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Fatty acid composition including *trans*-fatty acids in salty snack food from the Serbian market

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Abstract: The rapid increase in the consumption of salty snack products has led to increased concern about their composition and nutritional value. The aim of this study was to investigate the fat content and fatty acid profile in salty snack products from the Serbian market. A total of 58 different snack products from 3 categories (Baked products, Chips & flips products, Cereal products) were analyzed. The fatty acid composition was determined using gas chromatography. Total fat content ranged from 3.1 % in expanded rice to 35.7 % in potato chips. Palmitic, oleic and linoleic acids constituted > 80 % of all fatty acids (FAs) in categories Baked products and Chips & flips. Linoleic acid was more abundant in the category Cereal products (15.5–49.3 %). The *trans*-FAs elaidic (C18:1 - 9*t*) and linolelaidic FAs (18:2 - 9*t*, 12*t*) were identified in 66 % of the products. The flips products had the highest average *t*-FAs content (16.3 %), followed by flips group (9.3 %). Potential *t*-FAs intake from 100 g of analyzed products was in range 0.1–4.9 g. This study provided a large database on saturated fatty acids and *t*-FAs content in salty snack products and indicated that by consuming only one package of some products, the *t*-FAs intake could surpass the recommended maximum of 1 % of daily energy.

Keywords: savory snacks; lipid profile; gas chromatography.

INTRODUCTION

The consumption of snack products, such as chips, popcorn and crackers, has increased in the last years. Generally, this snack is highly appreciated, especially among young people. Snacks come in a variety of forms including packaged snack foods and other processed foods, as well as items made at home. Manufactured snack foods often contain substantial amounts of flour, hydrogenated vegetable

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fats, sugar, potato, cereals and additives, such as emulsifiers, flavor enhancers and raising agents. These products are often rich in energy, salt or sugar, fat, saturated fatty acids (SFAs) and *trans*-fatty acids (*t*-FAs), and poor in vitamins, minerals and dietary fiber. The fat content, fatty acid composition, and the presence of *t*-FAs are usually considered as very important parameters for nutritional and health profiling of snack products. There is wide consensus that SFAs and, even more, *t*-FAs have negative effect on blood lipids and that their dietary intake should be limited. Based on the recommendations of the World Health Organization (WHO), the daily intake of total fats should not exceed 30 % of the total energy intake, saturated fat intake should be less than 10 %, and *trans*-fat intake should be less than 1 % of the total energy.[1,2] The European Food Safety Authority (EFSA) issued in 2010 the opinion that the intake of SFAs and *t*-FAs should be as low as possible.[3] Understanding the importance of different foods as dietary sources of SFAs and *t*-FAs is significant for exploring the most effective practices and actions for reducing their intake in the overall population.

Due to their popularity and possible health impact, the fat profile of snack products has recently been investigated in several countries. The contents of total fats and the fatty acids profile in snack products available at the local markets was investigated in the United Kingdom,[4] Malaysia,[5] Brazil,[6] Sweden,[7] Spain[8] and Portugal.[9] These results are important not only for the establishment of nationally relevant nutrient databases, but also for evaluating the total fat, SFAs, and *t*-FAs intake from these products. It is interesting that several of the mentioned studies, especially those coming from developed countries, showed that the content of industrially produced *t*-FAs in food and snacks had decreased significantly in last decade.[4,7,8] The reasons for such a trend could not only be that evidence of the health effects of *t*-FAs is being made more transparent and publically available and that industry has made a reformulation of critical food items such as margarines and shortenings; but also that legal limits for *t*-FAs have been introduced in some countries. Although some studies show a negative trend in the saturated and *trans*-fat contents in food in some western countries, their intake is still surpassing the recommended values in many cases.[6,9] In the last years, although several studies[10-13] were conducted to evaluate the *t*-FAs in Serbian products, such as biscuits, margarines, shortenings and traditional white brined cheeses, there is lack of information concerning the fatty acid profiles and *trans*-fatty acid contents in industrially produced salty snack foods available on the Serbian market. Nutrition labeling will not be mandatory in Serbia until 2018, and at the same time, the existing nutrition labels often do not include information on SFAs and *t*-FAs.[14,15] This fact, together with the lack of comprehensive, nationally available, food tables database, complicate the process of evaluating snack foods from the Serbian market as sources of individual fats. Simultaneously, the WHO in its "policy brief" from 2015 on *t*-FAs in Europe as one of the main objectives for

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policy makers, indicated the identification of all products containing *t*-FAs that are available on the market.[16]

This study has been designed as a survey of the fatty acid composition in specific types of snacks most commonly consumed in Serbia. The main problem with snack food analysis is lack of common definition of this product category and hence, a wide range of diverse food groups, salty or sweet, liquid or solid, industrially/in-restaurants/home-made, have been included in different surveys. This research was focused on one sub-group of snack foods, namely salty snack foods, all industrially produced and pre-packaged. The main aim was to investigate the content of total fats as well as the fatty acids profile with special emphasis on SFAs and *t*-FAs. Data from this research could be useful in future estimations of population exposure to SFAs and *t*-FAs from this food category.

EXPERIMENTAL

Sample selection

A total of 102 samples that represented 58 different salty pre-packaged food products were purchased from supermarkets, local shops and health food stores in Serbia and included both nutritionally labeled and unlabeled products. The package size of the different products varied from 18 to 250 g. The chosen products originated from different countries (Serbia, FYROM, Bulgaria, Hungary, Croatia and Belgium), different producers, as well as different lots within the same producer. The selection of products was based on the eating habits of college students and teenagers that were previously investigated (unpublished data) and on in-store availability. The analyzed products were divided into 3 main categories according to the Guidance document describing the food categories of the European Commission.[17]

1. The baked products category included food groups: salted crackers, fish-shaped products, bake rolls (salty bread crisps based on wheat flour) and kubz (salty biscuit product based on rye grain and wheat), salted pretzels and salted sticks.

2. The Chips & Flips category included the food groups potato chips, tortilla chips, flips, flips products and clipsy (pellet-based product).

3. The cereal products category included the food groups fried corn nuts, popcorn, roasted soybean, expanded rice and rice cake (expanded rice products).

A list and the number of analyzed products are given in Table I.

Sample preparation

Food samples were homogenized immediately after purchase using blender machine and manual grinding in a mortar with pestle and kept in plastic capped bottles, coded with Arabic numerals and stored bellow 20 °C prior to analysis. All samples were analyzed in triplicate.

Total fat content

Total fat content was determined gravimetrically, after chloroform extraction, according to a modified Soxhlet method,[18] recognized by the Analytical Chemists Association as the standard method for analyzing the content of total lipids in samples of plant and animal origin. About 10 g of homogenized sample was extracted for 4–5 h. Chloroform (min. 99 % purity, provided from Sigma–Aldrich, USA) is one of commonly used, non-flammable, non-polar organic solvents for total fat extraction. The results are expressed in %.

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TABLE I. Sample description including information from the product label: po, palm oil; vo, vegetable oil; hvf, hydrogenated vegetable fat; poo, palmolein oil; non-hvo, non-hydrogenated vegetable oil; vf, vegetable fat; pf, palm fat; co, coconut oil; so, sunflower oil

Product type	Number of different products	Total number of analyzed samples	Type of fat used in production
Bakery products			
Crackers	4	11	po
Fish-shaped products	4	12	vo/hvf/poo
Bake rolls and kubz	3	3	po
Salted pretzels	2	5	non-hvo
Salted sticks	8	17	vf and-or/hvf/pf/co/so
Chips and flips			
Potato chips	5	5	vo and vf/po
Tortilla chips	2	3	vo
Flips	8	14	vf and vo/hvf/so
Flips products	2	7	pf and po
Clipsy	6	7	po and pf
Cereal products			
Fried corn nuts	4	8	vf and vo/pf
Popcorn	3	3	vo/co/po
Roasted soybean	2	2	
Expanded rice and rice cake	5	5	

Fatty acid methyl ester (FAME) preparation

The conversion of the extracted lipids into fatty acid methyl esters was achieved with 3 mol L^{-1} HCl in methanol. Approximately 0.2 g of lipids was transferred into a glass cuvette and 1.5 mL of 3 mol L^{-1} HCl was added, mixed, heated in a water bath at 85 °C for 45 min, and cooled. Hexane (min 99 % purity, Sigma–Aldrich, USA) was added for FAME extraction. After centrifugation for 15 min at 4000 rpm, the hexane (upper layer) containing the fatty acid methyl esters were transferred into vials using Pasteur pipettes and immediately analyzed.

Gas chromatography

The fatty acid methyl esters (FAMEs) were analyzed using an Agilent Technologies 7890 gas chromatograph (GC Agilent Technologies, Agilent 6890/7890 GC ChemStationOperation, Santa Clara, CA, USA) equipped with a flame ionization detector (FID). The FAMEs were separated on CP-Sil88 capillary column (100 m×0.25 mm internal diameter, coated with 0.2 µm cyanopropyl polysiloxane as the stationary phase), provided by Supelco (Bellefonte, PA, USA). The chromatographic conditions were: 1 µL injections of the FAME mixture were made at a split ratio of 20:1; the conditions for split inlet were: injector temperature, 250 °C; injector split flow, 20 mL min^{-1}; pressure, 31,623 psi and total flow, 24 mL min^{-1}. The oven temperature program started at 80 °C, increased at 4 °C min^{-1} to 220 °C (hold time, 5 min), then at 4 °C min^{-1} up to 240 °C and held at 240 °C for 10 min. Helium was the carrier gas (constant flow, 1.0 mL min^{-1}) and the make-up gas was nitrogen (flow rate, 25 mL min^{-1}). For the applied method, the FID detector was calibrated under the following conditions: FID detector temperature was 270 °C, makeup gas N_2; H_2 flow, 30 mL min^{-1}; air flow, 400 mL min^{-1}; makeup flow, 25 mL min^{-1}. Run time was 55 min. ChemStations was used for the collection and elaboration of the results (identification and quantification of the peaks). Identification of chromatographic peaks was

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achieved by comparing their retention times with those of an appropriate FAMEs standard mix (Supelco FAME Mix, Bellefonte, USA). Quantification was based on the ratio between the sum of the peak areas and the corresponding peak area. The results are expressed as the percentage of individual fatty acids to the total fatty acids. The identified *trans*-isomers were C18:1 – 9*t* and C18:2 – 9*t*, 12*t*. The efficiency of the column, expressed as the number of theoretical plateau of 3 standard fatty acids, palmitic, stearic, and oleic, was in range 362870–510262, while the reproducibility of the response was determined as a percentage of relative standard deviation (*RSD* %) of successive measurements of the same reference solution and was in range 2.3–4.6 for the same standard fatty acids.

Statistical analysis

Results for fat content and fatty acid profile are expressed as means ± standard deviation (*SD*) obtained for all analyzed products from one food group. For example, in food group of salted crackers, 11 individual samples of 4 different products were analyzed and presented as mean value, range and *SD* for this food group.

RESULTS AND DISCUSSION

The main characteristics of the analyzed products

All 58 different salty snack products were analyzed, 80 % of which were produced in Serbia. Considering the manufacturing process, 49 % were baked, 15.7 % were fried and 27.4 % extruded, while expanded products were represented only with 7.8 %. Products were grouped in 3 categories: baked products, chips & flips, and cereal products, and each category consisted of several groups of products similar in composition and/or manufacturing process.

Total fat analysis and individual fatty acids profile

The total fat content (TF) and the percentages of total SFAs, monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), and individual *t*-FAs for all three analyzed categories of salty snack products are given in Tables II–IV.

The total fat content and fatty acid composition in the category chips & flips that included five snack product groups (potato chips, tortilla chips, flips, flips products and clipsy) are summarized in Table III. This category is a rich and more uniform source of total fats with contents ranging from 29.4 to 35.7 %. Nine fatty acids were identified in this salty snack category. Oleic and palmitic acids accounted for more than 70 % of all FAs, followed with linoleic acid (9–15 %). In this category, even a small amount of α-linolenic acid, C18:3, were found (1.8–3.0 %). In all five groups of the chips & flips category, SFAs and MUFAs were the most abundant fatty acids, 28–47 %, and 37–50 %, respectively (Fig. 1).

From results in Table IV, it could be seen that cereal products (fried corn nuts, popcorn, roasted soybean and expanded rice and rice cakes) demonstrated lower but very extensive range of average total fats values. The group of expanded rice and rice cakes showed the lowest mean value of 3.1 %, while salted popcorn had the highest fat content (22.6 %). The same FAs were identified as in

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TABLE II. Total fat content and FA composition in baked products; TF, total fat; FAs, fatty acids; *t*, *trans*; *SD*, standard deviation; nd, not detectable; Σ*trans*FAs, sum of all *t*-FAs

FA	Crackers		Fish-shaped products		Bake rolls and kubz		Salted pretzels		Salted sticks	
	Range	Mean± ±*SD*	Range	Mean± ±*SD*	Range	Mean± ±*SD*	Range	Mean± ±*SD*	Range	Mean± ±*SD*
TF, %	14.9–29.5	20.8±5.2	17.6–25.8	21.6±2.8	15.5–25.2	19±5.4	7.1–10.5	8.4±1.4	6.0–42.5	14.8±10.5
Individual fatty acids content, % of total FAs										
C12:0	0.4–0.7	0.5±0.1	0.2–17.8	4.0±6.0	nd	nd	0.2–0.3	0.2±0.1	0.2–1.0	0.5±0.3
C14:0	1.0–1.3	1.1±0.1	0.6–8.1	2.2±2.4	1.2–1.2	1.2±0.04	0.8–0.9	0.9±0.1	0.5–0.9	0.8±0.2
C16:0	40.2–42.8	41.7±0.8	29.0–42.9	34.0±5.6	45.1–52.6	47.7±4.3	36.5–47.9	41.4±4.4	14.4–48.1	31.2±10.2
C18:0	4.4–11.5	5.4±2.0	4.1–10.1	5.9±1.5	5.3–5.6	5.5±0.3	4.7–15.7	9.2±5.6	2.4–11.3	5.0±2.5
C18:1	29.8–31.5	33.0±1.6	22–37.5	30.4±4.8	34.3–37.4	36.0±1.6	18.5–31.4	25.4±5.9	25.0–59.1	33.8±13.0
C18:1*t*	0.8–0.9	0.9±0.1	0.8–13.8	6.7±4.6	0–1.0	0.3±0.6	nd	nd	0.6–21.8	6.6±9.3
C18:2	15.2–20.6	17.2±0.6	12.0–26.0	17.7±4.6	10.7–11.5	11.1±0.3	15.9–27.6	22.2±4.6	12.5–43.8	23.6±7.9
C18:2*t*	0.3–0.6	0.5±0.2	0.5–1.2	0.8±0.5	0–0.2	0.1±0.1	nd	nd	0.5–1.4	0.9±0.4
Σt-FAs	1.1–1.5	1.3±0.9	0.8–14.2	6.2±8.7	0–1.2	0.4±0.7	nd	nd	1.4–21.8	6.6±8.5

TABLE III. Total fat content and FA composition in chips and flips; TF, total fat; FAs, fatty acids; *t*, trans; *SD*, standard deviation; *nd*, not detectable; Σ*trans*FAs= sum of all *t*-FAs

FA	Potato chips		Tortilla chips		Flips		Flips products		Clipsy	
	Range	Mean± *SD*	Range	Mean± *SD*	Range	Mean± *SD*	Range	Mean± *SD*	Range	Mean± *SD*
TF, %	31.6–40.4	35.7±4.1	22.9–28.2	25.0±2.8	20.3–39.4	30.0±5.8	28.7–44.5	33.2±5.3	31.1–33.7	32.4±2.2
Individual fatty acids content, % of total FAs										
C12:0	nd	nd	nd	nd	0–9.3	0.7±2.5	nd	nd	nd	nd
C14:0	nd	nd	nd	nd	0.7–7.2	3.9±4.6	nd	nd	nd	nd
C16:0	13.2–44.8	37.8±13.8	40.5–44.2	42.4±1.9	8.4–46.7	26.5±13.7	11.2–48.3	23.5±15.2	35.4–46.3	42.7±4.2
C18:0	4.5–5.1	4.9±0.2	4.4–4.6	4.5±0.2	2.8–7.9	4.9±1.5	3.7–7.6	5.5±1.7	3.7–5.1	4.7±0.5
C18:1	35.5–55.4	40.8±8.3	34.5–38.9	36.6±2.2	25.6–65.5	45.4±11.3	41.4–65.6	49.9±9.8	34.4–48.4	39.8±5.0
C18:1*t*	nd	nd	nd	nd	0.2–17.0	9.1±7.1	12.4–20.8	16.3±3.8	0–9.3	1.3±3.5

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TABLE III. Continued

FA	Potato chips		Tortilla chips		Flips		Flips products		Clipsy	
	Range	Mean± *SD*	Range	Mean± *SD*	Range	Mean± *SD*	Range	Mean± *SD*	Range	Mean± *SD*
Individual fatty acids content, % of total FAs										
C18:2	8.2–22.5	14.0±5.7	11.1–16.8	13.2±3.1	4.9–48.9	15.2±11.8	5.2–18.1	9.3±4.6	8.1–12.3	9.2±1.5
C18:2*t*	nd	nd	nd	nd	0.4––1.0	0.7± 0.4	nd	nd	0.0–0.4	0.06±±0.2
C18:3	2.0––3.2	2.4±0.6	1.5––4.4	3.0±2.0	nd	nd	1.3–3.3	2.3±1.4	1.5–2.0	1.8±0.2
Σ*t*-FAs	nd	nd	nd	nd	1.2–17.0	9.3±6.8	12.4––20.8	16.3±3.8	0.0–9.7	1.4±3.7

TABLE IV. Total fat content and FA composition in cereal products; TF, total fat; FAs, fatty acids; *t*, *trans*; *SD*, standard deviation; nd, not detectable; Σ*trans*FAs, sum of all *t*-FAs

FA	Fried corn nuts		Popcorn		Roasted soybean		Expanded rice and rice cakes	
	Range	Mean± ±*SD*	Range	Mean± ±*SD*	Range	Mean± ±*SD*	Range	Mean± ±*SD*
TF, %	9.4–30.8	16.3±8.6	19.9–27.9	22.6±4.6	20.9––22.5	21.7±1.1	1.1–3.9	3.1±1.1
Individual fatty acids content, % of total FAs								
C12:0	nd	nd	33.4	33.4	nd	nd	nd	nd
C14:0	nd	nd	14.7	14.7	nd	nd	nd	nd
C16:0	33.8––42.9	37.4±3.1	16.2–34.3	23.2±9.7	15.8––16.6	16.2±0.6	14.7–24.3	20.1±3.6
C18:0	3.3–4.8	4.1±0.5	3.8–4.0	3.8±0.1	5.3–6.6	6.0±1.0	3.3–4.7	4.2±0.7
C18:1	28.9––36.4	32.6±2.7	13.8–61.4	34.3±24.5	19.3––23.3	21.3±2.8	21.6–34.9	28.3±5.3
C18:1t	1.2–2.3	1.7±0.7	nd	nd	0.0–0.4	0.2±0.3	2.3–4.6	3.4±1.2
C18:2	14.5––31.6	22.1±5.9	13.0±18.2	15.5±2.6	48.2––50.5	49.3±1.6	20.2–39.3	30.7±7.1
C18:2t	0.0–1.0	0.1±0.4	nd	nd	0.0–0.1	0.05±0.1	0.7–5.4	2.7±2.1
C18:3	1.0–3.1	2.0±1.1	nd	nd	5.1–7.2	6.1±1.4	0.0–18.7	3.7±8.4
Σ*t*-FAs	1.2–3.3	2.3±1.5	nd	nd	0.0–0.5	0.25±0.4	3.0–7.9	6.2±2.2

the previous snack category. The only exception was one sample of salted popcorn where fatty acids with C12:0 and C14:0 were identified but in this sample, they represented together 48 % of all fatty acids. Linoleic acid was more abundant in this snack category than in the previous ones (15.5–49.3 %), and palmitic and oleic acids were present in high quantities. The profiles of SFAs, MUFAs and PUFAs differed significantly among the groups in this snack category. While in the roasted soybean and expanded rice and rice cake groups, PUFAs were the most abundant fatty acids, in salted popcorn and fired corn nuts, SFAs were the most abundant (Fig. 1).

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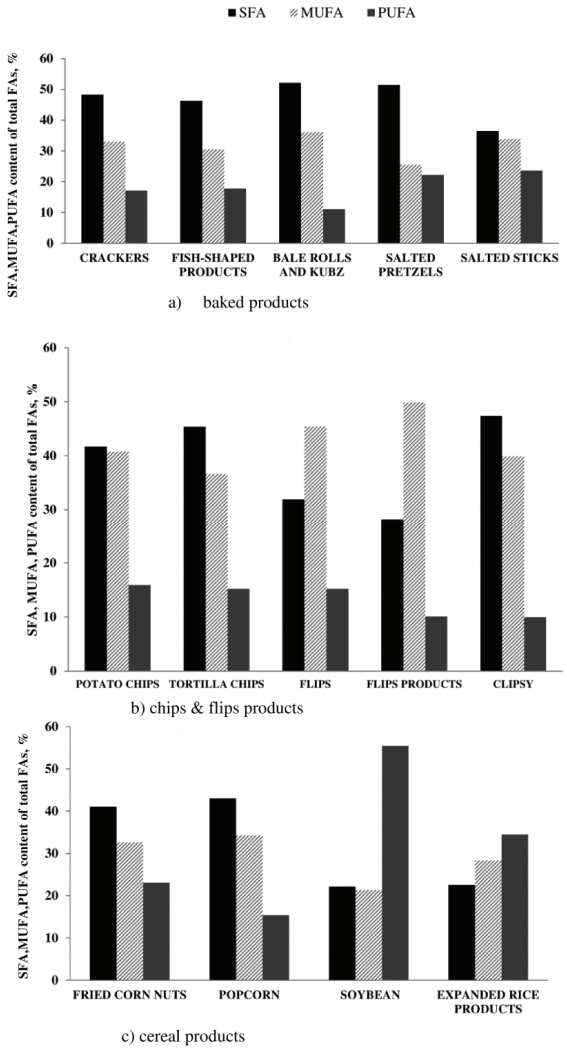

Fig. 1. SFA, MUFA, PUFA content in: a) baked products, b) chips & flips and c) cereal products (SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids).

Only two *trans*-isomers, elaidic (C18:1 - 9*t*) and linolelaidic (C18:2 - 9*t*, 12*t*) fatty acids, were identified in 38 out of 58 analyzed snack products. An example of a fatty acid chromatogram in one salty snack product with detected *trans* isomers is given in Fig. 2 (*trans*-isomers of fatty acids are labeled with circular lines; 2-C 18:1-9 *t*-elaidic, on 36.185 min, and C 18:2-9*t*, 12*t*-linolelaidic, on 37.790 min).

In four out of the five analyzed groups of baked products, both *trans*-isomers were present. In salted sticks and fish-shaped products, elaidic acid comprised on average more than 6 % of the total fatty acids, while in all products, values for C18:2 *trans*-isomer were <1 %. Only the salted pretzels samples had no *trans*-

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-isomers. Within the chips & flipsy snack category, potato and tortilla chips surprisingly had no measurable amounts of *trans*-fatty acids. Products from flips and flips products groups, on the contrary, had considerably high percentage of elaidic acid (average values 9.1 and 16.3 % of all FAs, respectively). Flips and clipsy products also had measurable values of C18:2 *t* isomer, but less than 1 %. Elaidic and linolelaidic acids together were present in varying degrees (0.3–6.2 %) in the majority of products from the cereal products category, while only in the popcorn samples were no *trans*-fatty acids detected. Several individual products from the snack groups, such as salted sticks, flips, and flips products, had elaidic acid content surpassing 20 % of all fatty acids Tables II–IV).

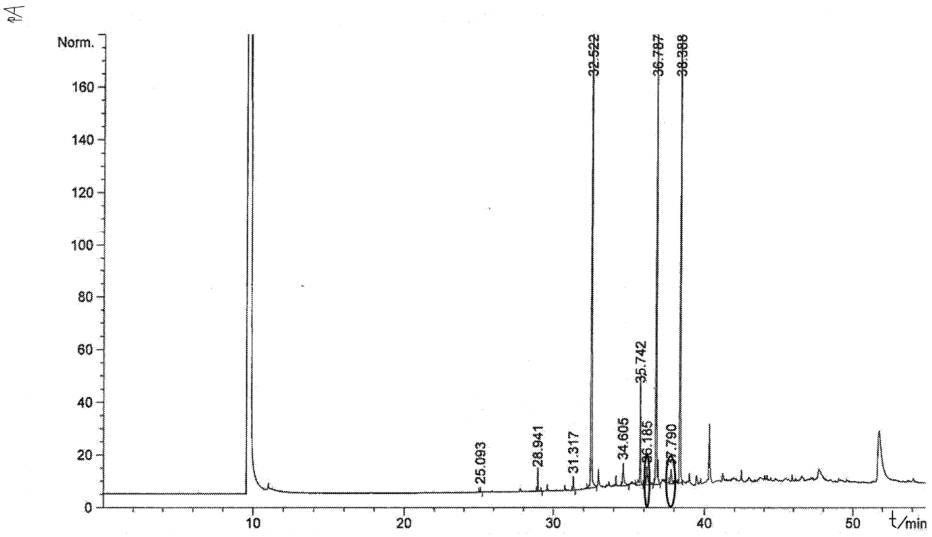

Fig. 2. Typical chromatogram of the fatty acid composition in an analyzed salty snack product.

An example of a fatty acid chromatogram in one salty snack product with detected *trans* isomers is given in Fig. 2 (*trans*-isomers of fatty acids are labeled with circular lines).

In recent years, there were several studies associated with fatty acids analysis in salty snack products. Observing previous research on salty snack products, most of it was related to potato chips, tortilla chips, pretzels, popcorn, crackers and snack cakes. The content of total fats was found to vary significantly between the different investigations, as well as between the types of analyzed snack products.[19–21] Similar variations were found in the results for individual fatty acids within the same product type. For example, the SFAs content in the 12 analyzed samples of potato chips differed significantly and ranged from 14.9 to even 50.4 % in the study of Kandhro *et al.*,[22] while the average value in

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the study of Albers *et al.*[23] was 20.6 and 30.3 % in the study of Innis *et al.*[24] Cracker samples also showed great variations in the SFAs results from 4.5[20] to 20.9 %.[23,24] The same *trans*-isomers were found in almost all of the above mentioned snack groups in previous studies. Innis *et al*.[24] showed that crackers had the highest mean value of *t*-FAs (40.3 % of all fats) and in another study popcorn had 23.2 % *t*-FAs.[23] The study of Vardavas *et al.*[19] showed that the amount of total *trans*-monounsaturated fatty acids (*t*-MUFAs) in the analyzed samples of corn chips ranged from 0.4 to 0.5 % of total FAs. Despite the noticed variations and differences, the findings support the fact that SFAs and MUFAs are the two main fatty acid groups in the salty snack products available on different markets, but also that the majority of these products contain *t*-FAs in varied quantities, especially elaidic acid could be expected.

Since the basic recipes for certain food products are similar, the reason for the noticed differences in fat content and profile in the same snack category is mainly the usage of different types of fats in the production process. Food producers may use hydrogenated or non-hydrogenated oils or fat combinations to achieve the desired characteristics of the final product. Variability in SFAs, MUFAs, PUFAs and *t*-FAs content within a food group or category is undoubtedly more influenced with these parameters than with the fat profile of basic ingredients, such as flour, cereals or potato. From Table I, it could be seen that only in 6 products that were analyzed (13 %) was no fat added during the production process and various vegetable fats and oils were used in the production of the analyzed salty snack products. Palm fat was commonly used in present survey (in 33 % of the products), but also hydrogenated vegetable fat (8.3 %). In a great number of products, the vegetable oil/fat type was not identified on the label, which means that inspection of the list of food ingredients could not give insight into the expected product fat profile.

The presence of *t*-FAs in 66 % of analyzed products could not only be explained by the use of partially hydrogenated vegetable oils, but also by the high temperatures of the applied frying/extruding/expanding or baking processes. Several studies indicated the relationship between the frying process and increasing *t*-FAs content.[25–28] Furthermore, changes in the *t*-FAs content could be induced by changes in the manufacturing conditions (temperature/moisture/rotation speed) during extrusion or expansion processes.[29] Daglioglu *et al.*[30] studied the effects of baking processes on the fatty acid composition and showed an apparent increase in elaidic acid levels in both microwave and conventional baking. In the present investigation, expanded rice and rice cakes were minority products with no added fats that had an average *t*-FAs content of 6.2 %, which could be explained by the effect of the expanding process on the basic ingredients. In the group of clipsy and flips products, only palm oil or palm fats were listed on the labels, but these products had surprisingly high levels of *t*-FAs,

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which indicate that the conditions of the production process also significantly affected *t*-FAs formation, but, as with the expanded products, could also indicate possible incomplete or inadequate labeling of the ingredients.

The potential *t*-FAs intake in grams from 100 g of analyzed snack products was calculated and expressed as an average value for each product group, but also as a maximum value was determined in each product group (Fig. 3).

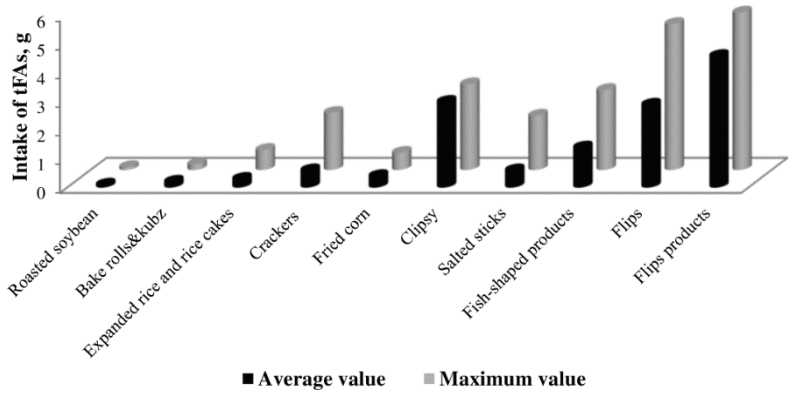

Fig. 3. Intake of *t*-FAs from salty snack products.

A wide range from 0.1 g to 4.9 g was seen in the average values with maximum levels in certain product reaching 6.2 g. The flips and flips product groups were identified as the snack types containing the highest amounts of *t*-FAs. The present calculations showed an alarming fact that in 9 of the analyzed individual products, the *t*-FAs content was so high that their consumers could easily reach 0.5–1 % of the daily energy in *t*-FAs with only one package (calculated based on 2000 kcal* daily energy intake). When the labels were evaluated, only 46 % of analyzed products had information on the SFAs content, only two products had the nutritional claim "no trans fats", and the information about the content of *t*-FAs was not available on any package.

Snack foods are very popular, especially in some vulnerable population groups, such as children, adolescents and students.[31] Some recent studies have shown that snack consumption can contribute more than 20 % to the daily energy intake.[32,33] Considering these findings on their fatty acid profiles, popular packaged salty snack products in Serbia could significantly contribute to the overall daily intake of SFAs and *t*-FAs.

In last years, a few papers on *t*-FAs in products from the Serbian market were published. Kravić *et al.*[10] reported on *t*-FAs in biscuits, Vučić *et al.*[11] analyzed the FAs composition in margarines made in Serbia, while Stender *et al.*[34] studied the *trans*-fat content in popular foods frequently consumed (biscuits/

* 1 kcal = 4184 J

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/cakes/wafers – more than 600 samples) in 2012 and in 2014 in six European countries, including Serbia. The present study is the first to report the FAs composition and industrially *t*-FAs content in salty snack food from the Serbian market. The comparison between FAs composition of biscuits and of salty snack products present on Serbian market revealed that the *t*-FAs content in biscuits was often higher (0–42.5 % of total fats) than in salty snack products (0 to 21.8 % of total fat). Due to the lack of proper food labeling legislation and no *t*-FAs limitation in Serbia, there is obviously a problem with the risk of high *t*-FAs intake from several sources.

CONCLUSIONS

The results of this study indicated that the analyzed samples showed considerable variations in total fats, SFAs and *t*-FAs within a food category, as well as in different brands of the same food item. The finding provides a large database on fatty acid composition in salty snack products manufactured in Serbia and the region and ensures a baseline for further research aimed at monitoring levels and types of fatty acids in food. Taking into account the fact that consumption of only one package could exceed the recommended maximum for *trans*-FAs and that the analyzed products are very popular, especially among young people, there should be an action plan to reduce intake of these nutrients. Better education concerning the importance of healthy eating habits and mandatory limitation of the *t*-FA content in the final products are two strategies that could be used to improve dietary habits.

ABBREVIATIONS

TF – total fat
FAs – fatty acids
t-FAs – *trans*-fatty acids
SFAs – saturated fatty acids
MUFAs – monounsaturated fatty acids
PUFAs – polyunsaturated fatty acids

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И З В О Д

МАСНЕ КИСЕЛИНЕ И ЊИХОВИ *trans*-ИЗОМЕРИ У СЛАНИМ СНЕК ПРОИЗВОДИМА

ЈАСМИНА Б ТИМИЋ[1], ИВАНА Д ЂУРИЧИЋ[1], ДАНИЈЕЛА К РИСТИЋ-МЕДИЋ[2] и СЛАЂАНА С ШОБАЈИЋ[1]

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Нагли пораст потрошње сланих снек производа довео је до тога да се више пажње обрати на њихов састав и нутритивну вредност. Циљ ове студије био је испитивање садржаја масти и профила масних киселина сланих снек производа са српског тржишта. Анализирано је 58 различитих производа из 3 категорије (печени производи, чипс и

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флипс производи и производи од жита). Састав масних киселина одређен је гасном хроматографијом. Укупан садржај масти кретао се од 3,1 % у експандираном пиринчу, до 35,7 % у чипсу. Палмитинска, олеинска и линолна киселина чиниле су преко 80 % свих масних киселина у категорији печених производа и чипс и флипс производа. Линолна киселина била је најзаступљенија у категорији производа од жита (15,5–49,3 %). *trans*--Изомери елаидинска (C 18:1 - 9*t*) и линолелаидинска масна киселина (C 18:2*t*) идентификовани су у 66 % узорака. Највећи просечан садржај укупних *trans*-изомера забележен је у групи флипс производа (16,3 %), и групи флипса (9,3 %). Израчунати потенцијални просечни унос *trans*-масних киселина из анализираних сланих снек производа кретао се у распону од 0,1 до 4,9 g. Ова студија пружа велику базу података о садржају засићених масних киселина и *trans*-изомера незасићених масних киселина и указује на чињеницу да конзумирањем само једног паковања производа унос *trans*-масних киселина може премашити препоручени максимум од 1 % дневног енергетског уноса.

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