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COMPARING THE QUALITY PROPERTIES OF FRESH AND DRIED APPLE FRUIT - VARIETIES *PINOVA* AND *RED DELICIOUS*

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Abstract

The quality and the nutritional composition of fresh and dried apple fruits of the varieties *pinova* and *red delicious* were tested. The apples were grown in the region of Bitola in the Republic of Macedonia. The fruits were harvested manually after the visual assessment on terrain and after determination of harvesting time. After analyzing the mechanical and chemical properties of the fresh fruit, the fruit was prepared for drying. The treatment of the raw material was done with 0.1 % solution of citric acid and 0.5 % solution of $K_2S_2O_5$, with time of immersion of five minutes. In order to compare the impact of applied treatments on the tested chemical properties, we also applied a variant of untreated fruit (control). Drying was performed in a chamber dryer from the type S-100, at a temperature between 65 °C to 70 °C for 6 to 8 hours. From the chemical composition of fresh and dried apple fruit, we examined: the total dry matter, total sugars, total acids, vitamin C, pectin, flavonoids, tannins and mineral matter. The fresh fruits from the *pinova* variety were characterized by better mechanical properties (weight 137.35 g, height 62.56 mm, width 68.78 mm) compared to the fruits of the r*ed delicious* variety. In fruits from this variety there were higher values 14.16 % for: total sugars, 0.34 % total acids, flavonoids 2.66 μg/g, tannins 1.39 μg/g and mineral matters 0.25 %. After the analysis of dried apple fruits, the varieties of p*inova* and *red delicious*, the higher content of vitamin C was found in fruits treated with 0.5 % solution of $K_2S_2O_5$. The process of drying in a chamber drier enabled preservation of the chemical properties and getting a quality final product.

Keywords: analysis, chamber dryer, nutrients, treatments.

Introduction

The apple is an important fruit crop used in the diet in fresh or processed form. The chemical composition and sensory characteristics of apple fruits are also referred to as the source of important nutrients (Dobričević et al., 2008). In the total production, trade and consumption of fruits in the world, apples occupy the third place. In Republic of Macedonia, the apple is the most common fruit crop, which in recent years covers about 60 % of the total fruit production (Стефановска, 2016). The apple belongs to the group of fruits where it can be stored fresh for a longer period by applying appropriate storage and warehousing conditions. The warehousing is an expensive process and is often not economically viable, but by applying the drying process will allow the apples to be available on the markets year around.

The drying process preserves the fruit, even in absence of the cooling storage, it significantly prolongs its shelf life (Каракашова, 2011). Although the primary goal of drying is the preservation of fruit, lately there are other reasons for drying the fruits, such as economic, nutritional and physiological, etc. (Lovrić and Piližota, 1994). The process of preservation by drying ensures the microbiological and enzymatic stability of the product, but it must be emphasized that during the drying, there is some loss of vitamins, aromatic substances, as well and darkening (oxidation) of the product (Bušić, 2014). The choice of the drying devices depends on the type and characteristics of the fruit, i.e., the final product (size, shape, co-existence), as well as the capacity and the cost of production. Apples are almost exclusively dried in microclimate conditions, so-called, dryers (Lovrić and Piližota, 1994). The chemical composition and the technological properties of the raw material determines the technological procedure that will be applied, which reactions can be expected during processing, what kind of product and the quantity will be obtained (Каракашова, 2003). According to Никетић-Алексић, 1994, in the production of dried apples, varieties with a dry matter content exceeding 12 % are preferring to be dried. Hariss et al. (2007) suggests that before the drying process, the pieces of apple should be pretreated with antioxidants in order to prevent them from becoming darker and, at the same time, to allow preservation of the taste and the vitamins. The aim of our research was to compare the quality and nutritional composition of the fresh and the dried apples from the varieties *pinova* and *red delicious*, by using three different pretreatments.

Material and methods

For the purpose of performance of this research the apples of the varieties *pinova* and *red delicious* were used. The apples were grown in the village Bistrica, region Bitola, at an altitude of 650 m. The apples were harvested in October 2014, after a visual assessment of the field and assessment of the moment of harvest.

The quality and nutritional composition of the two varieties of apple fruits were determined by analysis of the morphometric and chemical properties. The chemical properties were determined of both, the fresh and the dried apples.

The weight of the fruits was determined by measuring with a digital analytical balance of the type "Sartorius", with an accuracy of ± 0.01 g. The height and width of the fruits were measured by vernier caliper (subler) with an accuracy of ± 0.1 mm. The values for weight, height and width of fruits are expressed as the mean value of consecutive measurements on 30 apple fruits of each variety.
From the chemical composition, the following parameters were determined: total dry matters, total sugars, total acids as malic acid, vitamin C, pectins, flavonoids, tannins and mineral matters (total ash).
- The total dry matter was determined by oven dryer at 105 °C, up to constant mass (Vračar, 2001);
- The sugars were determined according to the Lane-Eynon method (1923), based on the reductive properties of sugars which, when heated, reduce the divalent copper ion (Cu^{2+}) from the Fehling solution to red sediment from Cu_2O;
- Total acids were determined by a volumetric method, with a 0.1 M NaOH solution and an indicator of 1 % phenolphthalein solution (Vračar, 2001), expressed as malic acid;
- Vitamin C was determined according to the Tillmans method (Vračar, 2001);
- The method of Carre - Haynes (Vračar, 2001) was used to determine the pectins in the form of Ca - pectin, where was made separation of Ca - pectin, its rinsing, drying and gravimetric measurement;
- The content of flavonoids and tannins were determined by the Folin-Ciocalteu spectrophotometric method (Folin; Ciocalteu, 1927), by measuring the samples on the wavelengths of 550 nm for tannins and on 425 nm for flavonoids;
- The mineral matter (total ash) was determined by a gravimetric method, by incineration and burning of samples in a Muffle oven, at a temperature of 525 ± 25 ° C (Vračar, 2001);
The fresh apple fruits, after the following operations: washing, removal of stalk and seeds, peeling and cutting on circles with a thickness of 4 mm, were treated with 0.1 % citric acid solution (variant 1) and 0,5 % solution of $K_2S_2O_5$ (variant 2), with a dipping time of the slices for five minutes. In order to compare the influence of the applied treatments on the examined chemical properties, we applied untreated fruit, as a control (variant 0). The drying was performed in a dryer chamber type S-100, at a temperature of 65 ° C to 70 ° C for 6 to 8 hours.
According to the obtained results for the examined chemical properties of the dried apples, statistical processing was made by using the statistical method ANOVA (ANalysis Of VAriance). There was also applied a standard operation in the Microsoft Excel 2010 program, as well as a statistical software package for statistical analysis (IBM SPSS Statistics 21), by which was made the LSD (Least Significant Difference) test at the level of statistical significance $p = 0.05$.

Results and discussion

The obtained results from the morphometric and chemical properties of the fresh apples of the two varieties of *pinova* and *red delicious* are presented in tab. 1. From

the presented data, it can be concluded that the fruits of the *pinova* variety are characterized by a higher average weight (137.35 g), compared to the *red delicious* varieties (126.18 g). The results of our examinations regarding the weight of fruits for the *pinova* variety correspond to the reference values according to which the weight of the apples of this variety ranges from 126 g to 139.70 g (Lanauskas et al, 2009, Fischer and Fischer, 2002; Пашалић и Ђурић, 2009). The average height of the examined apples was in ranges from 57.88 mm in *red delicious* to 62.56 mm in the *pinova* variety. The average width of apples of the variety *pinova* (68.78 mm) does not differ much in comparison with the average width of the *red delicious* varieties (68.58 mm). The obtained mean values for the height and width of the apples of the *pinova* variety are smaller compared to the results indicated by Пашалић и Ђурић (2009), according to which, the fruits of this variety are characterized by an average height of 66.44 mm and an average width of 75.4 mm. The established differences are the result of different climatic and soil conditions as well as the applied agro-technical measures. From the results of the examined chemical properties, shown in tab. 1 it can be concluded that the apples of the *pinova* variety were characterized by higher content of total dry matter (16.18 %) and total sugars (14.16 %) compared to the *red delicious* variety.

The obtained result for the content of total dry matter in the apples of the *red delicious* variety (12.06 %) is in correlation with the value for this parameter indicated by Никетић- Алексић (1994), according to which the total dry matter content is about 12,23 %. From the obtained results of our examination, we can conclude that the content of total sugars corresponds to the reference levels, according to which the content of sugars in the apples is in range from 6 to 17 %, depending on the variety, the substrate, the applied agrotechnical measures, etc. (Katalinić, 2006). In the apples of the variety *red delicious*, was determined the content of total acids (0.22 %), what is in the approximate limits with the indicated values of Никетић-Алексић (1994), according to which the fruits of this variety contain about 0,25 % total acids. Higher content of the vitamin C (2.38 mg/100 g) was found in apples of the *red delicious* variety compared to the vitamin C content of the fruits of the *pinova* variety (1.85 mg/100 g). According to Никетић-Алексић (1994), the content of vitamin C in the fruits of the *red delicious* variety is 4.9 mg/100 g, which was a higher value compared to the results of our research. The difference in values is expected, taking into account the sensitivity of the vitamin C to the external conditions (temperature, light, air), that leads to certain losses, as well as the various climatic conditions, agrotechnical measures, etc.

In the apples of *pinova* variety, a higher content of flavonoids was assessed (2.66 μg/g), compared to the *red delicious* variety, in which the content of flavonoids was 1.50 μg/g. Several authors (Price et al., 1999; Khanizadeh, 2008) found that the total content of flavonols in the flesh of the fruits is from 1.40 μg/g to 22.30 μg/g and in the skin, the content of flavonols was significantly higher, ranged from 86.60 μg/g up to 892.10 μg/g. The content of flavonoids varies considerably between different varieties, and depends on the degree of maturity,

storage conditions, and processing condition of the fruits. Most of these compounds are present in the skin of the apples, and by their peeling they reduced to a very low level (Boyer, Liu, 2004, Price et al., 1999). The content of the mineral matters in the fruits of both varieties, the *pinova* and *red delicious* ranges are within approximate limits with the reference values according to which the fruits contain from 0.2 to 0.7 % total ash (Karakasova et al. 2007., Мишић, 2004., Vračar, 2001., Katalinić, 2006).

Table 1. Morphometric and chemical properties of fresh apple fruits

Analyzed parameters	*Pinova*	*Red Delicious*
Weight (g)	137.35	126.18
Height (mm)	62.56	57.88
Width (mm)	68.78	68.58
Total dry matters (%)	16.18	12.06
Total sugars (%)	14.16	9.83
Total acids (%), as malic acid	0.34	0.22
Vitamin C (mg/100 g)	1.85	2.38
Pectins (%)	0.53	0.63
Flavonoids (µg/g)	2.66	1.50
Tannins (µg/g)	1.39	1.03
Mineral matters – total ash (%)	0.25	0.18

The results of the examined chemical properties of the dried apples are given in Table 2. From the presented results it can be concluded that the dried apples of the *pinova* variety were characterized by a higher average value for total dry matter (82.08 %) compared to the dried fruits of the *red delicious* variety (81.52 %). More research shows that the content of the total dry matter in dried apples ranges from 81.67 % to 84.61 % **(**Dobričević and Krička, 1998; Dobričević 1998; Каракашова, 2003; Dobričević et al., 2008), which corresponds to the average content of the total dry matter obtained during our research. In the dried apples of the *pinova* variety, a higher average content of total sugars (63.83 %) was determined, compared to the dried fruits of the *red delicious* variety, where the average content of total sugars was 61.68 %. According to Каракашова (2003), the content of total sugars in several types of dried fruits is about 68.60 %, depending on the applied

treatment, temperature and the drying time. The content of the total acids is higher in the *pinova* variety, in all three applied variants. According to the performed examination by Karakasova et al. (2015), the content of total acids in dried apples ranges from 1.32 % to 1.93 %. The highest content of vitamin C of 12.70 mg/100 g was determined in the dried apples of the *red delicious* variety treated with 0.5 % solution of $K_2S_2O_5$ (variant 2). The dipping of the apple pieces in a solution of sulphites before the drying process prevents them from darkening, and simultaneously preserves the vitamin C in the dried product (Hariss et al., 2007, Каракашова, 2003. Karakasova et al., 2013, Karakasova et al., 2015). From the data shown in Table 2, it can be concluded that the higher value of the vitamin C content in the examined varieties was found in apples treated with 0.5 % solution of $K_2S_2O_5$ (variant 2), which is in accordance with the reference data.

Table 2. Chemical composition of dried apple fruits

Varieties	Total dry matter (%)	Total sugars (%)	Total acids (as malic acid) (%)	Vitamin C (mg/100 g)	Pectins (%)	Flavonoids (µg/g)	Tanins (µg/g)	Total ash (%)
Pinova, 0	81.21	56.82	1.58	5.55	1.40	4.42	3.24	1.06
Pinova, 1	81.44	68.74	1.75	4.76	1.79	4.90	3.60	1.49
Pinova, 2	83.59	65.93	1.68	9.52	1.50	4.80	3.57	2.47
$\bar{X}$	**82.08**	**63.83**	**1.67**	**6.61**	**1.56**	**4.71**	**3.47**	**1.67**
SD	**1.31**	**6.23**	**0.09**	**2.55**	**0.20**	**0.25**	**0.20**	**0.72**
MIN	**81.21**	**56.82**	**1.58**	**4.76**	**1.40**	**4.42**	**3.24**	**1.06**
MAX	**83.59**	**68.74**	**1.75**	**9.52**	**1.79**	**4.90**	**3.60**	**2.47**
Red delicious 0	80.19	50.41	1.24	4.12	2.98	4.61	3.49	0.75
Red delicious1	81.23	66.44	1.38	4.76	3.62	4.65	3.44	0.99
Red delicious 2	83.14	68.20	1.21	12.70	2.34	3.97	2.92	1.76
$\bar{X}$	**81.52**	**61.68**	**1.28**	**7.19**	**2.98**	**4.41**	**3.28**	**1.16**
SD	**1.50**	**9.80**	**0.09**	**4.78**	**0.64**	**0.38**	**0.32**	**0.53**
MIN	**80.19**	**50.41**	**1.21**	**4.12**	**2.34**	**3.97**	**2.92**	**0.75**
MAX	**83.14**	**68.20**	**1.38**	**12.70**	**3.62**	**4.65**	**3.49**	**1.76**

0-untreated fruit (control), **1**-treatment with citric acid, **2**-treatment with $K_2S_2O_5$

The content of flavonoids was the highest in the dried apples of the *pinova* variety 4.90 µg/g (variant 1) and 4.80 µg/g (variant 2). The apples of the examined

varieties treated with 0.5 % solution of $K_2S_2O_5$ (variant 2) contained higher values of the mineral matter (total ash), compared with untreated fruits (variant 0) and fruits treated with 0.1 % citric acid solution (variant 1). The results of the statistical processing of the data for the influence of the variety and treatment on the chemical properties of the dried apples are shown in Table 3. According of the obtained data it can be concluded that the variety as a factor has a statistically significant influence on the variability for the majority of the tested parameters. The treatment of the fruits with citric acid had caused a statistically significant difference in the content of the vitamin C, the total dry matter and the minerals in relation to the untreated fruits (variant 0). The variant where the apple fruits were treated with $K_2S_2O_5$ showed no statistically significant influence on the content of the vitamin C, the total dry matter and the mineral matter. Untreated apples (variant 0) compared with the treated ones (variant 1 and 2) did not show statistically significant difference in the total sugar content of the dried fruits of the examined varieties of apples. For this parameter, statistically significant differences were determined only between the treated fruits (variant 1 and variant 2).

Table 3. Statistical analysis of impact factor variety and variant

Parameter	Variety		Variant					
Total dry matter (%)	P:RD	*	0:1	*	0:2	n.s	1:2	n.s
Total sugars (%)	P:RD	*	0:1	n.s	0:2	n.s	1:2	*
Total acids (%)	P:RD	n.s	0:1	*	0:2	*	1:2	*
Vitamin C (mg/100 g)	P:RD	*	0:1	*	0:2	n.s	1:2	n.s
Pectins (%)	P:RD	n.s	0:1	*	0:2	*	1:2	*
Flavonoids (µg/g)	P:RD	*	0:1	*	0:2	*	1:2	*
Tanins µg/g	P:RD	*	0:1	*	0:2	*	1:2	*
Total ash (%)	P:RD	*	0:1	*	0:2	n.s	1:2	n.s

P-*pinova*, **CD**- *red delicious*, **0**-untreated fruit (control), **1**-treatment with citric acid, **2**-treatment with $K_2S_2O_5$, ***p**=0.05, **n.s**- there is no statistically significant difference

During the processing of agricultural products, the yield has great economic and technological significance (Каракашова, 2003). From the data shown in Figure 1, it can be concluded that the apple variety of *pinova* provided a higher yield during the drying process, compared to the variety *red delicious*.

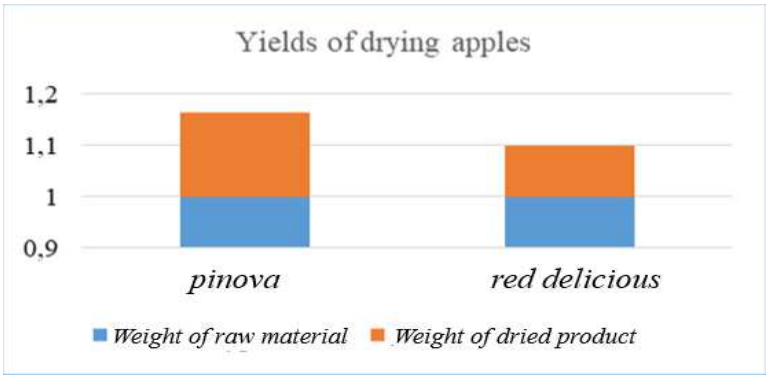

Figure 1. Yields of drying apples

Conclusions

Based on the determined morphometric properties of the apples (wight 137.35 g, height 62.56 mm and width 68.78 mm), the *pinova* variety was characterized by larger fruits compared to the fruits of the *red delicious* variety.

From the obtained results of the analyzed chemical properties, both in the fresh and dried apples, the variety pinova contained higher values for the most of the examined parameters (total dry matter, total sugars, total acids, flavonoids, tannins and total ash). Based on these findings, with certainty can be concluded that the fruits of the *pinova* variety were characterized by better quality properties compared to the fruit of the *red delicious* variety. For the same apple variety, a higher value of yield was determined during drying, and therefore it is a favorable raw material for drying.

The treatment of apples with 0.5 % solution of $K_2S_2O_5$, enabled the preservation of vitamin C in the dried fruits of the two examined varieties, compared to the untreated fruits and fruits treated with citric acid. The high sensitivity of the vitamin C to light, temperature, and air leads to inevitable losses during the fruit processing. Therefore, pretreatment of the apples before the drying process with a sulphites solution will significantly reduce the loss of the vitamin C and will allow its preservation in the dried product.

By analyzing of the variance (ANOVA) for the examined chemical properties of the dried apples, can be concluded that the variety and the applied pretreatment have a statistically significant influence on the variability of a large number of the chemical properties.

The convection drying in the drying chamber is completely independent from the external conditions, and, at the same time, it allows almost complete transfer of the nutrients from the fresh to the dried fruit. Therefore, we recommend to the producers this method of drying the fruit.

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