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Saturated fatty acids and total fat daily intake through consumption of processed meat products

Dejana Trbovic[1], Brankica Lakicevic[1], Mirjana Lukic[1], Vesna Jankovic[1], Zoran Petrovic[1], Aleksandra Nikolic[1], Ivan Nastasijevic[1]

A b s t r a c t: Processed meat/fish products (pâtés, cooked chicken sausages, canned chopped meat and dry fermented sausages) were evaluated for their contribution to the total daily intake of saturated fats and total fats, in relation to Serbian and European regulations. Estimations of saturated fat daily intakes indicated that fish pâté and chicken cooked sausages would provide similar amounts to the recommended daily limit of saturated fat (limited to 10% of total fat intake), while the calculated contributions from pork and beef meat products were much greater (pâtés 20–53%; canned chopped meat 22–23%; dry fermented sausages 65–81%). The ratio of n-6/n-3, as an indicator of lipid quality, was ≤4 in fish pâtés and was considerably higher in turkey, ham and chicken pâté (17.5, 21.9 and 46.9 respectively), cooked chicken sausages (8.55–14.98), canned chopped meat (13.28–16.07) and dry fermented sausages (22.12–26.78). The results obtained could be of importance for the establishment of tables for nutritional value of products. It was confirmed that a regular intake of saturated fat and total fat via consumption of processed meat products, in particular processed pork products, was likely to be high in the Serbian general population. We speculate that this is, in turn, is likely to increase the potential risk for development of coronary heart disease (CHD). The increased awareness of the meat industry regarding the importance of the fat content/quality in processed meat products and its impact on health, optimization of the product specifications (replacement of SFAs with unsaturated fats), health promotion activities by public health authorities, as well as better education of consumers about beneficial nutrition habits (e.g. Mediterranean diet) should reduce the rate of CHD.

Key words: *processed meat products, total fats, saturated fats, fatty acids.*

Introduction

In Western countries, the percentage of fat in the diet is high and a consequence is that the excess fat from consumed food is regularly deposited in adipose tissue (*Wood et al.,* 2008). Lipids in blood are transported by means of lipoproteins, which have a very important role in lipid metabolism. Higher levels of triglycerides in the blood usually increase the level of low density lipoprotein (LDL). LDL cholesterol, high density lipoprotein (HDL) cholesterol and triacyl-glycerol levels in blood are directly linked to quantity and quality of fat in the diet (*Vandendriessche*, 2008). The various saturated fatty acids (SFAs) differ in their effects on the blood lipoprotein profile, e.g. lauric (12:0), myristic (14:0) and palmitic (16:0) acids can raise blood total and LDL cholesterol concentrations, while stearic acid (18:0) has no effect (*EFSA*, 2010). Therefore, a healthy diet should include different types of fat, but in small amounts. Linoleic acid (18:2*n*-6) is the most important *n*-6 fatty acid of plant origin. In humans, it can lower levels of total and LDL cholesterol and, to some extent, HDL cholesterol, which is obviously an undesirable effect (*Lada & Rudel*, 2003). The most important *n*-3 fatty acids are eicosapentaenoic acid (20:5*n*-3, EPA), docosahexaenoic acid (22:6*n*-3, DHA) and α-linolenic acid (18:3*n*-3, ALA). ALA can be introduced into processed meats by changing the product specification through the introduction of ALA-rich vegetable oil instead of animal fat. However, it has been demonstrated that the increased consumption of *n*-3 from ALA has no beneficial effect on health (*Wang et al.*, 2006; *Fretts et al.,* 2014).

Desirable total fat intake in the diet, according to most experts, should amount to only 25–30% of the total daily energy intake (*EFSA*, 2010), provided that 10–15% of the daily energy intake comprises monounsaturated fatty acids (MUFAs), which have a neutral/favourable effect on development of coronary heart disease (CHD). In the UK, the recommended fat intake should be reduced to less than 30% of the total energy intake (*Department of Health*, 1994), while up to 10% of energy intake in

[1]*Institute of Meat Hygiene and Technology, Kacanskog 13, 11 000 Belgrade, Republic of Serbia.*

Corresponding author: Dejana Trbovic, *dejana.trbovic@inmes.rs*

the form of SFAs would enable the body to completely fulfil its essential metabolic functions, at the same time diminishing the risk of CHD (*Wood et al.,* 2008; *Micha & Mozaffarian*, 2010). Furthermore, although dietary guidelines often recommend reduction in SFA consumption, such guidelines often do not highlight any specific nutrient as preferable for replacing SFA in the diet (*U.S. Department of Agriculture and U.S. Department of Health and Human Services,* 2010).

Many authors have tried to develop meat products with a lower content of SFAs, *trans* fatty acids and/or cholesterol by trying to find fat replacers which preserve the sensory qualities and shelf life of the products and guarantee their acceptance by consumers (*Muguerza et al.,* 2002; *Sampaio et al.,* 2004). A variety of fat replacers and loads were evaluated to reduce the fat added to meat products; however, the ideal fat/load combination has not yet been identified. Sunflower, maize, peanut, tea seed, coconut, palm, soy, and olive oils as well as fish oil have been evaluated in numerous studies (*Muguerza et al.,* 2002; *Valencia et al.,* 2007; *Guillevic et al.,* 2009; *Rahimi et al.,* 2011). The use of vegetable oils can be compared with the use of soft fats, which result in products characterized by their poor appearance, difficulty to cut, and greater tendency to oxidize than hard fats (*Gandemer*, 2002). This tendency of products containing vegetable oils instead of lard to oxidize is due to the greater unsaturated fatty acid content; it has to be considered that shelf life reductions mainly result from increased rancidity and decolouration, which significantly affect the sensory acceptability of products. In many studies, even if total SFAs are decreased, such products still had very high total fat and especially saturated fat daily intake values (*Estévez et al.,* 2006; *D'Arrigo et al.,* 2004; *Terassa et al.,* 2016; *Xiong et al.,* 2016).

Observational studies have found that the Serbian population eats more fat than is recommended (*Gajic & Gudelj*, 2003). In the Province of Vojvodina and its rural areas, the consumption rate of animal fats and animal foods was the largest, and, at the same time, vegetable fat consumption was the lowest in the country. The SFA content in diets was low in all regions in Serbia, except in Vojvodina (*Gajic & Gudelj*, 2003). The greater part of the Serbian population consumes meat every day, and among them, more than 50% of children from 7 to 18 years of age follow this meat consumption pattern (*Sarcevic et al.,* 2013). Data from the Institute of Public Health of Serbia indicate that cardiovascular diseases were a leading cause of death in Serbia in 2014 (*Institute of Public Health of Serbia "Dr Milan Jovanovic Batut"*, 2014).

The aim of this study was to investigate: a) the fatty acid composition of processed meat products, and b) the daily SFA and total fat intake, as calculated by estimated consumption of processed meat/fish products (pâtés, cooked chicken sausages, canned chopped meat and raw, dry fermented sausages) present in the Serbian market. To our knowledge, there are no similar studies in Serbia nor in the Western Balkan countries, which share the same principles and technology in manufacturing these products.

Materials and Methods

Samples

Meat/fish products were purchased from meat companies from Serbia with production portfolios reflecting the typical processed meat products consumed in Serbia, as follows: twelve different flavours of meat or fish pâtés with net weights ranging from 60 g to 90 g, six cooked chicken sausages with net weights from 300 g to 370 g and four canned chopped meats with net weights of 150 g. Meat pâtés mainly consisted of about 30% mechanically separated poultry/turkey meat (chicken and turkey pâtés only), 30% soups/liquid and 30% of fat/oil, salt and spices. Refined sunflower oil was commonly used in the production process, and the microbiological safety of these products was achieved by commercial sterilization procedures (e.g. 118°C 25 min^{-1}; 2.5 bar^{-1}). Pâtés made of pork liver are traditional products in the Serbian meat industry that have been taken as a reference by the fish industry for the development of similar products elaborated with different fish species, including salmon and tuna.

Cooked chicken sausages were made from meat paste of different meat categories, fat tissue, and additives. The microbiological safety of these products was achieved by commercial pasteurization procedures (e.g. 74°C for 60–90 min – depending on the sausage diameter). Canned chopped meats were derived from at least 45–60% beef or pork meat, back fat, as well as salt, spices, and additives. The microbiological safety of these products was achieved by commercial sterilization procedures (e.g. 121°C 30 min^{-1}; 2.5 bar).

Twelve raw, dry fermented sausages typical of those products on sale in the Serbian market were also examined. These types of fermented sausages are typical of those traditionally manufactured in Serbia (Province of Vojvodina) and neighbouring countries, Croatia (Provinces of Slavonija and Baranja) and Hungary. Sausage production usually starts in winter when ambient temperatures are relatively low (e.g. <10 ºC). The meat batters intended for stuffing normally comprise 70/30 chilled lean pork and pork back fat, plus the main additives including red hot paprika powder, salt, raw garlic etc. Sausages are subjected to cold smoking, fermentation and ripening, whereby a specific colour, smell and taste are formed. After the end of the ripening process, sausages were packed in packaging that preserves freshness and juiciness of the product and also prolongs its shelf life.

Fatty acid analysis by capillary gas chromatography

The total fat content was determined according to ISO standard method (*ISO,* 1973). Total lipids for fatty acid determination were extracted from meat products by accelerated solvent extraction (ASE 200, Dionex, Sunnyvale, CA) according to the method of *Spiric et al.* (2010). Fatty acid methyl esters (FAMEs) in the extracted lipids were prepared by transesterification using 0.25 M trimethylsulfonium hydroxide (TMSH) in methanol (*ISO,* 2000). FAMEs were determined by gas-liquid chromatography (GLC, Shimadzu 2010) equipped with flame ionization detector and capillary HP-88 column (length 100m, i.d. 0.25 mm, film thickness 0.20 µm). Injector and detector temperature were 250 ºC and 280 ºC, respectively. Nitrogen was used as the carrier gas at flow rate of 1.33 mL min^{-1}. The injector split ratio was set at 1:50. To achieve complete separation of the examined compounds, a programmed column oven temperature starting at 125 ºC and ending at 230 ºC was applied. Total analysis time was 50.5 min. The chromatographic peaks in the samples were identified by comparing relative retention times of FAME peaks with peaks in Supelco 37 Component FAME mix standard (Supelco, Bellefonte, USA). Each sample was analysed in duplicate. Results were expressed as mass of fatty acid (g) in 100 g of fatty acids.

Calculation of daily intake total fat and saturated fats

Percentages of total fat and saturated fat derived from heat treated ready-to-eat pâtés and raw, dry fermented ready-to-eat meat products were calculated in relation to the reference intake of 2,000 kcal. The rules on labelling and advertising in Serbia (*Serbia*, 2013) and in the U.S. (*U.S. Department of Agriculture and U.S. Department of Health and Human Services*, 2010) recommend an intake of total fats of 70 g d^{-1}, and saturated fats of 20 g d^{-1}. These values are informative for consumers in interpreting nutritional values of food products. Total fat daily intake and saturated fat intake was calculated by dividing total fat and saturated fat content expressed in 100 g of product by 70 g and 20 g, respectively.

Statistical analysis

Data obtained for the fatty acid compositions were subjected to analysis of variance (ANOVA) with the Tukey-Kramer HSD test for the comparisons of means at the 5% level of significance. Statistical analysis was performed using SAS Institute Inc. JMP 10 software.

Results and Discussion

Pâtés

The average fatty acid compositions of the 12 pâtés are presented in Table 1.

Pâtés were generally characterized by low amounts of SFAs. However, significant differences ($P<0.05$) were found for the total SFA content of the pâtés. The smallest level of SFAs was found in the tuna pâté (9.52%) and the highest in the ham pâté (39.72%) The total MUFA content of the pâtés was significantly different ($P<0.05$), with oleic acid (C18:1n-9) being the most common MUFA. The amount of MUFAs in pâtés was the highest in fish pâtés (56.58% and 57.06%, tuna and salmon, respectively), while in turkey, chicken, pork liver and ham pâtés, levels of MUFAs were lower and ranged from 35.30% to 46.89%. The most common *n*-6 PUFA was linoleic acid. It was present in higher levels in turkey and chicken liver pâtés (Table 1). The most common *n*-3 PUFA was ALA, which was more abundant in fish pâtés (Table 1), while it occurred in lower amounts in turkey, chicken liver, pork liver and ham pâtés. Generally, significantly higher contents of EPA and DHA ($P<0.05$) were found in salmon pâté than in tuna pâté. However, in fish pâtés in our study, particularly in salmon pâté, the levels of EPA and DHA were higher than in commercial and experimental fish pâtés in the study of *Aquerreta et al.* (2002).

Polyunsaturated fatty acid to SFA ratios (P/S), as one of the quality parameters of lipid foods, were far greater than 0.4 in all pâtés (2.01–3.43), with the exception of pork pâtés and ham pâté, where these ratios were relatively close to the recommended ratio (0.38 and 0.33, respectively). The ratio of *n*-6/*n*-3 was ≤4 only in fish pâtés, while this ratio was considerably higher in pork liver pâté (15.49), turkey pâté (17.53), ham pâté (21.86) and chicken

Table 1. Fatty acid composition (%) of pâtés

Podnaslov	Tuna pâté n=2	Salmon pâté n=2	Turkey pâté n=2	Chicken liver pâtén=2	Pork liver pâtén=2	Ham pâté n=2
C14:0	0.36 ± 0.03 c	1.60 ± 0.01 a	0.40 ± 0.20 c	0.24 ± 0.03 c	1.26 ± 0.04 b	1.34 ± 0.15 ab
C15:0	0.05 ± 0.01 bc	0.12 ± 0.01 a	0.03 ± 0.01 c	0.03 ± 0.01 c	0.05 ± 0.01 bc	0.08 ± 0.03 b
C16:0	5.92 ± 0.13 d	8.83 ± 0.18 c	12.38 ± 1.24 b	13.78 ± 0.16 b	24.81 ± 0.48 a	25.70 ± 0.50 a
C16:1	0.63 ± 0.63 d	2.18 ± 0.10 c	1.42 ± 0.30 c	1.49 ± 0.08 bc	1.85 ± 0.01 ab	2.06 ± 0.05 a
C17:0	0.10 ± 0.01 b	nd	0.07 ± 0.02 b	0.08 ± 0.01 b	0.25 ± 0.01 a	0.33 ± 0.07 a
C18:0	2.16 ± 0.01 d	2.52 ± 0.05 d	4.18 ± 0.53 c	4.64 ± 0.23 c	12.81 ± 0.27 a	11.91 ± 0.28 b
C18:1*n*-9	53.95 ± 0.36 a	50.30 ± 0.81 b	34.07 ± 1.97 d	33.55 ± 0.45 d	42.16 ± 0.39 c	43.86 ± 1.14 c
C18:2*n*-6	25.82 ± 0.21 b	14.88 ± 0.21 c	43.76 ± 2.82a	43.58 ± 0.64 a	13.61 ± 0.19 c	11.75 ± 1.35 c
C18:3*n*-3	5.03 ± 0.20 a	4.73 ± 0.09 b	0.53 ± 0.03 d	0.94 ± 0.03 c	0.74 ± 0.02 cd	0.49 ± 0.10 d
C18:3*n*-6	nd	nd ±	nd	0.12 ± 0.02	nd	nd
C20:0	0.46 ± 0.02 a	0.39 ± 0.01 b	0.17 ± 0.01 c	0.17 ± 0.01 c	0.22 ± 0.01 c	0.20 ± 0.05 c
C20:1	2.00 ± 0.05 b	4.58 ± 0.11 a	0.27 ± 0.07 d	0.25 ± 0.02 d	0.93 ± 0.01 c	0.96 ± 0.16 c
C22:0	0.32 ± 0.01 a	0.19 ± 0.01	nd	0.32 ± 0.01 a	nd	nd
C20:2	0.17 ± 0.02 b	0.71 ± 0.15 a	0.10 ± 0.05 b	0.16 ± 0.03 b	0.56 ± 0.03 a	0.57 ± 0.01 a
C20:3*n*-6	nd	nd	nd	0.28 ± 0.02 a	nd	nd
C20:3*n*-3	0.27 ± 0.01 b	2.31 ± 0.07 a	nd	nd	0.09 ± 0.01 c	0.08 ± 0.01 c
C20:4*n*-6	1.23 ± 0.01 b	1.77 ± 0.02 a	0.15 ± 0.01 e	0.23 ± 0.02 d	0.28 ± 0.02 c	0.32 ± 0.01 c
C20:5*n*-3	nd	1.34 ± 0.15 a	nd	nd	nd	nd
C22:5*n*-3	0.25 ± 0.04 b	0.98 ± 0.09 a	nd	nd	0.06 ± 0.02 b	nd
C22:6*n*-3	0.77 ± 0.22 b	2.35 ± 0.24 a	nd	nd	nd	nd
C24:0	0.13 ± 0.01 a	nd	0.12 ± 0.01 a	0.10 ± 0.01 b	nd	nd
SFA	9.52 ± 0.14 d	13.66 ± 0.25 c	17.56 ± 2.19 b	19.38 ± 0.10 b	39.60 ± 0.61 a	39.72 ± 0.23 a
MUFA	56.58 ± 0.36 a	57.06 ± 0.80 a	35.76 ± 2.34 c	35.30 ± 0.56 c	44.95 ± 0.40 b	46.89 ± 1.36 b
PUFA	32.65 ± 0.22 b	27.51 ± 1.06 b	46.52 ± 4.53 a	45.07 ± 0.69 a	15.16 ± 0.19 c	13.04 ± 1.57 c
P/S	3.43 ± 0.03 a	2.01 ± 0.11 b	2.69 ± 0.60 b	2.32 ± 0.04 b	0.38 ± 0.01 c	0.33 ± 0.04 c
n-6	26.13 ± 0.05 b	15.78 ± 0.55 c	44.01 ± 2.63 a	44.13 ± 0.66 a	14.24 ± 0.16 c	12.47 ± 1.48 c
n-3	6.52 ± 0.27 b	11.72 ± 0.50 a	2.51 ± 1.90 c	0.94 ± 0.03 c	0.92 ± 0.03 c	0.57 ± 0.09 c
n-6/*n*-3	4.01 ± 0.17	1.35 ± 0.01 b	17.53 ± 2.86 a	46.98 ± 0.79 a	15.49 ± 0.32 ab	21.86 ± 1.04 ab

Legend: *n, number of samples; results are represented as mean ± SD; nd = not detected. Values in the same row with the same letter are not significantly different (P≥0.05). SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; P/S = polyunsaturated/saturated fatty acids

liver pâté (46.98). In other studies, the *n*-6/*n*-3 ratio was higher in commercial tuna (38.2) and salmon (9.3–11.3) pâtés (*Aquerreta et al.,* 2002; *Echarte et al.,* 2004). However, it is possible to produce pork pâtés with healthier *n*-6/*n*-3 ratios (<4) by using linseed oil with α-tocopherol addition for lipid stability, without producing negative effects on the textural or sensory properties (*D`Arrigo et al.,* 2004).

Cooked sausages and canned chopped meat

The FA compositions of different chicken cooked sausages and chopped canned meats are presented in Table 2.

Chicken cooked sausages were generally characterized by lower amounts of SFAs (26.07–31.92%) than canned chopped meat (41.43–43.12%), and high

Table 2. Fatty acid composition (%) of chicken cooked sausages and chopped canned meats

Fatty acids	Chicken sausage n=2	Mini chicken sausage n=2	Junior chicken sausage n=2	Pork luncheon meat n=2	Beef luncheon meat n=2
C14:0	0.34 ± 0.01 [e]	0.62 ± 0.01 [d]	0.79 ± 0.01 [c]	1.68 ± 0.06 [b]	2.22 ± 0.03 [a]
C15:0	0.07 ± 0.01 [b]	0.08 ± 0.01 [b]	0.08 ± 0.01 [b]	0.20 ± 0.01 [b]	0.30 ± 0.03 [a]
C16:0	19.84 ± 0.24 [c]	21.21 ± 0.41 [c]	23.53 ± 0.19 [b]	25.82 ± 0.23 [a]	26.78 ± 0.89 [a]
C16:1	3.14 ± 0.01 [c]	3.27 ± 0.10 [c]	3.75 ± 0.01 [b]	3.45 ± 0.01 [d]	4.26 ± 0.01 [a]
C17:0	0.10 ± 0.01 [c]	0.14 ± 0.01 [bc]	0.15 ± 0.01 [bc]	0.32 ± 0.04 [b]	0.70 ± 0.10 [a]
C18:0	5.62 ± 0.01 [d]	6.48 ± 0.11 [cd]	7.37 ± 0.04 [c]	13.10 ± 0.60 [b]	14.52 ± 0.01 [a]
C18:1*n*-9	41.12 ± 0.09 [b]	39.72 ± 0.56 [b]	39.69 ± 0.02 [b]	44.10 ± 0.41 [a]	45.49 1.39 [a]
C18:2*n*-6	24.74 ± 0.07 [a]	23.58 ± 0.81	21.45 ± 0.05 [b]	9.21 ± 0.94 [c]	5.93 ± 0.01 [d]
C18:3*n*-6	0.14 ± 0.03 [a]	0.11 ± 0.01 [b]	nd	nd	nd
C18:3*n*-3	2.92 ± 0.01 [a]	2.54 ± 0.17 [a]	1.28 ± 0.01 [b]	0.58 ± 0.12 [c]	0.45 ± 0.06 [c]
C20:0	0.11 ± 0.02 [ab]	0.11 ± 0.01 [ab]	nd	0.14 ± 0.04 [a]	0.09 ± 0.01 [ab]
C20:1	0.73 ± 0.01 [a]	0.78 ± 0.04 [a]	0.57 ± 0.01 [b]	0.80 ± 0.03 [a]	0.27 ± 0.03 [c]
C20:2	0.21 ± 0.01 [bc]	0.23 ± 0.06 [bc]	0.34 ± 0.01 [ab]	0.43 ± 0.05 [a]	0.12 ± 0.03 [c]
C20:3*n*-6	0.39 ± 0.01 [a]	0.34 ± 0.01	0.23 ± 0.01 [b]	0.17 ± 0.03 [b]	0.17 ± 0.01 [b]
C20:3*n*-3	nd	nd	nd	nd	nd
C20:4*n*-6	0.32 ± 0.01 [ab]	0.50 ± 0.15 [a]	0.58 ± 0.01 [a]	0.27 ± 0.01 [ab]	0.17 ± 0.06 [b]
C20:5*n*-3	nd	nd	0.19 ± 0.02 [a]	nd	nd
C22:5*n*-3	0.06 ± 0.01	0.11 ± 0.02 [a]	nd	nd	nd
SFA	26.07 ± 0.20 [d]	28.63 ± 0.54 [d]	31.92 ± 0.23 [c]	41.43 ± 0.52 [b]	43.12 ± 1.31 [a]
MUFA	44.98 ± 0.09 [b]	43.77 ± 0.71 [b]	44.01 ± 0.03 [b]	48.06 ± 0.46 [ab]	50.60 ± 2.24 [a]
PUFA	28.44 ± 0.11 [a]	26.91 ± 1.07 [a]	23.49 ± 0.03 [b]	10.24 ± 0.99 [c]	6.73 ± 0.01 [d]
P/S	1.09 ± 0.01 [a]	0.94 ± 0.05[b]	0.74 ± 0.01 [c]	0.25 ± 0.03 [d]	0.16 ± 0.01 [e]
n-6	25.47 ± 0.11 [a]	24.25 ± 0.86 [a]	22.02 ± 0.19 [b]	9.64 ± 0.85 [c]	6.24 ± 0.01 [d]
n-3	2.98 ± 0.01 [a]	2.66 ± 0.21 [a]	1.47 ± 0.02 [b]	0.60 ± 0.15 [c]	0.47 ± 0.03 [c]
n-6/*n*-3	8.55 ± 0.01 [b]	9.12 ± 0.40 [b]	14.98 ± 0.08 [ab]	16.07 ± 3.75 [a]	13.28 ± 1.02 [b]

Legend: *n, number of samples; results are represented as mean ± SD; nd = not detected. Values in the same row with the same letter are not significantly different (P≥0.05). SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; P/S = polyunsaturated/saturated fatty acids.

MUFA contents (44.01–44.98%), with oleic acid being the most common. The most common *n*-6 PUFA in chicken cooked sausages was linoleic acid, ranging from 21.45% to 24.74%, while it was present in lower levels in canned chopped meat (5.93–9.21%). Among the *n*-3 PUFAs, the most common was ALA in cooked sausages and canned chopped meat. The P/S ratio in cooked chicken sausages was higher than 0.4, ranging from 0.74 to 1.09. In canned chopped meat, it was lower than the recommended value (0.16–0.25). The FA profiles and *n*-6/*n*-3 ratios (8.55–14.98) observed in the current study were similar to those of a control group of chicken frankfurters (*Jeun-Horng et al.,* 2002). The *n*-6/*n*-3 ratios in pork luncheon meat and beef luncheon meat in the current study were 16.07 and 13.28, respectively. *Guillevic et al.* (2009) showed it was possible to cook and manufacture typical French cooked meats enriched in n-3 PUFA with *n*-6/*n*-3ratios below 4 and without deleterious effects on global consumer appreciation.

Fermented sausages

The fatty acid composition of dry fermented sausages is presented in Table 3.

Small variations in the composition of fatty acids were detected in the raw, dry fermented sausages, although they were mainly characterized by similar concentrations of SFAs, ranging from 36.07% to 37.10% and a high concentration of MUFAs, which ranged from 48.10% to 49.78%, with oleic acid as the most predominant. Among the *n*-6 PUFAs, linoleic acid was the most common,

Table 3. Fatty acid composition (%) of dry fermented sausages

Fatty acids	Čajna sausage n=3	Kulen n=3	Budimska sausage n=3	Sremska n=3
C14:0	0.98 ± 0.09	0.93 ± 0.07	1.04 ± 0.07	0.95 ± 0.06
C15:0	0.05 ± 0.01	0.03 ± 0.02	0.07 ± 0.01	0.02 ± 0.03
C16:0	23.65 ± 1.65	22.82 ± 1.22	23.21 ± 0.27	23.18 ± 1.20
C16:1	2.21 ± 0.38	1.94 ± 0.17	2.04 ± 0.07	1.91 ± 0.24
C17:0	0.36 ± 0.02	0.30 ± 0.07	0.34 ± 0.01	0.44 ± 0.11
C18:0	11.47 ± 1.05	12.02 ± 0.98	11.08 ± 0.32	12.30 ± 0.80
C18:1*n*-9	44.8 ± 0.39	46.87 ± 2.64	45.06 ± 2.74	46.91 ± 0.02
C18:2*n*-6	13.2 ± 3.58	12.1 ± 2.11	13.90 ± 2.35	11.44 ± 1.04
C18:3*n*-3	0.48 ± 0.11	0.45 ± 0.15	0.53 ± 0.17	0.35 ± 0.12
C20:0	0.20 ± 0.11	0.19 ± 0.01	0.18 ± 0.07	0.19 ± 0.08
C20:1	1.10 ± 0.20	0.98 ± 0.07	1.01 ± 0.04	0.89 ± 0.10
C20:2	0.69 ± 0.14	0.59 ± 0.12	0.64 ± 0.03	0.56 ± 0.08
C20:3*n*-6	0.39 ± 0.14	0.34 ± 0.14	0.28 ± 0.06	0.31 ± 0.20
C20:3*n*-3	0.07 ± 0.01	0.06 ± 0.01	0.07 ± 0.02	0.06 ± 0.01
C20:4*n*-6	0.29 0.01	0.32 ± 0.10	0.32 ± 0.05	0.39 ± 0.01
SFA	36.73 ± 2.94	36.3 ± 1.25	36.07 ± 0.40	37.10 ± 0.47
MUFA	48.11 ± 0.98	49.78 ± 2.46	48.10 ± 2.80	49.71 ± 0.36
PUFA	14.86 ± 3.92	13.61 ± 2.57	15.49 ± 2.57	12.78 ± 0.83
P/S	0.40 ± 0.14	0.37 ± 0.07	0.43 ± 0.07	0.34 ± 0.03
n-6	14.28 ± 3.86	13.07 ± 2.41	14.82 ± 2.31	12.32 ± 0.76
n-3	0.58 ± 0.06	0.54 ± 0.18	0.67 ± 0.26	0.46 ± 0.07
n-6/*n*-3	24.62 ± 3.97	24.20 ± 6.00	22.12 ± 7.78	26.78 ± 2.48

Legend: *n, number of samples; results are represented as mean ± SD; nd = not detected. Values in the same row without a letter are not significantly different (P≥0.05). SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; P/S = polyunsaturated/saturated fatty acids.

ranging from 11.44% to 13.90%. Among the *n*-3 PUFAs, the most common was ALA, which ranged from 0.35% to 0.53%. Dry fermented sausages enriched in ALA could be successfully elaborated with an adequate technological process by the incorporation of a gelled emulsion prepared with linseed oil (*Alejandre et al.,* 2016). Final acceptable products in that study had a lower fat content and very favourable *n*-6/*n*-3 ratio. The reformulation process did not cause oxidation problems, and no perceptible differences were reported for taste and juiciness as compared to a traditional product. This composition of fatty acids is typical for pork meat used as a raw material for the production of these sausages (*Wood et al.,* 2008). The FA profiles observed in the current study were similar to those of fermented sausages from a study by *Campos et al.* (2013). P/S ratios in the current study, as one of the quality parameters of food lipids in the fermented sausages, ranged from 0.34 to 0.43. However, these P/S ratios were close to the recommended ratio (0.4) (*Simopoulos*, 2002; *Wood et al.,* 2008).

The *n*-6/*n*-3 ratios in all dry fermented sausages were above the recommended levels of 4:1 (*Simopoulos*, 2002) and ranged from 22.12 (Budimska sausage) to 26.78 (Sremska sausage); these findings are in accordance with previously published data (*Saicic et al.,* 2010). The *n*-6/*n*-3 ratios were higher in our study than in the similar studies (*Campos et al.,* 2013; *Utrilla et al.,* 2014; *Valencia et al.,* 2007). In the study of *Pelser et al.* (2007), up to 20% of pork backfat was substituted with flaxseed oil or canola oil. The addition of flaxseed oil and canola oil progressively increased the

P/S ratio and decreased the *n*-6/*n*-3 ratio, leading to values closer to those considered optimal.

More scientific knowledge and new technologies will be necessary to fit the growing requirements of the market (*Vandendriessche*, 2008). If industry does not find an answer for the problem of fat in meat products, but without producing major differences in taste and flavour, substitutes for these products with other foods will be more likely. Quality will be judged by the consumer as sensorial quality first.

Nutritional value of processed meat products

The estimated percentage of daily fat intake for pâté is presented in Table 4.

Consumption of 100 g of fish pâtés per day equated to from 19% to 21% of total recommended fat intake, while turkey, chicken liver, pork liver and ham pâtés contained, on average ≥30% of fats. Only consumption of fish pâtés and chicken cooked sausages was estimated to result in the recommended daily intake of 10% saturated fats (6–12%), while consumption of the other types of pâtés and canned chopped meat was estimated to result in saturated fat intakes much greater than 10% (20–53%) (*Department of Health*, 1994; *Wood et al.,* 2008). However, no reduction of evaluated total fat and saturated fat intake was obtained in another study (*D`Arrigo et al.,* 2004) of pork liver pâté (intake of saturated fat was 67%, while it was estimated as 53% in our study, Table 4). In the study of *Terassa et al.* (2016), sunflower oil instead of pork back fat was applied to reduce fat content in chicken liver pâtés, but the reduction of the fat content was followed by decreasing oleic acid and increasing SFA levels. The evaluated intake of total fat was 44% and saturated fat intake was 20% higher than in our study (Table 4). The results obtained by *Xiong et al.* (2016) indicate that healthier chicken liver pâtés can be formulated with sunflower and canola oil combinations substituting 30–40% of the pork backfat. Even if a reduction of total fat intake was not obtained, the evaluated saturated fat intake ranged from 46% to 63% (*Xiong et al.,* 2016). However, these intakes were still higher than in our study (Table 4, estimated saturated fat intake was 20%).

In cooked, ready-to-eat meat products, estimated saturated fat daily intake was 7–12% (Table 5). However, reduction of evaluated total fat in chicken frankfurter fed with supplemental fish oil in the study of *Jeun-Horng et al.* (2002) was about 26%, and saturated fat intake was 30% which was higher than in our study (Table 5). There was a significantly lower oxidative stability of chops derived from pigs fed a linseed diet compared to pigs fed a control diet (*Guillevic et al.,* 2009), but also, higher evaluated total fat and saturated fat daily intakes via cooked sausages (about 27% and 40%, respectively) than in our study of pork products (Table 5). *Juárez et al.* (2009) showed that pork products can be modified to provide a significant increase in functional lipids, which can have positive influences on health. However, evaluated total fat was about 28% in control and about 30% in modified pork products, and saturated fat intake was about 35%, which was higher than in our study (about 22%, Table 5).

Consumption of 100 g of fermented dry sausages per day resulted in an estimated total fat intake ranging from 50% to 63% of the recommended daily fat intake, and a daily intake of saturated fats ranging from 65% to 81% of the recommended amount (Table 5). However, in *Campos et al.* (2013), the obtained fat intake via fermented sausages was reduced to 32%, with a saturated fat daily intake of 44.8%. These intakes were lower than the daily intakes calculated in our study (Table 5). *Campos et al.* (2013) made venison salchichon using 25% pork meat and 75% lean venison that ensured a pleasant texture, odour, flavour and appearance for the

Table 4. Percentage of total fat and saturated fat derived from heat treated, ready-to-eat pâtés in relation to the reference intake of 2,000 kcal per day

Daily intake	Tuna pâté	Salmon pâté	Turkey pâté	Chicken liver pâté	Pork liver pâté	Ham pâté
Total fat, g 100 g^{-1} of product	13.00	14.68	21.58	20.67	26.79	21.09
Total fat intake,%	19	21	31	30	38	30
Saturated fat, g 100 g^{-1} of product	1.24	2.01	3.79	3.74	10.61	8.38
Saturated fat intake,%	6	10	38	20	53	42

Table 5. Percentage of total fat and saturated fat derived from heat treated and dry fermented ready-to-eat meat products in relation to the reference intake of 2,000 kcal per day

Daily intake	Chicken sausage	Mini chicken sausage	Junior Chicken sausage	Pork luncheon meat	Beef luncheon meat	Čajna sausage	Kulen	Budimska sausage	Sremska sausage
Total fat, g 100 g^{-1} of product	8.95	4.77	4.40	11.23	10.50	44.11	42.53	37.67	34.79
Total fat intake,%	13	7	6	16	15	63	61	54	50
Saturated fat, g 100 g^{-1} of product	2.33	1.37	1.40	4.40	4.53	17.12	16.02	13.59	12.91
Saturated fat intake,%	12	7	7	22	23	81	77	68	65

consumer. *Valencia et al.* (2007) showed that algae oil can be used as a functional ingredient in dry fermented sausages in a limited amount. The obtained products had good sensorial quality, showed better *n*-6/*n*-3 ratios than traditional sausages, and supplied a relevant amount of DHA. However, even though their oxidation stability should be guaranteed with the use of antioxidants and storage under vacuum conditions, such products did not result in a reduced evaluated total fat intake (this was about 47%) or saturated fat intake (about 63%), which were lower than the intakes we estimated for our pork products (Table 5). Dry fermented sausages resulted in reduced total fat intake, down from 44% to 37.8% and reduced saturated fat intake, down from 52.2% to 42.3% (*Alejandre et al.,* 2016), which were also lower intakes than estimated in our study (Table 5). Although sensory and physical analyses showed that sausage formulations with encapsulated oils and control sausage were comparable, the new formula sausages were better liked by the sensory panel in the study of *Pelser et al.* (2007). However, the new sausages also resulted in higher evaluated total fat daily intake (up from 58% to 56%) and evaluated saturated fat daily intake (up from 68% to 81%), which were similar values to those calculated in our study (*Pelser et al.,* 2007) (Table 5).

Given that processed meats in Serbia might be consumed in amounts significantly greater than 100 g per serving, actual fat intakes per serving could be higher. Processed meats in Serbia are eaten not just at the main meal, but can be consumed for breakfast or as a between-meals snack. Given that the tinned pâté products are relatively inexpensive, they are often consumed by pensioners or others on limited budgets. They are also simple to prepare and consume (open and eat), so they are a common food for children. The fish pâtés look more interesting, in that some health benefits might ensue if people could be persuaded to consume these instead of meat pâtés.

Analysis of available data from forty countries indicated that calories from animal foods correlated positively with CHD mortality rates, while calories from vegetable foods correlated negatively. Differences in coronary disease mortality rates worldwide could largely be explained by differences in dietary cholesterol and saturated fat intake (*Odegaard*, *et al.,* 2012). Studies have indicated that healthy diet has an important role in the prevention of hypertension (*McEvoy et al.,* 2012).

Conclusion

Cholesterol and triglycerides are essential components of the body, which become harmful only when they occur in increased amounts, and they may be important risk factors for the development of atherosclerosis in humans. It was confirmed that a regular intake of saturated fat and total fat via consumption of processed meat products, in particular processed pork products, was likely to be high in the Serbian general population. We speculate that this is, in turn, is likely to increase the potential risk for development of CHD. The works of other authors have shown that it is difficult to make a product that will meet the sensorial criteria and at the same time achieve a reduced daily intake of total fat and especially saturated fat. However, the results obtained should be of importance for the establishment of tables for nutritional value of products. The increased awareness of the meat industry regarding the importance of the fat content/quality in processed meat products and its impact on health, optimization of the product specifications (replacement of SFAs with unsaturated fats), health promotion activities by public health authorities, as well as better education of consumers about beneficial nutrition habits (e.g. Mediterranean diet) should reduce the rate of CHD. Further research is needed to understand better the optimal combination of unsaturated fatty acids in processed meat products and recommended daily intakes which should maintain and enhance the health status of consumers.

Conflict of interest. The authors declare that they have no conflicts of interest.

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