Meat quality of Swallow-Belly Mangulica pigs reared under intensive production system and slaughtered at 100 kg live weight

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Abstract

Quality parameters including sensory and physical characteristics and proximate and mineral composition in *M. psoas major*, *M. semimembranosus*, *M. longissimus thoracis et lumborum* and *M. triceps brachii* of Swallow-Belly Mangulica pigs were determined. Type of muscles had no significant effect ($P > 0.05$) on water-holding capacity, protein, total fat and K, P and Ca content. The *M. psoas major* was the highest in pH_{24h}, water-holding capacity, CIEa^* and CIEb^* values, moisture, K, P and Cu content, and the lowest in visual marbling score and total fat content. The *M. semimembranosus* was the highest in Mg and Ca content, and the lowest in CIEL^* value (darkest muscle) and K content. The lightest colour (CIEL^* value), the highest content of protein, total fat and total ash, and the lowest visual colour score, pH_{24h}, CIEa^* and CIEb^* values, content of moisture, Na, Ca, Zn, Fe and Cu were found in *M. longissimus thoracis et lumborum*. The highest visual colour and marbling score, the highest content of Na, Zn and Fe, and the lowest water-holding capacity, content of protein, total ash, P and Mg were found in *M. triceps brachii*.

Keywords: pigs, Swallow-Belly Mangulica, intensive production system, meat quality.

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The major sources of variability in food (pork) quality are the wide diversity of soils and climatic conditions (geographical origin), seasonal variations, physiological state and maturity, as well as cultivar and breed [1]. The continuous innovations in the breeding systems, rearing practices, feeds composition, preslaughter handling, slaughtering methods, chilling and storage conditions largely contribute to induced changes in pork quality [2-4].

In recent years, demand for meat and meat products from southern European indigenous pig breeds has increased [5]. The most representative Serbian indigenous pig breed is the Mangulica, which is primarily bred in the Northern part of the country (Autonomous Province of Vojvodina, located in the Pannonian Plain). In Serbia, there are three varieties: White (Blond), Swallow-Belly and Red Mangulica [6–13]. This indigenous pig is mainly kept under free-range (outdoor) systems till live weight about 150 kg – approximately 2 years [11]. The free-range system increases the value of animal products due to the influence of outdoor rearing on the sensory, chemical and physical characteristics [5]. Traditionally, meat from indigenous, as well as Mangulica, pigs has been processed into unique highly-priced dry-cured meat products: dry-hams, loins, and sausages [14,15]. Most of these products still rely primarily on local, traditional manufacturing processes. However, there is a lack of information about characteristics of meat from Swallow-Belly Mangulica pigs, reared under intensive production system, for fresh consumption.

Having in mind that, the objective of this paper was to investigate the sensory (colour and marbling), physical (pH value, colour and water-holding capacity) and chemical (proximate and mineral composition) characteristics of *M. psoas major*, *M. semimembranosus*, *M. longissimus thoracis et lumborum* and *M. triceps brachii* of intensively reared Swallow-Belly Mangulica pigs. This study represents the continuation of the research on the meat quality of Swallow-Belly Mangulica pigs reared under different conditions.

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EXPERIMENTAL

Meat samples collection and preparing

This study included 15 Swallow-Belly Mangulica pigs. The composition of the intensive pig diet is presented in Table 1. The finishers were housed in pens with fully slatted floor and 0.80 m^2 space allocation per pig. Each pen contained 10 animals. The environmental temperature in the building was 22 °C. All pigs had ad libitum access to diet and water [16]. Carcasses were conventionally chilled for 24 h in a chiller at 2–4 °C. After chilling, *M. psoas major* (PM), *M. semimembranosus* (SM), *M. longissimus thoracis et lumborum* (LTL) and *M. triceps brachii* (TB) were removed from the right side of each carcass. The meat samples for measurements of sensory and physical characteristics and determination of proximate and mineral composition were prepared as described in detail by Tomović *et al*. [11].

Meat quality measurements

Sensory analysis (colour and marbling), physical measurements (pH value, water-holding capacity and colour), proximate composition (moisture, protein, total fat and total ash), mineral composition (phosphorous, potassium, sodium, magnesium, calcium, zinc, iron and copper), quality control programme and statistical analysis were performed as described in detail by Tomović *et al.* [11].

RESULTS

Scores for sensory evaluated colour ranged from 3.2 (LTL) to 5.1 (TB), while scores for sensory evaluated marbling ranged from 1.0 (PM) to 2.3 (TB), Table 2. The LTL muscles showed significantly ($P < 0.001$) the lightest visual colour and PM muscles showed significantly ($P < 0.001$) the lowest marbling score, comparing to other three muscles.

Table 2. Sensory characteristics of meat from Swallow-belly Mangulica pigs reared under intensive production system; PM – M. psoas major; SM – M. semimembranosus; LTL – M. longissimus thoracis et lumborum; TB – M. triceps brachii; ab, pq and wx indicate significant difference within column at P < 0.05, < 0.01 and < 0.001, respectively

Muscle	Value	Colour	Marbling
PM	*X*±*SD*	$4.9\pm0.6^{a,p,w}$	$1.0\pm0.0^{b,q,x}$
	Range	(4.0–5.8)	(1.0–1.0)
SM	*X*±*SD*	$4.9\pm0.4^{a,p,w}$	$1.8\pm0.5^{a,p,w}$
	Range	(4.5–5.4)	(1.0–2.4)
LTL	*X*±*SD*	$3.2\pm0.8^{b,q,x}$	$2.1\pm0.5^{a,p,w}$
	Range	(1.9–3.8)	(1.6–2.9)
TB	*X*±*SD*	$5.1\pm0.5^{a,p,w}$	$2.3\pm0.3^{a,p,w}$
	Range	(4.3–5.8)	(1.9–2.8)
P value		< 0.001	< 0.001
All muscles	*X*±*SD*	4.5±1.0	1.8±0.6
	Range	(1.9–5.8)	(1.0–2.9)

Table 1. The composition of pig diet

Ingredient	Starter (from 10 days to 8–9 kg body weight (approximately from 10 to 50 days)	Grover (from 8–9 to 25 kg body weight (approximately from 50 to 120 days)	Finisher 1 (from 25 to 60 kg body weight (approximately from 120 to 200 days)	Finisher 2 (from 60 to 100 kg body weight (approximately from 200 to 300 days)
Corn (dry)	56.57	58.76	–	–
Corn (silage)	–	–	62.93	68.76
Wheat meal	6.0	9.0	15.0	15.0
Soybean meal	17.1	15.7	14.0	9.1
Sunflower meal	2.5	3.5	5.0	4.0
Soy grits	10.0	5.0	–	–
Ekofish meal	–	4.0	–	–
Fish meal	4.5	–	–	–
Limestone	1.4	1.5	1.4	1.4
Monocalcium phosphate	0.5	1.0	0.6	0.7
Salt	0.18	0.32	0.40	0.45
Mineral premix	1.0	1.0	0.5	0.5
Synthetic lysine	0.05	0.02	0.07	0.09
Minazel plus	0.2	0.2	0.1	–
		Calculated composition		
Crude protein	20	18	15	13

The pH value was significantly ($P < 0.001$) the lowest in LTL muscles (5.56) than in PM (6.07), TB (6.05) and SM muscles (6.02). Water-holding capacity (*RZ*, *M*/*T* and *M*/*RZ* values) did not differ significantly ($P > 0.05$) among four muscles. Values for *RZ*, *M*/*T* and *M*/*RZ* varied between 5.06 (PM) and 6.66 (TB), 0.41 (TB) and 0.51 (PM), and between 0.74 (TB) and 1.11 (PM), respectively (Table 3). Significantly ($P < 0.001$) the lightest colour (highest CIE*L** value) was obtained for LTL muscles (48.39), comparing to other three muscles. CIE*L** values for other three muscles were: 38.56 (PM), 38.26 (TB) and 37.46 (SM). The PM muscles were the highest in redness (CIE*a** value, 21.03), followed by TB (17.69), SM (14.72) and LTL (10.13) muscles, with significant ($P < 0.001$) differences among all four muscles. Also, PM muscles were significantly ($P < 0.001$) the highest in yellowness (CIE*b** value, 6.98), comparing to other three muscles. CIE*b** values for other three muscles were: 4.98 (TB), 4.72 (SM) and 4.14 (LTL), Table 4.

Moisture content in the LTL muscles (72.03 g/100 g) was significantly lower comparing with PM muscles (74.22 g/100 g, $P < 0.01$) and TB muscles (73.20 mg/100 g, $P < 0.05$). The SM muscles exhibited intermediate level of moisture content (73.06 g/100 g). The TB muscles were significantly ($P < 0.05$) the lowest in total ash content (0.99 g/100 g), comparing to other three muscles. The LTL muscles showed numerically the highest total ash content (1.10 g/100 g). Protein content varied between 21.44 (TB) and 22.25 g/100 g (LTL), while total fat content was between 3.16 (PM) and 4.47 g/100 g (LTL), with no significant ($P > 0.05$) difference among all four muscles (Table 5).

Potassium content varied between 279 (SM) and 303 mg/100 g (PM), phosphorus content varied between 218 (TB) and 228 mg/100 g (PM), while calcium content was between 5.46 (LTL) and 7.68 mg/100 g (SM), with

Table 3. Physical characteristics of meat from Swallow-belly Mangulica pigs reared under intensive production system; PM – M. psoas major; SM – M. semimembranosus; LTL – M. longissimus thoracis et lumborum; SM – M. semimembranosus; TB – M. triceps brachii. WHC – water-holding capacity; M = surface of the pressed meat film; T = surface of the wet area on the filter paper; RZ = T – M; ab, pq and wx indicate significant difference within column at P < 0.05, < 0.01 and < 0.001, respectively

Muscle	Value	pH_{24h}	WHC		
			RZ / cm^2	*M*/*T*	*M*/*RZ*
PM	*X*±*SD*	6.07±0.23^{a,p,w}	5.06±1.22	0.51±0.09	1.11±0.46
	Range	(5.83–6.38)	(3.30–6.30)	(0.43–0.65)	(0.76–1.87)
SM	*X*±*SD*	6.02±0.07^{a,p,w}	5.75±0.47	0.45±0.02	0.86±0.10
	Range	(5.93–6.09)	(5.30–6.50)	(0.42–0.48)	(0.73–0.96)
LTL	*X*±*SD*	5.56±0.05^{b,q,x}	5.71±0.82	0.42±0.05	0.75±0.15
	Range	(5.49–5.62)	(4.70–6.40)	(0.37–0.48)	(0.60–0.92)
TB	*X*±*SD*	6.05±0.21^{a,p,w}	6.66±1.19	0.41±0.07	0.74±0.22
	Range	(5.79–6.27)	(5.15–8.40)	(0.31–0.51)	(0.45–1.06)
P value		<0.001	0.118	0.135	0.164
All muscles	*X*±*SD*	5.92±0.26	5.80±1.07	0.45±0.07	0.87±0.29
	Range	(5.49–6.38)	(3.30–8.40)	(0.31–0.65)	(0.45–1.87)

Table 4. Physical characteristics of meat from Swallow-belly Mangulica pigs reared under intensive production system; PM – M. psoas major; SM – M. semimembranosus; LTL – M. longissimus thoracis et lumborum; SM – M. semimembranosus; TB – M. triceps brachii; abcd, pqrs and wxyz indicate significant difference within column at P < 0.05, < 0.01 and < 0.001, respectively

Muscle	Value	Colour		
		CIE*L** (lightness)	CIE*a** (redness)	CIE*b** (yellowness)
PM	*X*±*SD*	38.56±2.32^{b,q,x}	21.03±2.19^{a,p,w}	6.98±1.01^{a,p,w}
	Range	(35.77–40.99)	(17.77–23.30)	(6.05–8.23)
SM	*X*±*SD*	37.46±1.42^{b,q,x}	14.72±1.39^{c,r,y}	4.72±0.51^{b,q,x}
	Range	(35.81–39.58)	(13.42–16.74)	(4.26–5.42)
LTL	*X*±*SD*	48.39±1.77^{a,p,w}	10.13±0,98^{d,s,z}	4.14±0.48^{b,q,x}
	Range	(47.13–51.42)	(8.93–11.24)	(3.71–4.87)
TB	*X*±*SD*	38.26±2.59^{b,q,x}	17.69±1.35^{b,q,x}	4.98±0.41^{b,q,x}
	Range	(35,15–41,33)	(15.44–18.94)	(4.55–5.41)
P value		<0.001	<0.001	<0.001
All muscles	*X*±*SD*	40.67±4.97	15.89±4.35	5.20±1.25
	Range	(35.15–51.42)	(8.93–23.30)	(3.71–8.23)

Table 5. Proximate composition (g/100 g) of meat from Swallow-belly Mangulica pigs reared under intensive production system; PM – M. psoas major; SM – M. semimembranosus; LTL – M. longissimus thoracis et lumborum; TB – M. triceps brachii; ab and pq indicate significant difference within column at P < 0.05, < 0.01 and < 0.001, respectively

Muscle	Value	Moisture	Protein	Total fat	Total ash
PM	*X*±*SD*	$74.22\pm0.82^{a,p}$	21.46±0.80	3.16±0.25	1.06 ± 0.07^{a}
	Range	(73.03–75.32)	(20.13–22.27)	(2.86–3.46)	(0.97–1.13)
SM	*X*±*SD*	$73.06\pm0.74^{ab,pq}$	22.16±0.39	3.58±0.94	1.08 ± 0.05^{a}
	Range	(71.94–73.77)	(21.81–22.64)	(2.45–4.82)	(1.00–1.14)
LTL	*X*±*SD*	$72.03\pm1.09^{b,q}$	22.25±0.41	4.47±1.13	1.10 ± 0.01^{a}
	Range	(70.44–73.03)	(21.70–22.80)	(3.35–6.08)	(1.09–1.11)
TB	*X*±*SD*	$73.20\pm0.60^{a,pq}$	21.44±0.53	4.22±0.44	0.99 ± 0.05^{b}
	Range	(72.49–73.99)	(20.74–21.97)	(3.47–4.60)	(0.93–1.06)
P value		0.007	0.058	0.064	0.023
All muscles	*X*±*SD*	73.13±1.10	21.82±0.64	3.86±0.89	1.06±0.06
	Range	(70.44–75.32)	(20.13–22.80)	(2.45–6.08)	(0.93–1.14)

no significant ($P > 0.05$) difference among all four muscles. Sodium content in the LTL muscles (50.3 mg/100 g) was significantly ($P < 0.05$) lower comparing with TB muscles (59.2 mg/100 g) and PM muscles (58.4 mg/100 g). The SM muscles exhibited intermediate level of sodium content (53.1 mg/100 g). The magnesium content was significantly higher in SM muscles (24.7 mg/100 g) than in LTL (23.5 mg/100 g, $P < 0.05$), PM (22.8 mg/100 g, $P < 0.01$) and TB muscles (22.6 mg/100 g, $P < 0.01$). The zinc content was significantly lower in LTL muscles (2.35 mg/100 g) than in PM (3.25 mg/100 g, $P < 0.01$), SM (3.47 mg/100 g, $P < 0.001$) and TB muscles (3.90 mg/100 g, $P < 0.001$). Also, zinc content was significantly ($P < 0.05$) lower in PM muscles than in TB muscles. The TB muscles were the highest in iron content (3.26 mg/100 g), followed by PM (2.74 mg/100 g), SM (1.85 mg/100 g) and LTL muscles (1.08 mg/100 g), with significant ($P < 0.01$ or <0.001) differences among all four muscles. The content of copper was significantly ($P < 0.01$ or <0.001) higher in PM (0.15 mg/100 g) and TB muscles (0.14 mg/100 g) than in SM (0.11 mg/100 g) and LTL muscles (0.10 mg/100 g), (Table 6).

DISCUSSION

Meat quality has five dimensions: sensory quality, technological quality, nutritional quality, hygienic and toxicological quality and immaterial quality (the last dimension has environmental, ethical, ethnical and religious aspects). The sensory factors of meat quality include colour, marbling, odour, taste, juiciness, consistency and tenderness, while technological factors of meat quality include pH value, colour, water-holding capacity, tenderness, protein content and its status, fat content and its status and connective tissue content [17,18].

The most important parameters, which enable identification of sensory and technological meat quality, include the pH value, measured in the muscle tissue 30–60 min (*pre-rigor* state) and 24 hours *post-mortem* (*post-rigor* state), meat colour and water-holding cap-

Table 6. Mineral composition (mg/100 g) of meat from Swallow-belly Mangulica pigs reared under intensive production system; PM – M. psoas major; SM – M. semimembranosus; LTL – M. longissimus thoracis et lumborum; TB – M. triceps brachii; abcd, pqrs and wxy indicate significant difference within column at P < 0.05, < 0.01 and < 0.001, respectively

Muscle	Value	K	P	Na	Mg	Ca	Zn	Fe	Cu
PM	*X*±*SD*	303±17	228±21	58.4 ± 6.1^{a}	$22.8\pm0.6^{b,q}$	7.38±1.40	$3.25\pm0.56^{b,p,wx}$	$2.74\pm0.30^{b,q,w}$	$0.15\pm0.02^{a,p.w}$
	Range	(285–327)	(196–247)	(52.6–65.1)	(22.1–23.6)	(5.34–8.92)	(2.78–3.95)	(2.36–3.20)	(0.14–0.19)
SM	*X*±*SD*	279±9	224±13	53.1 ± 1.9^{ab}	$24.7\pm0.6^{a,p}$	7.68±1.26	$3.47\pm0.33^{ab,p,w}$	$1.85\pm0.05^{c,r,x}$	$0.11\pm0.01^{b,q,wx}$
	Range	(267–292)	(204–241)	(50.9–56.0)	(24.0–25.4)	(5.59–8.89)	(3.11–3.85)	(1.80–1.91)	(0.09–0.12)
LTL	*X*±*SD*	296±22	224±4	50.3 ± 5.3^{b}	$23.5\pm1.0^{b,pq}$	5.46±1.08	$2.35\pm0.26^{c,q,x}$	$1.08\pm0.19^{d,s,y}$	$0.10\pm0.02^{b,q,x}$
	Range	(279–333)	(219–229)	(44.3–58.9)	(22.5–24.9)	(4.18–6.56)	(2.12–2.67)	(0.88–1.35)	(0.08–0.13)
TB	*X*±*SD*	286±28	218±12	59.2 ± 5.8^{a}	$22.6\pm0.9^{b,q}$	6.22±1.63	$3.90\pm0.29^{a,p,w}$	$3.26\pm0.41^{a,p,w}$	$0.14\pm0.02^{a,p,wx}$
	Range	(271–335)	(198–230)	(54.3–67.7)	(21.3–23.6)	(4.86–8.10)	(3.64–4.40)	(2.79–3.77)	(0.12–0.17)
P value		0.296	0.690	0.038	0.004	0.677	<0.001	<0.001	<0.001
All muscles	*X*±*SD*	291±21	223±14	55.3±6.0	23.4±1.1	6.69±1.55	3.25±0.68	2.23±0.89	0.13±0.03
	Range	(267–335)	(196–247)	(44.3–67.7)	(21.3–25.4)	(4.18–8.92)	(2.12–4.40)	(0.88–3.77)	(0.08–0.19)

acity measured 24 h *post-mortem* [18,19].

The rate of *post*-mortem pH value decline affects some other meat quality parameters (colour, water holding capacity) [20]. In this study PM, SM and TB muscles had significantly ($P < 0.001$) higher ultimate pH value than LTL muscles. Also, almost all individual ultimate pH values, except for LTL muscles, were over the characteristic range for pork (5.3–5.8 [18,21]) (Table 3). Ultimate pH of meat from Swallow-Belly Mangulica pigs reared under intensive production system were higher, especially in PM, SM and TB muscle, comparing with results previously published by Tomović *et al.* [11] for free-range reared Swallow-Belly Mangulica pigs slaughtered at 150 kg body weight. Similar results for ultimate pH in LTL muscles from other southern European indigenous pig breeds (Chato Murciano and Cinta Senese) were reported by Peinado *et al.* [22], Pugliese *et al.* [23] and Galián *et al.* [24].

Colour is one of the most important quality characteristic of fresh pork [3,19,25,26]. According to sensory analysis, colour of LTL muscles was evaluated as reddish pink (score 3.2), while other three muscles (PM, SM and TB) had significantly ($P < 0.001$) darker colour than reddish pink (higher than score 3), Table 2. Results of instrumental colour (CIEL^* value) measurement shown same trend, *i.e.*, LTL muscles were significantly ($P < 0.001$) the lightest (Table 4). Thus, regarding all individual values for lightness (CIEL^* value, Table 4) three groups of muscles (PM, SM and TB) had dark colour (dark colour: CIE$L^* < 42$ [27–29]). Also, the LTL muscles had all individual CIEL^* values lower than 53 (Table 4), what is the highest acceptable CIEL^* values for LTL muscle of normal quality [18,27–29]. Good relationship between visual evaluations of colour and instrumental colour measurements ($r = –0.91$, $P < 0.001$) was also determined. All this indicate that meat from Swallow-Belly Mangulica has from reddish-pink to purplish–red colour. Results for colour obtained in this study could be explained with previously elaborated effects of ultimate pH on colour and with calculated correlation coefficient between colour and ultimate pH ($r = 0.78$ and $r = –0.88$, $P < 0.001$). Colour of meat from Swallow-Belly Mangulica pigs reared under intensive production system parallel that reported by Tomović *et al.* [11], as well as results reported for LTL muscles from other southern European indigenous pig breeds by Cava *et al.* [14] and Estévez *et al.* [30] for Iberian pigs, Galián *et al.* [15,24], Poto *et al.* [31] and Peinado *et al.* [22] for Chuto Murciano pigs, and Pugliese *et al.* [23,32] for Nero Siciliano and Cinta Senese pigs.

Beside the colour, water-holding capacity is also one of the most important quality characteristic of fresh pork [3,16,20,25]. In this study water-holding capacity (*RZ*, *M*/*T* and *M*/*RZ* values) was not significantly ($P > 0.05$) affected by the type of muscle (Table 3), being in agreement with results previously published by Tomović *et al.* [11]. Obtained results indicated good water-holding capacity of meat from Swallow-Belly Mangulica (a bigger *M*/*T* ratio indicating a better water-holding capacity; exudative meat: $M/T < 0.35$, non-exudative meat: $M/T = 0.35–0.45$, dry meat: $M/T > 0.45$ [33]). As for colour, results for water-holding capacity obtained in this study could be explained with previously elaborated effects of ultimate pH on water-holding capacity, as well as with calculated correlation coefficient between water-holding capacity and ultimate pH ($r = 0.52$, $P < 0.05$ and $r = 0.57$, $P < 0.01$).

The nutritive factors of meat include proteins and their composition, fats and their composition, vitamins, minerals, utilization, digestibility, and biological value [17,18].

In this study protein and total fat contents were not significantly ($P > 0.05$) affected by the type of muscle. The protein level in all individual muscle was higher than 20 g/100 g (Table 5). Results for protein content are in agreement with results previously published by Tomović *et al.* [11] for Swallow-Belly Mangulica and for modern (Large White and Landrace) pigs [34], as well as with results reported for LTL muscles from southern European indigenous pig breeds by Cava *et al.* [14], Pugliese *et al.* [23,32] and Parunović *et al.* [9] for Iberian, Cinta Senese, Nero Siciliano and Mangulica pigs. Among the qualitative traits of meat, evaluating intramuscular fat content seems to be the best way to separate indigenous pigs from modern ones [5]. Considering that the sensory traits of raw meat are linked to intramuscular fat content it is believed that 2–2.5 g/100 g of intramuscular fat content is the minimum acceptable level [35]. Meat from Swallow-Belly Mangulica pigs reared under intensive production system had total fat content higher than 2.45 g/100 g (up to 6.08 g/100 g), Table 5. The corresponding value in modern (Large White and Landrace) pigs was less than 1.5 g/100 g [34]. Comparing with the data reported by Lawrie and Ledward [25] for lean pigs at the age of 6 months, another prominent characteristic of Swallow--Belly Mangulica muscles is almost twice higher total fat content. Total fat content determined in this study in PM, SM and TB muscles were at the similar level as previously reported results for Swallow-Belly Mangulica pigs, while the total fat content in LTL muscles was almost two times less [11]. Regarding fat content in LTL muscles from southern European indigenous pigs, results reported by other authors were in the wide range: 12.87–27.93 g/100 g for Iberian pigs [36], 2.26––4.79 for Iberian pigs [14], 2.51–3.34 g/100 g for Iberian pigs [30], 6.39 g/100 g for Chato Murciano pigs [22], 3.32–4.27 g/100 g for Nero Siciliano pigs [32], 3.29––4.04 g/100 g for Cinta Senese pigs [23], 10.21 g/100 g for Chato Murciano pigs [15], 10.47 g/100 g for Chato

Murciano pigs [31], <2 g/100 g for Casertana pigs [37], 6.1–7.9 g/100 g for Chato Murciano pigs [24] and 13.52 g/100 g for Swallow-belly Mangulica pigs and 17.54 g/100 g for White Mangulica pigs [9]. As expected, in this study, the inverse relationship of moisture content with protein (r = –0.75, P < 0.001) and with total fat content (r = –0.69, P < 0.01) was determined. In addition, correlation coefficient for the relationship between marbling and total fat content was good (r = 0.65, P < 0.01).

In scientific literature there is a lack of information about mineral content in meat from indigenous pigs. In this study, Na, Mg, Zn, Fe and Cu content was significantly (P < 0.05) affected by the type of muscle. The content of the minerals in decreasing order in all four muscles was: K, P, Na, Mg, Ca, Zn, Fe and Cu (Table 6). Only two minerals (sodium and iron) were present in different amount than in meat from free-range reared Swallow-Belly Mangulica pigs slaughtered at 150 kg body weight. Sodium was lower for all four muscles, while iron was higher only in TB muscles [11]. Considering all investigated minerals, iron and copper content obtained in this study for LTL muscles from Swallow-Belly Mangulica pigs were noticeably lower than in Chato Murciano pigs [15,31]. Meat exhibits natural variations in the amounts of nutrients contained and the limits of the natural nutrient variations are not defined. Major sources of variation in meat are the proportion of lean to fat tissue, and the proportion of edible to inedible materials (bone and gristle). Variations in the lean-fat ratio affect the levels of most other nutrients, which are distributed differently in the two fractions [1].

CONCLUSION

Comparing obtained results of meat quality of Swallow-Belly Mangulica pigs reared under intensive production system and slaughtered at 100 kg live weight with previously determined meat quality of free-range reared Swallow-Belly Mangulica pigs and slaughtered at 150 kg body weight, it can be concluded that Swallow-Belly Mangulica pigs can be reared indoor with remained typical and good sensory, technological and nutritive quality.

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REFERENCES

[1] H. Greenfield, D.A.T. Southgate, Food composition data: Production, management and use, 2nd ed., Food and Agriculture Organisation of the United Nations, Rome, 2003.

[2] K. Rosenvold, H.J. Andersen, Factors of significance for pork quality – A review, Meat Sci. **64** (2003) 219–237.

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

[4] H. Greenfield, J. Arcot, J.A. Barnes, J. Cunningham, P. Adorno, T. Stobaus, R.K. Tume, S.L. Beilken, W.J. Muller, Nutrient composition of Australian retail pork cuts 2005/2006, Food Chem. **117** (2009) 721–730.

[5] C. Pugliese, F. Sirtori, Quality of meat and meat products produced from southern European pig breeds, Meat Sci. **90** (2012) 511–518.

[6] B.D. Scherf, World watch list for domestic animal diversity, 3rd ed., Food and Agriculture Organisation of the United Nations, Rome, 2000.

[7] DAD-IS (Domestic animal diversity information system), http://dad.fao.org/

[8] I. Egerszegi, J. Rátky, L. Solti, K.-P. Brüssow, Mangalica – an indigenous swine breed from Hungary (Review), Arch. Tierz. Dummerstorf **46** (2003) 245–256.

[9] N. Parunović, M. Petrović, V. Matekalo-Sverak, D. Radojković, D. Vranić, Č. Radović, Cholesterol and total fatty acid content in *M. longissimus dorsi* of Mangalitsa and Swedish landrace, Acta Aliment. **41** (2012) 161–171.

[10] M.R. Jokanović, V.M. Tomović, B.V. Šojić, S.B. Škaljac, T.A. Tasić, P.M. Ikonić, Ž.S. Kevrešan, Cadmium in meat and edible offal of free-range reared Swallow-belly Mangulica pigs from Vojvodina (northern Serbia), Food Addit. Contam., B Surveill. **6** (2013) 98–102.

[11] V.M. Tomović, B.A. Žlender, M.R. Jokanović, M.S. Tomović, B.V. Šojić, S.B. Škaljac, Ž.S. Kevrešan, T.A. Tasić, P.M. Ikonić, M.M. Šošo, Sensory, physical and chemical characteristics of meat from free-range reared Swallow-Belly Mangulica pigs, J. Anim. Plant Sci. **24** (2014) 704–713.

[12] R.J. Šević, D.R. Lukač, V.S. Vidović, N.M. Puvača, B.M. Savić, D.B. Ljubojević, V.M. Tomović, N.R. Džinić, Some parameters of nutritional quality of meat obtained from Mangalitsa and Landrace pig breeds, Chem. Ind., 2016, in press, DOI:1 0.2298/HEMIND140604071S.

[13] V. Tomović, B. Žlender, M. Jokanović, M. Tomović, B. Šojić, S. Škaljac, Ž. Kevrešan, T. Tasić, P. Ikonić, Đ. Okanović, Physical and chemical characteristics of edible offal from free-range reared Swallow-Belly Mangalica pigs, Acta Aliment. **45** (2016) 190–197.

[14] R. Cava, M. Estévez, J. Ruiz, D. Morcuende, Physicochemical characteristics of three muscles from free-range reared Iberian slaughter at 90 kg live weight, Meat Sci. **63** (2003) 533–541.

[15] M. Galián, B. Peinado, C. Martínez, M.J. Periago, G. Ros, A. Poto, Comparative study of the characteristics of the

carcass and the meat of the Chato Murciano pig and its cross with Iberian pig, reared indoors, Anim. Sci. J. **78** (2007) 659–667.

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

[17] K. Hofmann, Definition and measurements of meat quality, in: Proceedings of the 36th international congress of meat science and technology, Havana, Vol. III, 1990, pp. 941–954.

[18] K.O. Honikel, Biochemical and physico-chemical characteristics of meat quality, Meat Technol. **40** (1999) 105–123.

[19] J.R. Bendall, H.J. Swatland, A review of the relationships of pH with physical aspects of pork quality, Meat Sci. **24** (1988) 85–126.

[20] E. Huff-Lonergan, S.M. Lonergan, Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes, Meat Sci. **71** (2005) 194–204.

[21] F.J.M. Smulders, F. Toldra, J. Flores, M. Prieto, New technologies for meat and meat products, Audet Tijdschriften, Utrecht, 1992.

[22] B. Peinado, A. Poto, F. Gil, G. López, Characteristics of the carcass and meat of the Chato Murciano pig, Livest. Prod. Sci. **90** (2004) 285–292.

[23] C. Pugliese, R. Bozzi, G. Campodoni, A. Acciaioli, O. Franci, G. Gandini, Performance of Cinta Senese pigs reared outdoors and indoors. 1. Meat and subcutaneous fat characteristics, Meat Sci. **69** (2005) 459–464.

[24] M. Galián, A. Poto, B. Peinado, Carcass and meat quality traits of the Chato Murciano pig slaughtered at different weights, Livest. Sci. **124** (2009) 314–320.

[25] R.A. Lawrie, D.A. Ledward, Lawrie's meat science, 7th ed., Woodhead Publishing Ltd. and CRC Press LLC, Cambridge, 2006.

[26] R.A. Mancini, M.C. Hunt, Current research in meat color, Meat Sci. **71** (2005) 100–121.

[27] S.T. Joo, R.G. Kauffman, B.C. Kim, G.B. Park, The relationship of sarcoplasmic and myofibrillar protein solubility to colour and water-holding capacity in porcine longissimus muscle, Meat Sci. **52** (1999) 291–297.

[28] V.M. Tomović, M.R. Jokanović, Lj.S. Petrović, M.S. Tomović, T.A. Tasić, P.M. Ikonić, Z.M. Šumić, B.V. Šojić, S.B. Škaljac, M.M. Šošo, Sensory, physical and chemical characteristics of cooked ham manufactured from rapidly chilled and earlier deboned M. semimembranosus, Meat Sci. **93** (2013) 46–52.

[29] V.M. Tomović, Lj.S. Petrović, N.R. Džinić, Effects of rapid chilling of carcasses and time of deboning on weight loss and technological quality of pork semimembranosus muscle, Meat Sci. **80** (2008) 1188–1193.

[30] M. Estévez, D. Morcuende, R. Cava López, Physico-chemical characteristics of *M. longissimus dorsi* from three lines of free-range reared Iberian pigs slaughtered at 90 kg liveweight and commercial pigs: a comparative study, Meat Sci. **64** (2003) 499–506.

[31] A. Poto, M. Galián, B. Peinado, Chato Murciano pig and its crosses with Iberian and Large White pigs, reared outdoors, Comparative study of the carcass and meat characteristics, Livest. Sci. **111** (2007) 96–103.

[32] C. Pugliese, G. Calagna, V. Chiofalo, V. Moretti, S. Margiotta, O. Franci, G. Gandini, Comparison of the performances of Nero Siciliano pigs reared indoors and outdoors. 2. Joints composition, meat and fat traits, Meat Sci. **68** (2004) 523–528.

[33] K. Hofmann, R. Hamm, E. Blüchel, Neues über die Bestimmung der Wasserbindung des Fleisches mit Hilfe der Filterpapierpressmethode, Die Fleischwirtsch. **62** (1982) 87–92.

[34] V.M. Tomović, B.A. Žlender, M.R. Jokanović, M.S. Tomović, B.V. Šojić, S.B. Škaljac, T.A. Tasić, P.M. Ikonić, M.M. Šošo, N.M. Hromiš, Technological quality and composition of the *M. semimembranosus* and *M. longissimus dorsi* from Large White and Landrace Pigs, Agric. Food Sci. **23** (2014) 9–18.

[35] P. Affentranger, C. Gerwig, G.J.F. Seewer, D. Schwörer, N. Künzi, Growth and carcass characteristics as well as meat and fat quality of three types of pigs under different feeding regimens, Livest. Sci. **45** (1996) 187–196.

[36] A.I. Mayoral, M. Dorado, M.T. Guillén, A. Robina, J.M. Vivo, C. Vazquez, J. Ruiz, Development of meat and carcass quality characteristics in Iberian pigs reared outdoors, Meat Sci. **52** (1999) 315–324.

[37] G. Salvatori, F. Filetti, C. Di Cesare, G. Maiorano, F. Pilla, G. Oriani, Lipid composition of meat and backfat from Casertana purebred and crossbred pigs reared outdoors, Meat Sci. **80** (2008) 623–631.

IZVOD

KVALITET MESA SVINJA LASASTE MANGULICE ODGAJANIH U INTENZIVNOM PROIZVODNOM SISTEMU I ŽRTVOVANIH SA TELESNOM MASOM OD 100 kg

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(Naučni rad)

Lasasta Mangulica je primitivna rasa svinja koja se najčešće uzgaja u ekstenzivnim uslovima. Cilj ovog rada bio je da se ispita kvalitet mesa svinja Lasaste Mangulice odgajanih u intezivnom proizvodnom sistemu. Senzorna (boja i mramoriranost) i fizička (pH vrednost, sposobnost vezivanja vode i instrumentalno određena boja – CIE$L^*a^*b^*$) svojstva, kao i osnovni hemijski sastav (vlaga, proteini, ukupna mast i ukupni pepeo) i sadržaj minerala (K, P, Na, Mg, Ca, Zn, Fe i Cu) određeni su u četiri mišića (*M. psoas major* – PM, *M. semimembranosus* – SM, *M. longissimus thoracis et lumborum* – LTL i *M. triceps brachii* – TB). Tip mišića ne utiče značajno ($P > 0,05$) na sposobnost vezivanja vode i sadržaj proteina, ukupne masti, K, P i Ca. Kod mišića PM utvrđena je statistički ili numerički najviša vrednost pH_{24h} (6,07), najbolja sposobnost vezivanja vode, najveći udeo crvene (CIEa^* = = 21,03) i žute (CIEb^* = 6,98) boje i najveći sadržaj vlage (74,22 g/100 g), K (303 mg/100 g), P (228 mg/100 g) i Cu (0,15 mg/100 g), kao i najmanja mramoriranost i najmanji sadržaj ukupne masti (3,16 g/100 g). Kod mišića SM utvrđen je statistički ili numerički najveći sadržaj Mg (24,7 mg/100 g) i Ca (7,68 mg/100 g), kao i najtamnija instrumentalno određena boja (CIEL^* = 37,46) i najmanji sadržaj K (279 mg/100 g). Najsvetlija instrumentalno određena boja (CIEL^* = 48,39), najveći sadržaj proteina (22,25 g/100 g), ukupne masti (4,47 g/100 g) i ukupnog pepela (1,10 g/100 g), kao i najsvetlija senzorski ocenjena boja, najniža vrednost pH_{24h} (5,56), najslabija sposobnost vezivanja vode, najmanji udeo crvene (CIEa^* = 10.12) i žute (CIEb^* = 4,14) boje, najmanji sadržaj vlage (72,03 g/100 g), Na (50,3 mg/100 g), Ca (5,46 mg/100 g), Zn (2,35 mg/100 g), Fe (1,08 mg/100 g) i Cu (0,10 mg/100 g) utvrđeni su u LTL mišićima, sa numeričkim ili značajnim razlikama. Najtamnija senzorski ocenjena boja, najveći sadržaj Na (59,2 mg/100 g), Zn (3,90 mg/100 g) i Fe (3,26 mg/100 g), kao i najslabija sposobnost vezivanja vode, najmanji sadržaj proteina (21,44 g/100 g), ukupnog pepela (0,99 g/100 g), P (218 mg/100 g) i Mg (22,6 mg/100 g) utvrđeni su u TB mišićima, takođe sa numeričkim ili značajnim razlikama.

Ključne reči: Svinje • Lasasta Mangulica • Intezivni proizvodni sistem • Kvalitet mesa