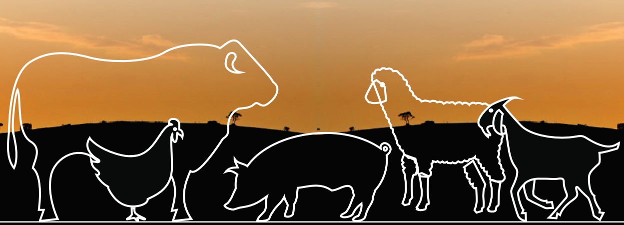
ISBN 978 - 86 -82431 - 71 - 8

4th INTERNATIONAL CONGRESS

PROCEEDINGS

NEW PERSPECTIVES AND CHALLENGES OF SUSTAINABLE LIVESTOCK PRODUCTION



Belgrade, Serbia 7th - 9th October 2015

COMPARISON OF THE FATTY ACID COMPOSITION OF FIVE DIFFERENT FAT TISSUES IN SWEDISH LANDRACE PIG

T. Šolević Knudsen[1], N. Stanišić[2]

[1] University of Belgrade, Institute of Chemistry Technology and Metallurgy, Njegoševa 12, 11000 Belgrade, Republic of Serbia
[2] Institute for Animal Husbandry, Autoput 16, 11080 Belgrade, Republic of Serbia
Corresponding author: tsolevic@chem.bg.ac.rs
Invited paper

Abstract: Fat is one of the most important edible products derived from slaughtered pigs and its fatty acid composition depends, among others, on the location in the carcass. The main objective of the present study was to compare the fatty acid composition of the five different fat tissues (taken from the lard, subcutaneous fat from back area, intramuscular fat from *M. Longissimus dorsi*, intermuscular fat from round and subcutaneous fat from belly region) in Swedish Landrace pig breed. A significantly higher share of total polyunsaturated fatty acid content was found in intermuscular fat (especially higher share of linoleic (18:2 n-6) and γ-linolenic (18:3 n-3) acid), compared to other fat depots ($p<0.05$). Total saturated fatty acid content was highest in lard fat, mainly due to a higher share of stearic acid (18:0). The highest share of total n-6 fatty acids was found in intermuscular fat, while intramuscular fat had the highest n-6/n-3 ratio (which is inconsistent with the nutritional recommendable values). Subcutaneous fat from back and belly region had similar content of major fatty acids. The obtained data confirm that the various pig adipose tissues are different in their fatty acid composition.

Keywords: pig fat tissue, fatty acid, Swedish Landrace pig breed

Introduction

The main parameters for the evaluation of pig carcasses are its weight, yield of warm and cold carcass, conformation and the ratio of muscle and fat tissue. The amount of muscle tissue is certainly the most important factor, but the distribution and quantity of fat tissue plays an important role in the value of the carcass, since excessive proportion of body fat (above the optimum) can have a very negative economic impact. Excess removable fat (intermuscular or subcutaneous), which is removed after cutting and processing, represent an economic loss for producers and processors *(Harper et al., 2001)*. As a result, particularly of the improvement of the genetic basis as well as progress in the field of animal nutrition, the fat tissue content in pigs is reduced*(Stanišić et al., 2011; 2013)*, however, with a negative impact on its physical and chemical characteristics *(Allen and Foegeding, 1981)*.

Fat is one of the most important edible products derived from slaughtered pigs and one of the main ingredients for the production of quality meat products *(Delgado et al., 2002; Stanišić et al., 2012)* and its too low content in the carcass may have a negative economic effect. There are different fat depots in pig carcass: visceral, subcutaneous, intermuscular (between muscles), or intramuscular (within muscle). Intermuscular fat tissue, and smaller portion of subcutaneous fat tissue is sold together with meat or used for the processing of the meat of various categories. Fat tissue can be used as an ingredient for making various meat products (sausages, canned and smoked meat products), for the manufacture of emulsions in sausage production, or processed into edible animal fats.

The fatty acids composition of the pig body fat are influenced by factors such as feeding *(Leszczynski et al., 1992; Scheeder et al., 2000; Rentfrow et al., 2003)*, breeding system *(Högberg et al., 2001; Muriel et al., 2002)*, gender and castration *(Wood et al., 1989)*, age and weight at slaughtering *(Palanska et al., 1993; Bragagnolo and Rodríguez-Amaya, 2002)* and the genotype *(Gandemer et al., 1992)*. Additionaly, fatty acid composition of body fat depends also on the location in the carcass *(Delgado et al., 2002; Suzuki et al., 2006)* and considerable anatomical variation in fatty acid composition in the pig has been reported *(Franco et al, 2006)*.

The main objective of the present study was to characterize the fatty acid composition of the five different fat tissues in Swedish Landrace pig breed, as the most represented commercial pig breed in Serbia.

Materials and Methods

Trial was carried out on the farm, in slaughterhouse and laboratory of the Institute for Animal Husbandry (Belgrade, Serbia) on 8 male fatteners of Swedish Landrace breed. Pigs were fed *ad libitum* a standard diet for commercial slaughter pigs. The diet was based on silage corn, sunflower and soybean meal (Table 1).

Table 1. Composition of feed used in the final stage of fattening of pigs (from 60 to 103 kg body weight)

Mixture ingredients	(%)
Corn – silage	68.76
Livestock flour	15.00
Soybean meal	9.10
Sunflower meal	4.00
Chalk	1.40
Monocalcium phosphate	0.70
Salt	0.45
Premix	0.50
Synthetic lysine	0.09
TOTAL	100.00

All animals were slaughtered on the same day. Average pre-slaughter weight of fatteners was 103.3 kg. Animals were denied food 12h prior to slaughtering, but had free access to water. After slaughtering, pig carcasses were processed using standard techniques. After hair removal and evisseration, carcasses were cut into carcass sides and put in cooling chamber at temperature of 2-4°C for next 24 hours. Each left carcass side was disected in to main parts, and samples were taken from the lard, back area (subcutaneous fat), *M. Longissimus dorsi* (intramuscular fat), round (intermuscular fat) and belly (subcutaneous fat). Samples of fat tissues were vacuum-packed and frozen at -18°C until analysed.

The extraction of lipids from ground homogenate of samples was done with a mixture of chloroform and methanol (2:1 v/v) according to *Folch et al. (1957)*, whereupon the solvent was removed in evaporator until dryness. Fat extract was further used for fatty acids determination.

Fatty acid methyl esters (FAMEs) were prepared by transesterification by using 14% BF_3 in methanol (Sigma Aldrich, Germany), as described by *Thurnhofer and Vetter (2005)*. In brief, 20 mg of extracted fat was treated with 0.5 mL of methanolic KOH (0.5M) for 5 min/80°C. After cooling, 1.0 mL of methanolic BF_3 solution (14%) was added and heated for another 5 min/80°C. Then, the reaction vials were cooled in an ice bath (for 10 min), 2.0 mL of saturated sodium chloride solution and 2.0 mL of n-hexane were added, and the organic phase including the FAMEs was separated and subjected to GC analysis.

The GC instrument Shimadzu 2014 (Kyoto, Japan), used for FAMEs determination, was equipped with a split/splitless injector, fused silica cianopropyl HP-88 column (length 60 m, i.d. 0.25 mm, film thickness 0.20 μm) and flame ionization detector (FID). The column temperature was programmed. Injector and detector temperature temperature was 260°C. The carrier gas was helium at a flow rate of 1.0 ml/min and injector split ratio of 1:110. Injected volume was 1 µl. The GC oven program started at 140°C (hold time 1 min), which then was raised at 4°C/min to 190°C, and at 3°C/min to 240°C (hold time 1 min). Chromatographic peaks in the samples were identified by comparing relative retention times of FAMEs peaks with peaks in a Supelco 37 Component FAMEs mix standard (Supelco, Bellefonte, USA) and the results are expressed as % of total fatty acids.

The total proportion of saturated fatty acids (SFA) was the sum of the weight percentages of caprylic (8:0), capric (10:0), lauric (12:0), myristic (14:0), palmitic (16:0), margaric (17:0) and stearic (18:0) acid. The total proportion of monounsaturated fatty acids (MUFA) was calculated by summing the weight percentages of palmitoleic (16:1 n-7), heptadecenoic (17:1), oleic (18:1 n-9), vaccenic (18:1 n-7) and gadoleic (20:1). Additionally, the total percentage of polyunsaturated fatty acids (PUFA) included linoleic (18:2 n-6), γ-linolenic (18:3 n-6), α-linolenic (18:3 n-3), eicosadienoic (20:2), eicosatrienoic (20:3 n-3), arachidonic (20:4 n-6) and adrenic (22:4 n-6) acid.

An analysis of variance (ANOVA) using the One-way ANOVA procedure of the SPSS 20.0 software (IBM SPSS Statistics, Version 20, IBM Corp, USA) was performed for all data considered. If the effect of main factor was found significant, Tukey-test was used to evaluate the significance of difference at $p<0.05$. All the data in are expressed as means ± standard deviation.

Results and Disscusion

Significant differences between samples were observed for the all measured fatty acids (Table 2), which is in agreement with findings of *Monziols et al. (2007)*. In general, palmitic acid (16:0) was the most abundant SFA, with average percentages between 28.08 (intramuscular fat – INMF) and 22.54 (intermuscular fat – IMF), oleic acid (18:1 n-9) the most abundant MUFA (between 34.13% – INMF and 27.99% – IMF), and linoleic acid (18:2 n-6) the most abundant PUFA (between 27.14% – IMF and 12.17% – INMF).

INMF of *Longissimus* muscles showed a significantly ($p<0.05$) greater content of palmitic (16:0), palmitoleic (16:1 n-7), vaccenic (18:1 n-7) and arachidonic (20:4 n-6) acid and a lower content of caprylic (8:0), lauric (12:0), margaric (17:0), heptadecenoic (17:1), γ-linolenic (18:3 n-3), gadoleic (20:1) and eicosadienoic (20:2) acid, compared to other fat tissues. Linolenic acid (18:3 n-3) is the precursor fatty acid for the synthesis of eicosapentaenoic acid (EPA; 20:5 n- 3) and docosahexaenoic acid (DHA; 22:6 n-3), which play a major role in the control of cardiovascular diseases *(Conquer and Holub, 1998)*. The greatest content of linoleic acid was found in intermuscular fat (IMF), with the addition of greatest content of lauric (12:0), margaric (17:0), heptadecenoic (17:1) and γ-linolenic (18:3 n-3) acid ($p<0.05$).

Fat extracted from lard had the lowest content of capric (10:0), palmitoleic (16:1 n-7) and vaccenic (18:1 n-7) acid, but the greatest content of stearic (18:0) acid. Subcutaneous fat from back region had the lowest content of margaric (17:0), heptadecenoic (17:1) and arachidonic (20:4 n-6) acid, but also the greatest content of gadoleic (20:1) and adrenic (22:4 n-6) acid ($p<0.05$). Subcutaneous fat from belly had similar content of major fatty acids (16:0, 18:1 n-9, 18:2 n-6) as the fat extracted from back region, with the exception in a significantly higher content of stearic acid (18:0).

Results for linoleic acid (18:2 n-6) are in agreement with those of *Nguyen et al. (2003)*, that it is stored preferentially in adipose tissue rather than in muscle. However, in contrast with *Nguyen et al. (2003)*, in our study, the highest content of linoleic acid is found in intermuscular fat, rather than in subcutaneous. In pigs, deposition of dietary fatty acids into tissue fat is preferential to endogenous synthesis and its largely reflects dietary fatty acid composition *(Hays and Preston, 1994; Moloney, 2002)*. In this regard, this difference could be due to a different quantity compositon of diets or the length of feeding.

Table 2. Fatty acid composition of the 5 fat tissue locations in Swedish Landrace pig

Fatty acid (%)	INMF[1]	IMF[2]	Lard	BSF[3]	Belly
8:0	ND[a4]	0.22 ± 0.02[b]	0.07 ± 0.01[c]	0.20 ± 0.02[b]	0.10 ± 0.02[c]
10:0	0.91 ± 0.04[a]	0.90 ± 0.06[a]	0.29 ± 0.02[b]	0.72 ± 0.05[c]	0.56 ± 0.02[d]
12:0	ND[a]	0.36 ± 0.10[b]	0.15 ± 0.01[c]	0.18 ± 0.03[c]	0.24 ± 0.06[c]
14:0	2.95 ± 0.14[a]	2.15 ± 0.10[b]	1.71 ± 0.08[c]	2.79 ± 0.17[ab]	1.85 ± 0.15[c]
16:0	28.08 ± 1.08[a]	22.54 ± 1.34[b]	25.49 ± 1.89[c]	26.65 ± 1.11[c]	24.89 ± 1.78[bc]
16:1 n-7	3.73 ± 0.09[a]	1.62 ± 0.08[b]	1.12 ± 0.01[c]	1.59 ± 0.01[b]	1.56 ± 0.01[b]
17:0	ND[a]	0.47 ± 0.02[b]	0.31 ± 0.11[c]	0.22 ± 0.04[d]	0.34 ± 0.05[c]
17:1	ND[a]	0.38 ± 0.06[b]	0.21 ± 0.06[c]	0.14 ± 0.02[d]	0.26 ± 0.01[c]
18:0	11.53 ± 0.91[a]	10.26 ± 0.63[a]	17.69 ± 0.73[b]	12.81 ± 0.41[a]	14.20 ± 0.44[c]
18:1 n-9	34.13 ± 1.85[a]	27.99 ± 1.15[b]	30.40 ± 2.01[b]	33.81 ± 2.14[a]	32.41 ± 2.43[a]
18:1 n-7	4.17 ± 0.42[a]	1.86 ± 0.07[b]	1.62 ± 0.09[c]	1.87 ± 0.11[b]	1.94 ± 0.04[b]
18:2 n-6	12.70 ± 1.37[a]	27.14 ± 2.91[b]	17.57 ± 2.44[c]	15.90 ± 2.59[c]	18.16 ± 2.07[c]
18:3 n-6	ND[a]	ND[a]	0.30 ± 0.06[b]	0.22 ± 0.05[b]	0.31 ± 0.03[b]
18:3 n-3	0.60 ± 0.31[a]	2.02 ± 0.42[b]	1.23 ± 0.25[c]	1.05 ± 0.33[c]	1.23 ± 0.18[c]
20:1	0.28 ± 0.23[a]	0.51 ± 0.17[b]	0.64 ± 0.16[bd]	0.86 ± 0.14[c]	0.70 ± 0.07[d]
20: 2	0.37 ± 0.08[a]	1.04 ± 0.06[b]	0.86 ± 0.02[b]	0.90 ± 0.07[b]	0.86 ± 0.06[b]
20:3 n-3	ND[a]	0.26 ± 0.01[b]	0.19 ± 0.01[b]	ND[a]	0.18 ± 0.02[b]
20:4 n-6	0.56 ± 0.04[a]	0.28 ± 0.02[b]	0.17 ± 0.01[c]	ND[d]	0.20 ± 0.02[c]
22:4 n-6	ND[a]	ND[a]	ND[a]	0.08 ± 0.01[b]	ND[a]

[1] INMF – Intramuscular fat; [2] IMF – Intermuscular fat; [3] BSF – Back-subcutaneous fat; [4] ND – not detected

[a-d]Different letters within the same row denote significant differences between means at $p<0.05$

Nutritionists recommend a reduction in total fat intake, particularly of SFA and trans fatty acids, which are associated with an increased risk of cardio-vascular diseases and some cancers *(Burlingame et al., 2009)*. Besides reducing fat intake, nutritionists urge consumers to increase their intake of PUFA, particularly the n-3 PUFA, at the expense of n-6 PUFA *(Simopoulos, 2004; Harris et al., 2009)*.

Statistical analysis of the results showed that the total saturated, monounsaturated and polyunsaturated fatty acid content was significantly different ($p<0.05$) in the five fat deposits (Figure 1). The lard fat showed the highest amount of SFA (45.69%) followed by the INMF and subcutaneous back and belly fat, while IMF had the lowest SFA content (36.90%). The higher melting point of the saturated fatty acids and the similar content of total SFA in INMF and subcutaneous fat could lead to the conclusion that the intramuscular fat have firm consistency. However, the consistency of the fat is determined not only by the degree of unsaturation and melting point of the fatty acids, but also by the amount and degree of maturation of the surrounding conjunctive tissue *(López-Bote and Rey, 2001)*. In this term, the most consistent fat is the subcutaneous fat, which is related to the greater amount and degree of maturation of the conjunctive tissue at this position on the carcass. The total MUFA showed a significantly higher percentage in the INMF (42.31%) than in other fat depots ($p<0.05$). The percentage of total PUFA was the highest in IMF (30.74%) and the lowest in INMF (14.22%).

Regarding nutritional recommendations for humans (<5), pork in general has too high ratio of n-6 and n-3 polyunsaturated fatty acids, primarily due to the high content of linoleic acid (18:2 n-6), which is found in high concentrations in corn *(Wood et al., 2003)*. The n-6/n-3 index was the highest in INMF (22.13), despite the lowest share of total n-6 fatty acids (13.25%), it had the lowest share of total n-3 fatty acids (0.60%), compared to other fat tissues (Figure 1). The highest share of total n-6 fatty acids was found in IMF (27.42%), but this is not reflected in the n-6/n-3 ratio.

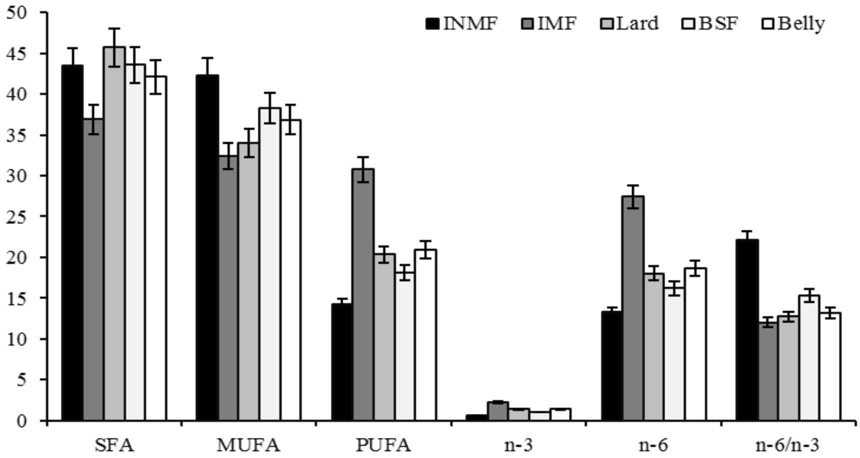


Figure 1. Total SFA, MUFA, PUFA, n-6 and n-3 fatty acid content and n-6/n-3 ratio of the 5 fat tissue locations in Swedish Landrace pig

Conclusion

The present data confirm that the various pig adipose tissues are different in their fatty acid composition. A higher percentage of PUFA, which are purportedly less harmful to human health, were measured in intermuscular fat, whereas this fat had significantly lower share of SFA compared to other fat tissues. The highest share of total n-6 fatty acids was found in INMF, but the highest n-6/n-3 ratio was found in IMF. Lard had the highest share of SFA, especially stearic acid. Subcutaneous fat from back and belly region had similar content of major fatty acids.

Poređenje sastava masnih kiselina u pet različitih masnih tkiva svinja rase Švedski Landras

T. Šolević Knudsen, N. Stanišić

Rezime

Glavni cilj ovog istraživanja bio je da se uporedi sastav masnih kiselina masti u pet različitih masnih tkiva (uzetih iz sala, potkožnog masnog tkiva leđa,

intramuskularne masti iz *M. Longissimus dorsi*, intermuskularne masti iz buta i potkožnog masnog tkiva potrbušine) svinja rase švedski landras.

Značajno veći udeo ukupnih polinezasićenih masnih kiselina nađen je u intermuskularnoj masti (naročito veći udeo linolne (18:2 n-6) i γ-linoleinske kiseline (18:3 n-3)), u poredjenju sa drugim depoima masti ($p<0.05$). Sadržaj ukupnih masnih kiselina bio je najviši u salu, uglavnom zbog većeg udela stearinske kiseline (18:0). Najveći udeo ukupnih n-6 masnih kiselina nađen je u intermuskularnoj masti, dok je intramuskularna mast imala najviši n-6/n-3 odnos (što je u suprotnosti sa preporučenim prehrambenim vrednostima). Potkožna mast iz regiona leđa i potrbušine imala je sličan sadržaj glavnih masnih kiselina. Dobijeni rezultati potvrđuju da se različita adipozna tkiva svinja razlikuju po sastavu masnih kiselina.

References

ALLEN C.E., FOEGEDING E.A. (1981): Some lipid characteristics and interactions in muscle foods-a review. Food Tech., 35, 253-257.
BRAGAGNOLO N., RODRÍGUEZ-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, 255-260.
BURLINGAME B., NISHIDA C., UAUY R., WEISELL R. (2009): Fats and fatty acids in human nutrition: introduction. Ann. Nutr. Metabol., 55, 5-7.
CONQUER J.A., HOLUB B.J. (1998): Effect of supplementation with different doses of DHA on the levels of circulating DHA as nonesterified fatty acid in subjects of Asian Indian background. J. Lipid Res., 39, 286-292.
DELGADO G.L., GÓMEZ C.S., RUBIO L.M.S., CAPELLA V.S., MÉNDEZ, M.D., LABASTIDA R.C. (2002): Fatty acid and triglyceride profiles of intramuscular and subcutaneous fat from fresh and dry-cured hams from Hairless Mexican pigs. Meat Sci., 61, 61-65.
FOLCH J., LEES M., STANLEY G.H. (1957): A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226, 497-509.
FRANCO I., ESCAMILLA M.C., GARCÍA J., GARCÍA FONTÁN M.C., CARBALLO J. (2006): Fatty acid profile of the fat from Celta pig breed fattened using a traditional feed: Effect of the location in the carcass. J. Food Compos. Anal., 19, 792-799.
GANDEMER G. (2002): Lipids in muscles and adipose tissues, changes during processing and sensory properties of meat products. Meat Sci., 62, 309-321.
HARPER G.S., BARENDSEL W.J., HYGATE L., ODDY V.H., PETHICK D., TUME R.K. (2001): Biological determinants of intramuscular fat deposition in beef cattle, Current mechanistic knowledge and sources of variation. Final report to

Meat and Livestock Australia (FLOT208). CRC, Armidale, New South Wales, Australia.
HARRIS W.S., MOZAFFARIAN D., LEFEVRE M., TONER C.D., COLOMBO J., CUNNANE S.C., HOLDEN J.M., KLURFELD D.M., MORRIS M.C., WHELAN J. (2009): Towards establishing dietary reference intakes for eicosapentaenoic and docosahexaenoic acids. J. Nutr., 139, 804-819.
HAYS V.W., PRESTON R.L. (1994): Nutrition and feeding management to alter carcass composition of pigs and cattle. In: Low-Fat Meats: Design Strategies and Human Implications. Edited by: Hafs H.D., Zimbelman R.G., Academic Press, Inc. San Diego, California, USA, 13-30.
HÖGBERG A., PICKOVA J., DUTTA P.C., BABOL J., BYLUNDO A.C. (2001): Effect or rearing system on muscle lipids of gilts and castrated male pigs. Meat Sci., 58, 223-229.
LESZCZYNSKI D.E., PIKUL J., EASTER R.A., MCKEITH F.K., MCLAREN D.G., NOVAKOFSKI J., BECHTEL P.J., JEWELL D.E. (1992): Characterization of lipid in loin and bacon from finishing pigs fed full-fat soybeans or tallow. J. Anim. Sci., 70, 2175-2181.
LÓPEZ-BOTE C., REY A.I. (2001): Susceptibility of adipose tissue of Iberian pigs is enhanced by free-range feeding and reduced by vitamin E supplementation. Nutr. Res., 21, 541-549.
MOLONEY A.P. (2002): The fat content of meat and meat products. In: Meat processing-Improving quality. Edited by: Kerry J., Kerry J., Ledward D., Woodhead Publishing Limited, Cambridge, England, 137-153.
MONZIOLS M., BONNEAU M., DAVENEL A., KOUBA M. (2007): Comparison of the lipid content and fatty acid composition of intermuscular and subcutaneous adipose tissues in pig carcasses. Meat Sci., 76, 54-60
MURIEL E., RUIZ J., VENTANAS J., ANTEQUERA T. (2002): Free-range rearing increases (n-3) polyunsaturated fatty acids of neutral and polar lipids of swine muscles. Food Chem., 78, 219-225.
NGUYEN L.Q., NUIJENS M.C.G.A., EVERTS H., SALDEN N., BEYNEN A.C. (2003): Mathematical relationships between the intake of n-6 and n-3 polyunsaturated fatty acids and their contents in adipose tissue of growing pigs. Meat Sci., 65, 1399-1406.
PALANSKA O., HETENYI L., ONDREJICKA R., MOJTO J., KMET'OVA E. (1993): Fatty acid composition of intramuscular fat of the Longissimus lumborum et thoracis in pigs of various slaughter weights. Zivocisna Vyrova, 38, 377-384.
RENTFROW G., SAUBER T.E., ALLEE G.L., BERG E.P. (2003): The influence of diets containing either conventional corn, conventional corn with choice white grease, high oil corn, or high oil high oleic corn on belly/bacon quality. Meat Sci., 64, 459-466.

SCHEEDER M.R.L., GLAESER K.R., EICHENBERGER B., WENK C. (2000): Influence of different fats in pig feed on fatty acid composition of phospholipids and physical meat quality characteristics. Eur. J. Lipid Sci. Tech., 102, 391-401.

SIMOPOULOS A.P. (2004): Omega-6/omega-3 essential fatty acid ratio and chronic diseases. Food Rev. Int., 20, 77-90

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. 6th Central European Congress on Food, CEFood2012, Novi Sad, Serbia, 23-26. May, Proceedings, 1319-1324.

STANIŠIĆ N., PETROVIĆ M., ŽIVKOVIĆ D., ŽIVKOVIĆ B., PARUNOVIĆ N., GOGIĆ M., NOVAKOVIĆ M. (2011): The effect of gender on properties of belly-rib part of pigs fed diet containing soybean oil. 3rd International Congress "New Perspectives and Challenges of Sustainable Livestock Production", 5-7th october Belgrade, Biotechnology in Animal Husbandry, 27, 825-833.

STANIŠIĆ N., ŽIVKOVIĆ D., PETROVIĆ M., DELIĆ N., MARINKOV G., STOJANOVIĆ LJ. (2013): Conjugated linoleic acid in pig nutrition: Effects on fattening performance and carcass composition. Proceedings of the 10th International Symposium Modern Trends in Livestock Production, October 2-4, Belgrade, Serbia, 200-211.

SUZUKI K., ISHIDA M., KADOWAKI H., SHIBATA T., UCHIDA H., NISHIDA A. (2006): Genetic correlations among fatty acid compositions in different sites of fat tissues, meat production, and meat quality traits in Duroc pigs. J. Anim. Sci., 84, 2026-2034.

THURNHOFER S., VETTER W. (2005): A gas chromatography/electron ionization−mass spectrometry−selected ion monitoring method for determining the fatty acid pattern in food after formation of fatty acid methyl esters. J. Agric. Food Chem., 53, 8896-8903.

WOOD J.D., ENSER M., WHITTINGTON F.M., MONCRIEFF C.B., KEMSTER A.J. (1989): Backfat composition in pigs: differences between fat thickness groups and sexes. Livest. Prod. Sci., 22, 351-362.

WOOD J.D., RICHARDSON R.I., NUTE G.R., FISHER A.V., CAMPO M.M., KASAPIDOU E., SHEARD P.R., ENSER M. (2003): Effects of fatty acids on meat quality: a review. Meat Sci., 66, 21-32.