Biblid: 1821-4487 (2014) 18; 4; p 187-190
UDK: 599.731.1: 574.915

Expert Paper
Stručni rad

PHYSICAL CHARACTERISTICS AND PROXIMATE AND MINERAL COMPOSITION OF ADIPOSE TISSUE FROM FREE-RANGE REARED SWALLOW-BELLY MANGULICA PIGS FROM VOJVODINA

FIZIČKA SVOJSTVA, OSNOVNI HEMIJSKI SASTAV I SADRŽAJ MINERALA U MASNIM TKIVIMA SVINJA LASASTE MANGULICE UZGAJANE U ,,FREE RANGE'' SISTEMU U VOJVODINI

Vladimir TOMOVIĆ[*], *Marija JOKANOVIĆ*[*], *Žarko KEVREŠAN*[**], *Snežana ŠKALJAC*[*], *Branislav ŠOJIĆ*[*], *Tatjana TASIĆ*[**], *Predrag IKONIĆ*[**], *Marija ŠKRINJAR*[*], *Vera LAZIĆ*[*], *Mila TOMOVIĆ*[***]
[*]*University of Novi Sad, Faculty of Technology, 21000 Novi Sad,Bulevar cara Lazara 1, Serbia*
[**]*University of Novi Sad, Institute for Food Technology, 21000 Novi Sad, Bulevar cara Lazara 1, Serbia*
[***]*Technical school "PavleSavić", 21000 Novi Sad, Šajkaška 34, Serbia*
e-mail: tomovic@uns.ac.rs

ABSTRACT

*This study was carried out on 15 castrated male purebred Swallow-belly Mangulica pigs. The Swallow-belly Mangulica pigs were free-range reared on the territory of natural protected area "Zasavica", SremskaMitrovica. After chilling, back fat (lard) and leaf fat were excised from the right side of each carcass.Physical properties of adipose tissue were examined by determining the pH and colour (CIEL*a*b* values), while composition was examined by determination of the moisture, protein, total fat, total ash and mineral (phosphorous, potassium, sodium, calcium, magnesium, iron, zinc, copper, manganese) contents. There was no significant difference (P>0.05) between back fat and leaf fat for any examined property, except for lightness (CIEL* value, P<0.001). Many significant relationships between examined quality properties were found.*

Key words*: pigs, Swallow-belly Mangulica, adipose tissue, physical characteristics, proximate composition, mineral composition.*

REZIME

*U ovom radu su obaljena ispitivanjana 15 kastriranih muških grla svinja Lasaste Mangulice. Svinje su odgajane u tradicionalnom slobodnom ispustu u specijalnom rezervatu prirode "Zasavica", Sremska Mitrovica. Uzorci leđnog potkožnog masnog tkiva i sala su izdvojeni sa svih desnih polutki, nakon hlađenja. Fizička svojstva (vrednost pH i boja– CIEL*a*b*), osnovni hemijski sastav (sadržaj vlage, proteina, ukupne masti i ukupnog pepela) i sadržaj minerala (fosfor, kalijum, natrijum, kalcijum, magnezijum, gvožđe, cink, bakar, mangan) su određeni standardnim metodama. Između potkožnog masnog tkiva i sala nije utvrđena značajna razlika (P>0,05) ni za jedno ispitano svojstvo, osim za svetloću (CIEL*). Prosečne vrednosti* pH_{24h} *u potkožnom masnom tkivu i salu iznosile su 6,50 i 6,62, respektivno. Boja, odnosno svetloća (CIEL*), potkožnog masnog tkiva bila je značajno (P<0,001) tamnija (74,44) u poređenju sa bojom sala (79,55). Prosečni udeli crvene (CIEa*) i žute (CIEb*) boje iznosili su 3,27 i 3,05 za potkožno masno tkivo, odnosno 2,56 i 2,86 za salo, respektivno. Za oba ispitana tkiva, sadržaj vlage je bio u intervalu od 4,34 do 7,09 g/100 g, sadržaj proteina je bio u intervalu od 0,59 do 2,04 g/100 g, sadržaj ukupne masti je bio u intervalu od 91,37 do 95,08 g/100 g, dok je sadržaj ukupnog pepela bio u intervalu od 0,05 do 0,09 g/100 g. Redosled prosečnih sadržaja minerala u mg/100g za oba ispitana tkiva je bio sledeći: P (17,38) > K (15,89) > Na (8,74) > Ca (3,33) > Mg (1,15) > Fe (0,47) > Zn (0,35) > Cu (0,06) > Mn (0,008). Između ispitanih svojstava utvrđene su brojne značajne zavisnosti.*

Ključnereči*: svinje, Lasasta Mangulica, masno tkivo, fizička svojstva, osnovni hemijski sastav, sadržaj minerala.*

INTRODUCTION

In Serbia, three indigenous pig breeds – Mangulica, Moravka and Resavka – are reared, but actually Mangulica – its three varieties, White (Blond), Swallow-belly and Red Mangulica – is most commonly reared. Today, the Mangulica pig is a representative example of the success of preserving endangered breeds, as it is one of the last autochthonous pig breeds in Europe. It is known for maturing late and for its soundness, vitality, resistance and longevity (*Scherf, 2000*). It is one of the fattiest pigs in the world. Generally 65–70% of the carcass is fat. The lean meat is only 30–35% compared to more than 50% in modern breeds (*Egerszegi et al., 2003*). According to *Egerszegi et al*. (*2003*) Mangulica meat quality, taste and consistence are unexcelled. It has the necessary amount of fat and the taste satisfy any expectation. Traditionally, meat from Mangulica pigs has been transformed into unique highly priced dry-cured meat products: dry-hams, loins and sausages. Most of these products still rely primarily on local, traditional manufacturing processes.

Technological (pH value, colour, water-holding capacity, tenderness, protein content and its status, fat content and its status, connective tissue content) and nutritional (proteins and their composition, fats and their composition, minerals, vitamins, digestibility) animal tissue quality characteristics may be influenced by multiple interacting factors before and after slaughter. These include breed, genotype, feeding, pre-slaughter handling, stunning, slaughter method, chilling and storage conditions (*Hofmann, 1990*; *Honikel, 1999*; *Rosenvold and Andersen, 2003*; *Olsson and Pickova, 2005*; *Tomović et al., 2010*).

Fat, total fat, crude fat and total lipids are all terms covering more or less the same components (*Leth, 2004*). There are four sources of lipid in meat animals: the muscle fibres; subcutaneous adipose tissue; intramuscular adipose tissue; and abdominal adipose tissue (*Smith et al., 2004*). In many countries, fat is an unpopular constituent of meat animals for consumers, being considered unhealthy. Yet fat and fatty acids, whether in adipose tissue or muscle, contribute importantly to various aspects of animal tissue quality and are central to the nutritional value of animal tissue. The number of studies examined the factors controlling fat deposition and fatty acid composition in adipose tissue and muscle of animals (*Wood et al., 2008*). However, there is lack of information about quality characteristics of adipose tissue from indigenous pig breeds (Swallow-belly Mangulica pigs), especially for mineral composition. Thus, the aim of this study was to determine the physical characteristics and proximate and mineral composition of back fat (lard) and leaf fat from free-range reared Swallow-belly Mangulica pigs from Vojvodina.

MATERIAL AND METHOD

Animals, diet, sampling and preparing. This study was carried out on 15 castrated male pure-bred Swallow-belly Mangulica pigs randomly selected over a 2-year period. The Swallow-belly Mangulica pigs were free-range reared on the territory of natural protected area ,,Zasavica'' (*FAO DAD-IS, 2003*), SremskaMitrovica, Autonomous Province of Vojvodina (northern Serbia). The growth and development of Swallow-belly Mangulica pig included different periods. During the first period (lactation and weaning), the piglets were nursed by the sow from birth to weaning, which lasted 50 days (7–8 kg). In the period of 10–50 days of age, the piglets also had ad libitum access to mixed diet containing maize (80%) and wheat, oat and barley (20%). From weaning to 90 days of age (13–15 kg), the piglets were fattened on the same mixed diet. The free-range pigs were then allowed toroam in pasture and oak groves, to feed naturally on grass, herbs, acorns and roots, until the slaughtering time approached.

The pigs were slaughtered at the weight of 150 kg (147.0±5.4 kg), which is considered as an optimum slaughtering weight for Swallow-belly Mangulica pork quality, at the age of about 20 months (604±14 days), in a commercial slaughterhouse according to the routine procedure. After the evisceration which was finished about 30 min *post-mortem*, the carcasses were divided into two sides. All carcasses were inspected and passed the government's official control. Mean back fat thickness, measured by ruler on the carcass split line over the *M. gluteus medius*, was 52.2 mm. Carcasses were divided into two sides, and conventionally chilled overnight in a chiller at 2–4 °C. The following two fat tissues were excised from the right side of each carcass: back fat (lard) and leaf fat.Physical characteristics were measured on fresh fat tissue. After determination of physical characteristics each fat tissue was homogenized, vacuum packaged in polyethylene bags and stored at –40 °C until determination of proximate and mineral composition.

Physical measurements.pH value was measured at 24 h (pH_{24h}) *post-mortem* using the portable pH meter (Consort T651, Turnhout, Belgium) equipped with an insertion glass combination electrode (Mettler Toledo Greifensee, Switzerland). The pH meter was calibrated before and during the readings using standard phosphate buffers (pH value of calibration buffers was 7.00 and 4.01 at 25 °C) and adjusted to the expected temperature of measured muscles (*ISO 2917, 1999*). Measurements were performed in triplicate.Eight replicate surface colour measurements were performed on each sample. The CIEL* (lightness), CIEa* (redness) and CIEb* (yellowness) colour coordinates (*CIE, 1976*) were determined using MINOLTA Chroma Meter CR-400 (Minolta Co., Ltd., Osaka, Japan) using D65 illuminant, a 2° standard observer angle and a 8-mm aperture in the measuring head.

Proximate and mineral composition. Moisture (*ISO 1442, 1997*), protein (nitrogen x 6.25; *ISO 937, 1978*), total fat (*ISO 1443, 1973*) and total ash (*ISO 936, 1998*) contents of both fat tissues were determined according to methods recommended by International Organization for Standardization. All analyses were performed in duplicate. The total phosphorous (P) content of the both fat tissues was determined according to ISO method (*ISO 13730, 1996*). The metal [potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn)] contents of the both fat tissues were determined by the flame atomic absorption spectrometry after mineralisation by dry ashing, as described in detail by *Tomović et al.* (*2011*). All analyses were performed in duplicate.

Statistical analysis. All data are presented as mean, standard deviation (SD) and range. Independent t-test were used to test the hypothesis about differences between two mean values. Correlation coefficients among tissues characteristics were also calculated. The software package STATISTICA 12.0 was used (*StatSoft, 2012*) for analysis.

RESULTS AND DISCUSSION

Physical characteristics of back fat (lard) and leaf fat of Swallow-belly Mangulica pigs are presented in Table 1. The difference between mean ultimate pH_{24h} values determined in back fat (6.50) and leaf fat (6.62) was not significant (P=0.165). The back fat had significantly (P<0.001) lower mean CIEL* value (74.44), indicating darker colour, than leaf fat (79.55). The type of adipose tissue did not significantly affect redness – CIEa* (P = 0.459) and yellowness – CIEb* values (P = 0.878). The CIEa* values ranged from 1.22 to 5.97, and the CIEb* values ranged from 0.60 to 7.11. As expected, CIEa* value was significantly positively (r=0.92, P<0.001) correlated with CIEb* value (Table 4).

Table 1. Physical characteristics of back fat (lard) and leaf fat of Swallow-belly Mangulica pigs

Adipose tissue		pH_{24h}	Colour		
			CIEL*	CIEa*	CIEb*
Back fat	Mean ± SD	6.50 ± 0.14	74.44 ± 1.41	3.27 ± 0.62	3.05 ± 0.95
	Range	(6.37–6.73)	(72.54–75.72)	(2.43–4.16)	(2.39–4.69)
Leaf fat	Mean ± SD	6.62 ± 0.11	79.55 ± 0.82	2.56 ± 1.94	2.86 ± 2.57
	Range	(6.45–6.76)	(78.60–80.79)	(1.22–5.97)	(0.60–7.11)
P value		0.165	< 0.001	0.459	0.878
Both tissues	Mean ± SD	6.56 ± 0.14	76.99 ± 2.91	2.92 ± 1.41	2.96 ± 1.83
	Range	(6.37–6.76)	(72.54–80.79)	(1.22–5.97)	(0.60–7.11)

Proximate composition of back fat (lard) and leaf fat of Swallow-belly Mangulica pigs are presented in Table 2. The differences in the proximate composition between the back fat and leaf fat were not significant (P>0.05). Moisture content in both tissues varied between 4.34 and 7.09 g/100 g, while protein content was between 0.59 and 2.04 g/100 g. Total fat content in both tissues varied between 91.37 and 95.08 g/100 g, while total ash content was between 0.05 and 0.09 g/100 g. Results obtained for proximate composition of adipose tissue are in agreement with results reported in literature (Table 5). As expected, moisture content was significantly negatively (r = –0.93, P<0.001) correlated with total fat content (Table 4).

Table 2. Proximate composition (g/100 g) of back fat (lard) and leaf fat of Swallow-belly Mangulica pigs

Adipose tissue		Moisture	Protein	Total fat	Total ash
Back fat	Mean ± SD	5.21 ± 0.56	1.33 ± 0.45	93.46 ± 0.85	0.06 ± 0.01
	Range	(4.62–5.93)	(0.90–2.04)	(92.46–94.72)	(0.05–0.08)
Leaf fat	Mean ± SD	5.78 ± 1.25	0.95 ± 0.32	93.13 ± 1.67	0.07 ± 0.01
	Range	(4.34–7.09)	(0.59–1.40)	(91.37–95.08)	(0.06–0.09)
P value		0.379	0.164	0.710	0.260
Both tissues	Mean ± SD	5.50 ± 0.96	1.14 ± 0.42	93.29 ± 1.26	0.07 ± 0.01
	Range	4.34–7.09	0.59–2.04	91.37–95.08	0.05–0.09

Mineral composition of back fat (lard) and leaf fat of Swallow-belly Mangulica pigs are presented in Table 3.

The type of adipose tissue had no significant (P>0.05) effect on the mineral contents. The order of the minerals in the adipose tissue and their content ranges in mg/100 g was: P (13.18–23.61, mean 17.38) > K (13.96–18.17, mean 15.89) > Na (6.08–13.00, mean 8.74) >Ca (2.47–4.31, mean 3.33) > Mg (0.99–1.64, mean 1.15) > Fe (0.34–0.67, mean 0.47) > Zn (0.25–0.50, mean 0.35) > Cu (0.03–0.09, mean 0.06) >Mn (0.006–0.011, mean 0.008). Results obtained for mineral composition of adipose tissue are similar or higher compering with results reported in literature (Table 5). Further (Table 4), CIE*a** and CIE*b** values were significantly positively correlated with P (r=0.75, P<0.05; r=0.81, P<0.01), Na (r=0.64, P<0.05; r=0.84, P<0.01), Ca (r=0.63, P<0.05; r=0.68, P<0.05) and Mg (r=0.64, P<0.05; r=0.70, P<0.05) content.

Moisture content was significantly positively correlated with Na (r=0.73, P<0.05) and Mg (r=0.65, P<0.05) content, while protein content was significantly positively correlated with Ca (r=0.70, P<0.05), and significantly negatively correlated with Zn (r=–0.79, P<0.01) content. Total fat content was significantly negatively correlated with Na (r=–0.66, P<0.05) and Ca (r=–0.71, P<0.05), and significantly positively correlated with Zn (r=0.63, P<0.05) content. Additionally, significantly positive correlation was determined between P and Na (r=0.86, P<0.01) content, K and Mn (r=0.68, P<0.05) content, Mg with Fe (r=0.69, P<0.05) and Mn (r=0.77, P<0.01) content, and Fe and Mn (r=0.81, P<0.01).

CONCLUSION

The results of the present study obtained for physical characteristics and proximate and mineral composition shown that there was no significant difference (P>0.05) between back fat and leaf fat for any examined property, except for lightness (CIE*L** value, P<0.001). Many significant relationships between examined quality properties were found.Nevertheless, more studies are necessary to provide a better knowledge about adipose tissue characteristics from free-range reared Swallow-belly Mangulica pigs especiallyabout fatty acid composition.

Table 3. Mineral composition (mg/100 g) of back fat (lard) and leaf fat of Swallow-belly Mangulica pigs

Adipose tissue		P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
Back fat	Mean ± SD	17.74 ± 3.60	15.58 ± 0.75	8.83 ± 2.75	3.36 ± 0.45	1.08 ± 0.05	0.42 ± 0.06	0.32 ± 0.06	0.06 ± 0.03	0.007 ± 0.001
	Range	(13.18–23.12)	(14.76–16.48)	(6.08–11.77)	(2.90–4.11)	(1.01–1.14)	(0.34–0.48)	(0.25–0.37)	(0.03–0.09)	(0.006–0.008)
Leaf fat	Mean ± SD	17.02 ± 4.24	16.20 ± 1.91	8.65 ± 2.66	3.29 ± 0.89	1.23 ± 0.25	0.53 ± 0.13	0.39 ± 0.08	0.05 ± 0.02	0.009 ± 0.002
	Range	(13.32–23.61)	(13.96–18.17)	(6.35–13.00)	(2.47–4.31)	(0.99–1.64)	(0.40–0.67)	(0.31–0.50)	(0.03–0.07)	(0.006–0.011)
P value		0.780	0.516	0.917	0.889	0.222	0.112	0.149	0.494	0.079
Both tissues	Mean ± SD	17.38 ± 3.73	15.89 ± 1.40	8.74 ± 2.55	3.33 ± 0.66	1.15 ± 0.19	0.47 ± 0.11	0.35 ± 0.08	0.06 ± 0.02	0.008 ± 0.002
	Range	(13.18–23.61)	(13.96–18.17)	(6.08–13.00)	(2.47–4.31)	(0.99–1.64)	(0.34–0.67)	(0.25–0.50)	(0.03–0.09)	(0.006–0.011)

Table 4. Overall correlation (r) between physical characteristics and proximate and mineral composition

Characteristics	CIE*L**	CIE*a**	CIE*b**	Moisture	Protein	Total fat	Total ash	P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
pH_{24h}	0.40	–0.69*	–0.42	0.12	0.00	–0.12	0.36	–0.43	–0.46	–0.13	–0.11	–0.20	0.08	–0.06	–0.25	–0.12
CIE*L**		–0.27	–0.15	0.11	–0.46	0.02	0.31	–0.33	0.22	–0.27	–0.08	0.44	0.56	0.53	–0.43	0.61
CIE*a**			0.92***	0.41	0.28	–0.43	0.09	0.75*	0.32	0.64*	0.63*	0.64*	0.10	–0.16	0.10	0.29
CIE*b**				0.61	0.29	–0.59	0.20	0.81**	0.24	0.84**	0.68*	0.70*	0.20	–0.12	0.10	0.37
Moisture					0.22	–0.93***	0.59	0.59	0.34	0.73*	0.53	0.65*	0.45	–0.40	0.21	0.31
Protein						–0.54	–0.14	0.04	–0.19	0.19	0.70*	0.06	–0.41	–0.79**	–0.12	–0.48
Total fat							–0.45	–0.48	–0.27	–0.66*	–0.71*	–0.62	–0.25	0.63*	–0.12	–0.15
Total ash								0.19	–0.19	0.23	0.24	0.31	0.35	–0.19	–0.12	0.06
P									0.24	0.86**	0.46	0.39	0.01	–0.04	0.59	0.23
K										0.20	–0.07	0.62	0.59	0.04	0.05	0.68*
Na											0.43	0.50	0.25	–0.19	0.36	0.33
Ca												0.49	–0.23	–0.43	0.03	–0.07
Mg													0.69*	–0.02	–0.25	0.77**
Fe														0.18	–0.31	0.81**
Zn															0.02	0.48
Cu																–0.13

*P< 0.05; **P< 0.01; ***P< 0.001.

Table 5. Proximate and mineral composition (mg/100 g) of pig's adipose tissue according to literature

Source	Samples	Moisture	Protein	Fat	Ash	P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
The US Department of Agriculture's	Leaf fat	4.09	1.76	94.16	0.10	19	31	5	1	1	0.09	0.18	0.009	0.001
	Lard			100			0.02	0.01	0.07	0.02		0.11		
Hopkins and Murphy (1962)	Fat - pork leg							18.0	2.2		0.3		0.02	
Honikel (2011)	Lard					3	1	2	1	1	0.05	0.1	0.02	

ACKNOWLEDGMENT: Research was financially supported by the Ministry of Science and Technological Development, Republic of Serbia, project TR31032. These results are also part of the project No 114-451-3464/2013 (Improvement of meat quality from indigenous and modern pig breeds produced in Vojvodina for the production of traditional dry fermented sausages and dry cured meat products), which is financially supported by the Provincial Secretariat for Science and Technological Development, Autonomous Province of Vojvodina, Republic of Serbia.

REFERENCES

CIE (1976). International Commission on Illumination, Colorimetry: Official Recommendation of the International Commission on Illumination, Publication CIE No. (E-1.31). Bureau Central de la CIE,Paris, France.

Egerszegi, I., Rátky, J., Solti, L., Brüssow, K.-P. (2009). Mangalica– an indigenous swine breed from Hungary (Review). ArchivTierzucht, Dummerstorf, 46 (3), 245–256.

FAO DAD-IS (Domestic animal diversity information system): http://www.dad.fao.org/.

Hofmann, K. (1990). Definition and measurements of meat quality. 36th International Congress of Meat Science and Technology, Havana, Cuba, 941–954.

Honikel, K. O. (1999). Biochemical and physico-chemical characteristics of meat quality. Meat Technology, 40 (3–5), 105–123.

Honikel, K. O. (2011). Composition and calories. In: Nollet, L. M. L, Toldra, F. (eds.) Handbook of analysis of edible animal by-products. CRC Press, Boca Raton, USA.

Hopkins, H. T., Murphy, E. W. (1962). Mineral content of meats, mineral elements in adipose tissue of lamb and pork. Journal of Agricultural and Food Chemistry, 10 (6), 515–517.

ISO 13730 (1996). Determination of total phosphorus content – Spectrometric method.Meat and meat products.International Organisation for Standardisation, Geneva, Switzerland.

ISO 1442 (1997). Determination of moisture content (Reference method). Meat and meat products.International Organisation for Standardisation, Geneva, Switzerland.

ISO 1443 (1973). Determination of total fat content.Meat and meat products. International Organisation for Standardisation, Geneva, Switzerland.

ISO 2917 (1999). Measurement of pH (Reference method). Meat and meat products. International Organisation for Standardisation, Geneva, Switzerland.

ISO 936 (1998). Determination of total ash.Meat and meat products.International Organisation for Standardisation, Geneva, Switzerland.

ISO 937 (1978). Determination of nitrogen content (Reference method). Meat and meat products.International Organisation for Standardisation, Geneva, Switzerland.

Leth, T. (2004). Major meat components. In: Jensen, W.K., Carrick, D., Dikeman, M. (eds.). Encyclopedia of meat sciences. Elsevier Ltd., Oxford, UK, 185–190.

Olsson, V., Pickova, J. (2005). The influence of production systems on meat quality, with emphasis on pork.Ambio, 34 (4–5), 338–343.

Rosenvold, K., Andersen, H. J. (2003). Factors of significance for pork quality – A review. Meat Science, 64 (3), 219–237.

Scherf, B. D. (2000). World watch list for domestic animal diversity (3rd ed.). FAO, Rome, Italy.

Smith, S. B., Smith, D. R., Lunt, D. K. (2004).Adipose tissue. In: Jensen, W.K., Carrick, D., Dikeman, M. (eds.). Encyclopedia of meat sciences. Elsevier Ltd., Oxford, UK, 225–238.

STATISTICA (Data Analysis Software System), v.12.0 (2012). Stat-Soft, Inc, USA (www. statsoft.com)

The US Department of Agriculture’s (2011). Nutrient Data Laboratory: http://www.ndb.nal.usda.gov/

Tomović, V., Petrović, Lj., Tomović, M., Kevrešan, Ž., Džinić, N., Jokanović, M. (2010). Content of manganese in *M. semimembranosus*, liver and kidney in commercial pigs produced in Vojvodina. Journal on Processing and Energy in Agriculture (former PTEP), 14 (1), 11–14.

Tomović, V. M., Petrović, Lj. S.,Tomović, M. S., Kevrešan, Ž. S., Džinić, N. R. (2011). Determination of mineral contents of semimembranosus muscle and liver from pure and crossbred pigs in Vojvodina (northern Serbia). Food Chemistry, 124 (1), 342–348.

Wood, J. D., Enser, M., Fisher, A. V., Nute, G. R., Sheard, P. R., Richardson, R. I., Hughes, S. I., Whittington, F. M. (2008). Fat deposition, fatty acid composition and meat quality – A review. Meat Science, 78 (4), 343–358.

Received: 28.02.2014. Accepted: 09.06.2014.