NUTRITIVE VALUE OF FLAKES PRODUCTS WITH SUNFLOWER NUTRITIVNA VREDNOST FLEKS PROIZVODA SA SUNCOKRETOM

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ABSTRACT

This paper investigates the influence of sunflower addition (3, 6 or 9 g/100 g of sample) on the essential amino acids pattern of flakes products. The nutritive value of proteins in flakes products is expressed by the amino acid score (AAS) and the protein digestibility-corrected amino acid score (PDCAAS). The results obtained indicate that the AAS and PDCAAS values in flakes products increased with an increase in the sunflower share. Sunflower in flakes products positively contributed to the nutritive value of proteins. Flakes products with 9 g/100 g of sunflower are particularly suitable for adults, an AAS of 0.60 ± 0.06 and a PDCAAS of 51.3 ± 0.3 .

Keywords: nutritive value, amino acid, digestibility of protein, flakes product, sunflower.

REZIME

Fleks proizvod je najčešći oblik žitarica za doručak. Potrošnja hrane se uglavnom određuje potrošnjom energije u funkciji bazalnog metabolizma i nivoa fizičke aktivnosti. Bazalni metabolizam, a samim tim i proteini, variraju u zavisnosti od satosti, pola i telesne mase. Fizička aktivnost varira u zavisnosti od načina života i stanja organizma. Kada je u pitanju hrana koja se konzumira u cilju zadovoljenja energetskih potreba, potreba u proteinima ili bilo kojih drugih nutritivnih sastojaka, takođe treba zadovoljiti odnos proteina ili drugih nutritivenata sa energetskim potrebama. Među, sastojcima koji mogu biti uključeni u formulaciju fleks proizvoda mogu se uvrstiti i konzumni suncokret, što može značajno poboljšati nutritivna svojstva fleksa proizvoda. U ovom radu je ispitan uticaj dodatka konzumnog suncokreta (3, 6 i 9 g/uzorku) na sastav esencijalnih aminokiselina i kvalitet proteina fleks proizvoda. Nutritivna vrednost proteina je izražena skorom aminokiselina i kvalitetom proteina. Score aminokiselina je pokazatelj efikasnosti iskorišćenja proteina u harani, a predstavlja odnos sadržaja esencijalne aminokiseline u ispitivanom proteinu i preporučenih potreba za odredene kategorije potrošača. Najniža vrednost score definiše limitirajuću aminokiselinu a potrebe se razlikuju zavisno od godina, pola, zličkog stanja, načina života i stresa. Kvalitet proteina (Protein digestibility-corrected amino acid score - PDCAAS) je određen na osnovu svarljivosti proteina i aminokiselinskog skora. Ovo se postiže poređenjem sadržaja limitirajuće aminokiseline, u proteinu sa njegovim sadržajem u posmatranoj namirnici. U ovom radu su posmatrane treonin, aminokiseline sa sumporom i lizin, kao najčešće deficitarne aminokiseline. Rezultati istraživanja pokazuju da je u fleks proizvodu sa suncokretom limitirajuća aminokiselina lizin. Zbog sadržaja aminokiselina sa povećanjem udela suncokreta povećava se nutritivna vrednost fleks proizvoda. Posmatrajući različite starosne grupe potrošača fleks proizvod sa suncokretom odgovara najviše potrebama odraslih osoba.

Ključne reči: nutritivna vrednost, aminokiseline, svarljivost proteina, fleks proizvod, suncokret.

INTRODUCTION

Cereals constitute the staple food of humans across the globe. In many countries, they are the mainstay of life and form the single largest component of people's daily diet. Ready-to-eat (RTE) cereals are processed grain formulations suitable for human consumption without further processing or cooking. Extrusion technology is of enormous importance to food processing and the production of breakfast cereals, which greatly affects the properties of corn flakes (Sumithra and Bhattacharya 2008; Kannadhasan et al. 2009; Košutić et al 2016a). Extrusion technology facilitates using different ingredients for the enrichment of cereal-based flakes or snack products (Filipović et al. 2010; Nor et al. 2013). The dietary requirements for protein and amino acids in food are set according to the age of consumers. Food consumption is primarily determined by energy expenditure, i.e. as a function of the basal metabolic rate and physical activity level. Energy food requirements change not only with the age, sex and body mass, but also with the physical activity associated with lifestyle. Protein requirements are independent of the body mass, sex (in adult life) and age (WHO 2002). The essential amino acids are as follows: leucine, isoleucine, valine, lysine, threonine, tryptophan, methionine, phenylalanine and histidine. The following amino acids are semi-essential: cysteine, tyrosine, proline, glycine, arginine, glutamine and taurine (under certain physiological and pathological conditions of the organism they can become essential amino acids). The non-essential amino acids provide a source of nitrogen for establishing the nitrogen balance and

include the following amino acids: alanine, serine and asparagine (WHO 2002). The amino acid score is the ratio of the amino acid content in the sample protein to the content of the same amino acid in the requirement pattern. It determines the effectiveness with which the absorbed nitrogen can meet the indispensable amino acid requirements at the safe level of protein intake. This is achieved by a comparison of the content of the limiting amino acid in the protein or diet with its content in the requirement pattern appropriate for age (WHO 2002). The protein quality evaluated relative to the protein digestibility-corrected amino acid score (PDCAAS) value is relatively new, and it is calculated on the basis of the protein digestibility and amino acid score (WHO 2002). Corn flakes are possibly the most common form of breakfast cereals. Flakes formulation with sunflower can improve the nutritive properties of products (Košutić et al 2016b; Gawlik-Dziki et al. 2012; Jozinović et al. 2016). The purpose of this paper is to examine the influence of sunflower addition (3, 6 or 9 g/100 g of sample) to flakes products on the limiting amino acids pattern and protein requirements of different consumer age groups.

MATERIAL AND METHOD

Corn flour and the sunflower cultivar 'Čepko' were obtained in 2015 from local producers (the mill Žitoprodukt d.o.o. Bačka Palanka and Vitastil Erdevik, respectively). Sunflower was dehulled and milled using a Hammer mill 2300 rev/min with a 2.5mm sieve. Flakes were processed under industrial conditions by extrusion in a twin-screw extruder (Yuninan Daily Extrusion,

Yunnan, Republic of China). The process of manufacturing flakes products is shown in Figure 1. A total of four formulations of corn flakes with different quantities of sunflower flour were tested, including the following samples: CF 1 (the control sample), CF 2 (97 g/100 g corn flour and 3 g/100 g sunflower flour), CF 3 (94 g/100 g corn flour and 6 g/100 g sunflower flour) and CF 4 (91 g/100 g corn flour and 9 g/100 g sunflower flour).

Amino acids

The samples were prepared for analyses using the 24h hydrolysis with 6N HCl, and then analysed by a liquid chromatograph Agilent 7890A GC system with a flame ionization detector FID, which is equipped with 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 of the Amino Acid Standard (Sigma-Aldrich, EC), as well as the internal library data (Košutić 2016). The results are expressed in percentages as a proportion of the individual amino acid in the total amino acids (Košutić 2016).

Protein quality Evaluation

The nutritive value of proteins is expressed by the following indicators: the amino acid score and PDCAAS. According to WHO (2002), threonine, sulphur containing aminoacids and lysine limiting amino acid were taken into consideration.

Amino acid score = mg of amino acid in 1 g test protein / mg of amino acid in the requirement pattern.

Protein digestibility-corrected amino acid score (PDCAAS) = amino acid score x digestibility.

The following data were used for digestibility (FAO/WHO/UNU, 2002):

- percent of utilization of corn is 85 %
- percent of utilization of sunflower is 90 %
- percent of utilization of flakes products with 3, 6 and 9 % of sunflower is calculated according to the following equations: $85 \times 0.97 + 90 \times 0.03 = 85.15$, $85 \times 0.94 + 90 \times 0.06 = 85.30$ and $85 \times 0.91 + 90 \times 0.09 = 85.45$, respectively.

Statistical analyses

Descriptive statistical analyses for all the amino acid scores obtained were expressed as the mean $\pm$ standard deviation (SD). The one-way ANOVA analyses of the results obtained were performed using the StatSoft Statistica 10.0® software. The collected data were subjected to a one-way analysis of variance (ANOVA) for the purpose of comparing the means obtained, and significant differences were calculated according to post-hoc Tukey's HSD (honestly significant differences) test at the $p < 0.05$ significant level (95% confidence).

RESULTS AND DISCUSSION

Protein quality evaluation aims to determine the capacity of food protein sources and diets to satisfy the metabolic demand for amino acids and nitrogen (WHO 2002). Therefore, any measure of the overall quality of dietary protein, if correctly determined, should predict the overall efficiency of protein utilization. Safe or recommended intakes can then be adjusted according to the quality measure for meeting the demands. The essential, semi-essential and non-essential amino acids of flakes products (CF1-CF4) with sunflower are presented in Figure 2 (the composition of individual amino acids in flakes products was reported by Košutić 2016). The addition of sunflower (3, 6 or 9 g/100 g) in corn flakes (CF2, CF3, CF4) contributes to an increase in the content of semi-essential and non-essential amino acids in comparison with the samples without the sunflower addition (CF1) (Figure 2). Amino acids of sunflower contributed to an insignificant change in the essential amino acids of corn

flakes (CF2, CF3, CF4). The nutritive value of flakes protein, expressed as the amino acid score, is presented in Table 1. According to WHO (2002), the following amino acids are defined as deficient in protein: lysine, sulfur amino acids and threonine.

Fig. 1. Process of manufacturing flakes products

Fig. 2. Amino acids of flakes products

The amino acid score is a useful tool for determining the effectiveness by which the absorbed dietary nitrogen meets the essential amino acid requirements at the safe level of protein

intake. WHO/FAO/UNU (2002) marked lysine, sulfur amino acids and threonine as the most deficient amino acids in food proteins. The research results show that lysine is the limiting amino acid in all flakes products (CF1-CF4). All the values are less than 1, and the addition of sunflower increased the score. The ANOVA test showed statistically significant differences ($p < 0.05$ level, a 95 % confidence interval) in the score values for lysine in the samples with 9 g/100 g of sunflower (CF 4) compared to the samples CF1, CF2 and CF3. The results obtained indicate the highest score in lysine (0.60 ± 0.01), sulfur amino acids (1.36 ± 0.05) and threonine (2.26 ± 0.13) in the corn flakes with 9 g/100 g of sunflower. According to the FAO / WHO / UNU (2002) data on the metabolic needs for protein and amino acids, the flakes AAS and PDCAAS values for four age groups of consumers are shown in

Table 1. Nutritive value of protein in flakes products

Sample	Amino acids score		
	Lysine	Sulfur amino acids	Threonine
CF 1	0.50 ± 0.01^a	1.32 ± 0.05^a	2.04 ± 0.10^a
CF 2	0.50 ± 0.02^a	1.32 ± 0.06^a	2.17 ± 0.08^a
CF 3	0.52 ± 0.03^a	1.36 ± 0.04^a	2.17 ± 0.07^a
CF 4	0.58 ± 0.01^b	1.36 ± 0.05^a	2.26 ± 0.13^a

The results are presented as mean $\pm$ SD, different letter within the same column indicates the significant difference in mean

Table 2. AAS and PDCAAS for different age groups of consumers

Sample	0-5 years		1-2 years		4-18 years		>18 years	
	score	PDCAAS	score	PDCAAS	score	PDCAAS	score	PDCAAS
CF 1	0.44 ± 0.02^a	37.4 ± 1.5^a	0.48 ± 0.01^a	40.8 ± 0.9^a	0.52 ± 0.02^a	44.2 ± 1.1^a	0.56 ± 0.06^a	47.6 ± 0.5^a
CF 2	0.44 ± 0.03^a	37.5 ± 1.2^a	0.48 ± 0.03^a	40.9 ± 1.1^a	0.52 ± 0.05^a	44.3 ± 1.1^a	0.56 ± 0.04^a	47.7 ± 0.3^a
CF 3	0.46 ± 0.05^a	39.2 ± 1.3^a	0.50 ± 0.03^a	42.6 ± 0.8^a	0.54 ± 0.05^a	46.1 ± 1.0^{ab}	0.58 ± 0.05^a	49.5 ± 0.4^b
CF 4	0.47 ± 0.05^a	40.2 ± 1.4^a	0.52 ± 0.04^a	44.4 ± 1.0^a	0.56 ± 0.04^a	47.9 ± 0.7^b	0.60 ± 0.06^a	51.3 ± 0.3^c

The results are presented as the mean $\pm$ SD, different letters within the same column indicate significant differences in the mean values ($p < 0.05$) according to the Tukey's HSD test.

values ($p < 0.05$), according to Tukey's HSD test.

Table 2. The changes in the AAS and PDCAAS within the same age group depend on the share of sunflower. The need for the limiting amino acid lysine is larger at an earlier age of life and the PDCAAS values are statistically significantly lower than those required for adults (over 18 years). The ANOVA test showed statistically significant differences ($p < 0.05$ level, a 95 % confidence interval) in the PDCAAS between the sample values with 6 and 9 g/100 g of sunflower (CF3, CF 4) compared to 0 and 3 g/100 g of sunflower (CF1, CF2) for age groups 4-18 years and >18 years. Sunflower addition positively affected the PDCAAS, which resulted in higher values, particularly for people over 18 years. Adding sunflower resulted in a statistically insignificant increase in the amino acid score in all the corn flakes analyzed. The results obtained show that protein flakes products with added sunflower are more suited to adults' needs (Table 3).

CONCLUSION

The results obtained indicate that the AAS and PDCAAS values in flakes products increased with an increase in the share of sunflower. The best AAS (lysine 0.58 ± 0.01 , sulfur amino acids 1.36 ± 0.05 , threonine 2.26 ± 0.13) and PDCAAS for nutritive attributes of corn flakes proteins were recorded in 9 g/100 g of sunflower.

Sunflower in flakes products positively contributed to the protein nutritive value. Flakes products are new products with the enhanced essential amino acid pattern, exhibiting functional properties due to the added sunflower. Flakes products with sunflower are particularly suitable for the diet of adults.

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REFERENCES

- Filipović, S., Kormanjoš, Š., Sakač, M., Filipović, J., Psodorov, Đ., Okanović, Đ. (2010). Effect of extrusion on nutritive value of animal feed, Extrusion technology in feed and food processing, 2nd Workshop Feed to food FP7 REGPOT-3, 97-116, Serbia.
- Gawlik-Dzik, U., Świeca, M., Dzik, D. (2012). Comparison of phenolic acids profile and antioxidant potential of six varieties of spelt (*Triticum spelta* L), *Journal of Agricultural and Food Chemistry*, 18, 4603-4612
- Jozinović, A., Šubarić, D., Ačkar, D., Babić, J., Miličević, B. (2016). Influence of spelt flour addition on properties of extruded products based on corn grits, *Journal of Food Engineering*, 172, 31-37.
- Kannadhasan, S., Muthukumarappan, K., Rosentrater, K.A. (2009). An effect of ingredients and extrusion parameters on aqua feeds containing DDGS and tapioca starch. *Journal of Aquaculture Feed Science and Nutrition*, 1, 6-21.
- Košutić, M. Extruded flakes products supplemented with sunflower and dry residue of wild oregano, Faculty of Technology, University of Novi Sad (2016).
- Košutić, M., Filipović, J., Pezo, L., Plavšić, D., Ivkov, M. (2016a). Physical and sensory properties of corn flakes with added dry residue of wild oregano distillation, *Journal of the Serbian Chemical Society*, 81, 1013-1024.
- Košutić M., Filipović J., Stamenković Z. (2016b). Characteristics flakes product with dry residue of wild oregano, *PTEP Journal on processing and energy in Agriculture*, 20, 93-96.
- Nor N Md, Carr A, Hardacer A, Bernnan C. (2013). The Development of expanded Snack Product Made from Pumpkin Flour-Corn Grits: Effect of Extrusion Conditions and Formulations on Physical Characteristics and Microstructure, *Foods*, 2, 160-169.
- Sumithra, B., Bhattacharya, S. (2008). Toasting of corn flakes: Product characteristics as a function of processing conditions. *Journal of Food Engineering*, 88, 419-428.
- WHO Technical Report Series, Protein and Amino Acid Requirements in Human Nutrition, Chapter: Protein-energy interactions, Joint FAO/WHO/UNU, Geneva, Switzerland, (2002).

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