IMPACT OF DRYING TEMPERATURES ON THE QUALITY OF CORN FLAKES WITH FUNCTIONAL COMPONENTS

UTICAJ TEMPERATURE SUŠENJA NA KVALITET FLEKS PROIZVODA SA FUNKCIONALNIM DODACIMA

Milenko KOŠUTIĆ, Jelena FILIPOVIĆ, Zvonko NJEŽIĆ, Ana VARGA, Dragana PLAVŠIĆ

Institute of Food Technology, University of Novi Sad, Bul. cara Lazara 1,

21000 Novi Sad, Serbia

e-mail: milenko.kosutic@fins.uns.ac.rs

ABSTRACT

As a mechanical, thermal, diffusion and chemical operation, extrusion causes changes in the properties of raw materials mainly due to the characteristics of the extruder and extrusion conditions (temperature, pressure and shear stress). As extruded products based on cereals occupy an important place in modern nutrition, they are suitable carriers of functional components. In every technological process, it is very important to correctly define the parameters of production in order to achieve a good and uniform quality of products with as little as possible losses of the nutritional and functional properties of raw materials. On the basis of the experimental results on the physical, chemical and antioxidant properties of corn flakes, as well as the use of Standard Score analysis, it can be concluded that the optimal drying temperature for corn flakes is 84 °C.

Keywords: corn flakes, drying temperature, functional products.

REZIME

U svakom tehnološkom postupku od izuzetne važnosti je pravilno definisati proizvodne parametre postupka kako bi se ostvario dobar i ujednačen kvalitet proizvoda uz što manje gubitke nutritivnih i funkcionalnih svojstava polaznih sirovina. U cilju umanjenja negativnog uticaja temperature na sadržaj funkcionalnih komponenata u gotovom proizvodu, neophodno je optimizovati temperaturu sušenja fleks proizvoda. Za optimizaciju temperature sušenja fleks proizvoda odabrane su karakteristike: kod kojih je došlo do najznačajnijih promena sa promenom temperature: stepen ekspanzije, hrskavost, sadržaj lizina, svetloća - L, udeo žute boje - b*, sadržaj palmitinske, stearinske, linolne i linolenske kiseline i tri pokazatelja antioksidativnih karakteristika (sadržaj fenola, IC₅₀ i FRAP vrednosti). Pomenute karakteristike su najvažniji pokazatelji kvaliteta jer definišu nutritivna i funkcionalna svojstva fleks proizvoda. Vrednost standardne ocene iznad 0,5 ukazuje na bolji kvalitet za posmatrane parametre, a kada je ocena manja od 0,5 pokazuje negativan uticaj na posmatrane karakteristike fleks proizvoda. Primenom viših temperatura sušenja došlo je do značajnog pogoršanja kvaliteta, a intenzitet nastalih promena je u direktnoj korelaciji sa temperaturom sušenja. Standardne ocene fleks proizvoda smanjuju se 1,6 puta pri povećanju temperature sa 84° C na 105° C i sa 105° C na 135° C, odnosno 2,2 puta kada se temperatura povećava na 148° C. Na osnovu prikazanih rezultata ispitivanja fizičkih, hemijskih i antioksidativnih osobina, kao i primene standardne ocene (Score analize) eksperimentalnih podataka zapaža se da je optimalna temperatura sušenja fleks proizvoda 84° C.*

Ključne reči: korn fleks, temperatura sušenja, funkcionalni proizvodi.

INTRODUCTION

As a mechanical, thermal, diffusion and chemical operation, extrusion causes changes in the properties of raw materials mainly due to the characteristics of the extruder and extrusion conditions (temperature, pressure and shear stress) (Riaz, 2000; Filipović et al., 2003). As extruded products based on cereals occupy an important place in modern nutrition, they are suitable carriers of functional components. In every technological process, it is very important to correctly define the parameters of production in order to achieve a good and uniform quality of products with as little as possible losses of the nutritional and functional properties of raw materials. For the purpose of the corn flakes production with added dry wild oregano and/or sunflower residues, the first part of this research was focused on the effect of drying temperature on the physical, chemical, nutritional and functional properties of corn flakes without supplements. Heat treatments of cereals were used to improve their nutritional, hygienic, physico-chemical and other properties, as well as to increase the nutritional value, improve the sensory properties and ensure the microbiological safety of the products (Sumitra and Bhattachary 2008, Filipović et al.

2010, Košutić 2016). The objective of this study was to examine the impact of drying temperature on the quality of corn flakes.

MATERIAL AND METHODS

The corn flour used in this study was obtained from the mill Žitoprodukt d.o.o. Bačka Palanka, Serbia, produced in 2014, with the following characteristics: moisture, sugar, protein, cellulose, starch and lipid content (on dry matter basis) were 13.3, 0.87, 5.59, 0.98, 79.43, and 1.57, respectively (AOAC 1990). Wild oregano (*Origanum minutiflorum* O. Schwarz & P.H. Davis) harvested in 2013, was produced by Inan tarim ECODAB - Antalia Turkey. The dry residue of wild oregano was prepared as follows: distillation of wild oregano (*Origanum minutiflorum*) is carried out in the production plant of the Institute of Medicinal Plant Research "Dr Josif Pančić" from Pančevo, Serbia. A mini distiller based on the water vapour principle was used for distillation. The distillation duration was 2 hours and 30 minutes. The residues obtained were cooled in an airy place and prepared for further research.

Preparation of corn flakes

The flakes were obtained by extrusion in a twin-screw extruder (Yuninan Daily Extrusion, Yunnan, China) under industrial conditions at Reprotrade doo Industrial Zone bb,

Temerin, Serbia. The extrusion parameters were as follows: a screw length of 140 cm, a diameter of 3x6 mm, a rotor speed of 180 rev / min, and temperature profiles of 131° C / 125° C / 114° C. Corn flour, was replaced by the dry residue of wild oregano added in a ratio of 1:100 g relative to corn flour samples. The extrudates obtained were dried in a dry unit at a temperature of 84° C, and subsequently cooled for 30 min at a controlled temperature of 25 ± 1° C (prior to storing in plastic bags until analysis).

Physical analyses

The expansion ratio (ER) was determined according to Kaludjerski and Filipović (1998) and calculated according to Kannadhasan et al. 2009: ER=volume flakes (ml)/volume crude flakes (ml).

Corn flake texture - Texture Analysis

The crunchiness of flakes was measured using a Texture Analyzer TA. HD plus (Stable Micro System, Godalming, Surrey,U.K.) equipped with a 50 kg load cell.

Corn flakes colour

The colour of flakes was measured using a colorimeter Chroma meter (CR-400, Konica, Minolta, Tokyo, Japan) and was determined according to the procedure previously described by Filipović et al.2015.

Amino acids

The samples were prepared for analyses using 24h hydrolysis with 6N HCl. The sample analysis was performed using a liquid chromatograph Agilent 7890A GC system with a flame ionization detector FID-equipped automatic sampler (auto sampler) and silica capillary column (SP-2560, 100 m x 0.25mm, ID, 0.20µm). Amino acid peaks were identified by comparing the retention time of the individual amino acids in the sample with the retention times proscribed by the Amino Acid Standard (Sigma-Aldrich, EC), as well as the internal library data. The results obtained are expressed in percentages as a proportion of the individual amino acids in the total amino acids.

Fatty acid analyses were performed according to the procedure previously described by Filipović et al. 2017.

Antioxidant activity

Antioxidant activity was determined according to the procedure previously described by Košutić et al. 2016. The Standard Score analysis uses the min-max normalisation of wheat quality parameters transforming them from their original unit system into a new dimensionless system where further mathematical calculations with different types of quality parameters are applicable (Jayalakshmi and Santhakumaran, 2011). The maximum values of normalised score present the optimum values of all the parameter values combined, indicating the optimum total quality of corn flakes. The score calculation is proposed as follows:

$$S_{ki} = \frac{(x_{ki} - x_{k \min})}{(x_{k \max} - x_{k \min})}; \quad k=1-9$$

where xk is the expansion ratio - ER, lysine - LIS, lightness - L*, yellowness colour - b*, stearic acid - C18:0, oleic acid C18:1, linoleic acid C18:2, phenol content, FRAP

$$S_{ni} = 1 - \frac{(y_{ni} - y_{n \min})}{(y_{n \max} - y_{n \min})}; \quad n=1-3$$

where yn is crunchiness CRU, palmitic C 16:0, DPPH The calculation for all three Scores is as follows: max [Si]→optimum

RESULTS AND DISCUSSION

In order to optimize the drying temperature of the product, the following features were analyzed: expansion ratio ER, crunchiness CRU, lysine content LIS, lightness - L*, yellowness - b*, palmitic, stearic, linoleic and linolenic acid content, as well as three indicators of antioxidant properties (phenolic content PHL, IC₅₀ and FRAP values). These characteristics are the most important quality indicators because they define the physical, nutritional and functional properties of corn flakes (Košutić 2016). The standard scores of corn flakes produced at different drying temperatures (84° C, 105° C, 135° C, and 148° C) are shown in Table 1. The value of the standard score above 0.5 indicates a better quality of the parameters observed, whereas scores less than 0.5 indicate a negative impact on the observed characteristics of the product's flexibility.

Table 1. Standard scores of the corn flake quality parameters

T (°C)	ER	CRU	LIS	L*	b*	C16:0	C18:0	C18:1	C18:2	PHL	DPPH	FRAP
84	1.00	1.00	1.00	0.63	0.53	1.00	0.77	1.00	1.00	1.00	1.00	1.00
105	0.00	0.69	1.00	0.00	1.00	0.28	1.00	0.84	0.20	0.33	0.77	0.75
135	0.51	0.06	0.50	0.17	0.93	0.00	0.73	0.10	0.40	0.11	0.61	0.41
148	0.98	0.00	0.00	1.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Higher drying temperatures caused a quality decrease in the following parameters: ER, CRU, LIS,L, C16:0, C18:1, and C. The standard product scores were reduced 1.6 times when the temperature increases from 84 ° C to 105° C and from 105° C to 135° C, or 2.2 times when the temperature increases to 148° C. On the basis of the experimental results on the physical, chemical and antioxidant properties of corn flakes, as well as the use of Standard Score analysis, it can be concluded that the optimal drying temperature for corn flakes is 84 ° C (Figure 1).

Standard score analysis

Fig. 1. Standard score analysis of the corn flakes quality depending on drying temperature

CONCLUSION

On the basis of the experimental results on the influence of drying temperatures (84, 105, 135, 148 °C) on the physical, nutritional and antioxidant properties of corn flakes, the following conclusions can be made:

- The application of drying temperatures above 84 °C causes structural changes in the protein of corn flakes, which are manifested in a mild lysine decrease (by 15%).
- The application of higher drying temperatures (105, 135, 148 °C) significantly reduces the phenolic content and antiradical activity of the corn flakes extracts. The corn flakes obtained by drying the flakes at 84° C had a maximum phenolic content of 1.75 mg GAE / g sample, maximum antiradical activity (1 / IC50 6.25 mg / ml, FRAP value 333.78 µg AAE / g sg).
- The highest standard score (0.91) was recorded in corn flakes obtained by drying at a temperature of 84 °C, whereas the lowest standard score (0.17) was recorded in corn flakes obtained by drying at a temperature of 148 °C, which confirms that the optimal drying temperature for corn flakes is 84 °C.

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