

PAPER • OPEN ACCESS

## Health lipid indices of dry fermented sausages made of pork meat

To cite this article: N Parunovic *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **854** 012069

View the [article online](#) for updates and enhancements.

You may also like

- [New Physics with Evanescent Wave Atomic Mirrors: The van der Waals Force and Atomic Diffraction](#)  
N Westbrook, C I Westbrook, A Landragin et al.
- [The Space Atom Interferometer project: status and prospects](#)  
F Sorrentino, K Bongs, P Bouyer et al.
- [Perturbations of the local gravity field due to mass distribution on precise measuring instruments: a numerical method applied to a cold atom gravimeter](#)  
G D'Agostino, S Merlet, A Landragin et al.



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

**241st ECS Meeting**

Vancouver, BC, Canada. May 29 – June 2, 2022

ECS Plenary Lecture featuring  
**Prof. Jeff Dahn,**  
**Dalhousie University**

Register now!

The banner features the ECS logo, a 'Register now!' button with a checkmark, and a photograph of Prof. Jeff Dahn pointing at a whiteboard. The background of the banner shows the Science World geodesic dome in Vancouver, BC, Canada, with modern buildings and water in the foreground.

# Health lipid indices of dry fermented sausages made of pork meat

N Parunovic<sup>1</sup>, D Trbovic<sup>1</sup>, J Ciric<sup>1</sup>, R Savic<sup>2</sup>, M Gogic<sup>3</sup>, N Betic<sup>1</sup> and C Radovic<sup>3</sup>

<sup>1</sup> Institute of Meat Hygiene and Technology, Kacanskog 13, Belgrade, Republic of Serbia

<sup>2</sup> University of Belgrade, Faculty of Agriculture, Institute of Animal Sciences, Nemanjina 6, Zemun-Beograd, Republic of Serbia

<sup>3</sup> The Institute for Animal Husbandry, Autoput 16, Belgrade, Republic of Serbia

E-mail: [nenad.parunovic@inmes.rs](mailto:nenad.parunovic@inmes.rs)

**Abstract.** This research presents the results of a comparison assessment of the cholesterol content, fatty acid profile, and atherogenic (IA) and thrombogenic (IT) health lipid parameters of four dry fermented sausages produced from Mangalitsa and Swedish Landrace pork meat. The highest cholesterol level was found in Sremska sausage prepared from Landrace meat (64.92 mg/100g). Polyunsaturated fatty acid (PUFA) levels were considerably greater in Landrace meat sausages than in other kinds. The main cause of these variations was a higher overall n-6 PUFA concentration. The sausages made from Mangalitsa meat had the highest levels of monounsaturated fatty acid (MUFA) and unsaturated fatty acid (USFA). The highest saturated fatty acid (SFA) level was found in sausages prepared from Landrace meat. Fermented sausages made from Mangalitsa pork meat show better health lipid indices, atherogenic (IA), thrombogenic (IT), and PUFA/SFA ratios.

## 1. Introduction

Mangalitsa is a fat pig breed, with carcass sides containing 65-70% fat and 30-35% meat [1]. The meat of the Mangalitsa pig was darker colour, its fat was whiter, and its intramuscular fat content and back fat thickness were considerably higher than other pig breeds' meat. Compared to meat from all other fat pig breeds, this meat has a lower saturated fatty acid (SFA) content and a higher percentage of unsaturated fatty acid (USFA) [2, 3].

The level of fat consumed and the fatty acid profile of the diet affect blood cholesterol levels [4]. The impact of fat on cholesterol content can also be seen through the atherogenicity (IA) and thrombogenicity (IT) indexes, which include fatty acids that affect cholesterol changes. Nutritionists advise limiting total fat intake, particularly saturated and trans fatty acids, which have been linked to an increased risk of cardiovascular disease and certain cancers. In addition to decreasing fat intake, nutritionists recommend that consumers increase their intake of polyunsaturated fatty acids (PUFA), particularly n-3 PUFA, at the expense of n-6 PUFA. As a result, the PUFA/SFA and n-6/n-3 PUFA ratios have become significant criteria in determining the nutritional value and healthfulness of foods [5, 6, 7]. In accordance with current trends aiming at revitalizing and expanding traditional food production techniques, autochthonous meat products manufactured from local breeds are gaining popularity [8].

The purpose of this study was to look into the fatty acid profile, cholesterol level, and IA and IT health lipid indices of several dry fermented sausages prepared from Mangalitsa and Swedish Landrace meat. Swedish Landrace was selected as the most frequent commercial meat/fattening pig breed in Serbia, whereas Mangalitsa was identified as the autochthonous Serbian pig breed.



## 2. Materials and methods

All of the animals were bred at the Institute for Animal Husbandry's test farm (Belgrade, Serbia). Green forages (pasture, clover) were available to all pigs at all times, with the addition of a corn- and wheat-based feed concentrate. At a local slaughterhouse, animals were stunned, slaughtered, and exsanguinated. Meat was processed and cooled for 24 hours after slaughter.

The investigated Kulen and Sremska sausage variants were produced at the Institute for Animal Husbandry's processing plant. Kulen sausage was made with meat that had little fat or connective tissue, primarily from the leg, shoulder, and some parts of the neck, as well as a firm backfat tissue. To achieve 10 mm granulation, muscle and adipose tissue (75:25) were chopped in a cutter (Seydelman K60, Germany). The chopped meat was placed in a mixer with the remaining filling ingredients: 2.3% table salt, 0.4% saccharose, 0.3% garlic (powder), 0.3% pepper, and 0.8% ground sweet and hot red paprika. After that, the filling was firmly stuffed into natural pig colon casings. The smoking and maturation of sausages took place during the winter months. Temperatures in the smokehouse ranged from 10 to 15 °C, with humidity levels ranging from 75 to 90%. During the first four weeks, Kulen sausages were smoked. The sausages were then moved to the ripening room, which was kept at a temperature of 10 to 12 °C. The ripening was done in a controlled environment in a drying chamber (Maurer, Germany).

The Sremska sausage variants under investigation were made on the same day and in the same way. In a cutter (Seydelman K60, Germany), meat and fat (85:15) were ground to 8 mm. The same amounts of salt, 0.011% NaNO<sub>2</sub>, 0.3% dextrose, 0.20% garlic, and 0.5% sweet red paprika were used in all Sremska sausage varieties. Pig small intestines with a diameter of 32 mm were filled with the mixture. After stuffing, the sausages were hung on sticks to dry, and the ripening was done in a controlled environment (Maurer, Germany).

Total lipids were extracted using the accelerated solvent extraction method on the Dionex ASE 200 to determine the concentration of fatty acids. Capillary gas chromatography with a flame ionization detector was used to determine fatty acids as methyl esters [9]. According to Maraschiello et al. [10], cholesterol content was determined using an HPLC/PDA on the Waters 2695 Separations Module with a Waters 2996 Photo Diode Array Detector.

The following were calculated using the fatty acid composition data:

1) The relationship between the total main SFAs and the main categories of UFAs is shown by the index of atherogenicity (IA) [11, 12]. The following equation was applied:

$$IA = [(4 \times C14:0) + C16:0 + C18:0] / [\Sigma MUFA + \Sigma PUFA-n6 + \Sigma PUFA-n3]$$

2) The thrombogenicity index (IT) indicates the probability of blood clots forming. The link between pro-thrombogenic (saturated) and anti-thrombogenic (MUFAs, PUFAs-n6 and PUFAs-n3) fatty acids [11, 12] is characterized. The following equation was applied:

$$IT = \frac{C14:0 + C16:0 + C18:0}{0.5 \times MUFA + 0.5 \times PUFA-n6 + 3 \times PUFA-n3 + PUFA-n3/PUFA-n6}$$

For each type of dry fermented sausage, two samples were evaluated. In each sample, each parameter was determined six times. The mean and standard error of descriptive statistics were determined. The data was analysed using single component analysis of variance (ANOVA). Tukey's technique was used to determine the differences between the various types of sausage. Statistica 7.0 was used to perform the calculations (StatSoft Inc.).

## 3. Results and discussion

Palmitic acid (C16:0) was the most abundant SFA, oleic acid (C18:1 n-9) the most abundant MUFA, and linoleic acid (C18:2 n-6) the most abundant PUFA in all varieties of fermented sausages (Table 1). PUFA levels were significantly higher (P<0.001) in Landrace meat Kulen and Sremska sausages than in other kinds. The main source of these differences was increased total n-6 PUFA content (P<0.001). Hoz [13]

and Valencia [14] both found lower n-6/n-3 fatty acid ratios (12.05 and 13.86, respectively) in their control groups of dry fermented sausages, compared to our findings. The content of essential PUFA, linoleic acid, in sausage types KM and SL ranged from 6.37% to 14.40% ( $P < 0.001$ ).

**Table 1.** Fatty acid composition (%), cholesterol content (mg/100g), Index of atherogenicity (IA) and Index of thrombogenicity (IT) (means  $\pm$  standard error) of different dry fermented sausages

Traits	Dry fermented sausages				P <sup>2</sup>
	KM <sup>1</sup>	KL	SM	SL	
C14:0	1.21 $\pm$ 0.04	1.18 $\pm$ 0.05	1.18 $\pm$ 0.04	1.02 $\pm$ 0.07	NS
C16:0	26.28 $\pm$ 0.07 <sup>a</sup>	24.77 $\pm$ 0.06 <sup>b</sup>	25.88 $\pm$ 0.13 <sup>a</sup>	23.99 $\pm$ 0.14 <sup>c</sup>	***
C16:1	3.87 $\pm$ 0.08 <sup>a</sup>	1.86 $\pm$ 0.05 <sup>b</sup>	3.87 $\pm$ 0.08 <sup>a</sup>	1.76 $\pm$ 0.11 <sup>b</sup>	***
C17:0	0.31 $\pm$ 0.02	0.35 $\pm$ 0.04	0.29 $\pm$ 0.01	0.30 $\pm$ 0.02	NS
C18:0	11.25 $\pm$ 0.10 <sup>a</sup>	14.12 $\pm$ 0.08 <sup>b</sup>	10.88 $\pm$ 0.21 <sup>a</sup>	14.19 $\pm$ 0.08 <sup>b</sup>	***
C18:1c9	42.73 $\pm$ 0.26 <sup>a</sup>	39.47 $\pm$ 0.11 <sup>b</sup>	43.41 $\pm$ 0.12 <sup>c</sup>	37.74 $\pm$ 0.12 <sup>d</sup>	***
C18:1c11	4.38 $\pm$ 0.10 <sup>a</sup>	3.26 $\pm$ 0.05 <sup>b</sup>	4.55 $\pm$ 0.07 <sup>a</sup>	2.91 $\pm$ 0.11 <sup>c</sup>	***
C18:2n6	6.37 $\pm$ 0.12 <sup>a</sup>	11.66 $\pm$ 0.12 <sup>b</sup>	6.58 $\pm$ 0.09 <sup>a</sup>	14.40 $\pm$ 0.13 <sup>c</sup>	***
C18:3n6	ND	ND	ND	ND	
C18:3n3	0.39 $\pm$ 0.03 <sup>ab</sup>	0.35 $\pm$ 0.04 <sup>a</sup>	0.46 $\pm$ 0.01 <sup>b</sup>	0.44 $\pm$ 0.02 <sup>ab</sup>	*
C20:0	0.17 $\pm$ 0.01	0.18 $\pm$ 0.02	0.17 $\pm$ 0.01	0.21 $\pm$ 0.02	NS
C20:1	0.85 $\pm$ 0.21	0.79 $\pm$ 0.06	0.84 $\pm$ 0.02	0.72 $\pm$ 0.03	NS
C20:2	0.63 $\pm$ 0.13 <sup>ab</sup>	0.70 $\pm$ 0.04 <sup>ab</sup>	0.54 $\pm$ 0.07 <sup>a</sup>	0.91 $\pm$ 0.04 <sup>b</sup>	*
C20:3n6	1.33 $\pm$ 0.11 <sup>a</sup>	0.67 $\pm$ 0.02 <sup>b</sup>	1.11 $\pm$ 0.06 <sup>ac</sup>	1.03 $\pm$ 0.03 <sup>c</sup>	***
C20:3n3	0.08 $\pm$ 0.05 <sup>ab</sup>	0.15 $\pm$ 0.02 <sup>a</sup>	0.09 $\pm$ 0.04 <sup>ab</sup>	ND <sup>b</sup>	*
C22:1	0.14 $\pm$ 0.03 <sup>a</sup>	0.48 $\pm$ 0.03 <sup>b</sup>	0.13 $\pm$ 0.02 <sup>a</sup>	0.37 $\pm$ 0.02 <sup>c</sup>	***
SFA	39.22 $\pm$ 0.14 <sup>a</sup>	40.60 $\pm$ 0.21 <sup>b</sup>	38.40 $\pm$ 0.22 <sup>c</sup>	39.70 $\pm$ 0.15 <sup>a</sup>	***
MUFA	51.97 $\pm$ 0.29 <sup>a</sup>	45.86 $\pm$ 0.24 <sup>b</sup>	52.80 $\pm$ 0.20 <sup>a</sup>	43.50 $\pm$ 0.15 <sup>c</sup>	***
PUFA	8.80 $\pm$ 0.31 <sup>a</sup>	13.53 $\pm$ 0.15 <sup>b</sup>	8.78 $\pm$ 0.12 <sup>a</sup>	16.78 $\pm$ 0.09 <sup>c</sup>	***
USFA	60.78 $\pm$ 0.50 <sup>a</sup>	59.39 $\pm$ 0.38 <sup>b</sup>	61.58 $\pm$ 0.22 <sup>ac</sup>	60.27 $\pm$ 0.20 <sup>abc</sup>	**
MU/PU	5.94 $\pm$ 0.19 <sup>a</sup>	3.39 $\pm$ 0.02 <sup>b</sup>	6.02 $\pm$ 0.09 <sup>a</sup>	2.59 $\pm$ 0.01 <sup>c</sup>	***
MU/SF	1.33 $\pm$ 0.01 <sup>a</sup>	1.13 $\pm$ 0.00 <sup>b</sup>	1.38 $\pm$ 0.01 <sup>c</sup>	1.10 $\pm$ 0.01 <sup>d</sup>	***
PU/SF	0.22 $\pm$ 0.01 <sup>a</sup>	0.33 $\pm$ 0.00 <sup>a</sup>	0.23 $\pm$ 0.00 <sup>a</sup>	0.42 $\pm$ 0.00 <sup>c</sup>	***
n-3	0.47 $\pm$ 0.04	0.50 $\pm$ 0.03	0.55 $\pm$ 0.04	0.44 $\pm$ 0.02	NS
n-6	7.70 $\pm$ 0.20 <sup>a</sup>	12.33 $\pm$ 0.11 <sup>b</sup>	7.69 $\pm$ 0.12 <sup>a</sup>	15.43 $\pm$ 0.11 <sup>c</sup>	***
n-6/n-3	16.96 $\pm$ 1.42 <sup>a</sup>	25.21 $\pm$ 1.70 <sup>b</sup>	14.38 $\pm$ 1.14 <sup>a</sup>	35.86 $\pm$ 1.59 <sup>c</sup>	***
Cholest.	50.16 $\pm$ 0.11 <sup>a</sup>	61.48 $\pm$ 0.26 <sup>b</sup>	59.65 $\pm$ 0.26 <sup>c</sup>	64.92 $\pm$ 0.12 <sup>d</sup>	***
IA	0.70 $\pm$ 0.01 <sup>a</sup>	0.74 $\pm$ 0.00 <sup>b</sup>	0.68 $\pm$ 0.00 <sup>c</sup>	0.71 $\pm$ 0.01 <sup>a</sup>	***
IT	1.24 $\pm$ 0.01 <sup>a</sup>	1.31 $\pm$ 0.01 <sup>b</sup>	1.19 $\pm$ 0.01 <sup>c</sup>	1.27 $\pm$ 0.01 <sup>ab</sup>	***

<sup>1</sup>Sausage samples depending on meat pig breeds (Kulen sausage – KM; Sremska sausage – SM / Mangalitsa pork meat, Kulen sausage – KL; Sremska sausage – SL / Swedish Landrace pork meat). Cholest. – cholesterol.

<sup>2</sup>NS – not significant ( $P \geq 0.05$ ); \*: Statistical significance at the level of  $P < 0.05$ ; \*\*: Statistical significance at the level of  $P < 0.01$ ; \*\*\*: Statistical significance at the level of  $P < 0.001$ ;

<sup>a-e</sup>Means in the same row with different letters are significantly different ( $P < 0.05$ ).

The levels of MUFA in Mangalitsa pork meat sausages were higher ( $P < 0.001$ ) than in other types. Higher levels of oleic acid, cis-vaccenic acid (C18:1 cis-11), and palmitic acid (C16:1) in these sausages were the main cause of these differences. Individual fatty acids in the SFA fraction showed significant variances, resulting in similar quantities for the total fraction. Sausage type KL had the highest total SFA content, while sausage type SM had the lowest. Stearic acid (C18:0), one of the major SFAs, was found in significantly different amounts in the sausage types ( $P < 0.001$ ). The PUFA/SFA ratios in fermented sausages made of Mangalitsa pork meat were found to be the lowest in our study (0.22 and 0.23 in Kulen and Sremska sausage, respectively).

The cholesterol content of fermented sausages ranged from 50.16 mg/100g (KM) to 64.92 mg/100g (SL), with significant variations ( $P < 0.001$ ) amongst the sausage types. The cholesterol level of an Italian style salami ranged from 48 to 57 mg/100g, according to Baggio and Bragagnolo [15]. In a study on fermented sausages in Croatia, Pleadin et al. [16] discovered that the average cholesterol level of

industrially fermented sausages ranged from 58.48 to 105.24 mg/100g, while that of home-made fermented sausages was up to 75.07 mg/100g in their study of fermented sausages from Croatia. Cholesterol levels in the blood are influenced by the ratio of unsaturated to saturated fatty acids, as well as cholesterol consumption from meals. From a nutritional standpoint, the PUFA to SFA ratio, the ratio of “bad” to “good” fatty acids (IA and IT), and the n-6/n-3 fatty acid ratio are all essential indicators of food healthfulness.

If a food's IA and IT are lower, it has a lower atherogenic and thrombogenic potential. In sausage type KL, the IA and IT were the highest, and they differed significantly from the other samples. In sausages made from Mangalitsa pork meat, the IA and IT were lower. Beef has an IA of 0.72, poultry has an IA of 0.50, and pork has an IA of 0.60 [17].

#### 4. Conclusion

Mangalitsa and Landrace meat sausages contain different amounts of cholesterol. Sremska sausage made from Landrace pig meat had the highest cholesterol content of the sausages in this study. Landrace pork sausages had much higher PUFA contents than other kinds of sausages. The main cause of these differences was a higher total content of n-6 PUFAs. The highest levels of MUFA and USFA were detected in Mangalitsa pork sausages. The sausages made from Landrace pig meat had the largest SFA content. Mangalitsa pork meat fermented sausages show better health lipid indices, thrombogenic (IT) and atherogenic (IA), as well as PUFA/SFA ratios.

#### Acknowledgments

This research was part of the project “Application of different breeding, selection and biotechnological methods for refinement of pig”, funded by Ministry of Science of the Republic of Serbia, record number 31081.

#### References

- [1] Egerszegi I, Ratky J, Solti L and Brussow K P 2003 Mangalica – an indigenous swine breed from Hungary (Review) *Arch. Tierzucht* **46** 245–56
- [2] Holló G, Seregi J, Ender K, Nürnberg K, Wegner J, Seenger J, et al 2003 Examination of meat quality and fatty acid composition of Mangalitsa *Acta Agraria Kaposvariensis* **7** (2) 19–32
- [3] Parunović N, Petrović M, Matekalo-Sverak V, Trbović D, Mijatović M and Radović Č 2012 Fatty acid profile and cholesterol content of *m. longissimus* of free-range and conventionally reared Mangalitsa pigs *S. Afr. J. Anim. Sci.* **42** 101–13
- [4] Bragagnolo N and Rodriguez-Amaya D B 2002 Simultaneous determination of total lipid, cholesterol and fatty acids in meat and backfat of suckling and adult pigs *Food Chem.* **79** (2) 255–60
- [5] Burlingame B, Nishida C, Uauy R and Weisell R 2009 Fats and fatty acids in human nutrition: introduction *Ann. Nutr. Metab.* **55** 5–7
- [6] Simopoulos A P 2004 Omega-6/Omega-3 essential fatty acid ratio and chronic diseases *Food Rev. Int.* **20** 77–90
- [7] Griffin B A 2008 How relevant is the ratio of dietary n-6 to n-3 polyunsaturated fatty acids to cardiovascular disease risk? Evidence from the OPTILIP study *Cur. Opin. Lipidol.* **19** 57–62
- [8] Salgado A, Fontan M C G, Franco I, Lopez M and Carballo J 2005 Biochemical changes during the ripening of Chorizo de cebolla, a Spanish traditional sausage. Effect of the system of manufacture (homemade or industrial) *Food Chem.* **92** (3) 413–24
- [9] Spirić A, Trbovic D, Vranic D, Djinic J, Petronijevic R and Matekalo-Sverak V 2010 Statistical evaluation of fatty acid profile and cholesterol content in fish (common carp) lipids obtained by different sample preparation procedures *Anal. Chim. Acta* **672** 66–71
- [10] Maraschiello C, Diaz I and Regueiro J A G 1996 Determination of cholesterol in fat and muscle of pig by HPLC and capillary gas chromatography with solvent venting injection *J. High Resolut. Chromatogr.* **19** 165–8
- [11] Ulbricht T L V and Southgate D A T 1991 Coronary heart disease: Seven dietary factors *Lancet* **338** 985–92

- [12] Senso L, Suarez M D, Ruiz-Cara T and Garcia- Gallego M 2007 On the possible effects of harvesting season and chilled storage on the fatty acid profile of the fillet of farmed gilthead sea bream (*Sparus aurata*) *Food Chem.* **101** (1) 298–307
- [13] Hoz L 2004 Development of an n-3 fatty acid and tocopherol enriched dry fermented sausage *Meat Sci.* **67** 485–95
- [14] Valencia I, Ansorena D and Astiasaran I 2006 Nutritional and sensory properties of dry fermented sausages enriched with n-3 PUFAs *Meat Sci.* **72** 727–33
- [15] Baggio S R and Bragagnolo N 2006 Cholesterol oxide, cholesterol, total lipid and fatty acid contents in processed meat products during storage. *Food Sci. Technol. (LWT)* **39** (5) 513–20
- [16] Pleadin J, Vahčić N, Perši N, Vulić A, Volarić M and Vraneš I 2010 Sadržaj kolesterola u domaćim i industrijskim kobasicama *Meso* **12** (3) 156–61
- [17] Žlender B and Gapšerlin L 2005 Značaj i uloga lipida mesa u bezbednoj i balansiranoj ishrani *Tehnol. mesa* **46** (1–2) 11–21