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Effect of pre-treatment conditions on content and activity of water and colour of freeze-dried pumpkin

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A B S T R A C T

This work shows the effect of blanching, osmotic dehydration duration, freezing method and duration of frozen storage on the colour, water activity and water content of osmotically dehydrated and freeze-dried pumpkin. Pumpkin was or was not subjected to blanching process in distilled water at a temperature of 100 °C for 1 min and osmotically dehydrated in starch syrup solution (0, 3 and 20 h) and frozen at −18° (24 h) or −70 °C (2 h). Then, after short (72 h) or long duration (60 days) the pumpkin in frozen storage was freeze-dried on heating shelves at a temperature of 10 °C. Different pre-treatment methods were not found to have clear effect on values of colour coefficient of freeze-dried pumpkin. Osmotic dehydration caused changes in water content and activity of samples. Elongation of osmotic dehydration duration influenced the decrease of water content and activity of freeze-dried pumpkin and had also slight effect on colour changes. Blanching decreased water content and activity, but no significantly. Similar results were obtained also for changes at a temperature of freezing and duration of frozen storage.

1. Introduction

Pumpkin is still an underrated vegetable in the food industry. Increased public awareness of healthy lifestyle results in buying products with high nutritional value and health-related properties, which in turn favours interest in richer assortment of fruit and vegetable products, including processed pumpkin (Nawirska-Olszańska, Kucharska, Sokół-Łętowska, & Biesiada, 2010). The content of β-carotene in pumpkin ranges from 3.3 to 7.6 mg/100 g of fresh mass and its increase during the storage, depending on the cultivar of pumpkin, was observed (Niewczas, Szweda, & Mitek, 2005).

Colour is one of the most important parameters which are taken into account during evaluation of the product by consumer. This attribute may be lost or altered during processing, depending on the water content in foods, particularly dried foods. Many researchers have recommended pre-treatment before drying, such as dipping in solutions with antioxidant compounds (Bechoff, Westby, Menya, & Tomlins, 2011), blanching (Nascimento, Fernandes, Mauro, & Kimura, 2009) and osmotic dehydration (Ciurzyńska & Lenart, 2009) to improve quality of dehydrated fruit and vegetables. Torres de, Díaz-Maroto, Hermosín-Gutiérrez, and Pérez-Coello (2010) show that freeze-dried grape skin may be used to improve the colour of the grape. It was found that freeze-drying is the most suitable drying method for maintaining the sweet pepper colour quality (Park & Kim, 2007). Changes in the colour of freeze-dried fruit depend on, for example the quality of raw material. Blueberries exhibit colour stability, while strawberries and raspberries show significant changes in colour parameters $L^*a^*b^*$ (Pasławska, 2005; Pasławska & Pełka, 2006). The carotenoid content in freeze-dried peppers is affected by temperature of heating shelves and also by blanching duration before drying process. Compared with other drying methods, freeze-dried peppers are characterized by the highest content of total carotenoids. Pre-treatment (blanching) and increase at a temperature of heating plates resulted in greater decrease in the content of carotenoids in food (Krzykowski, Polak, & Rudy, 2011).

Osmotic dehydration is a process of partial removal of water by soaking fruits and vegetables in hypertonic solution. The process is relatively simple, but many of fundamental mechanisms of this process are still being revealed (Kowalska, Lenart, & Leszczyk, 2008; Shi & Le Maguer, 2002). In food technology the osmotic dehydration may be used as a pre-treatment before various technological processes, such as drying and freezing, as well as the basic technological process for the preparation of minimally processed food (Pękosławska & Lenart, 2009). A number of authors have suggested physical pre-drying treatments of food products as

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means to improve product quality and to modify the structure of food products so as to improve mass transfer coefficients in drying (Arévalo-Pinedo, Murr, Giraldo-Zuñiga, & Arévalo, 2004).

Dewatering rate and degree of the material depend upon a number of different factors, and one of them is the duration of dehydration (Qui, Le Maguer, & Sharma, 1998). The type of osmotic solution and its concentration influences the efficiency of osmotic dehydration process. The highest efficiency of osmotic dehydration may be obtained with the use of 600 g/kg starch syrup solution or 200 g/kg glucose solution (use of higher concentration does not increase the process effectiveness) (Pękosławska & Lenart, 2009). Osmotic dehydration before freezing is used to maintain firmness of food products after thawing and to reduce the costs of freezing process. Ramallo and Mascheroni (2010) who osmotically dehydrated pineapple before freezing have shown that the duration necessary to freeze raw material is shorter than in the case of fruit without osmotic pre-treatment. Freeze-drying is one of the most modern drying methods, which consists of water extraction directly from the solid phase by sublimation of ice.

The aim of this work is to show the influence of different pre-treatment methods and their conditions on the properties of freeze-dried pumpkin. The range of this work includes analysis of the effect of blanching, duration of osmotic dehydration, freezing conditions and duration of frozen storage of pumpkin on colour coefficients and water activity and its content in freeze-dried pumpkin after pre-treatment.

2. Materials and methods

The raw material included fresh pumpkin from the *Gigantic Pumpkin* family, bought in Warsaw, harvested in a state of harvest maturity and cut into cubes of 10 mm side. Table 1 presents the changes in parameters of the processes conducted in order to obtain the freeze-dried pumpkin:

−Sample 1 was not subjected to any pre-treatment.
−Samples 4, 6, 8 and 10 were subjected to blanching process in distilled water at a temperature of 100 °C for 1 min, with raw material/water mass ratio of 1:10. After blanching samples were placed on a sieve for 5 min.
- Samples 2–10 were osmotically dehydrated in starch syrup solution (glucose equivalent DE 32.2, JAR, Jaskólski Aromats), containing 663 g/kg of sugars (determined refractometrically of extract in Brix degrees) at a temperature of 20 °C for 3 or 20 h, with raw material/water mass ratio of 1:4 in static conditions (Pękosławska & Lenart, 2009).

Both blanched and unblanched material was frozen at a temperature of −18 °C for 24 h in a home AFG 305 = G freezer (Whirlpool Company, Italy) and at a temperature of −70 °C for 2 h in a ProfiMaster Personal Freezer (PMU series, National Lab GmbH, Germany). Frozen material was stored at a temperature of −18 °C for 72 h or 60 days in a AFG 305 = G home freezer (Whirlpool Company, Italy) before freeze-drying.

Table 1
Parameters of technological processes of freeze-dried pumpkin samples preparation.

Sample symbol	Blanching	Osmotic dehydration	Freezing	Storage (−18 °C)	Freeze-drying
1	−	−	−18 °C, 24 h	72 h	10 °C 24 h
2	−	20 h	−18 °C, 24 h	72 h	10 °C 24 h
3	−	3 h	−18 °C, 24 h	72 h	10 °C 24 h
4	+	3 h	−18 °C, 24 h	72 h	10 °C 24 h
5	−	3 h	−18 °C, 24 h	60 days	10 °C 24 h
6	+	3 h	−18 °C, 24 h	60 days	10 °C 24 h
7	−	3 h	−70 °C, 2 h	72 h	10 °C 24 h
8	+	3 h	−70 °C, 2 h	72 h	10 °C 24 h
9	−	3 h	−70 °C, 2 h	60 days	10 °C 24 h
10	+	3 h	−70 °C, 2 h	60 days	10 °C 24 h

Freeze-drying process was conducted under pressure of 63 Pa and safety pressure of 103 Pa on heating shelves at a temperature of 10 °C for 24 h, in a Christ Company ALPHA1-4 LDC-1 m freeze-dryer. After freeze-drying, the material was stored in tightly closed jars to avoid contact with humidity in a dark place at the temperature of 20–25 °C.

2.1. Analytical methods

2.1.1. Water activity

Water activity was measured by HygroLab Rotronic Company apparatus according to the instruction of manufacturer in three iterations.

2.1.2. Water content

Water content [g H_2O/kg] was measured by drying method. Weighted material (3–4 g) in a weighing bottle was dried in a convective dryer at a temperature of 105 °C for 4 h in three repetitions. The analysed freeze-dried material was weighted on analytical scales before and after drying with the accuracy of 0.0001 g.

2.1.3. Colour measure

Colour determination was done for the surface of freeze-dried pumpkin (Ciurzyńska & Lenart, 2009). The colour of the freeze dried pumpkin surface was determined with the use of Chroma – Meter CR-300 Minolta (Austria) Company detector in CIE L^*, a^*, b^* system. The measurements were made in 5 repetitions for every dried sample. Average value was calculated for obtained results.

The colour indicators were calculated with the use of the following formulas:

C^*_{ab} – chroma

$$C^*_{ab} = \sqrt{(a^*)^2 + (b^*)^2} \quad (1)$$

ΔE – relative colour difference index

$$\Delta E = \sqrt{(L^{*0} - L^*) + (a^{*0} - a^*)^2 + (b^{*0} - b^*)^2} \quad (2)$$

where:

L^* – lightness coefficient [dimensionless value]
a^* – red colour coefficient [dimensionless value]
b^* – yellow colour coefficient [dimensionless value]
L^{*0}, a^{*0}, b^{*0} – colour coefficients for raw pumpkin (relate to) [dimensionless value]

2.1.4. Statistical analysis

Statgrafics Plus, version 4.1. (Microsoft), Excel 2010 (Microsoft) was used in the following statistical analysis. For the obtained results pooled standard deviations were calculated. Tukey's test for verification of the hypothesis of equality of means for analysed coefficients in measured samples and Pearson's correlation coefficient were used. The analyses were done with the significance level of 0.05.

3. Results and discussion

3.1. The influence of osmotic dehydration duration

Osmotic dehydration of pumpkin for 3 and 20 h before freeze-drying (2 and 3) (see Table 1) does not cause statistically