# Comparison the physicochemical quality indicators of *Musculus Longissimus Dorsi* from Mangalitsa Breed and their crossbreeds

# Porovnanie fyzikálno-chemických ukazovateľov kvality *Musculus longissimus dorsi* mangalice a jej krížencov

Ondrej DEBRECÉNI, Petra KOMOVÁ* and Ondřej BUČKO

Department of Animal Husbandry, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, Slovak Republic, *correspondence: komovapetra@gmail.com

## Abstract

In recent years, there has been a current trend in the market of pork to create products based on traditional, regional specialities, where is used technology such as drying, smoking and fermentation of products. These products require a specific quality of meat from pure-bred indigenous breeds or their crossbreeds with emphasis on dry matter content, intramuscular fat content in meat and fatty acid composition with higher share of unsaturated fatty acids and essential fatty acids. Due to this fact, indigenous breed such as the Mangalitsa has received attention from the aspect of high meat quality and meat products compared to pig meat breeds. The aim of study was to compare the meat quality of *Musculus longissimus dorsi* from Mangalitsa breed, the crossbreeds Mangalitsa x Duroc and the pig meat breed Slovak Large White. The experimental material comprised of 28 pcs of pigs, which were reared in the same intensive conditions and they were fed *ad libitum* by complete feed mixtures for fatteners. The fattening period lasted from 30 kg to 100 kg of body weight. In the presented study was found that the crossbreeds Mangalitsa x Duroc had lighter colour of meat and the Mangalitsa had darker colour than Slovak Large White ($P < 0.01$). From the point of texture of meat, it was found stiffer meat from Slovak Large White and more tender meat from crossbreeds Mangalitsa x Duroc compared to meat of Mangalitsa ($P < 0.01$). The crossbreeds Mangalitsa x Duroc had the highest intramuscular fat content and cholesterol content in meat ($P < 0.01$). The intramuscular fat content and cholesterol content was the lowest in Slovak Large White ($P < 0.01$). The results indicate that utilization of Mangalitsa breed for crossing with pig meat breeds can improve quality meat traits in their crossbreeds, which are requiring for production of special meat products.

**Keywords:** chemical composition, Mangalitsa, meat colour, pH, shear force

## Abstrakt

V posledných rokoch je aktuálnym trendom na trhu s bravčovým mäsom vytvárať produkty na báze tradičných, regionálnych špecialít, kde sa využíva technológia sušenia, údenia a fermentácie výrobkov. Tieto výrobky vyžadujú špecifickú kvalitu mäsa a tuku pri čistokrvných primitívnych plemenách alebo ich krížencov s dôrazom ku obsahu sušiny, obsahu intramuskulárného tuku v mäse a zloženia mastných kyselín s požadovaným vyšším podielom nenasýtených mastných kyselín a esenciálnych mastných kyselín. Z tohto dôvodu, primitívne plemeno mangalica získalo pozornosť z hľadiska vysokej kvality mäsa a mäsových výrobkov v porovnaní s mäsovými plemenami. Cieľom práce bolo porovnať kvalitu *Musculus longissimus dorsi* mangalice, krížencov mangalica x duroc a mäsového plemena slovenskej bielej ušľachtilej. Do pokusu bolo zaradených 28 ks ošípaných, ktoré boli chované v intenzívnych podmienkach a kŕmené systémom *ad libitum* kompletnou kŕmnou zmesou pre výkrm ošípaných. Výkrm trval od 30 kg do 100 kg živej hmotnosti. štúdii sme zistili, že mäso krížencov mangalica x duroc malo svetlejšiu farbu mäsa, pričom mäso mangalice bolo tmavšie v porovnaní so slovenskou bielou ušľachtilou ($P < 0.01$). Textúra mäsa bola významne tuhšia pri plemene biela ušľachtilá a jemnejšia pri krížencoch mangalica x duroc ($P < 0.01$) v porovnaní so slovenskou bielou ušľachtilou. Kríženci mangalica x duroc mali najvyšší obsah intramuskulárného tuku a cholesterolu v mäse ($P < 0.01$). Obsah intramuskulárneho tuku a cholesterolu v mäse bol najnižší pri slovenskej bielej ušľachtilej ($P < 0.01$). Výsledky naznačujú, že využitie plemena mangalica pre kríženie s mäsovými plemenami ošípaných môže zlepšiť kvalitatívne vlastnosti mäsa krížencov, ktoré sú žiaduce pre výrobu špeciálnych mäsových výrobkov.


**Kľúčové slova:** farba mäsa, chemické vlastnosti, mangalica, pH, strižná sila

## Introduction

In recent years, there has been increasing interest in indigenous breeds such as Mangalitsa breed (Petrović et al., 2011), because meat and meat products from indigenous breeds are highly accepted by consumers due to high sensory quality (Stanišić et al., 2015). In compliance with global trends aimed at advancing meat products, made from autochthonous breeds, are gaining on importance (Živković et al., 2012). The Mangalitsa is one of the most popular breeds in Europe for excellent properties of meat such as taste, marbling, and low cholesterol content (Pârvu et al., 2012). Also the meat is darker, more succulent, softer and its odour is stronger than the meat from other pig breeds. The red colour of meat corresponds to current requirements and his high dry matter content is suitable for making special meat products (Parunović et al., 2013). According to Stanišić et al. (2015), Mangalitsa had darker, redder and softer meat than the meat from Landrace, but Landrace had more yellow meat compared to meat of Mangalitsa. Poto et al. (2007) indicated that the meat of indigenous breed Chato Murciano was darker, redder and more yellow than the meat from crossbreeds Chato Murciano x Large White. The results of Morcuende et al. (2007) showed that crossbreeds Iberian x Duroc had darker, redder and more yellow meat compared to crossbreeds Duroc x Iberian. The meat colour mostly depends on myoglobin concentration, its chemical and physical state of meat (Estévez et al., 2003). Recent studies have shown that the meat of crossbreeds achieved higher pH values 45 minutes *post mortem* compared to meat from indigenous breeds, but the ultimate pH 24 h *post mortem* was almost identically in both genotypes (Poto et al., 2007; Sirtori et al., 2011). Sirtori et al. (2011) reported lower values of drip loss in meat from indigenous breed Cinta Senese than in crossbreeds Italian Duroc x Cinta Senese. The ability of indigenous pigs to deposit intramuscular fat is valuable in the production of dry-cured meat products. The intramuscular fat contributes to the juiciness of dry-cured hams due to the lipolytic and oxidative processes that occurs during the curing treatment (Stanišić et al., 2015). The Mangalitsa breed reared in the extensive conditions had lower values of water content, lower protein content, but higher share of intramuscular fat in the meat compared to Mangalitsa reared in the intensive conditions (Petrović et al., 2010; Petrović et al., 2012). According to Stanišić et al. (2015) Mangalitsa breed had lower water content, lower protein content, but higher content of intramuscular fat in the meat than Landrace. The cholesterol content varies from 58 mg*100g$^{-1}$ to 73 mg*100g$^{-1}$ of pork meat (Parunović et al., 2015). Nistor et al. (2012) found the smallest cholesterol content at thigh (50 mg*100 g$^{-1}$), but at the loin and neck were higher values of cholesterol content (54 mg*100 g$^{-1}$; 55 mg*100 g$^{-1}$) in Mangalitsa breed**.** Some studies (Petrović et al., 2010; Parunović et al., 2013) noted that the meat of Mangalitsa breed reared in the extensive conditions contained higher values of cholesterol compared to pig meat breeds**.** Pârvu et al. (2012) indicated that Mangalitsa had lower cholesterol content in meat than Large White. The Mangalitsa is a typical fat-type, curly-haired pig with relatively low reproductive performance, but it has good adaptability to rearing conditions (Egerzegi et al., 2003). This breed is also highly resistant to extreme climate conditions, stress, diseases and is not pretentious to fodder compared to pig meat breeds (Dornea et al., 2013). The Mangalitsa breed is characterized by slower growth rate with higher adiposity and lower lean deposition compared to pig meat breeds (Vranic et al., 2015). Generally, fat content of the carcass is 65-70% and lean meat is only 30-35% in carcass (Egerzegi et al., 2003). Due to this fact, producers lost their interest in producing these indigenous breed and their numbers declined in 50$^{th}$ years of the last century (Stanišić et al., 2013). Nowadays the Mangalitsa breed is reared in the intensive or extensive conditions and fed using complete mixtures or in traditional ways. The extensive production system increases the value of animal products due to influence on the sensory, chemical and physical properties (Tomović et al., 2015). The indigenous breeds have usually been crossed with commercial breed Duroc (Morcuende et al., 2007). The Duroc breed was introduced into Europe due to its higher intramuscular fat content compared to other breeds. The introduction of the Duroc breed can improve productive parameters such as higher weight at weaning and at the end of fattening. But the share of indigenous breeds can keep the high adaptability to the environment conditions without a significant decrease in the quality of the cured meat products (Ramírez and Cava, 2007). The aim of study was compared the physical and chemical parameters of *Musculus longissimus dorsi* from Mangalitsa breed, crossbreeds Ma x Du and Slovak Large White.

## Materials and methods

### Biology material and their housing

The experiment was realized in the Experimental center of animal near the Department of Animal Husbandry at the Slovak University of Agriculture (SUA) in Nitra. In the study, 28 pcs of pigs of different genotypes were used. First genotype was Mangalitsa breed (n=9), second genotype were crossbreeds Ma x Du (n=9) and last one was the Slovak Large White breed - SLW (n=10). The Mangalitsa breed and crossbreeds Ma x Du were housed in groups of 3. The SLW were housed in groups of 2. Pigs were reared in intensive conditions. The pen was consisted of concrete floor, which was bedding straw.

### Feeding

The pigs were fed by complete feed mixture OŠ-06, which is mixture for fatteners. The composition of complete feed mixture OŠ-06 is presented in Table 1. Nutrient content of complete feed mixture OŠ-06 is presented in Table 2. The pigs received drinking water and feed mixture by *ad libitum* system.

Table 1. The composition of complete feed mixture OŠ-06

Tabuľka 1. Zloženie kompletnej kŕmnej zmesi OŠ-06

| Ingredients (%) | |
|---|---|
| Corn | 50 |
| Barley | 10 |
| Wheat | 10 |
| Soybean meal (48% N) | 10 |
| Granuled alfalfa | 10 |
| Linseed meal | 7 |
| Mineral and vitamin supplement | 3 |

retihol 200 000 m.j., cholecalciferol 30 000 m.j., α-tocopherol 400 mg, riboflavin, 80 mg, pyridoxine 30 mg, cyanocobalamin 1000 mcg, niacinamide 300 mg, folic acid 2 mg, pantothenic acid 300 mg, cholinchlorid 4000 mg, Cu 600 mg, Fe 3400 mg, Zn 1000 mg, Mn 1000 mg, I 30 mg, Se 8 mg.

Table 2. The nutrient content of complete feed mixture OŠ-06

Tabuľka 2. Obsah živín v kompletnej kŕmnej zmesi OŠ-06

| Traits | |
|---|---|
| ME (MJ*kg$^{-1}$) | 12.69 |
| Dry matter (%) | 89.79 |
| Crude protein (%) | 13.75 |
| Crude fat (%) | 5.23 |
| Crude fibre (%) | 7.36 |
| Ash (%) | 5.39 |
| Ca (g*kg$^{-1}$) | 9.29 |
| P (g*kg$^{-1}$) | 5.57 |

**Sampling**

The fattening period was lasted from 30 kg to 100 kg of body weight. After the fattening period the pigs were slaughtered in slaughterhouse in the Experimental center of animals (SUA in Nitra). The pigs were electrically stunned and slaughtered according to government regulation NR SR 432/2012 (about the protection of animals during the slaughter). The dissection of carcasses was done according to standard practices of station of fattening and slaughter values in Slovakia (initially STN 46 61 64). The physical and chemical parameters were carried out on *Musculus longissimus dorsi* (MLD) from which the sample was taken 50 g.

**Physical analysis**

The actual acidity - log*molc$^{(H+)}$ in the MLD resp. pH values 45 min ($pH_{45}$) and 24 h ($pH_{24}$) *post mortem* were measured by pHmeter Hanna HI99161. The electric conductivity was also measured 45 min ($EC_{45}$) and 24 h ($EC_{24}$) *post mortem* by measuring instrument Tecpro in units mS*cm$^{-1}$. Drip loss of MLD was measured following the method of Honikel (1998). In time from 24 h to 48 h *post mortem*, a sample (50 g from MLD) was placed in vacuum plastic bags and hung in the refrigerator at 4 °C. Drip loss (%) was calculated by difference weight between 24 h and 48 h of storage. Then, the cores were sheared perpendicular to the muscle fibres orientation using a Warner-Bratzler shear device (Chatillon, U.S.A.), in accordance with Goodson et al. (2002).

**Instrumental colour**

The colour of samples was measured 24 h and 7 days *post mortem.* Commission Internationale de I'Eclaire (1975) determined the following colour coordinates*:* lightness (L*), redness (a*, red ± green) and yellowness (b*, yellow ± blue). Colour parameters were determined using spectrophotometer CM – 2600d with the CIE Lab space and illuminate D65.

**Chemical analysis**

The indicators of chemical composition such as total water, total protein and intramuscular fat were measured by the FT IR (FourierTransform InfraRed) method using device Nicolet 6700. FT IR principle of method was to measure the amount of absorbed infrared in the sample and creation the molecular fingerprint using the interferogram.

**Statistical analysis**

The data were subjected to statistical analysis by ANOVA using the Statistic Analysis System (SAS) package (SAS 9.2 using of application Enterprise Guide 5.1.). Differences between groups were analysed by Tukey's test.

## Results and discussion

Means and standard deviations of physical properties in *Musculus longissimus dorsi* (MLD) from genotypes are shown in Table 3. The $pH_{45min}$ values of MLD were from 5.85 $log*molc^{(H+)}$ to 6.12 $log*molc^{(H+)}$. The ultimate $pH_{24h}$ was significantly the lowest ($P < 0.01$) in SLW (5.50 $log*molc^{(H+)}$) compared to Mangalitsa and crossbreeds Ma x Du (5.64 $log*molc^{(H+)}$; 5.61 $log*molc^{(H+)}$). Pale, soft and exudative (PSE) pork was not an issue in the current trials, but the $pH_{24h}$ value in SLW was on the critical limit. In a similar study Parunović et al. (2012) determined decrease of pH values in MLD after 24 hours. On the contrary with our results Sirtori et al. (2011) and Poto et al. (2007) reported that $pH_{45min}$ in MLD was lower in indigenous breeds compared to crossbreeds, but the ultimate $pH_{24h}$ was almost identically in both genotypes. Nevertheless the studies showed decrease pH values in MLD after 24 h *post mortem*. In the current study, the electric $conductivity_{45min}$ was from 3.0 $mS*cm^{-1}$ to 5.9 $mS*cm^{-1}$ in MLD. The ultimate electric $conductivity_{24h}$ of MLD was significantly the lowest ($P < 0.01$) in SLW (8.15 $mS*cm^{-1}$) and the highest ($P < 0.01$) in crossbreeds Ma x Du (11.70 $mS*cm^{-1}$). The MLD of Mangalitsa achieved middle values (9.10 $mS*cm^{-1}$). It is accordance with results of drip $loss_{24h}$, where the crossbreeds Ma x Du had the highest loss of water in MLD and SLW had the lowest values of drip loss (9.04% vs. 7.30%). The differences were not statistically significant. Similarly Sirtori et al. (2011) indicated a higher value of drip loss in crossbreeds Italian Duroc x Cinta Senese than in indigenous breed Cinta Senese. An objective measure of tenderness is the force required to shear a piece of meat and more tender meat has lower values of shear force. In present study, the most tender meat ($P < 0.01$) was determined in crossbreeds Ma x Du and the stiffest meat ($P < 0.01$) in SLW (2.08 $kg*cm^{-2}$ vs. 4.30 $kg*cm^{-2}$). The meat of Mangalitsa reached middle values (2.33 $kg*cm^{-2}$). In the study, there was determined more tender meat in all genotypes compared to genotypes in study of Stanišić et al. (2015), but authors confirmed that Mangalitsa breed had more tender meat compared to Landrace. The crossbreeds Ma x Du exhibited lighter colour ($P < 0.01$) of MLD ($L^* = 63.62$) compared to Mangalitsa ($L^*=52.95$) and SLW ($L^*=57.39$), what is probably due to higher values of electric conductivity and higher drip loss in crossbreeds Ma x Du. The CIE a* value is a result of myoglobin content in the muscle. The MLD from crossbreeds Ma x Du was the reddest (a*=2.94) compared to Mangalitsa (a*=2.68) and SLW (a*=0.99). The differences between genotypes were not significant for CIE a*, while the highest values ($P < 0.01$) were measured in crossbreeds Ma x Du for CIE b* (b*=13.09) compared to Mangalitsa (b*=10.41) and SLW (b*=10.55). It is probably due to higher share of intramuscular fat in MLD of crossbreeds Ma x Du. The CIE L*, a* and b* values increased after 7 days of storage. The meat from Mangalitsa was darker, redder compared to crossbreeds Ma x Du and SLW, but crossbreeds Ma x Du had more yellow meat. These results are in agreement with findings of Stanišić et al. (2015), but authors suggested that Landrace had more yellow meat compared to Mangalitsa. Similarly Poto et al. (2007) indicated that the meat from Chato Murciano was darker, redder and more yellow than the meat from crossbreeds Chato Murciano x Large White. The results of Morcuende et al. (2007) showed that crossbreeds Iberian x Duroc had darker, redder and more yellow meat compared to crossbreeds Duroc x Iberian.

Table 3. The physical properties in MLD

Tabuľka 3. Fyzikálne vlastnosti v MLD

| Parameter | Mangalitsa (n=9) mean ± SD | Ma x Du (n=9) mean ± SD | SLW (n=10) mean ± SD |
|---|---|---|---|
| $pH_{45min.}$ (log*molc$^{(H+)}$) | 6.12 ± 0.34 | 5.85 ± 0.28 | 6.12 ± 0.28 |
| $pH_{24hours}$(log*molc$^{(H+)}$) | 5.64 ± 0.04$^{a}$ | 5.61 ± 0.04$^{a}$ | 5.50 ± 0.07$^{b}$ |
| $EC_{45min.}$ (mS*cm$^{-1}$) | 3 ± 1.65 | 5.9 ± 6.63 | 3.8 ± 2.15 |
| $EC_{24hours}$ (mS*cm$^{-1}$) | 9.1 ± 1.28$^{a}$ | 11.7 ± 1.22$^{b}$ | 8.15 ± 2.98$^{a}$ |
| Drip $loss_{24hours}$ (%) | 8.76 ± 2.89 | 9.04 ± 2.14 | 7.3 ± 2.89 |
| $Colour_{24hours}$ CIE L* | 52.95 ± 4.01$^{a}$ | 63.62 ± 3.7$^{b}$ | 57.39 ± 2.17$^{c}$ |
| $Colour_{24hours}$ CIE a* | 2.68 ± 1.45 | 2.94 ± 1.49 | 0.99 ± 1.85 |
| $Colour_{24hours}$ CIE b* | 10.41 ± 1.19$^{a}$ | 13.09 ± 1.54$^{b}$ | 10.55 ± 1.4$^{a}$ |
| $Colour_{7days}$ CIE L* | 54.84 ± 4.59$^{a}$ | 65.34 ± 3.06$^{b}$ | 58.43 ± 2.18$^{c}$ |
| $Colour_{7days}$ CIE a* | 5.57 ± 3.24 | 5.13 ± 1.93 | 4.33 ± 2.52 |
| $Colour_{7days}$ CIE b* | 13.92 ± 1.93 | 14.98 ± 1.93 | 12.92 ± 1.84 |
| Shear force (kg*cm$^{-2}$) | 2.33 ± 0.6$^{a}$ | 2.08 ± 0.59$^{a}$ | 4.3 ± 1.11$^{b}$ |

EC - Electric conductivity
a,b,c: Different letters in the same row indicate significant statistical differences (Tukey's test, $P < 0.05$).

Proximate chemical composition including cholesterol content in MLD from genotypes is shown in Table 4. The water content was the highest in SLW (74.30%) compared to crossbreeds Ma x Du (73.68%). The differences were statistically significant ($P < 0.05$). The Mangalitsa exhibited middle values of total water content in MLD (73.83%). In the protein content were not significant differences, but the highest protein content was measured in Mangalitsa (24.10%) compared to SLW (23.71%) and crossbreeds Ma x Du (23.67%). The intramuscular fat content was the highest ($P < 0.01$) in crossbreeds Ma x Du (2.37%) compared to SLW (1.24%). However, the SLW had less values of intramuscular fat ($P < 0.05$) compared to Mangalitsa (1.89%). Similarly, Stanišić et al. (2015) observed lower water content, higher content of intramuscular fat in meat from Mangalitsa compared to Landrace, but lower protein content. On the other hand, Petrović et al. (2012) found that Mangalitsa reared in the intensive conditions had higher water content, protein content in meat, but lower intramuscular fat content compared to Mangalitsa reared outdoor, what it is in agreement with findings of Petrović et al. (2010). Morcuende et al. (2007) obtained lower values of water content and protein content in meat, but higher values of intramuscular fat content in crossbreeds Iberian x Duroc compared to our results. Cholesterol content in MLD was the lowest ($P < 0.01$) in SLW (20 mg*100 $g^{-1}$) compared to Mangalitsa (37 mg*100 $g^{-1}$) and crossbreeds Ma x Du (44 mg*100 $g^{-1}$). These findings are in accordance with Petrović et al. (2010) and Parunović et al. (2013), but the pigs were reared in the extensive conditions and the values of cholesterol were higher. On the contrary Pârvu et al. (2012) indicated that Mangalitsa reared in the alternative production system had lower cholesterol content than Large White. The results obtained as well as results of authors that pigs reared in the intensive conditions have lower cholesterol content than pigs reared in the extensive conditions. However, it can be suggested that indigenous breed had higher cholesterol content in meat compared to pig meat breeds.

Table 4. The chemical composition and cholesterol content in MLD

Tabuľka 4. Chemické zloženie a obsah cholesterolu v MLD

| Parameter | Mangalitsa (n=9) mean ± SD | Ma x Du (n=9) mean ± SD | Large white (n=10) mean ± SD |
|---|---|---|---|
| Total water (%) | $73.83 \pm 0.36^{ab}$ | $73.68 \pm 0.73^{a}$ | $74.3 \pm 0.27^{b}$ |
| Total protein (%) | 24.1 ± 0.57 | 23.67 ± 0.39 | 23.71 ± 0.27 |
| Intramuscular fat (%) | $1.89 \pm 0.59^{a}$ | $2.37 \pm 0.63^{a}$ | $1.24 \pm 0.42^{b}$ |
| Cholesterol (mg*100 $g^{-1}$) | $37 \pm 0.07^{a}$ | $44 \pm 0.09^{a}$ | $20 \pm 0.04^{b}$ |

a,b: Different letters in the same row indicate significant statistical differences (Tukey's test, $P < 0.05$).

## Conclusions

The results indicated that the meat ripening was slower in Mangalitsa reared in the intensive conditions, because of lower values of electric conductivity compared to Slovak Large White. At the $pH_{45min}$ have not been determined differences in MLD of Mangalitsa and Slovak Large White. However the $pH_{24h}$ had considerable decreased in Slovak Large White, which was achieved the critical limit of PSE meat what is accordance with higher values of electric $conductivity_{24h}$. Nevertheless, the drip loss was higher in Mangalitsa. The meat of Mangalitsa was darker, redder and more tender compared to Slovak Large White. The meat of crossbreeds Ma x Du was lighter, redder, more tender with higher intramuscular fat content and cholesterol content. It can be conclude that Mangalitsa breed has favourable meat quality traits, which are desirable for production of specific meat products although the cholesterol content of meat is higher compared to pig meat breeds. The positive effect of crossing was shown by higher intramuscular fat content, lower water content, but higher cholesterol content and considerable tenderness of meat. The meat of crossbreeds Ma x Du has required properties for specific meat products.

## Acknowledgements

This study was supported by project VEGA 1/0364/15.

## References

Comission Internationale de I'Eclaire (1975) Comission Internationale de I'Eclaire 18th Session, London, UK, September 1975, C.I.E. publication, 36.

Dornea, M.M., Mateoc-Sirb, N., Gorun L.M., Raicov, M. (2013) Study of Rare Traditional Pork Breeds Concerning the Aspects of Biodiversity Conservation. Bulletin of University of Agriculture Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies, 69 (1-2), 308-310.

Egerszegi, I., Rátky, J., Solti, L., Brüssow, K. P. (2003) Mangalica- an indigenous swine breed from Hungary (Review). Archiv Tierzucht, Dummerstorf, 46 (3), 245-256.

Estévez, M., Morcuende, D., Cava, R. (2003) Oxidative and colour changes in meat from three lines of free-range reared Iberian pigs slaughtered at 90 kg live weight and from industrial pig during refrigerated storage. Meat Science, 65 (3), 1139-1146. DOI: http://dx.doi.org/10.1016/S0309-1740(02)00343-1

Goodson, K. J., Morgan, W. W., Reagan, J. O., Gwartney, B. L., Courington, S. M., Wise, J. W., Sawell, J. W. (2002) Beef customer satisfaction: factors affecting consumer evaluations of clod steaks. Journal of Animal Science, 80(2), 401-408.

Honikel, K. O. (1998) Reference methods for the assessment of physical characteristics of meat. Meat Science, 49, 447-457.

Morcuende, D., Estévez, M., Ramírez, R., Cava, R. (2007) Effect of the Iberian x Duroc reciprocal cross on productive parameters, meat quality and lipogenic enzyme activities. Meat Science, 76, 86-94. DOI: http://dx.doi.org/10.1016/j.meatsci.2006.10.016

Nistor, E., Bampidis, V., Pentea, M., Prundeanu, H., Ciolac, V. (2012) Nutritional Quality of Pork Produced by Mangalitsa Breed. Scientific Papers: Animal Science and Biotechnologies, 45 (2), 386-389.

Parunović, N., Petrović, M., Matekalo-Sverak, V., Trbović, D., Mijatović, M., Radović, Č. (2012) Fatty acid profile and cholesterol content of *m. longissimus* of free-range and conventionally reared Mangalitsa pigs. South African Journal of Animal Science, 42 (2), 101-113.

Parunović, N., Petrović, M., Matekalo-Sverak, V., Radović, Č., Stanišić, N. (2013) Carcass properties, chemical content and fatty acid composition of the *musculus longissimus* of different pig genotypes. South African Journal of Animal Science, 43 (2), 123-136.

Parunović, N., Petrovic, M., Djordjevic, V., Petronijevic, R., Lakicevic, B., Petrovic, Z., Savic, R. (2015) Cholesterol content and fatty acids composition of Mangalitsa pork meat. Procedia Food Science, 5, 215-218.

Pârvu, M., Bogdan, T.A., Andronie, C.I., Simion, E.V., Amfim, A. (2012) Influence of Cold Stress on the Chemical Composition of Carcass to Mangalica pigs. Scientific Papers: Animal Science and Biotechnologies, 45 (2), 394-396.

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. Biotechnology in Animal Husbandry, 26 (1-2), 21-27. DOI: http://dx.doi.org/10.2298/BAH1002021P

Petrović, M., Radović, Č., Mijatović, M., Radojović, D., Stanišić, N., Parunović, N. (2011) The share of tissues in pig carcass sides of autochthonous breeds depending on the body mass and sex. Biotechnology in Animal Husbandry, 27 (3), 561-569. DOI: http://dx.doi.org/10.2298/BAH1103561P

Petrović, M., Radović, Č., Parunović, N., Radojović, D., Savić, R. (2012) Composition of carcass sides and quality of meat from swallow-belly mangalitsa reared in two systems. Biotechnology in Animal Husbandry, 28 (2), 303-311. DOI: http://dx.doi.org/10.2298/BAH1202303P

Poto, A., Galián, M., Peinado, B. (2007) Chato Murciano pig and its crosses with Iberian and Large White pigs, reared outdoors. Comparative study of the carcass and meat characteristics. Livestock Science, 111, 96-103. DOI: http://dx.doi.org/10.1016/j.livsci.2006.12.005

Ramírez, M.R., Cava, R. (2007) Effect of Iberian x Duroc genotype on dry-cured loin quality. Meat Science, 76 (2), 333-341. DOI: http://dx.doi.org/10.1016/j.meatsci.2006.11.017

SAS Institute Inc. (2008) SAS® 9.2. Cary, NC: SAS Institute Inc.

Sirtori, F., Crovetti, A., Zilio, D.M., Pugliese, C., Acciaioli, A., Campodoni, G., Bozzi, R., Franci, O. (2011) Effect of sire breed and rearing system on growth, carcass composition and meat traits of Cinta Senese crossbred pigs. Italian Journal of Animal Science, 10 (4), 47. DOI: http://dx.doi.org/10.4081/ijas.2011.e47

Stanišić, N., Petrović, M., Radović, Č., Gogić, M., Parunović, N., Stajić, S., Petričević, M. (2013) The effect of gender and breed on some properties of pig meat. Biotechnology in Animal Husbandry, 29 (4), 651-658. DOI: http://dx.doi.org/10.2298/BAH1304651S

Stanišić, N., Radović, Č., Stajić, S., Živković, D., Tomašević, I. (2015) Physicochemical properties of meat from Mangalitsa pig breed. Meso, 17 (1), 50-53.

Tomović, V.M., Stanišić, N.Z., Jokanović, M.R., Kevrešan, Ž.S., Šojić, B.V., Škaljac, S.B., Tomašević, I.B., Martinović, A.B., Despotović, A.R., Šuput, D.Z. (2015) Meat quality of Swallow-Belly Mangulica pigs reared under intensive production system and slaughtered at 100 kg live weight. Hemijska industrija, 00, 63-63. DOI: http://dx.doi.org/10.2298/HEMIND150613063T

Vranic, D., Nikolic, D., Koricanac, V., Stanisic, N., Slobodan, L., Djinovic-Stojanovic, J., Parunovic, N. (2015) Chemical composition and cholesterol content in *M. longissimus dorsi* from free-range reared Swallow-belly Mangalitsa: the effect of gender. Procedia Food Science, 5, 316-319. DOI: http://dx.doi.org/10.1016/j.profoo.2015.09.066

Živković, D., Radulović, Z., Aleksić, S., Perunović, M., Stajić, S., Stanišić, N., Radović, Č. (2012) Chemical, sensory and microbiological characteristics of Sremska sausage (traditional dry-fermented Serbian sausage) as affected by pig breed. African Journal of Biotechnology, 11 (16), 3858-3867. DOI: http://dx.doi.org/10.5897/AJB11.3363