Biotechnology in Animal Husbandry 30 (4), p 705-715 , 2014 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 637.04'524
DOI: 10.2298/BAH1404705S

CHANGES IN CHEMICAL AND PHYSICOCHEMICAL CHARACTERISTICS DURING THE PRODUCTION OF TRADITIONAL SREMSKA SAUSAGE

N. Stanišić[1], N. Parunović[2], M. Petrović[3], Č. Radović[1], S. Lilić[2], S. Stajić[3], M. Gogić[1]

[1] Institute for Animal Husbandry, Autoput 16, 11080, Belgrade-Zemun, Republic of Serbia
[2] Institute of Meat Hygiene and Technology, Kaćanskog 13, 11000 Belgrade, Republic of Serbia
[3] University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Republic of Serbia
Corresponding author: nikola0135@yahoo.com
Original scientific paper

Abstract: The aim of this trial was to investigate changes in chemical and physico-chemical parameters during the production of traditional Sremska sausage (dry fermented sausage) from pork of three pig breeds: Mangalitsa (MA), Moravka (MO) and Swedish Landrace (SL). Analyses of all variants of sausages were carried out after stuffing (day 0) and on production days 3, 7, 14 and 21. The reduction in moisture during production caused the increase in protein, fat and ash contents ($p<0.001$) in all three variants of sausages, were found to be within the range for this type of sausages. Higher fat content in MA and MO sausages compared to SL variant was most likely a result of the different chemical composition of the meat from pigs of autochthonous breeds. All three sausage variants had a similar final pH value, but the mildest drop of pH was determined in MA sausages. Pig breed significantly affected ($p<0.05$) all three indicators of oxidative changes (thiobarbituric acid value, peroxide value and free fatty acid content). It was found that they were higher in SL compared with MA and MO sausages and to significantly increase during the production process.

Keywords: Sremska sausage, pig breed, chemical properties, physico-chemical properties

Introduction

Today, dry fermented sausages are produced from meat of modern pig breeds and manufacturing technology is based on the use of controlled ripening rooms and rapid curing techniques, resulting in lower production time and improved product safety *(Flores et al., 1997; Marco et al., 2008)*. The sausages obtained are excellent in appearance, but their typical sensory characteristics are poor and most often they have a vigorous acidic taste that is not accepted by the consumer *(Sanz et al., 1998)*. Opposed to them, traditionally produced dry fermented sausages are made from meat of late maturing breeds of pigs and by spontaneous meat fermentation at low temperatures, without additives (nitrate, nitrite, glucono-γ-lactone, etc) and starter cultures *(Marcos et al., 2007)*. Sausages produced in this way have usually very high sensory quality.

Sremska sausage is popular dry fermented sausage in Serbia and all Balkan region. It is characterized by specific hot taste, aromatic and spicy flavour, dark red colour and hard consistency *(Stanišić et al., 2012)*. Traditionally, it was produced from the meat of autochthonous pig breeds such as Mangalitsa and Moravka and in traditional smoking house. Today, however, it is produced from modern pig breeds in controlled ripening rooms and with the use of rapid curing techniques, which gives them a slightly modified characteristics in comparison to traditional products.

The scientific knowledge of traditional produced Sremska sausage is limited and its quality is very variable, because there is very little uniformity in the production by different homemade producers and meat industries. In order to preserve the quality of traditionally Sremska sausage and to describe production process, this trial was set to investigate changes in chemical and physico-chemical parameters of Sremska sausage manufactured in traditional manner from pork of three pig breeds: Mangalitsa, Moravka and Swedish Landrace. Mangalitsa and Moravka breeds were selected as autochthonous Serbian pig breeds *(Petrović et al., 2010)*, while Swedish Landrace, was chosen as the most represented commercial pig breed in Serbia.

Materials and Methods

All pigs used in the study were bred at the farm of the Institute for Animal Husbandry (Belgrade, Serbia). The diet of animals consisted of concentrated commercial feed administered "*ad libitum*". Water was provided using automatic feeding troughs. Pigs were slaughtered when they attained their target slaughter weight of 105 ± 5.0 kg. Sremska sausages were prepared in a meat processing plant of the Institute for Animal Husbandry (Belgrade, Serbia). Three different types of Sremska sausages were produced, each from the meat of different breeds of pig: Swedish Landrace (SL), Mangalitsa (MA) and Moravka (MO).

For the production of Sremska sausage, meat from shoulder was used and back fat in the ratio of 75:25. All three variants were produced on the same day and in an identical manner: meat and fat were chopped and minced to 8 mm particle size and mixed with in a cutter (Seydelman K60, Germany), whereupon they were transferred to a mixer and the same amounts of ingredients were added: 2.2% NaCl, 0.3% glucose, 0.17% garlic (powder), 0.55% hot red paprika (powder) and 0.5% sweet red paprika (powder). The sausage mixture was stuffed into natural casings (pig small intestines) of around 32 mm diameter. After stuffing (day 0) the sausages were drained in a cold store (4 ± 1°C) for 12 h, for the surface to dry, after which they were hung to dry in a traditional smoking house. The ripening was as follows: the first stage lasted 14 days in a traditional smoking house at 10-15°C with 75–90% relative humidity (RH), where they were smoked for 6 h each day; last 7 days (from day 15 to day 21) sausages were processed in a drying room at 14–16°C with about 75% RH, to reach about 35.0% moisture content. The total processing time was 21 day. Sampling of all variants of sausages was carried out after stuffing (day 0) and on production days 3, 7, 14 and 21.

The proximate composition of sausages was determined in the following manner: moisture content by drying samples at 105°C *(ISO 1442, 1997)*; protein content by Kjeldahl method and multiplying by factor 6.25 *(ISO 937, 1978)*; total fat content by Soxhlet method *(ISO 1443, 1973)*, and ash content by mineralization of samples at 550 ± 25°C *(ISO 936, 1998)*.

pH value was measured by pH-meter Hanna, HI 83141 (Hanna Instruments, USA), equipped with an puncture electrode. The pH meter was calibrated using standard phosphate buffers *(ISO 2917, 1999)*.

The 2-thiobarbituric acid (TBA) method was performed according to *Tarladgis et al. (1960)*. The absorbance was measured on a spectrophotometer (Spekol 1300, Analytic Jena, Germany) at 532 nm. TBA values were calculated against standard curve of malonaldehyde (MDA) and expressed as mg MDA/kg sample.

Peroxide value was determined by method described in the *ISO 3960 (1977)*, and peroxide values were expressed as milliequivalents of active oxygen per kg of fat (mEq O_2/kg).

Free fatty acid content was expressed as g oleic acid/100 g fat, after the titration with 0.1N NaOH and determining the total acidity, as described in *ISO 660 (2011)*.

An analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of the SPSS 20.0 software (IBM SPSS Statistics, Version 20, IBM Corp, USA) was performed for all variables considered. If the effect of main factor (breed or time) was found significant, LSD test was used to evaluate the significance of difference at $p<0.05$.

Results and Discussion

The changes in proximate composition during ripening of three variants of Sremska sausages are shown in Table 1. The reduction in moisture during ripening caused the increase in protein, fat and ash contents ($p<0.001$) in all three variants of sausages. The fat contents of the sausages on the day of preparation were close to, but did not exactly match between variants. Sausages made from the meat of

Mangalitsa (MA) and Moravka (MO) at the beginning (day 0) had the lower moisture content ($p<0.05$), but also the higher fat content ($p<0.01$), compared with SL sausages. This discrepancy was most likely a result of the different chemical composition of the meat from pigs of autochthonous breeds, which have been found to have a higher intramuscular fat content, compared with modern pig breeds *(Petrović et al., 2010)*.

At the end of ripening, moisture content decreased to the level from 27.16% (MA) to 30.21% (SL). Such low moisture content is typical for similar products in Greece, Hungary and Croatia *(Kozacinski et al., 2008)*. Although a SL sausages had significantly the highest water content at the beginning ($p<0.05$), at the end of the production process (day 21) no significant difference in water content between SA and MA variants were establish. This could be explained by higher share of intramuscular fat in MA sausages, which was reported to extent the dehydration process by decreasing moisture diffusivity coefficient *(Arnau et al., 1997)*.

Some studies have indicated the occurrence of lower protein content in meat from autochthonous pig breeds compared to meat from commercial pig breeds *(Kim et al., 2008; Parunović et al., 2012)*, thus partly explaining the slightly lower protein content at the end of the ripening (day 21) in MA and MO sausages compared with SL variants ($p<0.05$), in the current study.

The ash values significantly decreased with time in all three variants of sausages ($p<0.001$), which is in disagreement with findings of *(Salgado et al., 2005)*, who have reported that ash content remained constant during the ripening process of Chorizo, a traditional Spanish fermented sausage.

Table 1. Changes in the proximate composition of the three variants of Sremska sausage during the production process (means ± standard deviation)

(%)	Day					
	0	3	7	14	21	p
			Water			
SL	58.13 ± 1.06^{aA}	55.93 ± 0.80^{bA}	49.22 ± 1.9^{cA}	38.45 ± 0.88^{dA}	30.21 ± 0.96^{eA}	***
MA	55.74 ± 1.12^{aB}	54.06 ± 1.00^{aA}	45.74 ± 2.12^{bB}	33.72 ± 0.91^{cB}	29.31 ± 0.47^{dAB}	***
MO	55.45 ± 1.59^{aB}	52.65 ± 1.98^{aB}	47.28 ± 0.87^{bAB}	34.44 ± 0.55^{cB}	27.16 ± 0.45^{dB}	***
p	*	*	*	**	*	
			Fat			
SL	21.23 ± 1.43^{aA}	21.69 ± 0.98^{aA}	24.50 ± 1.02^{bA}	30.98 ± 2.54^{cA}	38.42 ± 1.43^{dA}	***
MA	25.14 ± 1.33^{aB}	24.37 ± 1.13^{aB}	31.29 ± 1.87^{bB}	38.38 ± 1.60^{cB}	42.09 ± 0.42^{dB}	***
MO	24.28 ± 1.12^{aB}	26.02 ± 1.04^{abB}	27.48 ± 2.19b^{AB}	35.36 ± 0.78^{cC}	40.73 ± 0.30^{dAB}	***
p	**	**	*	***	*	
			Protein			
SL	17.65 ± 0.98^{a}	19.36 ± 1.53^{ab}	21.79 ± 0.28^{b}	25.23 ± 1.52^{cA}	25.59 ± 2.21^{cAB}	***
MA	16.16 ± 1.75^{a}	18.36 ± 1.71^{b}	19.25 ± 0.80^{b}	22.69 ± 1.04^{cB}	23.26 ± 1.06^{cA}	***
MO	17.38 ± 1.44^{a}	18.19 ± 0.44^{ab}	21.04 ± 0.57^{b}	25.04 ± 1.13^{cA}	26.60 ± 0.67^{cB}	***
p	ns	ns	ns	*	*	
			Ash			
SL	2.85 ± 0.05^{a}	3.04 ± 0.13^{a}	4.41 ± 0.07^{bA}	5.31 ± 0.22^{c}	5.67 ± 0.09^{dA}	***
MA	2.94 ± 0.07^{a}	3.22 ± 0.09^{b}	3.70 ± 0.12^{cB}	5.21 ± 0.20^{d}	5.31 ± 0.14^{dB}	***
MO	2.91 ± 0.18^{a}	3.12 ± 0.09^{b}	4.20 ± 0.16^{cA}	5.18 ± 0.14^{d}	5.49 ± 0.11^{eAB}	***
p	ns	ns	**	ns	*	

$^{a-e}$ Different letters within the same row denote significant differences between means
$^{A-C}$ Different letters within the same column denote significant differences between means
^{ns} ($p \geq 0.05$); * ($p<0.05$); ** ($p<0.01$); *** ($p<0.001$)

During the fermentation lactic acid is formed, and the pH is reduced *(Lücke, 1994)*. In this trial pH dropped moderately and reached the minimum on day 14 of the process, and remained approximately the same until the end of the production process (day 21), for sausage variant MO and SL (Figure 1). As contrast to them, the variant MA had a significant decline in the pH value from the fourteenth to the twenty-first day when the minimum pH is determined. As the fat content was highest in the MA sausages (Table 1), this results is in agreement with the trend reported in similar studies *(Olivares et al., 2010; Lorenzo and Franco, 2012)*, where a greater decrease of pH values were obtained for low fat sausages. However, some authors found no significant effect of fat level on pH *(Liaros et al., 2009)*. At the end of the production process, all variants of sausages had similar pH value, which ranged from 5.0 to 5.1, which is lower than values reported by other authors (5.2 to 6.4), for naturally fermented dry sausages *(Comi et al., 2005)*. These established lower pH values are probably the result of added sugar in the sausage stuffing and the possible presence of sugar in spices, such as paprika *(Oberdick, 1988)*.

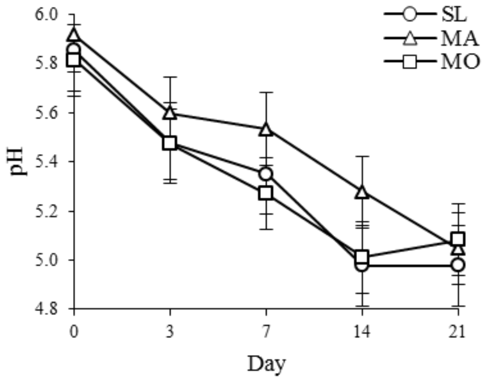

Figure 1. Changes in pH of the three variants of Sremska sausage during the production process. Each bar represents the mean value ± standard deviation.

The oxidative process during ripening of Sremska sausages was evaluated by the TBA values, peroxide index and FFA content in order to determine how it was affected by the different meat type (Figure 2).

Initial TBA values were approximately the same in all three variants of sausages, however, by the end of the production process SL sausages had the highest TBA value compared with MA and MO variants (Figure 2a). TBA values increased in all three variants of sausages during production through the manufacture process and this was also reported by other authors *(Fanco et al., 2002; Lorenzo and Franco, 2012)*. In this trial, the values for this parameter, both in the initial phase and in the final product, are lower than those found in the literature for other dry-fermented sausage varieties *(Lorenzo et al., 2000)*. The relatively low TBA values at the end of the process (0.12-0.19 mg MDA/kg) were similar to those described by *Fanco et al. (2002)*.

Peroxide values increased significantly ($p<0.05$) up to 14 days and then slightly decreased at day 21, in all three sausage variants (Figure 2b). The peroxide values in this trial were lower than one alleged by *Fanco et al. (2002)* of 16 and 28 meq O_2/kg in Androlla (a Spanish dry-cured pork sausage) at 0 and 14 days, respectively, and *Salgado et al. (2006)* who found that the average peroxide value in homemade Chorizo was 12.85 meq O_2/kg of fat. Pig breed had a significant effect on the value of peroxide, which was higher in the SL sausages compared to MO and MA sausages ($p<0.05$).

The FFA (expressed as % of oleic acid) during the production of Sremska sausages (Figure 2c), increase slightly in the first seven days of ripening and no statistically significant difference were established between the groups of sausages. However from day 7, there was the increase in the FFA content, which was very similar in MA and MO sausages, as opposed to SL variant where the increase of FFA content was more rapidly until the end of ripening ($p<0.05$). These results are in agreement with the results of *Bañón et al. (2010)*, that sausages made from meat of indigenous breeds of pigs had significantly lower acidity values ($p<0.001$) compared to those made from the meat of modern pig breed.

As shown in Figure 2 pig breed significantly affected ($p<0.05$) all three indicators of oxidative changes. It was found that they were higher in SL compared with MA and MO sausages. This results, are in disagree with findings of *Liaros et al. (2009)* and *Lorenzo and Franco (2012)*, that the higher degree of oxidative changes are established in sausages with higher fat content. However, a different fatty acid composition of meat from autochthonous pig breeds may be one of the reasons for this inconsistency.

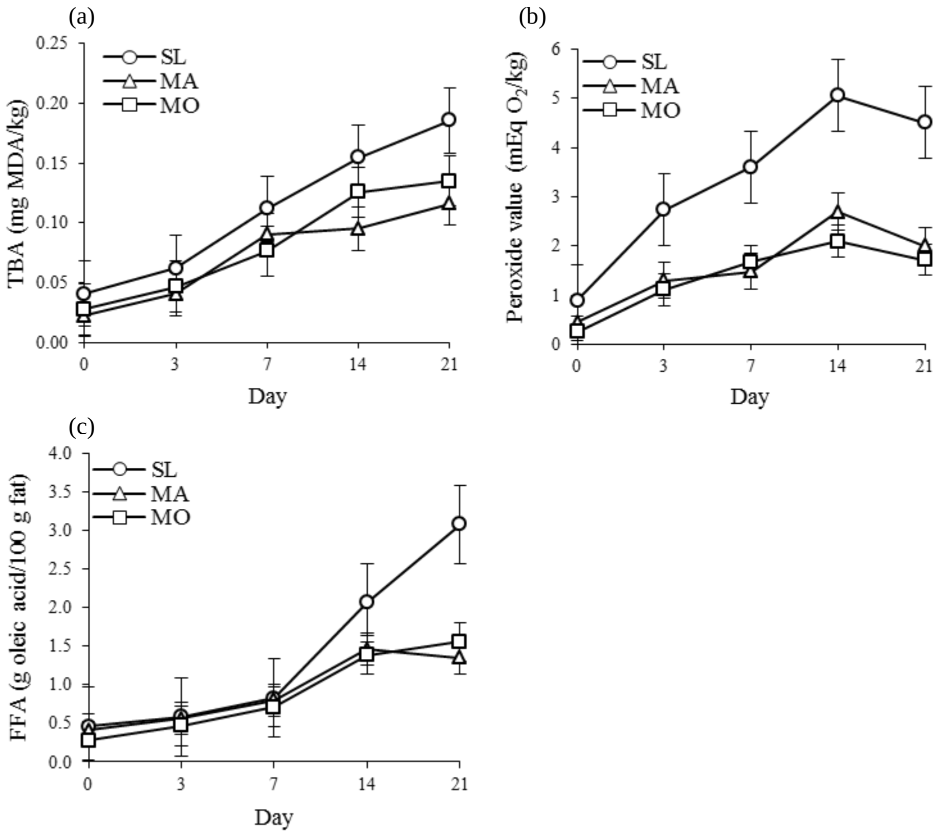

Figure 2. Changes in TBA (a), peroxide (b) and FFA (c) value of the three variants of Sremska sausage during the production process. Each bar represents the mean value ± standard deviation.

Conclusion

Traditionally produced Sremska sausage made from meat of autochthonous pig breeds (Mangalitsa nad Moravka), compared to the one produced from meat of Swedish Landrace breed, is characterised by higher fat content and consequently lower water content throughout the production process. The reduction in moisture during ripening caused the increase in protein, fat and ash contents in all three variants of sausages.

The mildest drop of pH was determined in MA sausages, although the final pH values were approximately the same in all variants. Oxidative changes, evaluated by the TBA values, peroxide index and FFA content, were significantly increasing during the production process, but were higher in SL compared with MA and MO sausages.

Acknowledgment

This paper is a result of the research within the projects TR31081, financed by the Ministry of Education, Science and Technological Development, Republic of Serbia.

Promene hemijskih i fizičko-hemijskih karakteristika tokom proizvodnje tradicionalne Sremske kobasice

N. Stanišić, N. Parunović, M. Petrović, Č. Radović, S. Lilić, S. Stajić, M. Gogić

Rezime

Cilj ovog ogleda bio je da se ispitaju promene tokom proizvodnje Sremske kobasice (suva fermentisana kobasica) na tradicionalan način od mesa tri rase svinja: Mangulica (MA), Moravka (MO) i Švedski Landras (SL). Analize svih varijanti kobasica su rađene nakon punjenja (dan 0) i nakon 3-, 7-, 14- i 21-og dana proizvodnje. Smanjenje udela vode tokom proizvodnje imalo je za posledicu povećanje udela proteina, masti i pepela u svim grupama ($p<0,001$), i bilo je karakteristično za ovaj tip kobasica. Utvrđen veći udeo masti kod MA i MO kobasica u poređenju sa SL varijantom, verovatno je posledica različitog hemijskog sastava mesa autohtonih rasa svinja. Sve tri varijante kobasica su imale sličnu finalnu pH vrednost, međutim, najblaži pad pH vrednosti tokom proizvodnje utvrđen je kod MA kobasica. Rasa svinja je imala značajan uticaj na parametre oksidativnih promena (broj tiobarbiturne kiseline, peroksidni broj i sadržaj

slobodnih masnih kiselina). Utvrđeno je da su bili veći kod SL u odnosu na MA i MO grupu kobasica i da se značajno povećavaju tokom procesa proizvodnje.

References

ARNAU J., GUERRERO L., SARRAGA C. (1997): Effects of temperature during the last month of ageing and of salting time on dry-cured ham aged for six-months. J. Sci. Food Agr., 74, 193-198.
BAÑÓN S., BEDIA M., ALMELA E., JOSÉ MARTINEZ P. (2010): Improving the quality of dry cured sausages using pork from rustic breed. Agr. Food Sci., 19, 240-251.
COMI G., URSO R., IACUMIN L., RANTSIOU K., CATTANEO P., CANTONI C., COCOLIN L. (2005): Characterisation of naturally fermented sausages producedin the North East of Italy. Meat Sci., 69, 381-392.
FANCO I., PRIETO B., CRUZ J.M., LÓPEZ M., CARBALLO J. (2002): Study of the biochemical changes during the processing of Androlla, a Spanish dry-cured pork sausage. Food Chem., 78, 339-345.
FLORES J., MARCUS J.R., NIETO P., NAVARRO J.L., LORENZO P. (1997): Effect of processing conditions on proteolysis and taste of dry-cured sausages. Z. Lebensm. Unters. Forsch. A, 204, 168-172.
ISO 1442 (1997): Meat and meat products – Determination of moisture content. Switzerland: International Organization for Standardization
ISO 1443 (1973): Meat and meat Products – Determination of total fat content. Switzerland: International Organization for Standardization
ISO 2917 (1999): Measurement of pH (Reference method). Switzerland: International Organisation for Standardisation
ISO 3960 (1977): Animal and vegetable fats and oils – Determination of Peroxide Value Switzerland: International Organization for Standardization
ISO 660 (2011): Animal and vegetable fats and oils – Determination of the acid value of the fat. Switzerland: International Organization for Standardization
ISO 936 (1998): Meat and meat products – Determination of ash content. Switzerland: International Organization for Standardization
ISO 937 (1978): Meat and meat products – Determination of nitrogen content. Switzerland: International Organization for Standardization
KIM J.H., SEONG P.N., CHO S.H., PARK B.Y., HAH K.H.,YU L.H., LIM D.G., HWANGN I.H., KIM D.H., LEE J.M. (2008): Characterization of nutritional value for twenty-one pork muscles. Asian-Australas J. Anim. Sci., 21, 138-143.
KOZACINSKI L., DROSINOS E., CAKLOVICA F., COCOLIN L., GASPARIK-REICHARDT J., VESKOVIĆ S. (2008): Investigation of microbial association of traditionally fermented sausages. Food Technol. Biotech., 46, 93-106.

LIAROS N.G., KATSANIDIS E., BLOUKAS J.G. (2009): Effect of the ripening time under vacuum and packaging film permeability on processing and quality characteristics of low-fat fermented sausages. Meat Sci., 83, 589-598.
LORENZO J.M., FRANCO D. (2012): Fat effect on physico-chemical, microbial and textural changes through the manufactured of dry-cured foal sausage. Lipolysis, proteolysis and sensory properties. Meat Sci., 92, 704-714.
LORENZO J.M., MICHINEL M., LÓPEZ M., CARBALLO J. (2000): Biochemical characteristics of two spanish traditional dry–cured sausage varieties: Androlla and Botillo. J. Food Compos.Anal., 13, 809-817.
LÜCKE F.K. (1994): Fermented meat products. Food Res. Int., 27, 299-307.
MARCO A., NAVARRO J.L., FLORES M. (2008): The sensory quality of dry fermented sausages as affected by fermentation stage and curing agents. Eur. Food Res. Technol., 226, 449-458.
MARCOS B., AYMERICH T., GUARDIA M.D., GARRIGA M. (2007): Assessment of high hydrostatic pressure and starter culture on the quality properties of low-acid fermented sausages. Meat Sci., 76, 46-53.
OBERDICK R. (1988): Paprika. Fleischwirtschaft, 68, 1086-1096.
OLIVARES A., NAVARRO J.L., SALVADOR A., FLORES M. (2010): Sensory acceptability of slow fermented sausages based on fat content and ripening time. Meat Sci., 86, 251-257.
PARUNOVIĆ N., PETROVIĆ M., MATEKALO SVERAK V., RADOJKOVIĆ D., VRANIĆ D., RADOVIĆ Č. (2012): Cholesterol and total fatty acid content in M. longissimus dorsi of Mangalitsa and Swedish Landrace. Acta Aliment., 41, 161-171.
PETROVIĆ M., RADOVIĆ Č., PARUNOVIĆ N., MIJATOVIĆ M., RADOJKOVIĆ D., ALEKSIĆ S., STANIŠIĆ N., POPOVAC M. (2010): Quality traits of carcass sides and meat of Moravka and Mangalitsa pig breeds. Biotechnol. Anim. Husb., 26, 21-27.
SALGADO A., GARCIÁ FONTÁN M.C., FRANCO I., LÓPEZ M., 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, 413-424.
SALGADO A., GARCIÁ FONTÁN M.C., FRANCO I., LÓPEZ M., CARBALLO J. (2006): Effect of the type of manufacture (homemade or industrial) on the biochemical characteristics of Chorizo de cebolla (a Spanish traditional sausage). Food Control, 17, 213-221.
SANZ Y., VILA R., TOLDRÁ F., FLORES J. (1998): Effect of nitrate and nitrite curing salts on microbial changes and sensory quality of non-fermented sausages. Int. J. Food Microbiol., 42, 213-217.
STANIŠIĆ N., LILIĆ S., PETROVIĆ M., ŽIVKOVIĆ D., RADOVIĆ Č., PETRIČEVIĆ M., GOGIĆ M. (2012): Proximate composition and sensory characteristics of Sremska sausage produced in a traditional smoking house.

Proceedings of the 6th Central European Congress on Food, Novi Sad-Serbia, 1319-1324.
TARLADGIS B.G., WATTS B.M., YOUNATHAN M., DUGAN L.R. (1960): A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc., 37, 44-48.

Received 27 October 2014; accepted for publication 20 December 2014