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Original scientific paper

Indexing of fatty acids in raw turkey meat and products for their characterization in a healthy diet

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ABSTRACT

The aim of this work was to determine the fatty acid profile and health lipid indices of fresh turkey meat, as well as products obtained from turkey meat, i.e. turkey sausage and pate. Turkey breast muscles were cut from the side of the carcass, separately vacuum packed and stored in a refrigerator before analysis. Sausages and pate were produced from turkey meat using a technological process. The fatty acid profile of the samples was determined by gas chromatography with a flame ionization detector (GC/FID), and lipid indices were calculated based on the composition. Turkey muscle had a higher percentage of C16:0 and C18:0 than turkey sausage and pate. A significantly higher proportion of saturated fatty acids (47.9%) than in sausage and pate, 27.2 and 8.9%, respectively, characterized turkey muscle. The lowest determined proportion of polyunsaturated fatty acids for turkey muscle was 12.0%. The atherogenicity index was satisfactory for all three tested products, while the thrombogenicity index was satisfactory only for the tested raw turkey muscle meat (1.656).

1. Introduction

A balanced diet affects the healthy growth and development of individuals throughout life, while otherwise imbalance can be the cause of chronic diseases and obesity. For this reason, part of food literacy includes awareness of nutritional value and information about the impact of food on the consumer's health status (*Guiné et al.*, 2023). Lipids are essential food components as they perform several physiological functions in the human body. Therefore, the modern consumer is increasingly concerned with their food and pays attention to its quality, nutritional composition and effects on human health. The profile of fatty acid composition in meat and meat products depends on their origin, their quality characteristics and oxidative stability. In addition, the ratios of PUFA/SFA and n-6/n-3 PUFA, the content of hypo/hypercholesterolemic fatty acids, and the atherogenicity and thrombogenicity indices have become important parameters for evaluating the nutritional value and health of foods (*Wo1oszyn et al.*, 2020).

In the scientific literature, there are many new improved methods for faster and more efficient preparation of samples for the determination of fatty acids in different matrices, one of them is single-phase preparation. One such method includes trans methylation of meat samples, using, e.g., 5% hydrochloric acid in methanol or 5% sulphuric acid in methanol plus 0.1 N sodium metal in methanol (0.5 ml), and then after that treatment by heating in an oven or by the effect of microwaves (*Perez-Palacios et al.,* 2022).

Turkey used to be considered a once-a-year delicacy, but today, more people know that turkey is an economical meat and low in fat compared to "red

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meat" and are making it part of their regular diet. Turkey is also a good source of protein and minerals such as Na, K and Fe (*Ferreira et al.*, 2000). In this paper, the aim was to compare the profile of fatty acids in turkey meat and turkey meat products, as well as to calculate the quality and health indices. Quality and healthy parameters were determined according to published calculations given by other authors (*Ulbritch and Southgate*, 1991; *Chen et al.*, 2016).

2. Materials and methods

Total lipids were extracted in triplicate from each 5 g of homogenized sample (raw turkey muscle (RTM), turkey extra sausage (TES) and turkey pate (TP)) by the Folch method and calculated gravimetrically (*Folch et al.*, 1957). Fatty acids were quantified as methyl esters (FAMEs) with a gas chromatography system Clarus 680 PerkinElmer (USA) equipped with a flame ionization detector and a long capillary columns 60 m × 0.25 mm ID, 0.25 μm df PerkinElmer Elite-WAX GC column. Individual FAME peaks were identified by comparison of their retention times with those of standards (37-component FAME mix, AccuStandard, USA). The sampling rate during the determination was 12.5 pts/s, the volume of injected sample was 1 μL, and the duration and recording time of the chromatogram was 45.0 minutes. The initial temperature of the GC oven was 140°C, which increased to 200°C at 5°C/min and was maintained at this temperature for 20 minutes; it was then increased to 280°C at 5°C/min and maintained for an additional 15 minutes. The average amount (n=5) of each fatty acid was used to calculate the total amount of SFAs, MUFAs, and PUFAs. Extracted fat (50 mg) was added to 1 ml of acetonitrile containing 0.4 mg/ml pentanoic acid ethyl ester (C5:0) (Dr Ehrenstorfer, LGC), as an internal standard (IS). Data were analyzed by one-way analysis of variance (ANOVA). The results were presented as the mean and pooled standard error of the mean, with $P<0.05$ considered statistically significant. Five representative samples from each group of tested products were used for testing.

3. Results

The determination methodology included the steps of solvent extraction of lipids and the step of derivatization of the FA in methyl esters (FAMEs) and quantification using the GC/FID method.

Table 1. The fatty acid profile (mean values ± standard deviation) of raw turkey muscle (RTM), turkey extra sausage (TES) and turkey pate (TP) (% of total fatty acids)

Fatty acid	Abbreviation	RTM	TES	TP	p -Value
Caprylic acid	C8:0	0.08±0.01	Nd	Nd	<0.001
Lauric acid	C12:0	Nd	Nd	0.07±0.02	<0.001
Myristic acid	C14:0	1.01±0.08	0.32±0.004	0.19±0.023	<0.001
Pentadecanoic acid	C15:0	0.14±0.019	Nd	Nd	<0.001
Palmitic acid	C16:0	33.24±0.35	20.89±0.26	6.33±0.15	<0.001
Palmitoleic acid	C16:1	3.16±0.24	2.94±0.25	0.96±0.10	<0.001
Heptadecanoic acid	C17:0	0.36±0.05	Nd	Nd	<0.001
cis-10-Heptadecenoic acid	C17:1	0.09±0.01	Nd	Nd	<0.001
Stearic acid	C18:0	12.84±0.51	5.87±0.32	1.95±0.26	<0.001
Oleic acid	C18:1n9c	34.62±0.32	40.15±0.35	56.72±0.33	<0.001
Elaidic acid	C18:1n9t	1.76±0.05	1.7±0.04	2.61±0.07	<0.001
Linolenic acid	C18:2n6c	10.75±0.95	25.22±1.17	22.31±1.22	<0.001
Linolelaidic acid	C18:2n6t	0.23±0.02	Nd	Nd	<0.001
α-Linolenic acid	C18:3n3	Nd	1.32±0.06	5.34±0.20	<0.001
Arachidic acid	C20:0	Nd	Nd	0.32±0.05	<0.001
cis-11-Eicosenoic acid	C20:1	0.18±0.02	0.08±0.03	0.83±0.11	<0.001
cis-5,8,11,14,17-Eicosapentaenoic acid	C20:5n3 (EPA)	0.92±0.045	Nd	Nd	<0.001
Behenic acid	C22:0	0.15±0.036	Nd	Nd	<0.001
Erucic acid	C22:1n9	0.31±0.05	0.66±0.10	0.13±0.02	<0.001
cis-13,16-Docosadienoic acid	C22:2n6	0.1±0.002	0.68±0.05	2.24±0.13	<0.001
Tricosanoic acid	C23:0	Nd	0.15±0.10	Nd	0.0018
Lignoceric acid	C24:0	0.05±0.05	Nd	Nd	0.0263

Nd – not detected, $p<0.05$ — statistically significant differences

Table 2. Quality and health parameters of detected fatty acids for raw turkey muscle (RTM), turkey extra sausage (TES) and turkey pate (TP) under the optimized GC/FID method (mean value, n=5)

Index	RTM	TES	TP
ΣSFA	47.87	27.23	8.86
ΣMUFA	40.12	45.53	61.25
ΣPUFA	12.00	27.22	29.89
Total n-6	11.08	25.90	24.55
Total n-3	0.92	1.32	5.34
Total n-9	36.87	42.59	60.29
n-6/n-3	12.04	19.62	4.60
PUFA/SFA	0.25	1.00	3.37
LA/ALA	10.98	25.22	22.31
EPA + DHA	0.92	0.00	0.00
AI	0.72	0.30	0.08
TI	1.656	0.682	0.143
HH	1.410	3.224	13.340
UI	66.880	101.290	126.370
NVI	1.48	2.28	9.68

Abbreviations: SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA- polyunsaturated fatty acids; LA/ALA – linoleic/α-linolenic acid; AI – atherogenic index; TI – thrombogenicity index; H/H, hypocholesterolaemic/hypercholesterolaemic index; NVI, nutritive value index; UI – unsaturation index.

The total amount of fat in the tested samples was expressed as the mean value of five measurements for raw turkey meat (RTM), turkey extra sausage (TES) and turkey pate, finely chopped, sterilized (TP), and was 3.5%; 18.6% and 26.7% respectively. The fatty acid profiles of raw turkey meat and products from the turkey meat are summarized in Table 1. The products have different lipid contents and different percentages of fatty acids. Both muscle and turkey meat products contain the same acids out of 37 different acids, except that lower amounts of fattyacids were present in the muscle, while α-linolenic acid was present only in the products. Also, cis-5,8,11,14,17-eicosapentaenoic acid and behenic acid were not determined in the products but only in the muscle of turkey meat, 0.92% and 0.15%, respectively. Differences in fatty acids are expected due to the processing process, as well as the addition of salt and additives in the production process. The difference in fatty acids is evidently extremely significant ($p < 0.05$) for all measured acids with an obvious change in fatty acid quantity. The most noticeable change in fatty acid content was for palmitic acid, stearic acid, and linolenic acid (Table 1). PUFA/SFA is the most commonly used index to assess the impact of certain foods on cardiovascular health, due to the view that all PUFAs are able to reduce low-density lipoproteins, lipoprotein cholesterol, as well as serum cholesterol, while all SFA can contribute to an increase in serum cholesterol. As a result, this is a direct index: higher values indicate better (positive) effect, given a certain intake of meat or meat products. The recommended value is greater than 0.4 according to the requirements of the World Health Organization (WHO, 2003).

4. Discussion

The ratio of n-6/n-3 needs to be a lower ratio because this composition of fatty acids is preferable for reducing the risk of many chronic diseases of high prevalence in Western societies. According to health recommendations, the n-6/n-3 ratio should be less than the value of 4, which was not achieved by any of the tested products (Table 2). Poultry products are high in omega-3 and omega-6 fatty acids, with a favourable n-6/n-3 ratio, especially turkey meat (*Lalev et al.*, 2021). cis-5,8,11,14,17-Eicosapentaenoic acid (EPA) and cis-4,7,10,13,16,19-docosahexaenoic acid (DHA) are important acids because they improve vascular endothelial function and help lower blood pressure, the serum triglyceride level and platelet sensitivity. The presence of DHA was not determined in muscle and turkey meat products. The H/H index takes into account the known effects of certain fatty acids (especially oleic and linoleic acids) involved in cholesterol metabolism. A higher value of this index shows better effects on human health, which was also obtained

for sausage and pate (*Ulbritch and Southgate*, 1991; *Chen and Liu*, 2020). The high value of UI indicates a high degree of complete unsaturation; for pork and its products, the value ranges from 73 to 124 (*Chen and Liu*, 2020). Also, UI is of great importance in determining oxidative stability. The LA/ALA ratio is the highest for turkey sausages, while in the scientific literature, lambs had lower LA/ALA. With the growing popularity of processed meat products among consumers, meat scientists are investigating the potential applications and benefits of structured emulsions (emulsion and oleogels hydrogels) as fat replacers in a variety of applications. The addition of plant-based oil in animal fat leads to a decrease in SFA, and an increase in MUFA, PUFA and omega-3. For example, addition of bioactive components (extract of black chokeberry (*Aronia melanocarpa*) can increase the stability of turkey meat (*Pasichniy et al.*, 2022). Moreover, the results of our study confirm that adding additives and oil leads to a decrease in SFA and an increase in MUFA and PUFA in turkey meat products compared with turkey meat.

5. Conclusion

Products with higher levels of PUFA in their composition have a better cardiovascular prognosis. The chemical composition and fatty acid profile of the analyzed meat products were considerably impacted by differences in components and production technology. Meat with a lower content of saturated fatty acids is more indicative, from the point of view of consumer health, because lauric, myristic and palmitic fatty acids, when consumed in large quantities, increase the concentration of low-density lipoprotein (LDL) and total cholesterol in the plasma, increasing the risk of cardiovascular disease. In contrast to other saturated fatty acids, stearic acid, which was found at a level of 12.84% in turkey muscle, has a neutral or even lowering effect on blood cholesterol levels.

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