

## INFLUENCE OF NUTRITION OF BLACK SLAVONIAN PIGS ON THE QUALITY OF HAM AND CURED HAM

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Two groups of pigs, each group comprising 16 Black Slavonian pigs, were fed up to 130 kg body weight in the first and the second fattening period. They were fed forage mixtures with lower level (12% and 10%) of crude protein (Group A) and higher level (14% and 12%) of crude protein (Group B). Compared to pigs from Group A, pigs from Group B had higher share of ham in carcasses (26.65% : 24.62%), higher share of muscle tissue in carcasses (15.62% : 14.62%) and higher share of muscle tissue in ham (7.95 kg : 7.49 kg). Hams of pigs from Group B had thinner subcutaneous adipose tissue (3.10 cm : 3.80 cm), lower lightness level  $L^*$  (35.30 : 39.50) of muscle tissue and lower fat content in muscle tissue (10.00% : 12.00%), whereas no significant differences were detected between the groups in terms of pH value,  $a_w$  value,  $CIE a^*$  and  $CIE b^*$  values, and water and ash content. Hams of pigs from Group B received better grades for cross-section appearance (5.00 : 4.90) and firmness (8.50 : 8.00), whereas no significant differences between the groups were detected in terms of appearance, smell and taste.

**Key words:** black Slavonian pigs; ham quality; cured ham quality

### ВЛИЈАНИЕ НА ИСХРАНАТА ВРЗ КВАЛИТЕТОТ НА ШУНКАТА И ПРШУТАТА КАЈ ЦРНИ СЛАВОНСКИ СВИЊИ

Две групи од по 16 грла црни славонски свињи беа гоени до 130 kg телесна маса во првиот и вториот период на гоеење. Тие беа хранети со крмни смески со помал процент (12% и 10%) сурови протеини (група А) и со поголем процент (14% и 12%) сурови протеини (група Б). Свињите од групата Б, за разлика од тие од групата А, имаа поголем удел на шунка во трупот (26,65% : 24,62%), поголем удел на мускулно ткиво во трупот (15,62% : 14,62%) и поголем удел на мускулно ткиво во шунката (7,95 kg : 7,49 kg). Бутовите на свињите од групата Б имаа потенко поткожно масно ткиво (3,10 cm : 3,80 cm), пониско ниво на светла боја  $L^*$  (35,30 : 39,50) на мускулното ткиво и помалку маснотија во мускулното ткиво (10,00% : 12,00%). Сепак, не беа забележани значајни разлики помеѓу свињите од двете различни групи во: рН-вредноста,  $a_w$ -вредноста, вредноста  $CIE a^*$  и  $CIE b^*$ , и во содржината на вода и пепел. Шунките од свињите од групата Б освоија подобри оценки за изгледот кога беа пресечени на пола (5,00 : 4,90) и за цврстината (8,50 : 8,00), додека значајни разлики во однос на мирисот, вкусот и изгледот не беа забележани.

**Клучни зборови:** црни славонски свињи; квалитет на шунка; квалитет на пршута

#### INTRODUCTION

In addition to the technology of ham processing, the quality of cured ham also depends on the quality of hams, i.e. quality of used raw materials. Factors influencing ham quality include genetic (pig genotype, sex) and paragenetic factors (body weight and age of pigs, housing system,

conditions of keeping, nutrition, handling pigs before slaughter), that is, technology of pig fattening. Nutrition has strong influence on the quality of hams. It can influence not only the content of both muscle and adipose tissue in hams, but also its chemical composition, thus indirectly influencing physical and chemical properties as well as sensory properties of cured hams. In earlier research

(Senčić et al., 2011) it was determined that the housing system (semi-outdoor and outdoor) had impact on the quality of cured hams produced from Black Slavonian pigs. This paper is focused on influence of nutrition (crude protein level in forage mixtures) on the quality of Slavonian cured ham.

## MATERIAL AND METHODS

The research was conducted on hams and cured hams originating from 32 Black Slavonian pigs, 16 of which were fattened in a semi-outdoor system with forage mixtures containing lower level of crude protein (group A), and 16 pigs were fed higher level of crude protein (group B). Pigs in group A were fed forage mixture containing 12.00% crude protein and 13.34 MJ ME/kg in the first phase of fattening (30 – 60 kg bodyweight), and 10.09% crude protein and 13.00 MJ ME/kg in the second phase of fattening (60 – 130 kg bodyweight). Pigs in group B were fed forage mixture containing 14.00% crude protein and 13.37 MJ ME/kg in the first phase of fattening (50 – 60 kg bodyweight), and 11.88% crude protein and 13.34 MJ ME/kg in the second phase of fattening (60 – 130 kg bodyweight). In addition to forage mixture, pigs were also fed fresh green alfalfa *ad libitum*. Each group of pigs comprised equal number of barrows and gilts. The content of hams in carcasses and tissue contained therein was determined by dissection carried out according to Weniger et al. (1963). Fresh hams were technologically processed, as described by Senčić (2009). Primary processing of hams, i.e. formation was carried out after 24 hour-period of cooling. The sacral bone and pelvic bones (the ischium, the ilium, and the pubis) were removed. After removal of pelvic bones, ham muscles were rounded in a semi-circle, so that the lower edge was approximately 6 cm away from the head of the femur.

Salting (dry curing) of hams was performed in a cold and airy room, at temperature of 8-10 °C and relative air humidity 85 %. Hams were manually rubbed with salt once at a time, first from internal and then from external side. Some salt was also put into the cut of the ankle joint. The amount of salt was equal to 6–8 % of ham weight. Hams were cured for 30 days, at 6 °C, and smoked in a traditional way, in a solidly built and airy room (*pušnica* – kiln). Beech and hornbeam wood were

used for smoking. Cold smoking was applied (temperature 16 – 22 °C) during 60 days. Ham ripening took place after smoking in a separate, cold and airy room (temperature 15°C, air humidity 75%) during 150 days.

The following physical and chemical properties were determined: pH<sub>1</sub> value (45 minutes post mortem) and pH<sub>2</sub> value (24 hours post mortem) of ham meat (M. semimembranous) and pH of cured ham meat (M. semimembranous) by means of “Mettler Toledo” pH metre, parameters of meat colour of fresh hams and cured hams (“L”, “a” and “b” values) by means of “Minolta CR-410” Chroma Metre, content of NaCl, water, crude proteins, crude fat and ash and a<sub>w</sub> value. The thickness of subcutaneous fat tissue was measured at the longitudinal cross-section of cured ham, at its thickest part. Chemical analyses were carried out on samples of m. semimembranous. The content of water was determined by drying a homogenized sample (200 g) at 105 °C up to the constant weight. Loss of weight was expressed as percentage of water in the sample. The content of crude fat was determined by means of the Soxhlet method, and the content of crude proteins was explored by means of the Kjeldahl method. The ash content was determined by burning organic matter at 550 °C until a constant weight. The ash content is expressed as percentage of the remaining weight of a sample. The a<sub>w</sub> value in cured hams was measured by means of “HygroLab 3 (Rotronic)” by applying the Aw Quick model on samples prepared by grinding and homogenization of 100 g from the central part of the cured ham.

The following sensory properties were graded: appearance (1–7 points), cross-section appearance (1–8 points), odour (1–10 points), firmness (1–10 points) and taste (1–15 points). Evaluation of sensory properties was carried out by a five-member expert board.

## RESULTS AND DISCUSSION

Quality (composition) of hams in relation to nutrition provided to pigs is shown in the Table 1. Carcasses of pigs fed with forage mixture containing a higher level of crude proteins (group B) had a higher share of hams in carcasses in relation to carcasses of pigs fed with a lower level of crude proteins.

Table 1

*The quality of hams of Black Slavonian pigs in relation to the manner of feeding*

Indicators	Method of feeding		Significance of differences
	A (n = 16)	B (n = 16)	
	$\bar{x} \pm s$	$\bar{x} \pm s$	
Body mass of a pig, kg	130.40 ± 6.70	130.37 ± 6.84	NS
Cold carcass mass, kg	51.22 ± 4.39	51.08 ± 3.87	NS
Mass of the unformatted ham, kg	12.59 ± 0.95	13.54 ± 1.02	NS
Share of the ham in carcass, %	24.62 ± 1.08	26.55 ± 1.42	**
Thigh meat in carcass, %	14.62 ± 1.10	15.62 ± 1.38	*
Shares of muscle tissue in the ham: kg	7.49 ± 0.56	7.95 ± 0.62	*
%	59.49 ± 3.16	58.81 ± 3.42	NS
pH <sub>1</sub> of meat	6.30 ± 0.20	6.28 ± 0.20	NS
pH <sub>2</sub> of meat	5.65 ± 0.18	5.60 ± 0.20	NS
CIE L*	47.40 ± 2.00	46.50 ± 1.95	NS
Meat colour: CIE a*	6.80 ± 2.20	7.00 ± 2.10	NS
CIE b	0.88 ± 1.90	0.60 ± 1.95	NS

\*\*  $p < 0.01$ ; \*  $p < 0.05$ ; NS  $p > 0.05$ 

No significant differences ( $p > 0.05$ ) were detected in the relative share of muscle tissue in hams between the groups of Black Slavonian pigs. However, meat from hams from group B had a higher share in carcasses in relation to the ham meat from group A. According to a research conducted by Nieto et al. (2003), reduction of a crude protein level in pig rations resulted in increased fat content in hams. However, Barea et al. (2008) did not detect influence of protein level in pig nutrition on the content of intramuscular and subcutaneous tissue in hams.

No significant differences ( $p > 0.05$ ) were detected in terms of pH<sub>1</sub> and pH<sub>2</sub> values of ham meat and colour parameters (CIE “L”, “a” and “b”) between the analyzed groups of pigs.

Physical and chemical properties of cured ham, in relation to nutrition, are shown in Table 2. No significant differences ( $p > 0.05$ ) were detected between the analyzed groups of pigs in terms of

cured ham weight. Cured hams originating from pigs fed with lower level crude protein mixtures (group A) had significantly ( $p < 0.05$ ) thicker subcutaneous adipose tissue. No significant differences ( $p > 0.05$ ) were detected between the analyzed groups of pigs in terms of pH value of cured hams. The pH value of cured hams in this research is similar to the values (5.97–5.85) reported by Karolyi et al. (2009) for *Drniš pršut* (cured ham produced in the Drniš area, Croatia) and Chizzolini et al. (1996) for *Parma prosciutto* (5.83), and lower than the values (6.45–6.65) reported by Vuković et al. (2005) for cured ham produced in Srijem, Croatia. Differences in pH value of cured hams among particular hams depend, among other, on the period of ripening. The extended ripening period and protein decomposition result in higher content of non-protein nitrogen, which leads to increased pH values of dry hams (Virgilli et al., 1999).

Table 2

*Physical and chemical properties of cured hams of Black Slavonian pigs in relation to the manner of feeding*

Indicators	Method of feeding		Significance of differences
	A (n = 10) $\bar{x} \pm s$	B (n = 10) $\bar{x} \pm s$	
Weight of cured ham, kg	6.80 ± 1.35	7.00 ± 1.30	NS
The thickness of subcutaneous adipose tissue, cm	3.80 ± 0.75	3.10 ± 0.80	*
Colour:			
CIE L*	5.75 ± 0.20	5.70 ± 0.20	NS
CIE L*	39.50 ± 2.00	35.30 ± 2.00	**
pH CIE a*	18.00 ± 2.00	17.50 ± 2.15	NS
CIE b*	6.50 ± 1.95	6.50 ± 2.00	NS
$a_w$	0.85 ± 0.04	0.85 ± 0.05	NS
NaCl, %	6.00 ± 0.40	5.95 ± 1.50	NS
Water, %	52.00 ± 1.50	54.00 ± 2.45	*
Crude proteins, %	27.55 ± 2.00	27.50 ± 2.20	NS
Crude fat, %	12.00 ± 2.20	10.00 ± 2.25	*
Crude ash, %	8.45 ± 2.00	8.50 ± 2.10	NS

\*\*  $p < 0.01$ ; \*  $p < 0.05$ ; NS  $p > 0.05$

The ham meat from group A was significantly ( $p < 0.01$ ) lighter in colour (L\* value) in relation to the ham meat from group B. This is probably related to higher content of intramuscular fat, which is also indicated by chemical composition of cured hams (Table 3). No significant differences ( $p > 0.05$ ) were established between the groups in terms of redness (a\*) and yellowness (b\*). Values for colour parameters (L\*, a\* and b\*)

of cured hams in this research are similar to values determined in the earlier research on the quality of Slavonian cured ham (Senčić et al., 2012). L\* values for meat colour in this research are somewhat lower, whereas a\* and b\* values are significantly higher than values reported by Bosi et al. (2000) for Parma cured ham and Cilla et al. (2006) for dry hams originating from Duroc crossbreeds.

Table 3

*Sensory properties of cured hams of Black Slavonian pigs in relation to the manner of feeding*

Indicators	Method of feeding		Significance of differences
	A (n = 10) $\bar{x} \pm s$	B (n = 10) $\bar{x} \pm s$	
Appearance	6.45 ± 0.45	6.50 ± 0.50	NS
Cross-section appearance	4.50 ± 0.55	5.00 ± 0.60	*
Firmness	8.00 ± 0.55	8.50 ± 0.60	*
Odour	8.45 ± 0.55	8.50 ± 0.60	NS
Taste	14.00 ± 0.50	14.00 ± 0.55	NS

\*  $p < 0.5$ ; NS  $p > 0.05$

No significant differences ( $p > 0.05$ ) between the analyzed groups of hams were detected in terms of water activity ( $a_w$ ) and NaCl content, and obtained values were within desirable limits. Cured hams originating from pigs fed with forage mixture containing a higher level of crude proteins (group B) had a significantly higher ( $p < 0.05$ ) content of water and less fat in relation to cured hams from pigs fed with a lower level of crude proteins. No significant differences ( $p > 0.05$ ) between the analyzed groups of pigs, i.e. cured hams were detected in terms of crude protein level and ash content.

Sensory properties of cured hams (Table 3) were similar in both analyzed groups of cured hams, and very significant differences ( $p < 0.01$ ) were determined only in terms of cross-section appearance. Cured hams originating from pigs fed with forage mixture containing a lower level of crude proteins had somewhat higher content of subcutaneous adipose tissue, which resulted in lower grades for cross-section appearance.

## CONCLUSION

The level of crude protein in forage mixtures has a significant influence on the share of hams and ham meat in carcasses and hams. Pigs fed with forage mixture containing a higher level of crude protein have a very significantly ( $p < 0.01$ ) higher share of hams in carcasses and significantly ( $p < 0.05$ ) higher share of ham meat in carcasses, and they produce hams with significantly ( $p < 0.05$ ) thinner subcutaneous fat tissue, with very significantly ( $p < 0.01$ ) a lower lightness level of muscular tissue and significantly ( $p < 0.05$ ) lower fat content in muscular tissue. Hams of pigs fed with a higher level of crude protein in forage mixtures have significantly ( $p < 0.05$ ) better cross-section appearance and firmness. Hams of Black Slavonian pigs in both analyzed groups received high grades for odour and taste, but no significant dif-

ferences ( $p > 0.05$ ) were detected for these properties.

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