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Original scientific paper

EFFECT OF TOASTING ON THE FAT CONTENT OF SOYBEANS (*Glycine max* L. Merrill)

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A b s t r a c t: The purpose of this research is to determine the influence of thermal processing of soybeans on changes in its lipid status. Two soybean varieties, Pella and Ilindenka, were keyed in the research, and the analyses to determine the lipid composition of soybeans were carried out in raw and thermally processed "toasted" soybeans. The thermal treatment was performed by exposing the material to a temperature of 125 ºC for 15 minutes. The purpose of heat treatment is inactivation of anti-nutritional compounds in the grain such as trypsin inhibitors and urease which are the main problem when using raw soybeans in the diet of monogastric animals. Due to the sensitive relationship of fats to thermal treatment, a comparative study was made in order to determine the oxidative degree of fats in soy. Based on the results obtained from the quantitative analyses carried out to determine the fat content in soybeans, it was concluded that the thermal treatment of soybeans does not cause changes in the content of total fats in soybeans, and with regard to the lipid profile, a difference was found between the content of total unsaturated fatty acids.

Key words: soybeans; toasting; fats; fatty acids

ЕФЕКТИ ОД ТОСТИРАЊЕТО ВРЗ СОДРЖИНАТА НА МАСТИ ВО СОЈА (*Glycine max* L. Merrill)

А п с т р а к т: Целта на ова истражување е да се одреди влијанието на термичката обработка на сојата врз промените во нејзиниот липиден статус. Во истражувањето беа вклучени две сорти соја, и тоа пела и илинденка, а анализите за определување на лиипидниот состав на зрното од соја беа спроведени на сурово и термички обработено „тостирано“ зрно соја. Термичкиот третман е извршен со изложување на материјалот на температура од 125 ºC за време од 15 минути. Целта на термичкиот третман е инактивирање на антинутритивните соединенија во зрното како што се инхибиторите трипсин и уреаза кои се главен проблем при користиње на суровата соја во исхраната на моногастричните животни. Поради сензитивниот однос на мастите кон термичкиот третман, направено беше компаративно истражување со цел да се утврди оксидативниот степен на мастите во сојата. Врз основа на добиените релултати од спроведените квантитативни анализи за определување содржина на масти во зрното од соја, беше констатирано дека термичкиот третман на сојата не предизвикува промени во содржината на вкупни масти во неа, а во однос на липидниот профил е констатирана разлика во содржината на вкупни незаситени масни киселини.

Клучни зборови: соја; тостирање; масти; масни киселини

INTRODUCTION

The rich and noble biochemical composition of soy gives it dominant importance in the modern way of nutrition and dietetics for humans, and at the same time it occupies a significant place as a raw material for animal nutrition and in technological cosmetology. Recenly, due

to its high protein content, it is also used as a raw material for isolation and obtaining protein supplements.

The heat treatment of soybeans causes inactivation of anti-nutritional compounds in the grain such as trypsin inhibitors and urease which are the main problem when using raw soybeans in the diet of monogastric animals. This is because anti-nutritional compounds disable the digestion and absorption of protein components.

On average, soybeans contain 35–50% protein, 18–24% fat, 34% carbohydrates, about 5% mineral substances, and are also rich in vitamins A, B, D, E, K, and C. It is also rich in essential elements (Ca, Mg, P, K, Fe, S, Mn, Na, Mo, Cu, B, I, Co, Zn, Se) (Vratarić and Sudarić, 2000). The lipid profile of soybean seeds includes saturated fatty acids: palmitic acid (C16:0 from 10 to 12%) and stearic acid (C18:0 from 2.2 to 7.2%), and from unsaturated fatty acids, oleic acid (C18:1 24%), linoleic acid (C18:2 54%) and linolenic acid (C18:3 8.0%). Soy does not contain cholesterol, only a few relatively more difficult-to-digest saturated fatty acids that are also found in animal foods, which makes soy far superior to animal fats (Lusas, 2004).

Saturated fatty acids (SFAs) in soy represent a diverse group of fatty acids with different biochemical properties and physiological effects. While excessive intake of SFAs is associated with cardiovascular disease (CVD) risk factors, including elevated low-density lipoprotein (LDL) cholesterol levels and inflammation, emerging evidence suggests that not all SFAs have equivalent health effects (Baum et al., 2012). In soybean, SFAs such as stearic acid (C18:0) and palmitic acid (C16:0) predominate, showing differential effects on lipid metabolism, insulin sensitivity, and inflammatory pathways (Lusas, 2004). Understanding the interaction between specific SFAs and metabolic outcomes is critical to elucidate their overall health effects in the context of soy consumption. According to the author, soy offers a balanced composition of SFAs, unsaturated fatty acids (UFAs) and other lipid constituents, providing a favorable fatty acid profile for human health. The ratio of SFA to UFA in soybean affects lipid bioavailability, membrane fluidity, and cell signaling pathways, thereby modulating physiological processes such as lipid metabolism, inflammation, and oxidative stress. In addition, soy contains bioactive compounds such as phytosterols, isoflavones and tocopherols, which synergistically interact with SFA to exert cardio protective effects and improve lipid profiles. The nutritional synergy between SFA and other soy components underscores their role in promoting cardiovascular health and overall well-being (Baum et al,, 2012).

The monounsaturated fatty acids (MUFA) in soybeans, as a distinct group of fatty acids, drive a myriad of biochemical processes and physiological responses that underpin human and animal health and well-being. Although the primary benefits of their consumption have been established based on cardio protective effects and metabolic benefits, modern research also points to secondary effects of specific monounsaturated fatty acids on various physiological systems. In soybeans, the MUFA group was dominated by oleic acid (C18:1), which exerts differential effects on lipid profiles, insulin sensitivity, anti-inflammatory action, and oxidative stress. Elucidating the molecular mechanisms and metabolic pathways through which MUFAs modulate health outcomes is critical to understanding their overall impact on human and animal physiology and the application of soy in the daily diet (Simopoulos, 2016).

Polyunsaturated fatty acids (PUFAs) contain a diverse array of fatty acids with profound biomedical effects on human and animal physiology. While omega-3 and omega-6 PUFAs have significant cardioprotective properties and anti-inflammatory effects, other PUFAs present in soy, such as linoleic acid (LA) and alpha-linolenic acid (ALA), also play a key role in cellular function, gene expression and metabolic regulation (Baum et al., 2012). Understanding the molecular mechanisms and physiological pathways through which PUFAs exert their effects is essential to elucidate their overall impact on human health with daily soy consumption. Soy offers a balanced composition of PUFAs, MUFAs and other lipid constituents, providing a favorable fatty acid profile for human nutrition. The ratio of omega-3 to omega-6 PUFA in soy affects inflammatory processes, lipid metabolism, and cardiovascular health, with implications for chronic disease prevention and management. In addition, soy contains bioactive compounds such as phytosterols, isoflavones, and tocopherols, which synergistically interact with PUFAs to enhance their bioavailability and physiological effects. Understanding the nutritional

synergy between PUFA and other soy components is critical to maximizing their health benefits (Simopoulos, 2016).

The purpose of this research is to determine the influence of thermal processing of soybeans on changes in its lipid status.

MATERIAL AND METHODS

The research includes the soybean crop (*Glycine max* L. Merrill), the varieties Pella and Ilindenka.

Average analytical samples were prepared in laboratory conditions and the content of total fats and fatty acids in the Ilindenka and Pella varieties was determined.

Preparation of an average analytical sample includes sorting of separate individual fractions and their homogenization. The material is brought to an air-dry state and is transferred to cold grinding and sieving through a sieve with 0.5 mm openings. In the plant material prepared in this way, the content of total fats was determined according to the standard Soxhlet method, and in the extracted fats with the help of gas chromatography, the fat fractions were determined, i.e. the content of fatty acids in soy.

The extraction of total fats was carried out using a Soxhlet apparatus using petroleum ether (33–37 °C) as an extraction agent. The reversible extraction was carried out for 8 hours. After the extraction, the total fat content was determined gravimetrically, and the obtained extract was further used for the extraction of the lipid fractions (Јевков и Ѓорговска, 2022).

The qualitative and quantitative composition of fatty acids was determined using gas chromatography. The method is based on the conversion of fats into methyl esters of fatty acids which are determined by capillary gas. A column with dimensions of 30×0.32 mm was used, and the thickness of the film of the stationary phase was 0.25 μm. The carrier gas is hemium with a flow rate of 1.0 ml/min. The temperature of the injector is 200 °C, and the temperature of the detector is 300 °C. The temperature of the column is linearly programmed from 60 to 280 °C, with a change of 3 °C/min. (EN ISO 12966-1:2015).

Thermal processing, i.e. toasting of soybeans, was carried out in a thermal reactor at a temperature of 125 °C for 15 minutes (Lakić, 2016).

RESULTS AND DISCUSSION

Fats or lipids are a group of organic substances that are not soluble in water, but dissolve in organic solvents such as ether, acetone and chloroform. They are important for the organism because of their role as a basic source of energy and participate in the structure of cellular components. Lipids are hydrophobic, meaning they do not mix with water, but they can form emulsions that play a key role in many biological processes. Together with carbohydrates and proteins, they build the basis of the cell membrane and serve as a protection and reserve source of energy for the cells. Lipids are stored as reserve substances in the body, mostly in the form of adipose tissue in animals and in seeds or fruits in plants.

The results obtained from the conducted research on the influence of toasting on the content of total fat and the fractional analysis of fatty acids in the two soybean varieties are presented in Table 1. The results for total fat are expressed as percentages of the air-dry condition of the soybean grain, and the results of the fatty acid content are expressed as % of total fat.

The results presented in Table 1 from the research carried out to determine the total fat content in raw soybeans confirm the fact that soybeans are a plant species with a high fat content. The tested variety Pella contains 22.78% fat, while the Ilindenka variety is characterized by a slightly lower content, i.e. 24.06%. The obtained results are in correlation with the researches of Михајлов (2009), where it was found that the fat content in soybeans ranges from 18 to 24%. The thermal treatment of the grain resulted in a reduction in the total fat content, with the values for Pella being 19.11%, while the total fat value was reduced by 3.67% in Pella and 5.05% in Ilindenka. Contrary to the reduced content of total fat, the percentage share of saturated fatty acids slightly increased under the influence of toasting by 0.2% in both tested varieties. The obtained results are in correlation with the researches of (Lusas, 2004).

No significant differences were found in omega-9 fatty acids. MUFA values range from 18.40 to 18.70% of total fat content.

The presented data indicate a high PUFA content in both varieties, a content of 64.70% in the Pella variety and 65.90% of total fat in the Ilindenka variety. The toasting process has caused a decrease in the PUFA values of the Pella variety by 0.20% and in Ilindenka variety by 0.10%. The obtained results are in correlation with the researches of Baum et al. (2012) and Kulig et. al. (2023).

Table 1

Lipid profile of raw and toasted soybeans

Designation/variant	Pella raw	Ilindenka raw	Pella toasted	Ilindenka toasted
Total fat (%)	22.78	24.06	19.11	19.01
SFA (% of TF)	16.90	15.40	17.10	15.60
C:14 (% of TF)	0.10	0.10	0.10	0.10
C:16 (% of TF)	11.00	10.10	11.30	10.40
C:17 (% of TF)	0.10	0.10	0.10	0.10
C:18 (% of TF)	4.70	4.10	4.70	4.10
C:20 (% of TF)	0.40	0.40	0.40	0.40
C:22 (% of TF)	0.40	0.40	0.40	0.30
C:24 (% of TF)	0.20	0.20	0.10	0.20
MUFA (% of TF) C:18:1-cis-9 (ω-9)	18.40	18.70	18.40	18.60
PUFA (% of TF)	64.70	65.90	64.50	65.80
C:18:2-cis-9,12(ω-6)	53.90	55.30	53.60	55.50
C:18:3-cis-9,12,15(ω-3)	10.80	10.60	10.90	10.30

CONCLUSION

Soy, as a rich source of fat, offers significant nutritional benefits through its composition of saturated, monounsaturated, and polyunsaturated fatty acids. Soy has a favorable ratio between saturated and unsaturated fatty acids, with a high percentage of unsaturated fats. This is nutritionally beneficial, as unsaturated fats help lower cholesterol and support cardiovascular health, while saturated fats should be consumed in moderation. The fats and fatty acids in soybeans offer significant nutritional advantages. The high content of healthy, unsaturated fats and omega-3 and omega-6 fatty acids make soy beneficial for supporting heart health, reducing inflammation and providing essential nutrients to the brain and body. The applied toasting treatment caused a significant reduction of 3.67% in Pella and 5.05% in Ilindenka in total fat, and a slight increase of 0.2% in both cultivars in the SFA ratio. No significant differences were observed in the rest of the fat components.

Soybean, with its positive ratio between saturated and unsaturated fats, is an excellent choice for a balanced diet and can be a key segment in the modern way of eating, special nutrition and diet therapy.

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