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THE EFFECT OF FEEDING AND HOUSING CONDITIONS OF GROWING-FINISHING PIGS ON PORK QUALITY

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K e y w o r d s: pork, proximate chemical composition, physicochemical properties.

A b s t r a c t

The objective of this study was to determine the quality of meat from pigs housed on litter and in litterless pens and fed during the fattening period (from 48 kg to 105 kg bw) complete diets and complete diets supplemented with green forage. Hybrid growing-finishing pigs [♀(♀Polish Landrace x ♂Polish Large White) x ♂(♀Pietrain x ♂Duroc)] were divided into 4 experimental groups, each of 12 animals. *M. longissimus dorsi* samples were collected from pig carcasses for an analysis of proximate chemical composition and physicochemical properties. It was found that the applied feeding and housing conditions had no significant effect on the chemical composition and quality of pork (*m. longissimus dorsi*).

JAKOŚĆ MIĘSA W ZALEŻNOŚCI OD SPOSOBU UTRZYMANIA I ŻYWIENIA TUCZNIKÓW

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S ł o w a k l u c z o w e: mięso wieprzowe, podstawowy skład chemiczny, ocena fizykochemiczna.

A b s t r a k t

Badano jakość mięsa świń utrzymywanych w kojcach ściołowych lub bezściołowych i żywionych w okresie tuczu (od 48 kg do 105 kg) mieszanką pełnoporcjową lub mieszanką pełnoporcjową i dodatkowo podawaną zielonką. Tuczniki mieszańcowe [♀(♀polska biała zwisłoucha x ♂wielka

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biała polska) x ♂ (♀pietrain x ♂duroc)] podzielono na 4 grupy doświadczalne po 12 sztuk w każdej. Z tusz tuczników pobrano próbki mięśnia najdłuższego grzbietu *(m. longissimus dorsi)* do analizy podstawowego składu chemicznego i oceny fizykochemicznej. Nie stwierdzono istotnego wpływu zastosowanych sposobów żywienia i utrzymania na skład chemiczny oraz jakość mięsa mięśnia najdłuższego grzbietu (*m. longissimus dorsi*) tuczników.

Introduction

Meat quality is affected by both genetic and environmental factors. The main indicators of meat quality, which determine its processing suitability and eating attributes, are acidity, color (including uniformity and stability), water--holding capacity, water-binding capacity, emulsifying and gelling properties, shelf-life, production yield, appearance (color and marbling), texture (tenderness and juiciness) and palatability (Koćwin-Podsiadła, Krzęcio 2005). Genetic factors are believed to be responsible for meat quality in 30%, whereas environmental factors, i.e. management conditions, pre-slaughter handling, slaughter and post-slaughter procedures – in 70% (Koćwin-Podsiadła 1993). The quality of meat and meat products has become an important consideration in recent years. Efforts to improve production results through raising welfare standards (access to bedding and roughage) are appreciated by consumers who are ready to pay more for organic pork.

Available Polish literature provides information on the impact of different genotypes on the quality and processing suitability of meat (Florkowski et al. 2007, Florkowski et al. 2008), as well as on the influence of feeding schemes on the rate of changes in blood biochemical parameters (Falkowski, Raubo 2007, Kluczek, Kluczek 2008, Migdał et al. 2003, Rekiel 2008). However, only a few studies have investigated the combined effects of roughage (green forage, hay-silage, alfalfa silage), housing systems and feeding regimes on fattening results, carcass quality and animal welfare (Kapelański et al. 2004, Kozera 2007, Karpiesiuk, Falkowski 2008a, 2008b). Therefore, the objective of the present study was to analyze the chemical composition and physicochemical properties of meat from hybrid growing-finishing pigs as dependent on the applied housing and feeding system.

Materials and Methods

Samples were collected from the carcasses of 48 hybrid growing-finishing pigs produced by simple four-breed crossing [♀(♀Polish Landrace x ♂Polish Large White) x ♂ (♀ Pietrain x ♂ Duroc)]. Experimental animals were selected by the analogue method, based on body weight, age and sex. Pigs were divided into 4 experimental groups, each of 12 animals, and were placed in pens (4.2 m x 3.6 m), according to the following design: group I (control) – litterless housing (solid floor), a complete diet offered *ad libitum*; group II – litterless housing (solid floor), a complete diet offered *ad libitum*, supplemented with alfalfa meal; group III – shallow litter, a complete diet offered *ad libitum*; group IV – shallow litter, a complete diet offered *ad libitum*, supplemented with alfalfa meal. All pigs were fed complete balanced cereal-soybean diets, in accordance with *Normy żywienia świń...* 1993, offered *ad libitum* from self-feeders. Pigs of two experimental groups received also alfalfa meal in the amount of approximately 5 kg, off the floor, in the morning and evening.

Slaughter and a carcass analysis were carried out in accordance with the relevant provisions. Meat content was determined on hot hanging right half-carcasses, using UltraFom 300. Carcasses were graded under the EUROP classification system (Polish Standard *Mięso w tuszach...* PN-91/A-82001/A1/1995). A fragment of *m. longissimus dorsi* was taken for a physicochemical analysis. LD samples were collected at the level of the 1st – 3rd lumbar vertebra. pH_{45} and pH_{24} were measured using a pH-meter (POL--EKO-APARATURA) and a Double Pore glass-combination electrode (Hamilton). Pork color parameters, i.e.: L^* – lightness, a^* – redness, b^*- yellowness, were determined with the use of a Minolta CR colorimeter. Measurements were performed on fresh samples collected together with samples for a physicochemical analysis. Pork samples were assayed for the content of: dry matter (*Mięso...* PN-ISO 1442:2000), total protein – by the Kjeldahl method (*Produkty...* PN-75/A-04018/Az3:2002), crude fat – by the Soxhlet method (*Mięso...* PN-ISO 1444:2000) and crude ash (*Mięso...* PN-ISO 936:2000). The water-holding capacity of meat (i.e. the ability to retain own water) was determined by the method proposed by GRAU and HAMM (1952), modified by POHJ and NINIVARA (1957). The analyses were conducted at the Department of Commodity Science and Animal Raw Material Processing, University of Warmia and Mazury in Olsztyn.

The results were validated statistically. The significance of differences between the mean values of the analyzed parameters in experimental groups was estimated by a two-factorial analysis of variance and Duncan's test. The relationships between selected quality attributes of *m. longissimus dorsi* were determined by a cluster analysis, as described by STRZELECKI (2004). Calculations were performed using STATISTICA PL ver. 7.0 software.

Results and Discussion

The results of a physicochemical analysis of pork are presented in Table 1. There were no statistically significant differences between groups as regards the chemical composition of meat contained in *m. longissimus dorsi*. The content of meat components (except for fat) was at a similar level in all experimental groups. Dry matter content ranged from 25.98% in group 4 to 26.16% in group I (control), while total protein content – from 23.44% in group I to 23.66% in group II. Pork fat content was affected by the housing system. Meat from pigs kept on litter contained less crude fat (1.40% in group IV and 1.29% in group II). The fat content of meat from pigs placed in litterless pens

Table 1

Proximate chemical composition and physicochemical properties of *m. longissimus dorsi* of experimental pigs

<table>
<tr><th rowspan="3">Specification</th><th rowspan="3">Unit</th><th rowspan="3">Statistical measure</th><th colspan="2">Litterless housing</th><th colspan="2">Shallow-litter housing</th></tr>
<tr><th>complete diet</th><th>complete diet supplemented with green forage</th><th>complete diet</th><th>complete diet supplemented with green forage</th></tr>
<tr><th>group I (control)</th><th>group II</th><th>group III</th><th>group IV</th></tr>
<tr><td>Dry matter</td><td>%</td><td>$\bar{x}$
s</td><td>26.16
0.48</td><td>26.01
0.60</td><td>25.99
0.49</td><td>25.98
0.29</td></tr>
<tr><td>Total protein</td><td>%</td><td>$\bar{x}$
s</td><td>23.44
0.41</td><td>23.66
0.48</td><td>23.52
0.87</td><td>23.64
0.55</td></tr>
<tr><td>Crude fat</td><td>%</td><td>$\bar{x}$
s</td><td>1.68
0.54</td><td>1.58
0.55</td><td>1.29
0.20</td><td>1.40
0.42</td></tr>
<tr><td>Ash</td><td>%</td><td>$\bar{x}$
s</td><td>1.087
0.025</td><td>1.092
0.014</td><td>1.082
0.035</td><td>1.096
0.081</td></tr>
<tr><td>pH_{45}</td><td></td><td>$\bar{x}$
s</td><td>5.99
0.18</td><td>5.95
0.22</td><td>5.89
0.29</td><td>5.97
0.21</td></tr>
<tr><td>pH_{24}</td><td></td><td>$\bar{x}$
s</td><td>5.29
0.19</td><td>5.22
0.09</td><td>5.27
0.16</td><td>5.22
0.12</td></tr>
<tr><td>Water-holding capacity</td><td>cm^2</td><td>$\bar{x}$
s</td><td>8.20
0.80</td><td>7.99
0.47</td><td>7.74
0.64</td><td>8.03
0.43</td></tr>
<tr><td>Color lightness L^*</td><td>1</td><td>$\bar{x}$
s</td><td>55.90^{b}
2.69</td><td>56.93^{Aa}
2.39</td><td>55.60^{B}
2.39</td><td>55.33^{B}
2.81</td></tr>
<tr><td>a^*</td><td>1</td><td>$\bar{x}$
s</td><td>0.119^{B}
1.188</td><td>0.299^{b}
1.076</td><td>0.677^{Aa}
1.323</td><td>0.165^{b}
0.838</td></tr>
<tr><td>b^*</td><td>1</td><td>$\bar{x}$
s</td><td>10.41
0.851</td><td>10.31
1.003</td><td>10.34
0.968</td><td>10.14
0.972</td></tr>
</table>

A, B – $P \leq 0.01$
a, b – $P \leq 0.05$

was 1.58% in group II and 1.68% in group I (control). However, the above differences were non-significant. According to KOŁACZ et al. (2004), differences in the content of dry matter, intramuscular fat and protein in pork may be affected by, among others, carcass tissue composition. Scandinavian researchers (JOHANSSON et al. 2002), who investigated the effect of genotype and red clover silage as a feed supplement on the fat content and fatty acid composition of pork loin, reported similar values of dry matter content (from 25.9% in the group fed red clover silage to 26.2% in the group fed a complete diet), and lower values of total protein content (20.3–20.6), in comparison with the present study. The cited authors noted a higher fat content of pork, ranging from 1.7% (pigs fed a diet supplemented with red clover silage) to 2.2% (pigs fed a standard diet). The value in the group receiving a roughage-supplemented diet was highly significantly lower. It should be stressed that in this group the energy content of the ration was by around 2% lower than in the control group.

Based on active acidity measurements (pH_{45} from 5.89 to 5.99), none of the samples was identified as PSE or partially PSE (Table 1). The measurement of pH_{24} enables to eliminate DFD pork whose pH is higher than 6.2. Normal-quality meat has pH in the range of 5.5–5.8 to 6.0 within 24 hours post mortem (KORTZ 2001). In this experiment pH_{24} ranged from 5.22 in group 2 to 5.29 in group 1, thus indicating the absence of DFD pork.

Water-holding capacity (WHC) is defined as the ability to retain the water contained in meat, mostly by proteins and tissue fibrillar structures. WHC is also an indicator of the processing suitability of meat. A low WHC may result in high weight loss due to drip loss during storage and distribution. In our study, pork from group 3 pigs had the highest WHC (7.74 cm^2), while the lowest WHC (8.20 cm^2) was noted in pork from control group pigs fed a complete diet and kept in litterless pens. RASSMUSSEN et al. (1996), as cited in KSOBIAK et al. (2005), demonstrated that an unacceptably high drip loss may be caused by muscle protein denaturation, chill shrinkage and low pH levels.

KOZERA (2007) studied the influence of two different housing (indoor and free-range) and feeding (a complete diet and a silage-supplemented diet) systems on fattening results, pig behavior and carcass quality. The above systems were found to have no significant effect on the majority of the analyzed parameters. A trend towards a lower fat content of pork from free-range pigs was only observed, although the values noted in most of the experimental groups were higher than those obtained in our experiment. The percentage protein content of pork was by approximately 2% lower than in the present study. In the cited experiment, the lean meat content of carcasses was high (approx. 54%) in all experimental groups. The values of WHC were also higher in experimental groups in the above study. The highest WHC

($8.90\ cm^2$) was observed in the group of pigs kept indoor and fed a diet supplemented with alfalfa silage, and the lowest – in the group kept indoor and fed a standard diet ($8.56\ cm^2$).

Meat color is an important quality attribute, which affects consumer preferences and shows significant correlations with other meat traits (KORTZ et al. 2000). Color is characterized by three physical parameters, i.e. the predominant wavelength, saturation and lightness. Exudative meat with a low water-holding capacity is lighter in color, because its texture does not permit light penetration into deeper layers which results in a low percentage of light reflection at the surface. Color lightness (L^*) of pork in the present study was relatively high, ranging from 55.33 in group IV to 55.93 in group II. Highly significant differences were noted with respect to this parameter between groups IV and III and group II, and significant differences were observed between group II and group I. As regards the contribution of redness (a^*) to pork color, highly significant differences were reported between group III and group I, and significant differences – between group III and groups IV and II. The average values of yellowness (b^*) ranged from 10.14 in group IV to 10.41 in group I, and they did not differ significantly. Similar values of color lightness (L^*) were obtained by KOZERA (2007): from 55.68 to 56.44 in experiment 1 and from 55.07 to 56.22 in experiment 2.

The lean meat content of carcasses was similar in all groups, at 55.70% on average. Table 2 shows the percentage of carcasses classified into different grades under the EUROP system in each group. Grade E carcasses dominated in all experimental groups (77.1%), followed by grade U carcasses (20.8%). Only 2.1% carcasses were classified to grade R. None of the carcasses belonged to grades O and P. A gradual increase in the percentage content of lean meat in pork carcasses observed in Poland (by 6.4% over 10 years) has resulted in a higher percentage of high-grade carcasses in the EUROP system. In 2006, the structure of pig purchase according to the EUROP classification system was as follows: E – 39.6%, U – 36.4%, R – 17.2%, O – 5.5%, P – 1.3%. This shows that pigs slaughtered in Poland during the period covered by this study were characterized by a lower percentage of high-grade carcasses (E and U), compared with the animals used in our experiment (*Zintegrowany...* 2007).

PRZYBYLSKI et al. (2008) found that a cluster analysis allows to discriminate between meat samples differing in quality, and to select those with the most desirable traits and best eating quality. Figure 1, illustrating the technological properties of *m. longissimus dorsi*, shows three clusters of the investigated parameters. The first cluster comprises the values of pH_{45}, pH_{24} and WHC, the second cluster – the content of fat and ash, and the third cluster – the percentage levels of dry matter and protein in pork. Color lightness (L^*) in the CIE Lab system proved to be a quality indicator of lesser significance. Pork samples collected in all experimental groups were characterized by comparable quality and technological properties. Similar hierarchical relationships between the analyzed quality attributes, i.e. the pH_{45} and WHC of normal pork, were reported by STRZELECKI (2004). The presented computational procedures pertain to selected quality indicators, but they also adequately describe the processing suitability of meat. Similar results of clustering the values of pH_{45}, pH_{24} and WHC were noted by CHWASTOWSKA (2006).

Table 2

Carcass classification into grades under the EUROP system and the percentage content of lean meat in the carcass

Class	Range (%)	Litterless housing		Shallow-litter housing		Number of carcasses in the class	Percentage of carcasses in the class
		complete diet	complete diet supplemented with green forage	complete diet supplemented with green forage	complete diet supplemented with green forage		
		group I (control)	group II	group III	group IV		
E	> 55	10	10	9	8	37	77.1
U	50–54.9	2	2	3	3	10	20.8
R	45–49.9	–	–	–	1	1	2.1
O	40–44.9	–	–	–	–	–	–
P	< 40	–	–	–	–	–	–

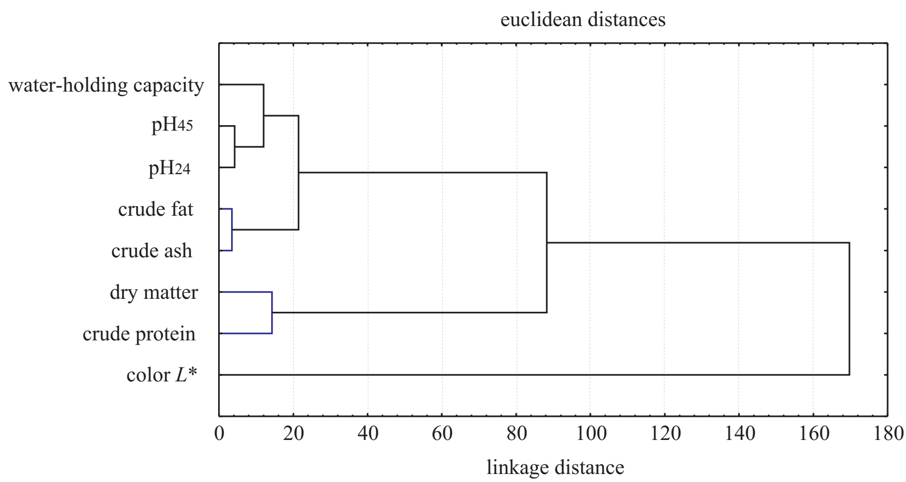

Fig. 1. Cluster analysis of the quality attributes of pork

Conclusions

The applied feeding and housing systems had no significant effect on the chemical composition of *m. longissimus dorsi* samples collected from growing--finishing pigs.

The values of color lightness and active acidity, as well as a cluster analysis show that pork in all experimental groups was characterized by the desired quality attributes and could be used for both processing and consumption.

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