Original Paper

The technological meat quality of the White Mangalitsa breed

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The aim of the experiment was to evaluate the technological meat quality of the breed White Mangalitsa through the pH, electric conductivity, drip loss and meat color parameters. Totally, 20 pigs of the breed White Mangalitsa (10 barrows and 10 gilts) were evaluated. Pigs were bred under the intensive breeding conditions. The animals were fed *ad libitum* using a complete feed compound with the added silage. Pigs were slaughtered upon reaching 110 kg of live weight. The muscles of MLD (*Musculus longissimus dorsi*) and MSM (*Musculus semimembranosus*) were evaluated. The meat quality analysis showed that pH_1 was similar between the muscles. The evidently lower pH_2 value was in MLD (P <0.01). The EC_1 value (P <0.01) was significantly higher in the MSM muscle. The EC_2 values in MLD and MSM were similar. Between the muscles, an evidentiary difference was observed in water drip loss (P <0.01), higher losses were recorded in MLD. In the SCI *a** and SCI *b** values, which express the redness and yellowness of the meat, the values in MSM were higher. The lightness of the meat (SCI *L**) was the same in both muscles. The differences between the sexes in the observed qualitative parameters were not detected.

Keywords: mangalitsa, *Musculus longissimus dorsi*, *Musculus semimembranosus*, pork, quality

1 Introduction

According to Honikel (1998a), a technological quality of meat is particularly important for its processing and preparation. At present, we follow a range of criteria for assessing the technological quality of pig meat, such as pH, colour of meat, conductivity, dripping of meat juice, fat content, collagen content, etc. (Honikel, 1992).

The indigenous breeds, such as Iberian and Mangalitsa, are known to have desirable quality properties of meat that could be of interest to many farms giving them the possibility to produce unique high-quality meat products (Straadt et al., 2013). Mangalitsa is one of the most popular rustic pig breeds in Europe (Pârvu et al., 2012). It is a typical representative of a fatty pig breed. This means that of the total body weight, fat tissue accounts for 65–70% and proportion of meat represents 30–35% (Egerszegi et al., 2003). Fresh meat of this breed is darker, more juicy and softer than the meat of other pig breeds. Its smell is more specific. Fragility is also much higher compared to other pig breeds (Flegler, 2015). Meat has got excellent properties, such as taste, marbling and a low content of cholesterol (Pârvu et al., 2012). The meat is of very good quality, but it has a very high content of fat at a bad lifestyle (Steffen et al., 2008).

Within the context of the practical control of the meat quality, the most important qualitative criteria are, in particular, the pH value, electrical conductivity, dripping of meat juice (Honikel, 2007). The meat colour plays a key role for a consumer as he/she combines the red colour of the meat with freshness, palatability and softness, although there does not have to be any connection between these qualitative parameters (Tikk et al., 2008; Mancini and Hunt, 2005). Productive parameters of pigs and meat quality traits may be influenced by multiple interacting factors before and after slaughter. These include breed, sex, genotype, feeding, production systems, pre-slaughter handling, stunning method, slaughter procedure, chilling and storage conditions (Rosenvold and Andersen, 2000; Olsson and Pickova, 2005; Nevrkla et al., 2016).

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The aim of this study was to evaluate the meat quality of the breed White Mangalitsa in the *Musculus longissimus dorsi* and *Musculus semimembranosus* under the intensive breeding conditions with regard to sex.

2 Material and methods

2.1 Biological material

The experiment was implemented at the Experimental Centre of Animals at the Slovak University of Agriculture (SUA) in Nitra. Totally, 20 pigs of the breed White Mangalitsa (10 barrows and 10 gilts) were evaluated.

2.2 Feeding and rearing conditions

Pigs were housed in the group pens on a full concrete floor with litter. Automatic feeders for dry fodder and two pin feeders were part of the pen. The temperature in the building was maintained at 18–20 °C. The air exchange in the building worked on the principle of vacuum ventilation. The air is drawn into the building through the ventilation self-regulating flaps, which were located in the suction channels and supply the fresh air from the outside. The livestock manure removal was carried out manually by means of a rotary swathe. The housing pen was manually cleaned every day and manure was temporarily stored in a container.

The pigs were fed by using a conventional compound feed with the addition of voluminous feed (clover-grass silage and maize silage in a ratio 1 : 1). Animals were fed and watered *ad libitum*. The basic nutrient composition is to be seen in Table 1.

Table 1 Basic Content of Nutrients in Feed

In % in the original mass	Feed compound	Silage mix
Dry matter	90.20	34.89
Crude protein	14.85	5.76
Fat	3.27	0.90
Fibre	4.41	9.16
Ash	3.58	3.50
Nitrogen free extract	64.09	15.57
Metabolisable energy (MJ/kg)	13.10	2.88

2.3 Technological parameters of the meat quality

Pigs were slaughtered upon reaching 110 kg of live weight. Firstly, the animals were electrically stunned by electric forceps during 4 s with the voltage 250 V and the amperage 1.3 A. The slaughtering was realized according to Government Regulation (SR) no. 432/2012 of the coll. of the Slovak Republic establishing the protection of animals during the slaughter. The meat quality parameters were evaluated in the longest MLD back muscle (*Musculus longissimus dorsi*) at the level of the last thoracic vertebra and in the MSM muscle (*Musculus semimembranosus*).

The values pH 45 minutes (pH_1) a 24 hours (pH_2) *post mortem* were measured by the pH meter Hanna HI99161 in units-log10[H^+]. The electric conductivity was determined 45 minutes (EC_1) and 24 hours (EC_2) *post mortem* by using an instrument Tecpro in unit mS/cm. Drip losses in MLD and MSM were measured 24 h *post mortem* by the method according to Honikel (1998b). The meat colour was measured in MLD and MSM 24 hours *post mortem* by using the spectrophotometer CM-2600d with CIE Lab space and illuminate D65 (Konica Minolta, Japan). The following colour coordinates were determined: *L** (lightness, white ± black), *a** (redness, red ± green) and *b** (yellowness, yellow ± blue). The values were recorded from the average of the three random readings across each muscle surface.

2.3 Statistical analysis

The data were analysed using the SAS statistical program, Version 9.1. The following was calculated within the descriptive statistics: number (*n*), average, minimum (min), maximum (max), standard deviation (S_x) and variation coefficient (V_x). Within a detailed statistical analysis, normality was tested in individual groups and indicators using the Shapiro-Wilk test. The statistically evidentiary differences between the compared groups were tested in the case of the normal distribution using the General Linear Model method. If the file did not have a normal distribution, a non-parametric Mann-Whitney *U*-test was used.

3 Results and discussion

Table 2 shows the results of the pH values compared according to muscles and sex. According to Kim et al. (2016), the initial pH and the final *post mortem* pH belong to the essential factors in determining the quality of pork. The differences in the pH_1 values between the muscles and sex were not statistically significant. We have recorded a lower pH_1 in the MSM muscle, where the minimum values pointed to the occurrence of the PSE qualitative variation (pale, soft, exudative), since according to Honikel (2007), meat is considered PSE when the pH_1 value is lower than 5.80. The variability of the measured values was relatively low and ranged from 2.60 to 5.36%. 24 hours after slaughter, we have found a statistically significant difference in pH_2 between the MLD and MSM muscles (P <0.001). We have recorded a greater decrease of pH_2 in the MLD muscle (MLD 5.74 and MSM 5.84). The variation coefficient was relatively low and ranged from 0.78 to 1.04%. Unlike us, a more significant decrease in pH_2 was recorded in the mangalitsa breed in MLD (5.69 ±0.07) (Lípová et al., 2019). Parunovic et al. (2013) found the pH_2 values at the level of 5.77 ±0.05 in the breed White Mangalitsa, which are comparable with our results. We have not found any gender differences between the groups. Similarly, Kasprzyk et al. (2015) have not find any gender differences in pH_1 and pH_2 values when comparing different pig genotypes.

Thanks to the *post mortem* changes in the muscle, detection of electrical conductivity enables to determine quality deviations. According to Honikel (2007), the conductivity in the intact and lively muscle is very low, since the cell membrane prevents the flow of ions. The death start leads to a partial destruction of the cell membrane, which becomes ion-permeable and electrical conductivity increases. Table 3 demonstrates the values of electrical conductivity by muscle and sex 45 minutes (EC_1) and 24 hours (EC_2) after slaughter. We have found statistically evidentiary higher conductivity of EC_1 ($P < 0.001$) in the MSM muscle (6.15 mS/cm), while the maximum value of the electrical conductivity in MSM was 17.10 mS/cm. The EC_1 value in the MLD was at the level of 3.46 mS/cm. We have not found any statistically evidentiary differences between the sexes in the EC_1 values. The variability was considered relatively high and ranged from 44.12 to 78.02%. We have not found any statistically evidentiary differences in EC_2 between the sexes, nor between MLD and MSM. The average EC_2 values ranged from 10.81 to 11.34 mS/cm. The relatively steady values have been also confirmed by the coefficient

Table 2 Comparison of the pH Values by Muscle and Sex

Parameter	Group	*n*	Mean	S_x	Min	Max	V_x (%)	Significance
pH_1	MLD	20	6.25	0.18	5.90	6.49	2.96	$p > 0.05$
	MSM	20	6.05	0.28	5.55	6.38	4.61	
pH_1 MLD	Barrows	10	6.26	0.16	6.04	6.43	2.60	$p > 0.05$
	Gilts	10	6.24	0.22	5.90	6.49	3.59	
pH_1 MSM	Barrows	10	5.99	0.24	5.61	6.23	4.05	$p > 0.05$
	Gilts	10	6.11	0.33	5.55	6.38	5.36	
pH_2	MLD	20	5.74	0.05	5.66	5.83	0.81	$p < 0.01$
	MSM	20	5.84	0.05	5.77	5.94	0.93	
pH_2 MLD	Barrows	10	5.74	0.04	5.66	5.76	0.78	$p > 0.05$*
	Gilts	10	5.74	0.05	5.69	5.83	0.93	
pH_2 MSM	Barrows	10	5.85	0.05	5.77	5.89	0.89	$p > 0.05$
	Gilts	10	5.83	0.06	5.79	5.94	1.04	

*Mann-Whitney *U*-test

Table 3 Comparison of the EC Values by Muscle and Sex

Parameter	Group	*n*	Mean	S_x	Min	Max	V_x (%)	Significance
EC_1	MLD	20	3.46	0.41	3.10	4.40	11.89	$p < 0.01$
	MSM	20	6.15	4.15	3.80	17.10	67.40	
EC_1 MLD	Barrows	10	3.48	0.54	3.10	4.40	15.39	$p > 0.05$*
	Gilts	10	3.44	0.30	3.10	3.80	8.87	
EC_1 MSM	Barrows	10	7.14	5.57	4.50	17.10	78.02	$p > 0.05$*
	Gilts	10	5.16	2.28	3.80	9.20	44.12	
EC_2	MLD	20	11.34	1.28	9.20	13.60	11.29	$p > 0.05$*
	MSM	20	10.81	1.53	6.90	12.50	14.13	
EC_2 MLD	Barrows	10	11.82	1.48	9.50	13.60	12.54	$p > 0.05$*
	Gilts	10	10.86	0.96	9.20	11.50	8.80	
EC_2 MSM	Barrows	10	10.66	2.20	6.90	12.50	20.64	$p > 0.05$*
	Gilts	10	10.96	0.59	10.20	11.50	5.38	

*Mann-Whitney *U*-test

of variation, which was ranging from 8.80 to 20.64%. According to Mörlein et al. (2007), the PSE meat has got the value 24 hours *post mortem* higher than 9–7 mS/cm. It follows that some animal individuals might have had deteriorated meat quality. The lower EC_2 values in MLD (9.31 ±1.91 mS/cm) were found at the evaluation of the Mangalitsa meat quality by Lípová et al. (2019).

Water loss caused by dripping is not only considered an aspect of the meat quality, it is also an important economic factor due to the weight loss of the carcass. A good water binding characterizes a high grade of the pork quality (Otto et al., 2005). Between the MLD (5.95%) and MSM (1.99%) muscles, we have found statistically evidentiary differences (P <0.001) in water loss by dripping (Table 4). Intersexual differences were not found. Similarly, Kasprzyk et al. (2015) have not found any statistical differences between the sexes, when comparing different breeds of pigs. A good quality meat should keep the value of the water, lost through dripping, up to 7–9% (Mörlein et al., 2007). We can state for the reasons given that the meat of the tested animals has shown good quality. A higher drip loss in Mangalitsa in MLD (7.15 ±2.99%) was found by Lípová et al. (2019). In organic farming, Millet et al. (2005) have found the water loss by dripping at the level of 7.3% and Hansen et al. (2001) from 6.25 to 6.53%.

Results of the meat colour are shown in the Table 5. The SCI L^* values reflect the lightness of the meat. The higher the

Table 4 Comparison of the Free Water Losses by Dripping according to Muscle and Sex

Parameter	Group	*n*	Mean	S_x	Min	Max	V_x (%)	Significance
Drip loss	MLD	20	5.95	1.65	3.62	7.80	27.81	p <0.01*
	MSM	20	1.99	2.31	0.31	6.81	116.11	
Drip loss MLD	Barrows	10	6.21	1.47	4.45	7.80	23.61	p >0.05
	Gilts	10	5.69	1.96	3.62	7.79	34.45	
Drip loss MSM	Barrows	10	0.63	0.28	0.36	1.02	43.98	p >0.05
	Gilts	10	3.34	2.70	0.31	6.81	80.88	

*Mann-Whitney *U*-test

Table 5 Comparison of the Meat Colour Values by Muscle and Sex

Parameter	Group	*n*	Mean	S_x	Min	Max	V_x (%)	Significance
SCI L^*	MLD	20	54.03	4.41	48.87	63.59	8.16	p >0.05*
	MSM	20	54.30	10.52	40.41	65.09	19.37	
SCI L^* MLD	Barrows	10	52.32	3.53	48.87	56.98	6.74	p >0.05
	Gilts	10	55.73	4.91	50.69	63.59	8.80	
SCI L^* MSM	Barrows	10	53.18	11.29	40.41	65.09	21.24	p >0.05
	Gilts	10	55.42	10.87	40.92	64.75	19.62	
SCI a^*	MLD	20	4.00	1.45	2.41	7.21	36.38	p <0.01
	MSM	20	9.03	4.23	3.95	14.56	46.85	
SCI a^* MLD	Barrows	10	4.45	1.89	2.42	7.21	42.39	p >0.05
	Gilts	10	3.55	0.83	2.41	4.45	23.42	
SCI a^* MSM	Barrows	10	9.36	4.34	3.95	14.56	46.34	p >0.05
	Gilts	10	8.70	4.61	4.43	13.99	52.92	
SCI b^*	MLD	20	11.39	1.80	8.82	14.51	15.82	p <0.01
	MSM	20	13.92	1.76	11.45	15.84	12.62	
SCI b^* MLD	Barrows	10	11.02	1.92	8.82	13.82	17.40	p >0.05
	Gilts	10	11.76	1.81	10.26	14.51	15.41	
SCI b^* MSM	Barrows	10	13.74	1.96	11.45	15.77	14.29	p >0.05
	Gilts	10	14.10	1.73	12.09	15.84	12.30	

*Mann-Whitney *U*-test

value, the lighter the meat. The average SCI *L** in MLD was 54.03 and in MSM 54.30, with no evidentiary differences between the muscles. The values ranged from 52.32 to 55.73 between the sexes in the MLD muscle. They ranged from 53.18 to 55.42 in MSM. The gilt meat was lighter, but the differences were not statistically significant. Unlike us, Tomovic et al. (2014) found evidentiary differences in the meat lightness of the breed Swallow-Belly Mangalitsa between the MLD and MSM (46.29 ±2.00 against 40.86 ±5.83). Lípová et al. (2019) have found that the Mangalitsa breed has evidently darker meat than the crossbreed Mangalitsa × Slovak Large White (53.06 ±4.34 vs. 58.12 ±4.93). Similarly, Ender et al. (2002) have found that mangalitsa has evidently darker meat than other breeds of pigs: Mangalitsa 38.80, German Saddle Pig 47.40 and German Landrace 48.50. A significantly lower SCI *L** value in Mangalitsa found by Ender et al. (2012) could have been caused by the fact, that the mentioned authors slaughtered the Mangalitsa at an average live weight of 155 kg, that is, at a higher age.

In the SCI *a** values, which reflect the redness of the meat, we have found statistically significant differences (P <0.001) between MLD and MSM. The redder meat was found in the MSM muscle (9.03) versus the MLD (4.00). In accordance with our results, Tomovic et al. (2014) found out that the MSM muscle was evidently redder compared to MLD (16.59 ±0.52 versus 12.79 ±1.20). The barrows were redder than gilts in both MLD and MSM, but the differences were not statistically significant. Contrary to our findings, Kasprzyk et al. (2015) found, when comparing the breeds Pulawska and Polish Landrace, that the gilts had evidently redder meat than barrows. In the SCI *b** color scale describing the blue-yellow spectrum, we have found out a statistically evidentiary difference between the muscles (P <0.001), whereas the yellower meat was found in the MSM muscle (13.92) compared to MLD (11.39). Comparable values in MLD for the breed Mangalitsa (10.41 ±1.53) and the crossbreeds Mangalitsa × Slovak Large White (11.89 ±1.45) were found by Lípová et al. (2019). Bednářová et al. (2014) found the average values of SCI *b** in the range of 9.53–10.14 in the muscle MSM. Significantly lower levels of the meat yellowness were found in the muscle of the Swallow-Belly Mangalitsa Tomovic et al. (2014), which was at the level of 6.47 ±1.08 in MSM and 5.21 ±0.81 in MLD.

4 Conclusions

This study provides the data on the technological parameters of the fresh meat of the breed White Mangalitsa bred under the intensive farming conditions. Comparing the technological parameters of the MLD and MSM quality, we can conclude that regarding the pH and EC indicators, the MSM meat showed a kind of worse results because some individuals had the pH_1 values below 5.8 and the EC_1 were provably higher (P <0.001) compared to MLD. However, from the point of view of the water loss through dripping, the MSM has achieved evidently lower losses than MLD (P <0.001). Similarly, for the colour assessment, the MSM muscle was evidently redder (SCI *a**) and yellower (SCI *b**) compared to MLD (P <0.001). The lightness of the meat (SCI L *) was the same in both muscles. We have not recorded any differences between the sexes in the observed qualitative parameters. Based on the complex assessment of the average values of all the observed technological indicators we can state, that the White Mangalitsa breed is suitable for production of the quality pork and production of traditional durable meat products.

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