Carcass quality traits of three different pig genotypes, White Mangulica, Duroc × White Mangulica and Large White pigs, reared under intensive conditions and slaughtered at 150 kg live weight

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Abstract. The effect of breed on carcass composition was studied for autochthonous purebred White Mangulica (WM), crossbred Duroc x White Mangulica (DWM) and purebred Large White (LW) pigs. Pigs were slaughtered at a target body weight of about 150 kg. After slaughter, carcass yield, backfat thickness, the thickness of the lumbar muscle and chilling loss were measured and calculated. WM pigs had the highest percentage of carcass yield, while DWM produced an intermediate carcass yield, between those of the pure breeds. The backfat thickness was highest in WM pigs, compared to DWM and LW pigs (67, 41 and 27 mm, respectively, \(P < 0.001\)). WM and LW pigs had respectively the lowest and the highest thickness of the lumbar muscle (62 and 72 mm), with DWM pigs at an intermediate position (69 mm). As regards chilling loss, WM and DWM pigs showed better results than LW pigs (1.74, 1.75 and 1.92 %, respectively). Overall, evidence of additive genetic effects was present for all investigated parameters, with crosses showing intermediate values between pure breeds.

1. Introduction
Mangulica is one of three primitive autochthonous pig breeds in Serbia and is considered endangered. In Serbia there are three varieties: White (Blond), Swallow Belly and Red. This breed emerged in Hungary as a result of crossing several Hungarian aboriginal pig breeds which disappeared or were altered by the end of the nineteenth century by crossing with the Serbian Šumadinka pig [1].

However, in the middle of the last century, the population decreased and nearly disappeared because of the carcass composition, and poorer reproductive and growing performance than modern commercial breeds. Mangulica meat belongs to the group of fat-rich meats [2]. Its average total mass consists of 65% - 70% fat tissue and 30% - 35% meat [3]. Its fresh meat is darker, more succulent and
softer than the meat from other pig breeds. Its odour is stronger. The tenderness of Mangulica pork is much higher than that obtained from any commercial pig breed [2].

The Mangulica breed is very resistant when kept in extensive conditions (free-range) on pasture, foraging on acorns, tubers, rhizomes and roots, it is well adapted to continental climate conditions and resistant to some pig diseases [1,2]. Today, the Mangulica breed is reared in an organized system in several herds in Serbia and is the most numerous indigenous pig breed [4]. Recently, the interest in this autochthonous breed has increased, not only for the purpose of gene preservation but also for production of meat products manufactured in traditional ways, which are much appreciated by consumers.

Crossbreeding is extensively used in pig production to increase the total efficiency of pig production and to improve the quality of the meat. Crossing with the Duroc pig breed is often used to improve the productivity of the autochthonous animals without greatly affecting their hardiness or reducing the level of intramuscular fat [5,6], because Duroc is notable in having a high muscle lipid (marbling fat) content relative to subcutaneous fat compared with other modern breeds [1,5-7].

This paper reports on carcass quality characteristics of White Mangulica pigs, both pure and crossbred with Duroc, reared under intensive farming conditions (system). Additionally, one of the tasks was to compare determined carcass quality traits of White Mangulica and its crosses with other European autochthonous breeds and their crosses with modern pig breeds.

2. Materials and Methods

A total of 60 pigs (female and castrated male) were studied: 20 purebred White Mangulica (WM) pigs, 20 crossbred pigs (Duroc sires crossed with White Mangulica dams - DWM) and 20 purebred Large White (LW) pigs. All animals were raised on a modern farm and slaughtered in a modern slaughterhouse in Serbia according to national legislation which is mainly harmonized with EU legislation. All animals were reared under the same environmental and production regime. Pigs were fed the same commercial diets and were slaughtered at a target body weight of about 150 kg. All pigs had ad libitum access to feed and water. Feed was withdrawn 12 h before slaughter, but water was freely available. On the slaughter day, pigs were individually weighed and transported to the slaughterhouse. The pigs were held in lairage for 2 h, with free access to water. All the animals were slaughtered and dressed in three days (20 pigs on each day), using standard commercial procedures [8].

All measurements were performed on the right side of the carcass. Carcass measurements were performed on the day of slaughter. Backfat thickness with the skin was measured in millimetres at the thinnest point over M. gluteus medius (S value). The thickness of the lumbar muscle in millimetres was measured as the shortest distance from the front (cranial) end of the M. gluteus medius to the upper (dorsal) edge of the spinal canal (M value). Chilling loss was expressed as the percentage of weight loss, measuring the mass of one carcass side after slaughter and at the end of the chilling process (24 h post mortem).

All data are presented as mean, standard deviation and range. Data were analysed statistically with one way ANOVA and post-hoc test (DUNCAN’S test). The software package STATISTICA 12 was used (StatSoft, 2015) for analysis.

3. Results and Discussion

The results of the determination of carcass quality traits (carcass yield, S value, M value and chilling loss) of three different pig genotypes (WM, DWM and LW) are presented in Table 1. The highest average carcass yield was found in WM pigs (84.7%), slightly lower average carcass yield was found in DWM pigs (84.0%), while LW pigs had the lowest average carcass yield (83.6%), but differences between the examined groups were not significant, indicating that the genotype did not affect carcass yield. The individual values of carcass yield ranged from 83.0 to 85.8% (WM), from 82.5 to 85.5% (DWM) and from 82.1 to 84.7% (LW).
Table 1. Carcass quality traits of three different pig genotypes (White Mangulica-WM, Duroc x White Mangulica-DWM and Large White pigs-LW).

| Parameter                      | WM          | DWM         | LW          | P value |
|--------------------------------|-------------|-------------|-------------|---------|
| Carcass yield (%)              | 84.7±1.0    | 84.0±0.9    | 83.6±0.9    | 0.055   |
| Range of carcass yield         | 83.0–85.8   | 82.5–85.5   | 82.1–84.7   |         |
| S (mm)                         | 67±7a,o,x   | 41±4b,p,y   | 27±4c,q,z   | <0.001  |
| Range of S                     | 55–80       | 35–46       | 22–35       |         |
| M (mm)                         | 62±3b,p,y   | 69±6o,xy    | 72±5a,o,x   | <0.001  |
| Range of M                     | 55–65       | 60–80       | 65–80       |         |
| Chilling loss (%)              | 1.74±0.10b  | 1.75±0.16b  | 1.92±0.20a  | 0.031   |
| Range of chilling loss         | 1.65–1.92   | 1.44–2.00   | 1.38–2.05   |         |

abc Means with different letters in the same row indicate significant differences at P<0.05.

opq Means with different letters in the same row indicate significant differences at P<0.01.

xyz Means with different letters in the same row indicate significant differences at P<0.001.

By comparing the obtained values for the carcass yield with the results of other authors who have also comparatively examined the carcass quality (carcass yield) of autochthonous breeds and/or their crosses with modern breeds, it can be concluded that in this study, higher average carcass yields were observed [9,10,11,12,13,14,15,16,17,18,19]. In this investigation, the slaughter of all pigs was carried out at a body weight of 150 kg, or at an average age of 244 (LW), 308 (DWM) and 532 (WM) days. However, according to a number of similar studies, increase in pigs’ body weight (age increase) leads to a significant increase in pigs’ carcass yield [16,20-23].

The highest average S value was found in WM pigs (67 mm), a lower average S value was found in DWM pigs (41 mm), while the lowest S value was found in LW pigs (27 mm). The individual S values ranged from 55 to 80 mm (WM), from 35 to 46 mm (DWM) and from 22 to 35 mm (LW). Differences in the average S values were statistically significant (P < 0.001) among all three examined pig genotypes, which indicates that the pig genotype affected the backfat thickness measured at the thinnest point over M. gluteus medius (S value). Comparable measurements for backfat thickness were found by several other authors [9,10,24,25] who have also comparatively examined the quality of carcasses of autochthonous breeds and/or their crosses with modern breeds and/or modern breeds, and reported the same trend. However, some authors [11,19,26,27] reported no significant difference in the backfat thickness between pigs of autochthonous breeds and their crosses with modern breeds of pigs.

Further, analysing the S value, it can be concluded that the S value varies greatly depending on the genotype [15,18,23,25,28,29]. Generally, native or autochthonous breeds have greater ability for fat deposition in comparison with modern breeds [10,21,30,31]. In similar studies, the highest backfat thickness over the M. gluteus medius at the thinnest point was found in the Iberian Retinto pigs (65.3 mm) reared under intensive production systems and whose pre-slaughter age was 231 days and the pre-slaughter weight was 144.4 kg [24], while in the case of Corsican x LW pigs, reared under the extensive conditions, fed with a concentrated diet and slaughtered with body weight of 141 kg, the highest backfat thickness over the M. gluteus medius was 48 mm [11]. The lowest backfat thickness over the M. gluteus medius was determined in LW pigs reared indoors and fed a commercial mixture (26.1 mm) [9,10].
Regarding the M value, the highest average value was found in LW pigs (72 mm), slightly lower average M value was found in DWM pigs (69 mm) and the lowest average M value was determined in WM pigs (62 mm). The individual M values ranged from 65 to 80 mm (LW), from 60 to 80 mm (DWM) and from 55 to 65 mm (WM). The average M value in LW and DWM pigs was statistically significantly higher ($P < 0.01$) in comparison with average M value in WM pigs. The results are in agreement with those of other studies. Other authors have also measured the thickness of $M.\ longissimus\ thoracis\ et\ lumborum$, ranging between 3rd and 4th lumbar vertebra [31] and at the last rib [32] in similar pig genotypes. Their results showed that the thickness of $M.\ longissimus\ thoracis\ et\ lumborum$ was significantly higher in modern pigs compared to autochthonous pigs or in comparison with the crossbred pigs (modern x autochthonous pigs). There is also a relationship between the $M.\ longissimus\ thoracis\ et\ lumborum$ surface (the loin eye area) and pig genotype [33]. An increase in the age and/or weight of similar pig genotypes leads to an increase in the area of the loin eye muscle [12,21,34,35].

Furthermore, the highest average chilling loss was found in LW pigs (1.92%), while in DWM and WM pigs, slightly lower average chilling loss was detected (1.75 and 1.74%, respectively). The values of chilling loss for LW pigs ranged from 1.38 to 2.05%, for DWM pigs from 1.44 to 2.00% and for WM pigs from 1.65 to 1.92%. The average chilling loss of LW pigs was statistically significantly higher ($P = 0.031$) compared to the average chilling loss of DWM and WM pigs, indicating that pig genotype affected the chilling loss. The average chilling loss found in carcasses of the modern pig (LW) is characteristic for a commercial carcass chilling process for commercial pigs [8].

4. Summary
Overall, additive genetic effects were evident for carcass traits, with crosses showing intermediate values between pure breeds. The performance of the DWM crossed pigs confirmed the theory according to which additive genetic effects mainly control morphology and body composition. Our study indicates significant differences between breeds for backfat thickness with the skin at the thinnest point over $M.\ gluteus\ medius$, the thickness of the lumbar muscle and chilling loss. No significant differences were observed for carcass yield.

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