of fresh fruits was ranged from 9.33 to 15.10 mg.100 g^{-1}. Its highest value was determined in case of 'Orange' variety. The storage and the thermal treatment of fruit pulp in case of baking had positive impact from the total carotenoid content point of view. The baking resulted in the increase of its value in winter squash. On the contrary, sterilization tended to the decrease of total carotenoid content in edible part of squash. The total carotenoids content in the baking pulp was ranged from 14.27 to 31.87 mg.100 g^{-1}. The vitamin C content before storage and technological processing ranged in interval from 13.88 to 18.69 mg.100g^{-1}. Particular thermal methods of processing and storage resulted in decrease of vitamin C content in the pulp of all winter squash varieties.

Keywords: *Cucurbita moschata*, winter squash, cultivar, total carotenoids, ascorbic acid, technological processing, storage

INTRODUCTION

Cucurbita moschata Duch. ex Poir. is an annual plant of the family *Cucurbitaceae*. It was native to the low lands of tropical and sub-tropical America (Mexico and South America) (Bisognin, 2002). *C. moschata* is eaten as vegetable and cultivated for its young shoots, fedible flowers and above all, for its fruits (Jacobo-Valenzuela *et al.*, 2011). Its fruits are one of the most important crop-plants in traditional agricultural systems in the world. Meanwhile, it is growth only rare in our conditions, in south parts of Slovakia and on very small areas (Meravá, 2012). It is believed that squash is a healthy and functional vegetable because of its rich nutrients and bioactive compounds contents such as phenolics, flavonoids, vitamins (including β-carotene, vitamin A, vitamin B2, α-tocopherol, vitamin C, and vitamin E), amino acids, carbohydrates and minerals (especially potassium), and its low energy content (about 17 kcal/100 g of fresh pumpkin) and its large amount of fiber (Tamer *et al.*, 2010).

Based on epidemiological studies a positive link is suggested between higher dietary intake and tissue concentrations of carotenoids and lower risk of chronic diseases (Rao and Rao, 2007). Total carotenoids content in the winter squash can

be influenced by many of factors what includes variety, level of ripeness, place of growing, climate conditions, harvest, storage conditions, as well as very analyzes (Rodriguez-Amaya *et al*., 2008). Another compound that is associated with a low risk of developing degenerative diseases such as cancer, diabetes, cardiovascular, and neurological diseases and is present in this squash is the vitamin C (Jacobo-Valenzuela *et al*., 2011). The winter squash is a vegetable which fruits are harvested in botanical ripeness and it can be stored from 90 to 180 days in case of suitable store conditions (Uher *et al*., 2012; Valšíková and Kopec, 2009). Food preparation at home, in particular, cooking is often the final step in food processing. Most of the vegetables are commonly cooked either by simple boiling or baking before consumed. These cooking processes would bring about a number of changes in physical characteristics as well as chemical composition of the vegetables (Azizah *et al*., 2009).

The aim of contributed thesis was to find out a variety influence on chosen content of qualitative parameters (total carotenoids and vitamin C) in fresh winter squash pulp as well as dynamics of its bioactive substances changes under the influence of storage conditions and various methods of technological treatment (baking, cooking, sterilization).

MATERIALS AND METHODS

A field experiment was founded in 2013 in Botanical Garden of Slovak University of Agriculture (below BG SUA). There were included 5 varieties of winter squash: 'Liscia', 'Orange', 'Hannah', 'UG 205 F1' and 'Waltham' (Tab. I).

There was planted out 5 plants in 2.50×1.50 m row spacing in frame of every observed variety. Sowing of seeds was holding on 2nd of May, 2013 in heated greenhouse of BG SUA in Nitra. In trial area there was applied LAD (27%) in dosage 201 kg.ha^{-1} two weeks before outplanting on the base of soil agrochemical analyses (Tab. II). This represents 60% of recommended norm.

Plant gardening was realized 30th of May 2013. During vegetation term the plants were fertilized by Ammonium nitrate with dolomite (LAD) – 27% N in dosage 134 kg.ha^{-1} in 17th of July 2013. Treatment of plants was held by conventional agricultural process. Harvest of fruits in botanical ripeness was realized in two terms: 24th of September 2013 and 10th of October 2013.

Average pattern was created from 5 fruits of the second harvest term from various plants within the frame of every observed variety. Total carotenoids, as well as vitamin C, were estimated immediately after harvest in fresh winter squash pulp including control variant, followed by estimation in fresh pulp after storage (52 days) in conventional store conditions (15 °C) and subsequently after thermal treatment.

Variants of Experiment

Control – raw squash:

I. raw squash after storage before thermal treatment,
II. baked squash after storage,
III. boiled squash after storage,
IV. sterilized squash after storage.

Before the analysis of samples, the fresh pumpkins were washed under tap water and hand-peeled. Technological treatment – baking was running for 20 min at the temperature of 180 °C in air oven. The fruits of winter squash were cut in 15 mm thick sheets. Modification – cooking was realized by cutting of winter squash to 20×20 mm big pieces, which were dipped in to the boiling water for 10 min. Sterilization of equally big pieces in 20% sweet pickle (m) was in progress for 20 min at the 80 °C temperature. The edible pulp was homogenized using a kitchen food processing machine. Measurements were realized in three repetitions on the Department of Vegetables Production, HLEF, and SUA in Nitra.

Total Carotenoids

Carotenoids were estimated by spectrophotometric measurement of substances absorbance in petroleum ether extract on spectrophotometer PHARO 100 at 445 nm wavelength. As a dissolution reagent there was used acetone.

I: *Assortment of evaluated winter squash varieties*

Variety	Pulp colour	Origin
Liscia	yellow-orange	Semo a. s., Czech Republic
Orange	orange	ZKI Vetőmag KFT., Hungary
Hannah	yellow-orange	Enza Zaden, Holland
UG 205 F1	yellow-orange	Orosco KFT., Hungary
Waltham	yellow-orange	Botanical Interests, Colorado, USA

II: *Agrochemical characteristics of the soil before the experiment foundation according to Mellich*

Year	pH/KCl	Nutrients content in mg.kg^{-1} of soil				
		N	P	K	Ca	Mg
2013	6.96	4375	199	609	4976	576

Ascorbic Acid

Most frequent method of vitamin C content estimation is titration method, where oxidative attribute of ascorbic acid (vitamin C) is used for its quantity estimation. Ascorbic acid reacts with 2.6 dichlorphenolindolphenol whereby dehydroascorbic acid is created and reduced in to colorless base.

Statistical Analysis

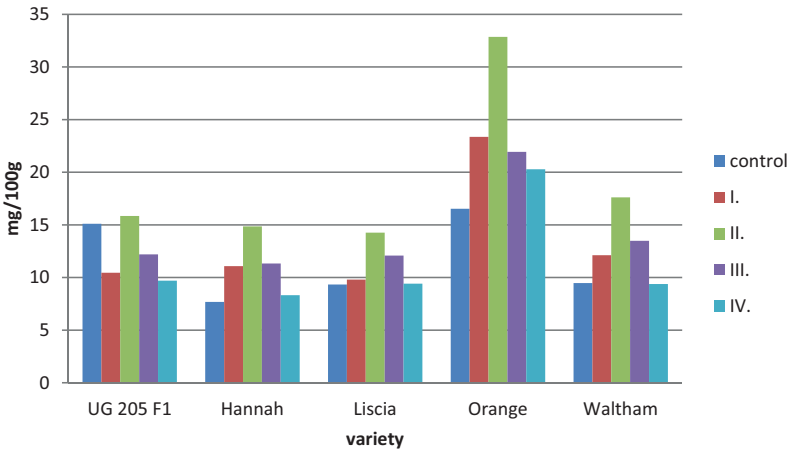
The analysis of variance (ANOVA), the multifactor analysis of variance (MANOVA) and the multiple Range test were done using the Statgraphic Centurion XV (StatPoint Inc. USA).

RESULTS AND DISCUSSION

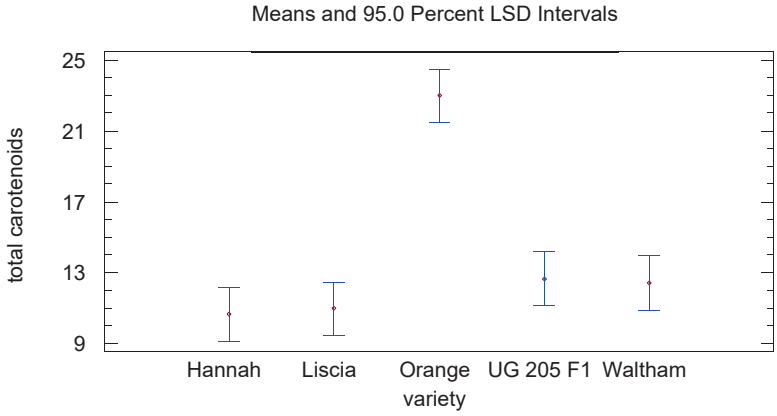
Evaluation of Total Carotenoids Content

The total carotenoids content in the fresh fruits pulp of selected winter squash varieties was ranged from 9.33 to 15.10 mg.100g^{-1} (Fig. 1). In dry matter the content ranged in interval from 67.05 to 150.44 mg.100g^{-1}. The highest content was determined in 'Orange' variety, which was noted for intensive orange color of pulp. Our results are comparable with results of various authors, who are featuring the total carotenoids content of winter squash dry matter in interval from 16.00 to 139.94 mg.100g^{-1} (Jacobo-Valenzuela *et al.*, 2011; Philandra-Kumar *et al.*, 2001; Tamer *et al.*, 2010). On the basis of statistical evaluation by the analysis of variance methods there was found very significant variety influence on total carotenoids content. Significant differences were found between 'Orange' variety and other evaluated varieties (Fig. 2).

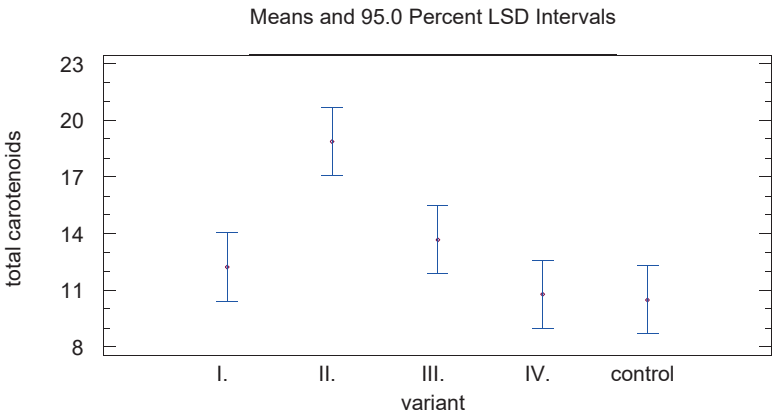
The stability of carotenoids differs in different foods, even when the same processing and storage conditions are used (Rodriguez-Amaya, 1997). According to Provesi *et al.* (2011), who were observed carotenoids concentration in 'Menina Brasileira' variety, storage in period of 180 days didn't significant influence monitored carotenoids concentration. On the basis of our measurement, conclusion could be declared; 52 days storage had positive influence on total carotenoids content in raw pulp in case of all winter squash varieties, except of one variety. On the contrary in case of 'UG 205 F1' there was decrease in total carotenoids content (Fig. 1).



1: *The average content of total carotenoids in different varieties of winter squash, depending on storage and thermal treatment (mg.100 g^{-1} green matter)*



2: *The total carotenoids content of selected winter squash varieties (mg.100g^{-1})*



3: *The total carotenoids content in winter squash dependency to observed variants (mg.100g^{-1})*

In case of 'Orange' variety there was increase about 41% in comparison with the control variant. Carotenoid biosynthesis may continue in fruits, fruit vegetables, and root crops, even after harvest, provided these plant materials are kept intact and not treated in any way that would inactivate the enzymes responsible for carotenogenesis. In leaves and other vegetables, post-harvest degradation of carotenoids appears to prevail, especially at high storage temperature and under conditions that favor wilting (Rodriguez-Amaya, 1997).

Baking of pumpkins belongs to traditional way of cooking. In case of baking (variant II.) there was observed an increase of total carotenoids content in pulp of all observed winter squash varieties in comparison with control variant as well as with variant I (after storage, without thermal treatment). Heat processing increases the bioavailability of carotenoids by breaking cell walls and allowing extraction of the lycopene from the chromoplasts, where it is found in raw pumpkins. The total carotenoids content in the baking pulp was ranged from 14.27 to 31.87 mg.100 g^{-1}. On the basis of statistical evaluation by the analysis of variance (ANOVA) method it can be established that the variant influence on total carotenoids content was high significant and statistically significant differences were determined between variant II (bake squash after storage) and other monitored variants (Fig. 3).

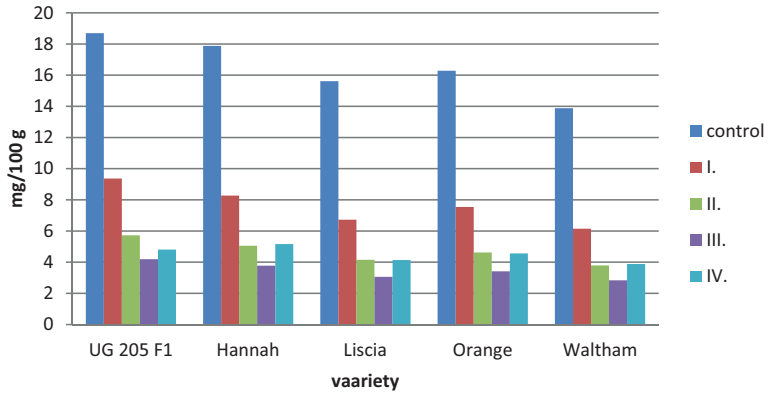
The influence of squash boiling on total carotenoids content is varied according to results of studies. On the basis of our experiment there was noticed moderate increase of total carotenoids content in variant III (boiled in water for 10 minutes) by comparison with variant I (after storage, without thermal treatment) in case of varieties: 'UG 205 F1', 'Hannah', 'Liscia' and 'Waltham'. Also Azizah *et al.* (2009) present positive influence of squash pulp cooking for 2, 4 and 6 min to evaluated carotenoids content (lykopene, β-carotene), whereby there was noticed the highest increase in case of longest cooking time when compared with control variant. On the contrary Rodriguez-Amaya (2008) in his tasks declares that boiling treatment for 10 minutes providing winter squash 'Menina brasileira' variety have led to moderate decrease of chosen carotenoids content (α-carotene, β-cartotene).

After sterilization the total carotenoids content in pulp of observed varieties was ranged in interval from 8.32 mg.100 g^{-1} ('Hannah') to 20.28 mg.100 g^{-1} ('Orange'). Thermal treatment – sterilization of squash led to decrease of carotenoids content in comparison with variant I (before thermal treatment) in case of all evaluated winter squash varieties.

Evaluation of Vitamin C Content

According to vitamin C content evaluation in fresh fruits of observed winter squash varieties can be established that average content of vitamin C before storage ranged in interval from 13.88 to 18.69 mg.100 g^{-1} in fresh matter, whereby the highest content was found in case of 'UG 205 F1' variety (Fig. 4). Storage had negative influence on vitamin C content in fresh winter squash fruits, whereby there was noticed 50% decrease in most of varieties. Gonçalves *et al.* (2011) mentioned similar values (15.46 mg.100g^{-1}) in their task, whereby they monitored content of vitamin C in *Cucurbita maxima* raw fruits. There was also noticed decrease of vitamin C concentration to 10.64 mg.100g^{-1} in case of raw fruits storage in frost conditions.

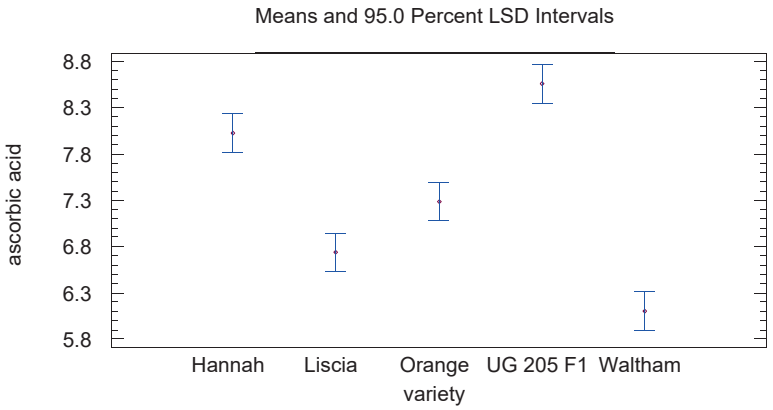
Cooking is often responsible for the greatest losses of ascorbic acid, and the extent of the loss depends upon variations in the cooking methods and periods (Bineesh *et al.*, 2005). Because the preparation and stabilization of home-cooked products, such as soups and sauces from squash pulp, would involve thermal treatments, the ascorbic acid retention in squash pulp held for 30 min at 95 °C was investigated. The percentage of ascorbic acid retention was 82.43 + 2% (Roura *et al.*, 2007). On the basis of our results there can be confirmed conservation of vitamin C, providing the thermal treatment – baking, only on 61% in average in case of all observed varieties (Tab. III) Under the impression of cooking for 10 min there was decreasing of



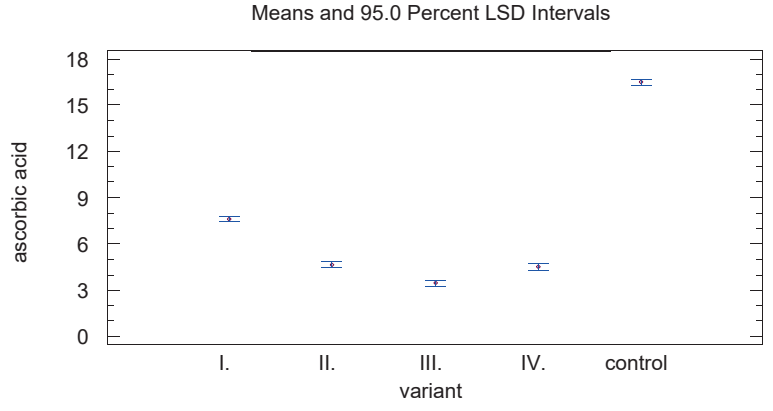
4: *The average content of ascorbic acid in different varieties of butternut squash, depending on storage and thermal treatment (mg.100 g^{-1})*

III: *The vitamin C preservation (%) in winter squash pulp according to various thermal treatments*

Variety	Variant (before tethermal treatment variant)		
	II. (baked)	**III. (cooked)**	**IV. (sterilized)**
UG 205 F1	61.00	44.76	51.36
Hannah	61.02	45.60	62.71
Liscia	61.70	45.44	61.55
Orange	61.27	44.10	60.48
Waltham	61.63	46.07	63.09



5: *The vitamin C content in selected winter squash varieties (mg.100g^{-1})*



6: *The vitamin C content in winter squash dependency to observed variants (mg.100g^{-1})*

vitamin C content even more marked. The pulp sterilization led to preservation of vitamin C at the level of 51.36–63.09% in dependence on variety.

According to statistical analysis there can be confirmed influence of variety as well as variant to vitamin C content in winter squash pulp. With regard to Figs. 5–6 this influence was very high statistically significant.

Significant differences were found also in content of vitamin C between all of observed varieties and variants. There wasn't found any significant difference between variant II (baked squash) and variant IV (sterilized squash).

CONCLUSION

The winter squash (*Cucurbita moschata* Duch. ex Poir.) belongs to less known vegetables, which are consumed in small rate in Slovak Republic. The aim of submitted research was to find out variety influence on total carotenoids and vitamin C content in winter squash fruits as well as dynamics of bioactive substances changes influenced by storage and various methods of technological treatment (cooking, baking, and sterilization). In the experiment there was observed 5 winter squash varieties 'Liscia', 'Orange', 'Hannah', 'UG 205 F1' and 'Waltham'. The total carotenoids content in pulp of winter squash fruits was varied in the interval from 9.33 from 15.10 mg.100g^{-1} in fresh mass. Winter squash belongs to crops, which can come to after – harvest maturing and that is the reason of carotenoids increase in squash pulp. Storage during 52 days had positive influence on total carotenoids content in case of all observed varieties except of 'UG 205 F1' variety. Equally there was an increase of total carotenoids content in all winter squash varieties following the thermal treatment – baking (20 min by 180 °C temperature). In effect of squash pulp boiling in water for 10 minutes there was found moderate increase of total carotenoids content by comparison with variant I (after storage, without thermal treatment) in case of varieties: 'UG 205 F1', 'Hannah', 'Liscia' and 'Waltham'. Thermal treatment – sterilization of squash led to decrease of carotenoids content in comparison with variant I (before thermal treatment) in case of all evaluated winter squash varieties. Average content of vitamin C in winter squash fresh pulp before storage ranged in interval from 13.88 to 18.69 mg.100 g^{-1} in fresh matter. In consequence of storage as well as various thermal treatments there was found out decrease of vitamin C content in winter squash pulp. Because the winter squash is usually consumed by some thermal treatment, the consumer can influence the content of these substances in pulp with culinary making – up. Baking is considered to be the most suitable thermal treatment, which leads to increase of total carotenoids in the squash pulp and preservation of vitamin C is also the highest.

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