

Carcass Composition and Meat Quality of Crna Slavonska Pigs from Two Different Housing Conditions

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Summary

The aim of the study was to compare carcass composition and meat quality of pigs held in two housing systems suitable for production of Crna slavonska pigs. The experiment was conducted on 104 Crna Slavonska pigs (equal number of barrows and gilts) from two housing systems, outdoor (n=56) and indoor (deep bedding, n=48). The pigs in the outdoor group were reared until 18 months of age, and pigs in deep bedding group were raised until 15 months of age. After reaching the final age, the pigs were sacrificed and following carcass and meat quality traits were determined at the slaughter house and in laboratory: backfat and muscle thickness, length of the carcass from *os pubis* to *atlas* and from *os pubis* to 1st rib, ham length and circumference, loin eye area and fat area of *longissimus lumborum* muscle, pH values, water holding capacity and drip loss, colour reflectance scores (CIE L* a* b*) and instrumental tenderness. The carcasses of the pigs raised outdoors had lower backfat thickness, higher muscle thickness and lower fat area than pigs raised on deep bedding. Their carcasses were longer with longer hams. However, their ham circumference, as well as the loin eye area was lower than in pigs raised on deep bedding indicating higher production of muscle tissue in the latter. Out of investigated meat quality traits, the pigs raised outdoor had lower pH₂₄ values measured in *logissimus lumborum* muscle and in *semimembranosus* muscle, higher drip loss and water holding capacity, higher cooking loss and yellowness (CIE b*).

Key words

local pig breeds, housing system, carcass composition, meat quality

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Introduction

Crna Slavonska pig is an autochthonous breed from the eastern region of Croatia. This breed is reared in a closed population and is included in the National Programme for Farm Animal Resources. It is a fatty-lean type of pig, usually used for production of lard and bacon, but also for traditional high quality meat products. Traditionally it is raised outdoors on grasslands or in silvopastoral systems to approximately 18 months of age or up to the 130-150 kg live weight (LW). These systems are cost-effective, environmentally and animal-friendly, which can result with improved meat quality traits and nutritional characteristics of the pork product (Budimir et al., 2013). However, the main shortcomings of such production systems are uncontrolled mating with wild boars and transmission of contagious diseases (Kušec et al., 2015), as well as the duration of the fattening period. One of the alternatives that could be used for overcoming these disadvantages is raising the animals indoor in deep litter (straw-bedded) facilities. Margeta et al. (2013) described this system as a natural housing for growing pigs, where these old breeds can express their full genetic potential. Number of scientific reports confirm the advantages of deep litter over conventional housing system, such as influence on their welfare (Morrison et al., 2007) and environment (Margeta et al., 2004) with feed conversion and meat quality equal or superior to those raised in conventional housing system (Kralik et al., 2004; Morrison et al., 2007). Compared to outdoor rearing, pigs raised on deep bedding have lower lean meat percentage and higher daily weight gain, with most technological meat quality traits, such as colour, cooking loss, Warner-Bratzler Shear Force and pH, being similar to outdoor rearing (Stern et al., 2003). The carcass and meat quality traits of Crna slavonska pigs reared outdoor were extensively studied (Karolyi et al., 2007; 2010; Luković et al., 2007; Senčić et al., 2008; Baković et al., 2016), however investigations on the influence of different housing systems on these traits are scarce. Nonetheless, Butko et al. (2007) compared the carcass composition and meat quality traits of Crna slavonska pigs raised outdoors (on pasture) and indoors (conventional housing system) to approximately 135.00 kg live weight, determined that pigs raised outdoor were leaner, had heavier hams, and lower percentage of the belly-rib part in the carcass. The differences between two production systems in pH values, water holding capacity, colour and marbling were not significant. The aim of present study was to evaluate the effect of two different housing systems, outdoor and indoor on deep bedding, on the carcass characteristics and meat quality traits of Crna Slavonska pigs.

Material and methods

Animals

The experiment was performed on 104 Crna Slavonska pigs, equal number of gilts and barrows. The animals were distributed into two housing systems: 56 pigs outdoor (O) and 48 pigs on deep bedding (DB). Pigs belonging to O group were raised on approximately 300 m² per pig of pasture with 80 m² of canopy shelters; whilst pigs belonging to DB group were raised in a barn allowing 3 m² per pig of available space floor. Every day 1.5 kg of straw-bedding was added per pig. Both groups were fed alfalfa *ad libitum* with addition of 2 kg of whole grains (50% corn, 25%

barley, 10% triticale, and 15% extruded soybeans) per pig per day. The pigs in O group were reared until 18 months of age, and pigs in DB group were raised until 15 months of age, both approximately reaching their biological maximum of growth (cessation of increase in live weight). After the end of fattening period, pigs were transported to the nearby slaughterhouse, where they were slaughtered after being stunned with CO₂. The carcasses were dressed according to commercial procedure.

Carcass composition

After 24 h of cooling the carcass backfat thickness and muscle thickness according to "Two points" method approved in Croatia, length "a" (from *os pubis* to *atlas*), length "b" (from *os pubis* to 1st rib), ham length (from the anterior edge of the symphysis pubis to the hock joint), together with the ham circumference at its widest point, were determined. Loin eye area (cm²) and fat area (cm²) of *longissimus lumborum* (LL) muscle were determined according to procedure as described by Comberg et al. (1978) and expressed as fat/lean ratio.

Meat quality traits

At the slaughterhouse 45 minutes after exsanguination initial pH (pH₄₅) was measured at *m. semimembranosus* (MS) and LL muscle using a Mettler MP 120-B (Mettler-Toledo, Schwerzenbach, Switzerland). Ultimate pH values (pH₂₄) were determined 24 h *post mortem* at the same places as pH₄₅. Water loss was measured according to EZ drip method (Christensen, 2003) and water holding capacity (WHC) by gravimetric method according to Grau and Hamm (1953). Meat colour (CIE L*a*b*; CIE 2007) was determined using a Minolta CR-410 Colorimeter (Konica Minolta Sensing Ltd, Singapore) calibrated against a ceramic white plate (Y = 84.9; x = 0.32 and y = 0.3381), with a D65 light source and a two-degree standard observer. Prior to determination of instrumental tenderness LL slices were kept at -18°C for two weeks. Before analysis the chops were cut to 2.54 cm width, defrosted for 24h, cooked in water bath to 73°C internal temperature and cooled at 4°C for 24h. Cooking loss was calculated from weights taken before and after cooking LL samples and expressed as percentage. Warner-Bratzler shear force was determined using a TA.XTplus Texture Analyser (Stable Micro Systems, London, UK) fitted with a 1-mm-thick Warner-Bratzler shear attachment and expressed in Newtons.

Statistical analysis

Kolmogorov-Smirnov normality test followed by Levene's test for equality of variances were performed for all investigated traits. As Levene's test showed no significance, the differences between investigated housing systems were analysed using mixed ANCOVA (analysis of covariance), a procedure of the general linear model with housing system and sex as main factors, and batch number as random effect. Since there was no significant influence of the sex nor housing system*sex interaction on investigated traits, sex was excluded from further analysis. Cold carcass weight was used as a covariate when proved to be significant for a trait. The differences between housing systems were determined by Tukey honest significant difference (HSD) test, where P < 0.05 was classified as significant. All data were analysed using Dell Statistica (data analysis software system), version 12. (Dell Inc., 2015).

Results and discussion

The pigs from DB group were raised only for 15 months because they entered the problems connected to increased fatness; they could hardly stand due to their overweight and their weight gain was significantly reduced. It could be concluded that they reached their biological maximum at this age. These pigs had approximately 210.00 kg live weight (LW), while pigs reared outdoors (O) had approximately 130.00 kg LW at the age of 18 months.

to 16% longer carcasses than pigs the same age raised indoors. Ham length and circumference represent important traits due to the possibility of selecting the best carcasses for further processing into valuable dry-cured products, such as ham or prosciutto (Kušec et al., 2016). The pigs reared outdoor (O) had longer hams, but lower ham circumference than the pigs from DB group indicating higher fatness of the later. Previous studies showed that the superior seasoning ability is likely related

Table 1. LS means and standard error of means (SEM) for carcass composition of pigs raised in two different rearing conditions

Trait	Housing system		SEM	P value
	Outdoor (O)	Deep bedding (DB)		
Backfat thickness, mm	37.75 ^b	64.64 ^a	5.32	0.012
Muscle thickness, mm	71.53 ^a	54.22 ^b	3.46	0.012
Fat area, cm ²	31.90 ^b	77.23 ^a	2.75	<0.001
Loin eye area, cm ²	32.53 ^b	37.07 ^a	1.82	0.105
Fat/meat ratio at LL cut	1.01 ^b	2.12 ^a	0.10	<0.001
Length "a", cm	96.77 ^a	92.09 ^b	1.55	0.116
Length "b", cm	112.43 ^a	110.40 ^b	2.00	0.592
Ham length, cm	37.60 ^a	36.70 ^b	0.90	0.599
Ham circumference, cm	77.31 ^b	88.30 ^a	1.13	0.095

^{a, b} P<0.05; LL-longissimus lumborum

Results presented in Table 1 show that carcasses of pigs from group O had lower backfat thickness and higher muscle thickness than DB pigs. The difference in the backfat thickness and fat area between the pigs from investigated groups indicated that the amount of fat was nearly doubled in DB pigs. However, loin eye area of DB pigs was significantly higher than in O pigs. Nevertheless, fat to meat ratio at the LL muscle cut of the DB pigs was twice as high when compared to the pigs from group O. It is known that at certain point pigs start to gain the weight predominantly by accumulation of fat (Vincek et al., 2013); so it could be expected that DB pigs would have had much higher backfat thickness and fat area of LL muscle. In the research similar to present study, Gentry et al. (2002) investigated the influence of housing system on carcass and meat quality traits of the Newshams genetics pigs (originating from Yorkshire, Landrace and Duroc breeds) and found that animals raised outdoors had lower backfat thickness than animals raised indoors (both in deep-bedded and slatted floor). This is in concordance with the results of the present study. In addition, Butko et al. (2007) reported significantly lower fat thickness of Crna Slavonska pigs fattened to approximately 135.00 kg LW outdoors than in pigs raised indoor, but on concrete floor. Interestingly, in present study the loin eye area of the BD group was higher than in O group of pigs indicating higher production of muscle tissue in the former. From Table 1 it can be noticed that pigs from the O group had longer carcasses (both "a" and "b") than DB pigs; these differences could be explained by lower age of the latter, but also the housing system. Several studies showed that bones react to exercise-induced mechanical loads by adaptive responses, which among others include an increase in length (Cullen et al., 2000). Supporting this statement, Filletti et al. (2003) found that Cinta Senese pigs raised outdoors for 13 months had 11

to the higher adiposity of heavier hams and higher fat thickness preventing water evaporation, especially in the later processing phases (Čandek-Potokar and Škrlep, 2012). This indicates that housing system such as deep bedding could be an acceptable alternative for the producers aiming to raise the animals for dry/cured ham production.

Results on the investigated meat quality traits are presented in Table 2. Among analysed meat quality traits, the housing system significantly influenced pH values measured 24 h *p.m.* in both MS and LL muscles, EZ drip, water holding capacity (WHC) and yellowness (CIE b*) (Table 2). The pigs from group O exhibited lower final pH values in ham (MS) and loin (LL) muscles than those from DB group. This is probably due to the fact that pigs kept outdoor produce more glycogen and consequently more lactate after slaughter (Enfält et al., 1997; Terlouw et al., 2009), but can be also attributed to stress response prior to slaughter. The outdoor system includes rearing with minimal contact to humans, while pigs raised on deep bedding were exposed every day to humans, so operations prior to slaughter (loading, unloading the truck etc.) are possibly more stressful for the pigs reared outdoor. Indeed, Foury et al. (2011) found that pigs raised indoor exhibited lower levels of stress indicators (plasma CK, cortisol and catecholamine) at slaughter. The meat samples of pigs from group O had higher drip loss and consequently higher cooking loss than pigs from DB group. This is in agreement with the results of Enfält et al. (1997), who reported high drip loss and cooking loss values in crossbreds reared outdoor. Interestingly, in present study WHC was lower in DB group than in the group O. The samples originated from DB pigs had higher fat/meat ratio and therefore most probably the higher intramuscular fat (IMF) content in LL muscle. As Daszkiewicz et al. (2005) explained, an increase of IMF content

Table 2. Least square means (LSM) and standard error of means (SEM) for meat quality traits of pigs from different housing systems

Trait	Housing system		SEM	P value
	Outdoor (O)	Deep bedding (DB)		
pH ₄₅ , MS	6.48	6.66	0.13	0.439
pH ₄₅ , LL	6.44	6.62	0.09	0.317
pH ₂₄ , MS	5.64 ^b	5.89 ^a	0.08	0.019
pH ₂₄ , LL	5.69 ^b	5.89 ^a	0.08	0.041
EZ drip, LL, %	3.58 ^a	1.65 ^b	0.90	0.021
WHC, LL	8.66 ^a	6.66 ^b	1.12	0.037
CIE L*	47.03	45.76	2.41	0.775
CIE a*	10.99	10.88	1.23	0.216
CIE b*	2.00 ^a	0.82 ^b	0.48	0.009
Cooking loss, %	33.84 ^a	27.81 ^b	2.31	0.169
WBSF, N	51.54	57.52	6.96	0.549

^{a, b} P < 0.05; MS - *m. semimembranosus*; LL - *longissimus lumborum*; WHC - water holding capacity; WBSF - Warner-Bratzler Shear Force

in pork correlates with a tendency to lower water-holding capacity in the case of endogenous water. The housing system did not affect CIE L* (lightness) and CIE a* (redness) values; however, significant influence was found for CIE b* (yellowness). It is likely that this difference occurred as a consequence of stressful response in the O group of pigs, which could cause higher muscle temperature, but also higher CIE b* values as reported by Lindahl et al. (2005). Opposite to our results, Gentry et al. (2004) found that pigs that were born and reared outdoors had redder (CIE a*) loins than pigs born and reared indoors, without influence on loin lightness (CIE L*) or yellowness (CIE b*).

Conclusions

Indoor rearing of Crna Slavenska pigs on deep bedded facilities significantly influenced all of the carcass traits, mainly due to their increased fatness when compared to pigs reared using traditional outdoor rearing practice. Additionally, increased loin eye area at LL cut of DB pigs points at the higher production of lean in their carcasses. In order to better understand the relationships between the muscle and fat tissue in Crna Slavenska pigs from different housing systems, further investigations are suggested. Considering favourable ham characteristics and desirable meat quality traits of DB pigs found in present study, indoor housing on deep bedding could be used as a good alternative for producers raising Crna Slavenska pigs for dry/cured ham production.

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