FATTY ACIDS PROFILES, CHOLESTEROL CONTENT AND SENSORY PROPERTIES OF FERMENTED DRY "SREMSKA" SAUSAGES MADE OF PORK MEAT FROM VARIOUS BREEDS

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Abstract – In this paper, the comparative investigations on cholesterol content, fatty acid profiles and sensory properties of fermented dry "sremska" sausages are presented. Three types of sremska sausages were made, which varied depending on the percentage of meat and fat derived from different pig breeds: autochthonous (Mangalitsa and Moravka) and commercial (Swedish Landrace). The highest cholesterol content was found in sausage made from the meat of the commercial pig breed. However, sausage made from the Mangalitsa pork meat contained higher levels of monounsaturated fatty acid (MUFA) and unsaturated fatty acid (USFA), and lower saturated fatty acid levels (SFA). The level of PUFA in sausage made of Landras pork meat was significantly higher than levels in other types. These differences were mainly produced by higher total *n*-6 PUFA content. The atherogenic (IA) and thrombogenic (IT) health lipid indices was lower in sausage made from the Mangalitsa pork meat. Sremska sausage made from the Mangalitsa pork meat was superior in terms of color, odor, taste, aftertaste and overall acceptability. This research indicates that pig breed affects the chemical and sensory characteristics of dry fermented sremska sausages.

Key Words – Mangalitsa, autochthonous pork meat products, chemical composition, sensory qualities.

I. INTRODUCTION

In Europe, especially in Mediterranean countries, there is a growing interest in autochthonous meat products produced from local pig breeds from extensive, sustainable breeding programs. Meat and meat products from traditional breeds generally have a good public and media image, and they are often considered to be better, and of better quality, than the meat and meat products from modern pig breeds and crossbreeds. Mangalitsa is a typical fat breed of pig, i.e. carcass sides are 65-70% fat and approximately 30–35% meat [1]. The meat of the Mangalitsa pig had a darker colour, its fat was whiter and the intramuscular fat content of meat and thickness of back fat was considerably greater than meat of other pig breeds. The lower saturated fatty acid (SFA) content and higher proportion of unsaturated fatty acid (USFA) compared with that in meat from other fat pig breeds is advantageous from a human-nutrition point of view [2, 3].

However, in line with modern trends aimed at reviving and advancing traditional food production processes, autochthonous meat products made from local breeds are gaining importance. Moreover, numerous studies have been conducted to determine the characteristics of traditional and naturally fermented sausages throughout the world [4, 5, 6].

The aim of this study was to analyze the chemical composition and sensory quality, and to detect potential differences in traditionally fermented dry sremska sausage manufactured from the meat and fat of three pig breeds: Mangalitsa, Moravka and Swedish Landrace. Mangalitsa and Moravka breeds were selected as autochthonous Serbian pig breeds, while Swedish Landrace was chosen as the most common commercial meat/fattening pig breed in Serbia.

II. MATERIALS AND METHODS

All animals were bred at the test farm of the Institute for Animal Husbandry (Belgrade, Serbia). All pigs had access to green forages (pasture, clover) ad libitum, with the addition of a feed concentrate based on corn and wheat. Animals were stunned, slaughtered and exsanguinated at a local slaughterhouse. Meat was processed 24 h after slaughter and cooling. The examined variants of sremska sausages (Table 1) were manufactured

in a processing plant of the Institute for Animal Husbandry. Three sausages were taken from each variant for all analyses and each analysis was done in duplicate. The examined variants of sremska sausage were produced on the same day and in an identical manner. Meat and fat (85:15) were ground in a cutter (Seydelman K60, Germany) to 8 mm. The same amounts of ingredients were added to sausage variants: 2.3% salt, 0.011% $NaNO_2$, 0.3% dextrose, 0.20% garlic and 0.5% sweet red paprika. The mixture was filled in pig small intestines of around 32 mm diameter. After stuffing, the sausages were hung on sticks and the ripening was carried out in a drying chamber under controlled conditions (Maurer, Germany). To determine the concentration of fatty acids, total lipids were extracted by the accelerated solvent extraction method on the Dionex ASE 200. Fatty acids, as methyl esters, were determined by capillary gas chromatography with a flame ionization detector. Cholesterol content was measured with a HPLC/PDA on the Waters 2695 Separations Module, with a Waters 2996 Photo Diode Array Detector, as reported by Maraschiello *et al.* [7].

From the data on the fatty acid composition, the following were calculated:

1) Index of atherogenicity (IA): indicating the relationship between the sum of the main saturated fatty acids and that of the main classes of unsaturated [8, 9].

The following equation was applied: IA = [(4 x C14:0) + C16:0 + C18:0]/[ΣMUFA + ΣPUFA-*n6* + ΣPUFA-*n3*]

2) Index of thrombogenicity (IT): showing the tendency to form clots in the blood vessels. This is defined as the relationship between the pro-thrombogenetic (saturated) and the anti-thrombogenetic fatty acids (MUFAs, PUFAs-*n*6 and PUFAs-*n*3), [8, 9].

The following equation was applied:

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

Two samples were analyzed from each type of dry fermented sausage. Each parameter was determined six times in each sample. For sensory evaluation of sremska sausages, quantitative descriptive analysis was used. The evaluation of sensory properties of sremska was conducted by 10 selected and trained professional assessors. During testing, one sample of sremska sausage was presented at a time and the assessors were asked to rate the following nine attributes of the sremska on a numeric-descriptive scale from 1 (extremely unacceptable) to 7 (extremely acceptable): appearance, cross-section, color intensity, odor intensity, taste, consistency, acidity, aftertaste and overall acceptability.

Table 1 The percentage of meat originating from specified pig breeds in different types of fermented dry sremska sausages

Pig meat	Fermented dry sremska sausage types		
%	SM	SMM	SL
Mangalitsa	100	50	-
Moravka	-	50	-
S.Landrase	-	-	100

Descriptive statistics (means and standard error) were calculated. The results were processed by single factor analysis of variance (ANOVA). The differences between the different types of sausage were tested using Tukey's method. Calculations were conducted using the software Statistica 7.0 (Statsoft Inc.).

III. RESULTS AND DISCUSSION

The levels of PUFA in sremska sausages made of Landras pork meat were significantly higher ($P<0.001$) than levels in other types (Table 1). These differences were mainly caused by higher total *n*-6 PUFA content ($P<0.001$). The lower *n*-6/*n*-3 ratios were established in sausages type SM. In spite of that though, the *n*-6/*n*-3 ratio of unsaturated fatty acids in SM sausage type was 17 and above the recommended level of 1:1-5:1 [10]. In separate trials, Hoz [11] and Valencia [12], both found, in their control groups of fermented dry sausages, lower ratios of *n*-6/*n*-3 fatty acids (12.05 and 13.86, respectively), compared to our findings. The content of essential PUFA, linoleic acid, ranged from 6.58% in sausage type SM, to 14.40% in sausage type SL ($P<0.001$). The levels of MUFA in sausages made of Mangalitsa pork meat were higher ($P<0.001$) than levels in other types. These differences were mainly caused by higher oleic acid, cis-vaccenic acid, (C18:1 *cis*-11) and palmitic acid (C16:1) levels in these sausages. In relation to the SFA fraction, significant differences were observed for individual fatty acids, giving rise to similar amounts for the total fraction. The

total content of SFA was highest in sausage type SMM and the lowest in sausage type SM. The sausage types contained significantly differing levels of stearic acid (C18:0), one of the major SFA (P<0.001).

Table 2 Fatty acid composition (%), cholesterol content (mg/100g), Index of atherogenicity (IA) and Index of thrombogenicity (IT) (LSM ± standard error) of different fermented dry sremska sausages.

Traits	Fermented dry sausages			
	SM	SMM	SL	P[1]
C14:0	1.18±0.03 [a]	1.09±0.03 [ab]	1.02±0.03 [b]	**
C16:0	25.87±0.07[a]	25.26±0.07[b]	23.99±0.07[c]	***
C16:1	3.87±0.08[a]	2.12±0.08[b]	1.76±0.08 [c]	***
C17:0	0.29±0.02	0.31±0.02	0.30±0.02	NS
C18:0	10.88±0.08[b]	14.09±0.08[a]	14.19±0.08[a]	***
C18:1c9	43.41±0.07[a]	38.77±0.07[b]	37.74±0.07[c]	***
C18:1c11	4.55±0.07[b]	3.17±0.07[a]	2.91±0.07[a]	***
C18:2n6	6.58±0.09[c]	11.91±0.09[b]	14.40±0.09[a]	***
C18:3n6	ND	ND	ND	
C18:3n3	0.47±0.05	0.35±0.05	0.44±0.05	NS
C20:0	0.17±0.02	0.19±0.02	0.21±0.02	NS
C20:1	0.84±0.03	0.73±0.03	0.72±0.03	NS
C20:2	0.54±0.05[b]	0.83±0.05[a]	0.91±0.05[a]	***
C20:3n6	1.11±0.05[a]	0.91±0.05[b]	1.03±0.05[ab]	*
C20:3n3	0.15±0.02[a]	0.09±0.04[ab]	ND[b]	*
C22:1/C20:4	0.13±0.02[c]	0.26±0.02[b]	0.37±0.02[a]	***
SFA	38.40±0.11[c]	40.93±0.11[a]	39.70±0.11[b]	***
MUFA	52.79±0.15[a]	45.05±0.15[b]	43.50±0.15[c]	***
PUFA	8.70±0.13[c]	14.00±0.13[b]	16.79±0.13[a]	***
USFA	61.49±0.21[a]	59.05±0.21[c]	60.28±0.21[b]	**
MU/PU	6.08±0.05[a]	3.22±0.05[b]	2.59±0.05[c]	***
MU/SF	1.37±0.00[a]	1.10±0.00[b]	1.10±0.00[b]	***
PU/SF	0.23±0.00[c]	0.34±0.00[b]	0.42±0.00[a]	***
n-3	0.47±0.05	0.35±0.05	0.44±0.05	NS
n-6	7.69±0.09[c]	12.82±0.09[b]	15.43±0.09[a]	***
n-6/n-3	17.33±3.87[a]	37.36±3.87[b]	38.94±3.87[b]	**
Cholest.	59.65±0.17[b]	53.47±0.17[c]	64.92±0.17[a]	***
IA	0.68±0.00[c]	0.75±0.00[a]	0.71±0.01[b]	***
IT	1.20±0.01[c]	1.35±0.01[a]	1.27±0.01[b]	***

[1]NS-not significant ($P>0.05$); *:Statistical significance at the level of $P<0.05$;**:Statistical significance at the level of $P<0.01$;***:Statistical significance at the level of $P<0.001$;
[a-c]Means in the same row with different letters are significantly different (P<0.05).

In our study, the PUFA/SFA ratio was determined to be the lowest in fermented sausages made of Mangalitsa pork meat (0.23). The cholesterol content in fermented sausages ranged from 53.47 mg/100g (SMM) to 64.92 mg/100g (SL), with significant differences between the samples (P<0.001). Baggio and Bragagnolo [13], for an Italian type salami, found the cholesterol content ranged from 48 to 57 mg/100g. In their study of fermented sausages in Croatia, Pleadin *et al.* [14] established that the average cholesterol content of industrially fermented sausages was 58.48 to 105.24 mg/100g, while that of home-made fermented sausages was up to 75.07 mg/100g. Fatty acid composition of lipids is important from the nutritional viewpoint, especially the ratio between PUFA and SFA, the ratio between 'bad' and 'good' fatty acids (IA and IT) and the ratio *n-6/n-3*. If the IA and IT of certain foods is lower, it's atherogenic and thrombogenic potential is also lower. The IA and IT were lower in sremska sausages made from the Mangalitsa pork meat and significantly differs from other samples. IA of beef is 0.72, poultry 0.50 and pork 0.60 [15].

Table 3 Sensory properties of different types of fermented dry sremska sausages rated by professional assessors (scale test rating)

Sensory properties	Fermented dry sausages		
	SM	SMM	SL
Appearance	5,50	4,67	6,08
Cross-sec.	5,33	3,75	5,25
Consistency	5,17	4,83	5,42
Color	5,75	5,08	5,50
Odor	6,33	6,33	5,67
Taste	6,08	5,08	5,25
Acidity	4,92	4,00	4,58
Aftertaste	5,33	5,25	5,25
Overall	5,50	4,83	5,25

The results of sensory analyses by professional trained assessors are presented in Table 3. Sremska sausage SMM was awarded the lowest marks the cross-section and so had the least acceptable appearance. Fermented dry sausage type SL was rated the most acceptable. Sausage type SL was the most consistent sausage produced, while the lowest consistency score was given to sausage type SMM. Product color was correlated with the color of the meat used in production. Relationships have been reported between physical meat quality characteristics and sensory characteristics, such as muscle fiber and overall tenderness [16, 17], and between quantity and composition of intramuscular fat and flavor [18]. Odor was the sensory indicator most affected by the pig breed. The most typical and the best sausage was the one made from the meat of Mangalitsa breed. Professional evaluators gave sremska sausage SM the highest marks for both taste and aftertaste. The overall sensory acceptability scores of the examined products showed that the sremska sausage type SM has the highest stable quality.

IV. CONCLUSION

The results of this research indicated that pig breed affects the chemical and sensory characteristics of dry fermented sremska sausages. According to the results of the present research, with the appropriate combination of meat and fat from autochthonous pig breeds alone, it is possible to produce sremska sausages, with a respectable chemical content, a favorable and reasonably healthful fatty acid composition, and with sensory qualities acceptable to discerning consumers. Provided market opportunities exist for sremska sausage, these results should contribute to encouraging the endangered Mangalitsa pigs.

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