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Meat quality traits of *M. longissimus lumborum* from White Mangalica and (Duroc × White Mangalica) × White Mangalica pigs reared under intensive conditions and slaughtered at about 180-kg live weight

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ABSTRACT

The objective of the study was to evaluate the meat quality of the Serbian autochthonous White Mangalica pure bred pig and its crossbreed with Duroc. A total of 24 pigs [White Mangalica – WM, $n = 12$, and (Duroc × White Mangalica) × White Mangalica) – (DWM)WM, $n = 12$)] were slaughtered on average 638 and 509 d of age, respectively. Colour and marbling score, and all physical (pH, instrumental colour and water holding capacity) and chemical (proximate and mineral composition and fatty acids profile) analyses were performed on *M. longissimus lumborum*. Pork from WM had higher marbling score and intramuscular fat content and was redder in colour than from (DWM)WM; while opposite was determined for moisture content. In intramuscular fat, WM had higher content of oleic acid as well as total monounsaturated fatty acids than (DWM)WM, while (DWM)WM had higher linoleic and arachidonic acids as well as total polyunsaturated fatty acids content. Inclusion of 25% Duroc gave pork with lower content of iron, copper and manganese. In summary, irrespective of differences in some particular traits White Mangalica crossbreds can represent a good alternative to pure White Mangalica without worsening the meat quality.

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Introduction

The Mangalica pig is endangered breed present in Hungary, Austria, Czech Republic, Germany, Romania, Slovakia, Switzerland and Serbia. Today, three types, characterised by a coloured coat, of Mangalica exist – White (Blond), Swallow Belly and Red. Reproductive performance, productive traits as growth rate and feed conversion, carcass composition and meat quality of this breed have been demonstrated in several studies (Scherf 2000; Egerszegi et al. 2003; Zsolnai et al. 2006; Tomović et al. 2014a, 2016a, 2016b; DAD-IS 2017). These pure-bred animals are traditionally reared under extensive conditions (Tomović et al. 2014a). One of the alternatives applied to improve productive parameters is to cross it with modern pig breed (mainly with Duroc or with Large White or Landrace) sire line at 50% (Coutron-Gambotti et al. 1998; Franci et al. 2005; Poto et al. 2007; Salvatori et al. 2008; Sirtori et al. 2011; Robina et al. 2013; Franco et al. 2014; Tomović et al. 2016a) to exploit additive and non-additive genetic variances and/or reared indoors and fed on concentrates. Generally, Duroc is utilised most frequently as a terminal/paternal sire in a cross-breeding programme (Vidović 1994). Also, crossing with the Duroc pig breed does not greatly affect reduction of intramuscular fat level in meat from crossbred (Edwards 2005; Pugliese and Sirtori 2012), because Duroc is notable for having a high muscle lipid (marbling fat) content relative to subcutaneous fat compared with other modern breeds (Wood et al. 2008). This is particularly important for the further cuts and meat fabrication, especially for dry-cured meats products (hams, loins, shoulders), where marbling is recognised as a criterion of quality (Lopez-Bote 1998; Gandemer 2002; Edwards 2005).

There is the limited amount of research regarding the influence of crossing endangered breed with

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Duroc sire line at 25%. Therefore, the aim of this study was to compare *M. longissimus lumborum* quality of purebred White Mangalica with (Duroc × White Mangalica) × White Mangalica pigs reared under intensive conditions and slaughtered between 170 and 200 kg live weight. This study represents the continuation of the research on the meat quality of Mangalica pig and their crosses reared under different management conditions in order to determine the effective genetic potential of this breed.

Materials and methods

This study was carried out with 12 White Mangalica (WM) pigs (castrated males and females) and 12 (Duroc – sires × White Mangalica – dams) – sires × White Mangalica – dams ((DWM)WM) pigs (castrated males and females). All animals were raised in modern farm and slaughtered in modern slaughterhouse in Serbia according to national legislations, which are mainly harmonised with EU legislation. At the age of 5 ± 2 d, males were castrated. Piglets of both genotypes had the same average initial weight after birth, 1.5 kg. All pigs were reared in intensive production system, as previously described in detail by Tomović et al. (2016a). Pigs were fed the same commercial diets (Table 1). Animals stayed at the rearing farm until they reached target slaughter weight. In this trial, the average slaughter weight was 179.9 kg (ranged from 170.7 to 193.5 kg) for WM pigs and 184.7 kg (ranged from 172.1 to 198.1 kg) for (DWM)WM pigs, while average slaughter age was 638 d (ranged from 602 to 666 d) for WM pigs and 509 d (ranged from 485 to 529 d) for (DWM)WM pigs. Pre-slaughter animal handling, slaughter of animals, post-slaughter carcass handling, sampling and preparation of meat samples was also applied as

Table 1. Pig age and weight range, and ingredients and chemical composition of diets.

Pig age and weight range All group of pigs	Pre-starter I from birth to weaning	Pre-starter II first 7 d after weaning	Starter to 15 kg	Grower to 25 kg	Pre-finisher to 60 kg	Finisher I to 120 kg	Finisher II from 120 kg
Ingredients, %							
Corn	24	41	57	67	68	70	68
Soybean meal (44% CP)	13	21	21	23	15	8	3
Soybean grits	7						
Soybean oil	3	2	2				
Sunflower meal (33% CP)					5	6	6
Wheat meal				3	6	10	15
ActiProt (protein-rich feed)					3	3	5
Mixomel 38 (diary feed)	17	12	7				
Fokkamix 80 (source of lactose)	22	10	4				
Fish meal	4	4	4	2			
Dextrose	5	5					
Premix (vitamin mineral mixture)[a]	5	5	5	5	3	3	3
Analysed chemical composition, %							
Crude protein ($N \times 6.25$)	22.00	21.30	20.50	18.30	16.30	14.30	13.40
Crude fat	7.00	5.00	5.00	3.50	3.60	3.80	4.00
Cellulose	2.70	3.20	3.50	3.90	4.80	4.90	5.10
Lysine	1.60	1.50	1.40	1.15	0.85	0.70	0.58
Methionine	0.40	0.38	0.35	0.30	0.25	0.20	0.22
Threonine	0.90	0.85	0.75	0.67	0.55	0.50	0.44
Tryptophan	0.28	0.28	0.25	0.20	0.19	0.16	0.14
Lactose	21.50	10.50	5.00	0.00	0.00	0.00	0.00
ME, MJ kg^{-1}	15.00	14.50	14.40	13.75	13.55	13.10	13.10

CP: crude protein.

[a]Pre-starter I and II: vitamin A, 350,000 U; vitamin D_3, 40,000 U; vitamin E, 1.500 mg; vitamin K_3, 70 mg; vitamin B_1, 80 mg; vitamin B_2, 150 mg; vitamin B_6, 100 mg; vitamin B_{12}, 0.8 mg; vitamin C, 1.000 mg; niacin, 800 mg; Calpan, 400 mg; biotin, 6 mg; folic acid, 30 mg; choline, 10,000 mg; Se, 4 mg; I, 25 mg, Fe, 2.000 mg; Cu, 600 mg; Zn, 3.000 mg, Mn, 1.000 mg; phytase, 3.000 mg; CRINA piglets, 6.000 mg; protease, 4.000 mg; amylase, 4.000 mg; RONAZYME WX, 3.000 mg; ROXAZYME G2G, 3.000 mg; RONOZYME VP, 3.000 mg; VEVOMIN Cu, 1.400 mg; VEVOMIN Fe, 2.000 mg; VEVOMIN Mn, 1.000 mg; VEVOMIN Zn, 2.000 mg; VevoVitall, 100,000 mg; organic Se source, 2.000 mg; antioxidant, 2.000 mg; lysin, 7.0%; methionin, 5.5%; Ca, 8.0%; P, 4.5%; Na, 3.0%; probiotics, 1.000 mg; carrier, to 1.000 g. Starter: vitamin A, 350,000 U; vitamin D_3, 40,000 U; vitamin E, 1.500 mg; vitamin K_3, 70 mg; vitamin B_1, 80 mg; vitamin B_2, 150 mg; vitamin B_6, 100 mg; vitamin B_{12}, 0.8 mg; vitamin C, 1.000 mg; niacin, 800 mg; Calpan, 400 mg; biotin, 6 mg; folic acid, 30 mg; choline, 10,000 mg; Se, 4 mg; I, 25 mg, Fe, 2.000 mg; Cu, 600 mg; Zn, 3.000 mg, Mn, 1.000 mg; phytase, 3.000 mg; CRINA piglets, 6.000 mg; protease, 4.000 mg; RONAZYME WX, 3.000 mg; ROXAZYME G2G, 3.000 mg; RONOZYME VP, 3.000 mg; VEVOMIN Cu, 1.400 mg; VEVOMIN Fe, 2.000 mg; VEVOMIN Mn, 1.000 mg; VEVOMIN Zn, 2.000 mg; VevoVitall, 100,000 mg; organic Se source, 2.000 mg; antioxidant, 2.000 mg; lysin, 6.5%; methionin, 5.0%; Ca, 12.0%; P, 4.0%; Na, 3.0%; probiotics, 1.000 mg; carrier, to 1.000 g. Grower: vitamin A, 350,000 U; vitamin D_3, 40,000 U; vitamin E, 1.500 mg; vitamin K_3, 70 mg; vitamin B_1, 60 mg; vitamin B_2, 150 mg; vitamin B_6, 90 mg; vitamin B_{12}, 0.6 mg; vitamin C, 1.000 mg; niacin, 600 mg; Calpan, 400 mg; biotin, 6 mg; folic acid, 30 mg; choline, 8.000 mg; Se, 4 mg; I, 20 mg, Fe, 3.000 mg; Cu, 1.000 mg; Zn, 3.000 mg, Mn, 1.000 mg; phytase, 3.000 mg; CRINA piglets, 6.000 mg; protease, 4.000 mg; RONAZYME WX, 3.000 mg; ROXAZYME G2G, 3.000 mg; RONOZYME VP, 3.000 mg; VEVOMIN Cu, 1.400 mg; VEVOMIN Fe, 2.000 mg; VEVOMIN Mn, 1.000 mg; VEVOMIN Zn, 2.000 mg; VevoVitall, 100,000 mg; organic Se source, 2.000 mg; antioxidant, 2.000 mg; lysin, 7.0%; methionin, 3.0%; Ca, 14.5%; P, 4.0%; Na, 3.0%; probiotics, 1.000 mg; carrier, to 1.000 g. Pre-finisher, finisher I and II: vitamin A, 300,000 U; vitamin D_3, 60,000 U; vitamin E, 2.000 mg; vitamin K_3, 80 mg; vitamin B_1, 66 mg; vitamin B_2, 160 mg; vitamin B_6, 70 mg; vitamin B_{12}, 0.6 mg; niacin, 800 mg; Calpan, 600 mg; biotin, 4 mg; folic acid, 20 mg; choline, 10,000 mg; Se, 15 mg; I, 50 mg, Fe, 4.000 mg; Cu, 1.100 mg; Zn, 4.200 mg, Mn, 3.000 mg; phytase, 5.000 mg; RONAZYME WX, 5.000 mg; ROXAZYME G2G, 5.000 mg; RONOZYME VP, 5.000 mg; VevoVitall, 150,000 mg; antioxidant, 3.333 mg; lysin, 4.0%; methionin, 1.5%; Ca, 22.0%; P, 3.0%; Na, 5.0%; carrier, to 1.000 g.

described previously by same authors (Tomović et al. 2008, 2014a). Colour and marbling score, and all physical and chemical analyses were performed on *M. longissimus lumborum* (LL). Twelve (six female and six male) selected and trained (ISO 8586 2012) panellists evaluated colour and marbling using sets of NPPC (2000) official colour (1 = white to pale pinkish grey to 6 = dark purplish red) and marbling (1 = devoid to 6 and 10 = abundant) standards. Chops for colour and marbling evaluation were taken perpendicularly to the long axis of LL muscle; the minimum thickness was 2.54 cm (Tomović et al. 2014a). pH was measured in the centre of LL muscles of all carcasses at 45 min (pH45 min) and 24 h (pH24 h) post-mortem (ISO 2917 1999; Tomović et al. 2008). Instrumental colour parameters (eight replicates on the same chop taken perpendicularly to the long axis of LL muscle; minimum thickness: 2.54 cm) lightness (L^*), redness (a^*), yellowness (b^*), C^* [chroma – saturation index; $C^* = (a^{*2} + b^{*2})^{1/2}$], h [hue angle; h = arctangent (b^*/a^*)] and λ [dominant wavelength (nm)] were determined using a Konica Minolta Chroma Meter CR-400 on the cut surface after 60 min of blooming at 3 °C, using D-65 lighting, a 2° standard observer angle and an 8 mm aperture in the measuring head (CIE 1976; Honikel 1998; Tomović et al. 2008, 2014a; AMSA 2012). Determination of the water-holding capacity (WHC) was based on measuring water released when pressure was applied to the muscle tissue (exudative juice). Exudative juice was assessed using a filter paper press method (Grau and Hamm 1953; van Oeckel et al. 1999). A cube of 300 ± 25 mg of meat from the inside of the muscle sample was placed on a filter paper (Schleicher & Schull No. 2040 B, Dassel, Germany) between two plexiglas plates. Plates were then screwed together tightly for exactly 5 min. The analysis was performed in triplicate. The difference between the areas (RZ), as determined by mechanical polar planimeter (REISS Precision 3005, Bad Liebenwerda, Germany), of the pressed meat film (M) and the wet area on the filter paper (T) is a measure of the exudative juice or WHC. Alternatively, the WHC was expressed as the ratio of M over RZ and the ratio of M over T. Moisture (ISO 1442 1997), protein (nitrogen ×6.25; ISO 937 1978), total fat – intramuscular fat (IMF) (ISO 1443 1973) and total ash (ISO 936 1998) contents of muscle were determined according to methods recommended by the International Organisation for Standardisation. The fatty acid composition was determined by gas-liquid chromatography (GLC). The method chosen was in situ transesterification (ISTE) (Park and Goins 1994). The content of fatty acid methyl esters was determined by GLC, on an Agilent Technologies (Wilmington, DE, USA) 6890 gas chromatograph with a flame ionisation detector and a capillary column Agilent Technologies (Wilmington, DE, USA) HP-88 (Cat. No. 112-88A7) (100 m × 0.25 mm ×0.2 μm). Separation and detection were performed as described by Polak et al. (2008). The total phosphorous (P) content was determined according to ISO method (ISO 13730 1996). The contents of potassium (K), sodium (Na), magnesium (Mg), calcium (Ca), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) were determined using inductively coupled plasma-optical emission spectrometry (ICP-OES) (iCAP 6000 Series, Thermo Scientific, Cambridge, UK), method 984.27 (AOAC 2005), after microwave digestion (MWS-3C, Berghof, Germany).

All data are presented as average and standard error. Independent *t*-test was used to test the hypothesis about differences between two values. The software package STATISTICA 12 was used (StatSoft Inc. 2015) for analysis.

Results and discussion

In this study, live weights were recorded only at birth and at the end of trial. WM pigs showed lower growth rate than crosses with the Duroc, with average daily gains of 279 (WM) and 361 g ((DWM)WM). (DWM)WM reached target slaughter weight (about 180 kg) on average 129 d earlier than WM, what was in agreement with other studies that compared European autochthonous breeds with their crosses (Franci et al. 2005; Salvatori et al. 2008; Sirtori et al. 2011; Robina et al. 2013; Franco et al. 2014; Tomović et al. 2016a). The autochthonous pigs are prone to greater adipogenesis than the improved ones. Thus, the slower growth rate of WM in comparison to (DWM)WM could be explained with different pattern in the development of tissues with a marked tendency to backfat accumulation (Acciaioli et al. 2002; Franci et al. 2005; Salvatori et al. 2008; Sirtori et al. 2011; Robina et al. 2013; Ivić et al. 2017).

The colour and marbling of the LL muscles from WM and (DWM)WM pigs are shown in Table 2. No significant ($p = .149$) difference was found in colour score due to genotype; the average difference was .42 units. Each individual LL muscle had colour score higher

Table 2. Colour and marbling of *M. longissimus lumborum* from White Mangalica – WM and (Duroc × White Mangalica) × White Mangalica – (DWM)WM pigs.

Traits	WM	(DWM)WM	*p* Value
Colour	5.30 ± 0.18	4.88 ± 0.22	.149
Marbling	3.16 ± 0.10	2.11 ± 0.07	<.001

WM: White Mangalica; DWM: Duroc × White Mangalica.

than 4.00 (dark reddish-pink), according to NPPC (2000) photographic standard. IMF content is muscle parameter that influences meat and meat products quality, because meat with higher content of IMF has better characteristics for the manufacture of high quality meat products, especially of slices (Gandemer 2002). As reviewed by Gandemer (2002), the redness and brightness scores of dry-cured ham cut decrease as intramuscular lipid content increases. Further, high intramuscular lipid content has a positive impact on ham tenderness. Also, hams produced from genotypes with high intramuscular lipid content have more intense fat aroma because intramuscular triacylglycerols are a good solvent for most aroma compounds. The higher is the intramuscular triacylglycerol content of muscle, the higher is the quantity of aroma compounds traps in the ham. WM showed significantly higher ($p < .001$) marbling score than (DWM)WM; difference due to genotype was 1.05 units. According to NPPC (2000) photographic standard, average marbling score of LL muscles were somewhat higher than slight (WM) and traces ((DWM)WM). In our previous similar study, colour score of loin muscles differed, while marbling score did not differ between WM and their crosses with Durok at 50% reared under intensive production system and slaughtered at 150-kg live weight (Tomović et al. 2016a).

The physical traits of the LL muscles from WM and (DWM)WM pigs are shown in Table 3. There was no significant ($p = .576$) difference in ultimate pH value measured 24 h *post-mortem*; the average difference was only 0.06 units. The ultimate pH values were, on average, below the critical threshold (6.0 as suggested by Tomović et al. 2014b) for considering the pork as DFD (dry, firm and dark). Higher average ultimate pH in loin muscles were determined in several studies which investigated meat from autochthonous pigs and/or their crosses with modern breeds (Franci et al. 2005; Poto et al. 2007; Sirtori et al. 2011; Tomović et al. 2016a).

Table 3. Physical traits of *M. longissimus lumborum* from White Mangalica – WM and (Duroc × White Mangalica) × White Mangalica – (DWM)WM pigs.

Traits	WM	(DWM)WM	*p* Value
pH_{24h}	5.83 ± 0.08	5.77 ± 0.05	.576
L^*	40.28 ± 0.80	40.88 ± 0.69	.579
a^*	11.99 ± 0.52	9.94 ± 0.39	.006
b^*	4.63 ± 0.30	4.05 ± 0.25	.155
C^*	12.87 ± 0.58	10.76 ± 0.43	.010
h	20.75 ± 0.66	21.91 ± 0.93	.320
Λ, nm	614 ± 5	612 ± 2	.383
WHC-M, cm^2	5.07 ± 0.15	5.34 ± 0.15	.214
WHC-T, cm^2	9.28 ± 0.09	9.18 ± 0.17	.609
WHC-RZ, cm^2	4.21 ± 0.23	3.84 ± 0.27	.301
WHC-M/RZ	1.25 ± 0.09	1.47 ± 0.13	.174
WHC-M/T	0.55 ± 0.02	0.59 ± 0.02	.233

WM: White Mangalica; DWM: Duroc × White Mangalica; L^*: a measure of darkness/lightness (higher value indicates a lighter colour); a^*: a measure of redness (higher value indicates a redder colour); b^*: a measure of yellowness (higher value indicates a more yellow colour); C^*: saturation index (higher values indicates greater saturation of red); h: hue angle (lower values indicates a redder colour); WHC-M: surface of the pressed meat film; WHC-T: surface of the wet area on the filter paper; WHC-RZ = WHC-T – WHC-M. A bigger WHC-M/T ratio indicates a better WHC.

Regarding instrumental colour parameters, the effect of genotype was small and only redness (a^* value) and chroma (C^* value) were significantly ($p = .006$ and $p = .010$, respectively) higher in WM than in (DWM)WM. Thus, inclusion of 25% Duroc genetics leads to pork with significantly reduced redness. The results for redness of LL muscles are in agreement with those of other similar studies (Sirtori et al. 2011; Franco et al. 2014; Tomović et al. 2016a) but disagree with results in similar studies obtained by Franci et al. (2005), Poto et al. (2007) and Robina et al. (2013). There were no significant ($p > .05$) differences found in L^* (lightness), b^* (yellowness), h (hue angle) and λ (dominant wavelength) due to genotype. Data of lightness (average L^* value = 40.28 (WM) and 40.88 ((DWM)WM) showed that the colour of LL muscles of both genotypes can be considered 'dark' (Tomović et al. 2014b), what is in agreement with previously discussed results for colour score.

Genotype did not significantly ($p > .05$) affect any water-holding capacity trait (WHC-M, WHC-T, WHC-RZ, WHC-M/RZ and WHC-M/T). According to criteria for pork, both average WHC-M/T values indicated good WHC (a bigger WHC-M/T ratio indicates a better WHC) (WHC-M/T > 0.45 – dry pork; Hofmann et al. 1982; Tomović et al. 2014b). Only one LL muscle (from WM pigs) had WHC-M/T value below 0.45 (non-exudative pork; Hofmann et al. 1982; Tomović et al. 2014b), confirming good water hold of loin muscles from autochthonous breeds and their crosses with modern breeds (Franci et al. 2005; Sirtori et al. 2011; Franco et al. 2014; Tomović et al. 2014a, 2016a, 2016b). Nevertheless, Franci et al. (2005), Sirtori et al. (2011), Franco et al. (2014) and Tomović et al. (2016a) determined that loin muscles from autochthonous breeds had better WHC compared to their crosses with modern breed.

The proximate composition of the LL muscles from WM and (DWM)WM pigs are shown in Table 4. Genotype affected moisture and IMF content of LL muscles. WM showed higher IMF content ($p = .012$) than (DWM)WM. Thus, according to results in this and other similar studies (Franci et al. 2005; Sirtori et al. 2011; Franco et al. 2014; Tomović et al. 2016a), crossing of autochthonous breeds with Duroc leads to pork with significantly lower IMF content. These differences

Table 4. Proximate composition (g 100 g^{-1}) of *M. longissimus lumborum* from White Mangalica – WM and (Duroc × White Mangalica) × White Mangalica – (DWM)WM pigs.

Traits	WM	(DWM)WM	*p* Value
Moisture	69.75 ± 0.54	71.53 ± 0.29	.009
Protein	22.03 ± 0.27	22.48 ± 0.17	.175
Total fat (IMF)	6.95 ± 0.72	4.64 ± 0.41	.012
Total ash	1.08 ± 0.02	1.13 ± 0.03	.199

IMF: intramuscular fat; WM: White Mangalica; DWM: Duroc × White Mangalica.

in IMF content are caused by the high lipid synthesis capacity of the autochthonous pig breed (Lopez-Bote 1998; Alfonso et al. 2005). In addition to genotype, IMF content in loin muscles might also be explained by age, because the increase in IMF content with age have been described (Mayoral et al. 1999; Lawrie and Ledward 2006; Wood et al. 2008; Galián et al. 2009; Franco et al. 2016). Consequently, WM showed lower moisture content ($p = .009$) than (DWM)WM, confirming opposite relationship between IMF and moisture (Keeton and Eddy 2004; Lawrie and Ledward 2006; Tomović et al. 2014a, 2014b, 2016a, 2016b). Although, meat from these animals is intended for the production of dry-cured meats it is important to note that sensory acceptability of pork may be improved by increasing IMF content, but this effect disappeared for IMF contents higher than 3.5%, which are associated with a high risk of meat rejection due to visible fat (Fernandez et al. 1999). Results obtained in this study shown that IMF content reached 9.90% (WM pigs). No significant ($p > .05$) differences were found for protein and total ash content due to genotype.

The fatty acid compositions of the IMF of the LL muscles from WM and (DWM)WM pigs are shown in Table 5. In general, the most abundant fatty acid was the C18:1*cis*-9 (oleic acid) with percentages 49.2 (WM) and 47.2 (DWM) of total analysed fatty acid methyl esters, followed by palmitic (C16:0), stearic (C18:0), linoleic (C18:2*cis*-9,12) and palmitoleic (C16:1*cis*-9) fatty acids, which averaged 25.1, 10.1, 5.91 and 4.84% of total fatty acids, respectively. Content of C18:1*cis*-9 as well as total monounsaturated fatty acids (MUFAs) in LL muscles from WM was higher ($p < .05$) than from (DWM)WM. Beside genotype, it is important to note that the increase in MUFAs for loin muscles with age is evident (Salvatori et al. 2008; Zemva et al. 2015). Further, content of C18:2*cis*-9,12 and C20:4*cis*-5,8,11,14 as well as total polyunsaturated fatty acids (PUFAs) was lower ($p < .05$–.01) in LL muscles from WM than from (DWM)WM. Results reported in the literature (Salvatori et al. 2008; Robina et al. 2013; Franco et al. 2014; Tomović et al. 2016a) for PUFAs contents of loin muscles from similar genotype are not consistent,

Table 5. Fatty acid composition (% of total fatty acids) of *M. longissimus lumborum* from White Mangalica – WM and (Duroc × White Mangalica) × White Mangalica – (DWM)WM pigs.

Fatty acid of intramuscular fat	WM	(DWM)WM	*p* Value
C10:0	0.246 ± 0.030	0.261 ± 0.037	.749
C11:0	0.142 ± 0.022	0.142 ± 0.019	.990
C14:0	1.68 ± 0.07	1.69 ± 0.07	.905
C16:0	25.1 ± 1.1	25.0 ± 0.8	.941
C16:1*trans*-9	0.233 ± 0.020	0.225 ± 0.019	.791
C16:1*cis*-9	4.74 ± 0.27	4.94 ± 0.23	.593
C17:0	0.207 ± 0.035	0.302 ± 0.036	.073
C18:0	10.31 ± 0.39	9.92 ± 0.45	.524
C18:1*trans*-9	0.218 ± 0.012	0.254 ± 0.022	.170
C18:1*cis*-9	49.2 ± 0.7	47.2 ± 0.6	.047
C18:2*cis*-9,12	5.02 ± 0.22	6.80 ± 0.43	.002
C18:3*cis*-9,12,15	0.059 ± 0.007	0.064 ± 0.006	.585
C20:0	0.135 ± 0.010	0.131 ± 0.016	.842
C20:1*cis*-11	0.899 ± 0.141	0.747 ± 0.066	.343
C20:2*cis*-11,14	0.194 ± 0.020	0.208 ± 0.030	.693
C20:4*cis*-5,8,11,14	0.583 ± 0.099	0.950 ± 0.112	.024
C22:0	0.076 ± 0.012	0.108 ± 0.012	.071
C22:5*cis*-7,10,13,16,19	0.098 ± 0.026	0.141 ± 0.024	.250
ΣSFAs	37.9 ± 0.72	37.6 ± 0.53	.712
ΣMUFAs	55.3 ± 0.55	53.4 ± 0.67	.041
ΣPUFAs	5.96 ± 0.34	8.17 ± 0.53	.002
ΣOFAs	0.83 ± 0.02	0.87 ± 0.02	.121

WM: White Mangalica; DWM: Duroc × White Mangalica; SFAs: saturated fatty acids (C10:0, C11:0; C14:0, C16:0, C17:0; C18:0, C20:0, C22:0); MUFAs: monounsaturated fatty acids (C16:1*trans*-9, C16:1*cis*-9, C18:1*trans*-9, C18:1*cis*-9, C20:1*cis*-11); PUFAs: polyunsaturated fatty acids (C18:2*cis*-9,12, C18:3*cis*-9,12,15, C20:2*cis*-11,14, C20:4*cis*-5,8,11,14, C22:5*cis*-7,10,13,16,19); OFAs: other fatty acid.

because it is well known that fatty acid composition is mainly affected by rearing and feeding conditions (Cava et al. 1997; Coutron-Gambotti et al. 1998; Andrés et al. 2001; Tejeda et al. 2002). Robina et al. (2013) also found higher content of PUFAs in loin muscles from Iberian pigs than in their crosses with Duroc. Moreover, differences observed on the fatty acid composition between genotypes must probably derived from differences in the IMF content, and probably different proportions of neutral and polar lipids between genotypes (Wood et al. 2008). In this study, WM pigs had a high IMF content, reflecting in high oleic acid content and consequently high MUFA content. The (DWM)WM pigs, because had lower IMF content, probably had lower content of neutral lipids and higher content of polar lipids compared with WM pigs, what reflected in high PUFA content, particularly linoleic and arachidonic, which are known to accumulate preferentially in polar lipids (Kouba et al. 2003). There were no significant ($p > .05$) differences for other analysed fatty acids due to genotype.

The mineral compositions of the LL muscles from WM and (DWM)WM pigs are shown in Table 6. Genotype did not significantly ($p > .05$) affect K, P, Na, Mg, Ca and Zn content in LL muscle. However, there were the differences ($p < .01$) for Fe, Cu and Mn content. Despite the fact that the major source of

Table 6. Mineral composition (mg $100\,g^{-1}$) of *M. longissimus lumborum* from White Mangalica – WM and (Duroc × White Mangalica) × White Mangalica – (DWM)WM pigs.

Mineral	WM	(DWM)WM	*p* Value
K	334 ± 5	339 ± 6	.530
P	228 ± 7	227 ± 3	.828
Na	40.2 ± 0.7	41.4 ± 0.9	.308
Mg	25.4 ± 0.4	25.4 ± 0.7	.995
Ca	5.85 ± 0.68	6.16 ± 0.71	.760
Zn	1.79 ± 0.05	1.68 ± 0.02	.062
Fe	0.73 ± 0.02	0.63 ± 0.02	.002
Cu	0.064 ± 0.007	0.043 ± 0.002	.009
Mn	0.0061 ± 0.0005	0.0038 ± 0.0005	.005

K: potassium; P: phosphorous; Na: sodium; Mg: magnesium; Ca: calcium; Zn: zinc; Fe: iron; Cu: copper; Mn: manganese; WM: White Mangalica; DWM: Duroc × White Mangalica.

variation in animal products is the proportion of lean to fat tissue (Greenfield and Southgate 2003), LL muscles with the higher IMF content (WM pigs) had higher Fe, Cu and Mn content than from (DWM)WM. Thus, according to results in this and other studies (Ventanas et al. 2006; Franco et al. 2014; Tomović et al. 2016a), crossing with Duroc leads to pork with significantly lower Fe content as well as Cu and Mn content (Tomović et al. 2016). Beside genotype, increase in myoglobin (Fe) concentration is evident with age (Mayoral et al. 1999; Lawrie and Ledward 2006; Zemva et al. 2015; Franco et al. 2016), what also explains previously discussed difference in redness of LL muscles. Regard Fe and Cu, opposite trend was obtained by Galián et al. (2007) for Chato Murciano pigs and their crosses with Iberian pigs. Considering all investigated minerals, Fe and Cu contents obtained in this study were noticeably lower than those obtained by Galián et al. (2007) and Poto et al. (2007) for Chato Murciano pigs and their crosses with Iberian and Large White pigs.

Conclusions

This study was conducted to compare the colour and marbling score and physical (pH, instrumental colour and water holding capacity) and chemical (proximate and mineral composition and fatty acids profile) quality traits of meat (*M. longissimus lumborum*) from White Mangalica pigs and their crosses with Duroc. Duroc breed inclusion at 25% decrease marbling score as well as intramuscular fat content, redness (and saturation index), oleic acid as well as total monounsaturated fatty acids content, and Fe, Cu and Mn content; the opposite trend were determined for moisture, linoleic and arachidonic fatty acids as well as total polyunsaturated fatty acids content. Thus, use of Duroc at 25% improves average daily gain without markedly negative effects on meat quality of White Mangalica pigs.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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