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EFFECT OF SEX ON THE CHEMICAL COMPOSITION AND FATTY ACID PROFILE OF THE LONGISSIMUS DORSI MUSCLE IN DANBRED HYBRID PIGS

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Abstract

*The aim of the study was to determine the effect of sex on meat quality and the fatty acid (FA) profile of DanBred hybrid pigs. Longissimus dorsi (LD) muscle samples were collected from gilts and entire male pigs. Sex was used as the selection criterion. During the fattening period, animals of each sex were kept in separate group pens and fed complete feed mixtures. A four-phase feeding programme was used. Feed and water were available ad libitum. Slaughter was carried out in accordance with the applicable regulations. Longissimus dorsi muscle samples were collected from the right half-carcasses, from the lumbar section between the 3rd and 4th vertebrae. The pH24 value was measured and meat colour was determined in the CIE L*a*b* system. The contents of dry matter, crude protein by the Kjeldahl method, crude fat by the Soxhlet method, and total ash (AOAC, 2007), as well as the FA profile of meat samples, were determined. Fatty acids were separated by gas chromatography. Fatty acid methyl esters (FAME) were prepared according to a modified Peisker method. Fatty acids were identified by comparing their retention times with pure FAME standards (Sigma-Aldrich, St. Louis, Missouri, USA) and with peaks in the analysed samples. The degree of acidification did not differ according to sex. A higher carcass lean meat percentage was recorded in gilts. Longissimus dorsi muscle samples collected from females were characterised by higher contents of the basic chemical components. Significant and highly significant differences were found between animal sex and the fatty acid profile.*

Keywords: fatty acids, chemical composition, fattening pigs, sex, DanBred

Introduction

The main objective of pig production and breeding is to obtain high-quality pork. Despite the increase in consumption of poultry products, pork remains the most commonly consumed meat in Poland, and this situation has persisted for years. However, consumer requirements concerning selected characteristics of slaughter material and its quality are increasing from year to year

(Karpiesiuk et al., 2019). When choosing food products, consumers increasingly consider not only price but also quality and animal welfare. Changing socio-economic conditions force livestock producers to seek new production methods that increase herd comfort while ensuring profitability. One such system is pork production based on entire male pigs. Its purpose is to improve welfare and eliminate the pain associated with castration. Omitting this procedure reduces not only animal stress but also the risk of microorganisms entering through tissue that has not yet healed. The production of entire males is also economically justified. Boars have clearly higher growth rates (by 13%), use feed more efficiently (9.5%), and their meat contains less fat (–20%) (EFSA, 2004). This production system also has a lower environmental impact than the rearing of immunocastrates (Kress et al., 2019). However, meat from entire males is tougher, has a lower water-holding capacity and contains less fat. Deviations in pH and colour are also observed (Bonneau and Weiler, 2019; Škrlep et al., 2020). A disadvantage of rearing entire males is the risk of boar taint. The compounds responsible are androstenone and skatole. Androstenone, the main component of boar taint, is produced by the testes during sexual maturation and acts as a sex pheromone regulating female behaviour and reproductive development. It was first described by Patterson as a cause of sex odour (Skrzypczak et al., 2011). Skatole, in turn, is produced by bacterial metabolism of tryptophan in the large intestine. Despite evidence that surgical castration is painful for animals at any age, it still predominates in most European countries. Increasingly, however, this surgical procedure is being questioned from an animal-welfare perspective (Fredriksen et al., 2011). In countries such as Spain, Ireland, the United Kingdom and Portugal, boars are slaughtered before reaching sexual maturity and at body weights below 100 kg (Weiler and Bonneau, 2019). In this way, producers reduce the risk of boar taint in meat.

The rearing of gilts in large-scale pig production also has advantages and disadvantages. Female carcasses have a 2–3% higher lean meat percentage than barrow carcasses and a higher dressing percentage (Nałęcz-Tarwacka, 2006), but gilts show lower daily growth rates. Over the years, a number of factors affecting pork quality have been identified. The fatty acid composition of meat may influence fat quality and oxidative stability. The FA profile can be modified by diet, which affects carcass fatness (Świątkiewicz et al., 2021; Wood et al., 2004). Pauly et al. (2012) showed that concentrations of saturated fatty acids were lower and concentrations of polyunsaturated fatty acids were higher in entire males than in gilts and immunocastrates. In view of the above, the present study examined whether sex affects meat quality and the fatty acid profile of DanBred hybrid pigs. These animals play an increasingly important role in improving production efficiency. Their origin was selected because DanBred pigs are becoming increasingly common on large commercial farms in Poland.

Material and methods

The experimental material consisted of longissimus dorsi muscle samples obtained under commercial conditions from 10 gilts and 10 entire DanBred hybrid males. All animals originated from the same breeding farm and were transferred to a finishing farm for the fattening period. During fattening, the pigs were housed in a slatted-floor system and fed ad libitum according to the recommendations of Schothorst Feed Research (SFR). Continuous access to water was provided. A four-phase feeding programme was used:

– Finisher 1 feed mixture was intended for pigs with a body weight of 23–43 kg,
– Finisher 2 was intended for pigs with a body weight of 43–63 kg,
– Finisher 3 was intended for pigs with a body weight of 63–85 kg,
– in the final stage of fattening, the animals were fed the complete Finisher 4 feed mixture. The ingredient and chemical composition of the diets is presented in Tables 1 and 2.

Table 1. Composition of feed mixtures

Ingredients	Finiszer 1	Finiszer 2	Finiszer 3	Finiszer 4
Triticale (%)	45,00	40,00	28,27	37,74
	0,00	5,00	20,00	15,00
Barley (%)	15,00	10,00	10,00	
Rye (%)	11,79	18,69	10,00	15,00
	0,00		10,00	10,00
Soybean meal [46%] (%)	9,00	10,00	12,00	13,00
	8,34	4,73	1,50	0,00
Sunflower oil (%)	4,00	4,00	3,00	2,31
	3,03	2,54	2,72	2,65
Wheat bran (%)	0,00	2,00	0,00	2,00
Ground limestone (%)	1,17	1,02	0,89	0,83
Liquid lysine 50% (%)	0,79	0,80	0,71	0,70
Poultry haemoglobin (%)	0,50	0,00	0,00	0,00
Salt (%)	0,48	0,48	0,35	0,35
Monocalcium phosphate (%)	0,26	0,10	0,10	0,00
Premix Grower/Finisher 0.2% (%)	0,20	0,20	0,18	0,13
Threonine [L 98%] (%)	0,17	0,16	0,14	0,16
Magnesium oxide (%)	0,10	0,10	0,00	0,00
Methionine [DL 99%] (%)	0,09	0,08	0,05	0,04
ROVABIO EXCEL AP 10 (%)	0,05	0,05	0,05	0,05
Optiphos 5000 Plus CT (%)	0,02	0,02	0,02	0,02
Tryptophan [L 98%] (%)	0,02	0,02	0,01	0,01
Valine (%)	0,00	0,01	0,00	0,00

Table 2. Chemical composition of feed mixtures

Nutrients	Finiszer 1	Finiszer 2	Finiszer 3	Finiszer 4
Crude protein (g/kg)	169,707	154,422	142,474	138,878
Crude fibre (g/kg)	39,082	40,052	38,916	38,362
Crude fat (g/kg)	47,487	44,653	43,847	45,000
Crude ash (g/kg)	47,588	43,914	39,778	36,964
Lysine (g/kg)	11,198	10,110	9,106	8,737
Methionine (g/kg)	3,671	3,376	2,980	2,861
Calcium (g/kg)	6,909	6,084	5,499	5,020
Phosphorus (g/kg)	4,809	4,492	4,367	4,243
Sodium (g/kg)	2,000	2,000	1,500	1,500
Starch (g/kg)	423,015	445,708	457,103	467,739
Moisture (%)	119,647	121,496	124,277	124,788

After reaching the body weight desired by the meat-processing plant, the animals were sent for slaughter, which was performed in accordance with the applicable procedures. Lean meat percentage was measured on warm hanging right half-carcasses using a SYDEL CGM ultrasonic device. After 24 h of carcass chilling, muscle tissue pH24 was measured using a WTW 340 pH meter fitted with a Hamilton Double Pore combination glass electrode. The electrode was calibrated with standard solutions of pH 4.01 and 7.00 at 20°C. Calibration was checked at the beginning of and during the measurements.

Colour was measured on the cross-section of the longissimus dorsi muscle in the CIE L*a*b* system. The surface colour of meat samples was determined using a spectrophotometer (MiniScan XE Plus, Hunter Lab; 31.8-mm aperture, 10° observer, D65 illuminant). The instrument was calibrated before measurements using white and black calibration tiles. The parameters were measured over a wavelength range of 400–700 nm at a resolution of 10 nm. Colour parameters were described according to the L*a*b* standard, and mean spectral distributions at selected measurement points were analysed statistically. In the collected longissimus dorsi muscle (musculus longissimus dorsi – m.l.d.) samples, dry matter, total protein (Kjeldahl method), crude fat (Soxhlet extraction without hydrolysis) and crude ash (AOAC, 2007) were determined.

Fat was extracted by the Soxhlet method (AOAC, 2007). Fatty acids were separated and determined by gas chromatography. Fatty acid methyl esters (FAME) were prepared according to the modified Peisker method (methanol:chloroform:concentrated sulphuric acid, 100:100:1, v/v) (Żegarska et al., 1991). The resulting FAME were stored in tightly sealed tubes and analysed by gas chromatography with flame ionisation detection (GC-FID; column: 50 m × 0.25 mm × 0.25 μm). The GC injection port temperature was set at 225°C in split mode (split ratio 50:1), with helium as the carrier gas at a constant flow rate of 1.2 ml min−1. The detector temperature was 250°C and the column temperature was 200°C. Fatty acids were identified by comparing their retention times with pure FAME standards (Sigma-Aldrich, St. Louis, Missouri, USA) and peaks in the analysed samples. The relative FA content was expressed as a percentage of the total peak area of all FA detected in each sample.

The collected data were subjected to statistical analysis. One-way analysis of variance was performed, and the significance of differences between means was determined using Duncan's test and verified at two significance levels, $p \leq 0.05$ and $p \leq 0.01$. The results were analysed statistically using Statistica PL 13.5.

Results

During fattening, the animals were fed feed mixtures whose main ingredients were cereals and protein components, namely extracted rapeseed meal and soybean meal (Table 1). The chemical composition met the nutrient requirements of each age group (Table 2). Table 3 presents the physicochemical analysis of the longissimus dorsi muscle of boars and gilts. Carcass lean meat percentage was higher in females. The difference between the sexes was 1.44%, but this trend was not statistically confirmed. Analysis of the basic chemical indices of meat (percentage contents of dry matter, protein, crude fat and ash) showed higher values in gilts. The degree of muscle tissue acidification did not differ according to sex and amounted to 5.22. Measurement of pH24 makes it possible to identify the occurrence of the DFD defect in meat. According to Pospiech (2000), this defect occurs when the value exceeds 6.3. The values obtained excluded the occurrence of this defect.

Meat colour is an important parameter in consumer assessment of meat and is also affected by other quality traits (Myung-Hwa et al., 2013). In the present study, meat from boars was darker than meat from gilts. Redness (a*) was lower in gilts, whereas yellowness (b*) was lower in boars.

Table 3. Slaughter value of carcasses and physicochemical analysis of the longissimus dorsi muscle

Parameters	Boars	Gilts
Carcass lean content (%)	59,65	61,09
Cold carcass weight (kg)	96,33	98,33
Dry matter (%)	26,34	26,52
Protein (%)	22,32	22,62
Crude fat (%)	2,91	3,11
Crude ash (%)	1,14	1,12
pH24	5,22	5,22
Meat colour L	 61,34	 63,45
a*	3,18	2,84
b*	13,08	13,41

Table 4. Fatty acid profile of the longissimus dorsi muscle of pigs (g/100 g total fatty acids)

Specification	Boars	Gilts
C 10:0	0,119[a]	0,061[b]
C 12:0	0,110	0,106
C 14:0	1,629	1,611
C 14:1	0,019	0,022
C 15:0	0,048[A]	0,030[B]
C 16:0	28,71	29,34
C 16:1	3,156[B]	3,719[A]
C 17:0	0,209[A]	0,123[B]
C 17:1	0,221[A]	0,155[B]
C 18:0	15,37	15,34
C 18:1	39,62[A]	41,76[B]
C 18:2	8,487[A]	5,745[B]
C 18:3	0,461[A]	0,246[B]
C 20:0	0,211	0,213
C 20:1	0,725	0,717
C 20:2	0,356[A]	0,245[B]
C 20:4	0,519	0,537
C 22:0	0,021	0,014
SFAs	46,43	46,84
UFAs	53,57	53,15
MUFAs	43,74[B]	46,38[A]
PUFAs	9,823[A]	6,775[B]
n-3 PUFAs	0,461[A]	0,247[B]
n-6 PUFAs	9,362[A]	6,528[B]
DFAs=UFAs+C18:0	68,94	68,49
OFAs=C14:0+C16:0	31,06	31,50

A, B – Means within rows marked with different letters differ significantly at p≤0.01.
a, b – Means within rows marked with different letters differ significantly at p≤0.05.

The nutritional value of pork depends on the chemical composition of the carcass, particularly the content of fats and fatty acids (FA), which not only have health-promoting properties but also beneficially affect the composition of meat and meat products (Čandek-Potokar and Škrlep, 2012). The content of individual chemical components varies according to species, sex, feeding system and feeds used, as well as the anatomical location of a given muscle within the carcass. Table 4 presents the fatty acid profile of the longissimus dorsi muscle. In the m.l.d. of gilts, a statistically significantly higher content of capric acid was found than in boars. Highly significantly higher levels of unsaturated fatty acids, including the monounsaturated oleic acid and polyunsaturated fatty acids from both the n-3 family (α-linolenic acid, eicosapentaenoic acid – EPA, and docosahexaenoic acid – DHA) and the omega-6 family (linoleic acid), were observed in meat obtained from boars. A highly significantly lower content of margaric acid was also found in boars than in gilt carcasses. Gilt carcasses were characterised by a more desirable and highly significantly higher proportion of monounsaturated fatty acids (MUFA) than entire males. The proportion of polyunsaturated fatty acids (PUFA) was highly significantly higher in boars than in gilts. The contents of n-3 and n-6 fatty acids also differed highly significantly between boars and females. No relationship was recorded between sex and the content of DFAs (neutral and hypocholesterolaemic fatty acids) or OFAs (hypercholesterolaemic fatty acids) in muscle tissue.

Discussion

Because only a small number of farms keep DanBred gilts and entire males, the scientific literature provides little information on the meat quality of these animals. Therefore, further research in this area is justified.

Pork consumption is controversial because many consumers consider pork to be a fatty meat. It should be noted, however, that genetic selection has produced animals with a high proportion of lean meat in the carcass. Crude fat content averages 18.06% at a carcass weight of 80.1–85 kg. Depending on the EUROP commercial class, the amount of this chemical component is, respectively: class E – above 12%, and class U – 24–26% (Krzęcio-Nieczyporuk, 2015).

In the present study, 20% of carcasses were classified as class S, in which crude fat content is the lowest. Irrespective of sex, the carcass lean meat percentage obtained in the present study was higher than the value reported in Poland during the same period, which amounted to 58.9% (Integrated Agricultural Market Information System, 2023).

The content of individual analytical components varies according to the anatomical location of a particular muscle. Meat quality in relation to the breeds of pigs kept in Poland has been compared in many studies (Szulc et al., 2012; Szulc and Skrzypczak, 2015), although sex was not considered as a criterion. These studies mainly analysed the basic chemical composition of the muscle. One of the analysed parameters was protein content. In the present study, the value of this parameter was similar irrespective of sex (a difference of 0.3%). Kozera et al. (2023), studying the effect of sex on meat quality in DanBred pigs, obtained similar protein contents in the longissimus dorsi muscle, ranging from 22.47% in immunocastrated males to 22.78% in barrows. With regard to breed, the highest crude protein content was reported for Złotnicka Spotted pig carcasses (24.57%) (Szulc et al., 2012), and the lowest for Polish Landrace pigs (21.80%) (Florowski et al., 2006). Even higher carcass protein contents were recorded in Polish Landrace × Polish Large White and Polish Landrace × (Duroc × Pietrain) crossbreds, amounting to 23.76% and 24.01%, respectively.

Another analysed trait was crude fat content, which was similar to the results obtained by Kozera et al. (2023) for barrows and immunocastrated males. It was also very close to the value reported in Złotnicka pigs. Florowski et al. (2006) obtained the following results: Polish Landrace – 1.30%, and Złotnicka Spotted – 3.10%.

Crude ash content in the longissimus dorsi muscle did not differ significantly according to sex and was comparable with values reported for Polish breeds, e.g. Polish Landrace – 1.2% (Florowski et al., 2006). The pH value and colour differed from those reported for other breeds or their crossbreds. The collected longissimus dorsi muscle samples were more acidified than those of Polish Landrace × Polish Large White and Polish Landrace × (Pietrain × Duroc) crossbreds (pH above 6). With regard to colour, it can be stated that DanBred pig muscle tissue had higher L values irrespective of sex.

Choosing lean pork is beneficial in the prevention of atherosclerosis and ischaemic heart disease. Pork contains relatively few trans isomers of unsaturated fatty acids, which have a stronger atherogenic effect than saturated fatty acids. They increase total cholesterol and its LDL fraction while reducing the desirable HDL fraction. A very important aspect of the quality of animal-derived raw materials is the content of essential unsaturated fatty acids. These fats are required for normal body function but are not synthesised in the body and therefore must be supplied in the diet. Longissimus dorsi samples collected from gilts contained more oleic acid, representing the monounsaturated fatty acids. By contrast, the loin from boar carcasses contained more polyunsaturated fatty acids, with the exception of arachidonic acid. Comparison of the present results with those of Grześkowiak et al. (2010) shows that the muscles of Polish Landrace × Polish Large White and Polish Landrace × (Pietrain × Duroc) crossbreds contained more oleic, linoleic and α-linolenic acids but less arachidonic acid.

The content of saturated fatty acids did not differ significantly according to sex (difference of 0.31%). Samples from boar muscle contained less SFA. Animals of Polish breeds were characterised by lower contents of this group of fats. UFA content also did not differ significantly and exceeded 53% irrespective of sex. Higher values were reported by Grześkowiak et

al. (2010) and Czech et al. (2015). In the cited studies, meat from (Polish Landrace × Polish Large White) × Polish Landrace fattening pigs contained 60.01% unsaturated fatty acids. Pork also contained 26% more UFA than beef. However, the highest content of this group of fats was found in poultry meat (Czech et al., 2015).

Summary and conclusions

1. Although gilts were characterised by a higher carcass lean meat percentage, the difference was not statistically significant;
2. Muscle tissue acidity (pH24) was the same irrespective of sex – 5.22. This value excludes the occurrence of the DFD defect;
3. Longissimus dorsi muscle samples collected from gilts were characterised by higher contents of the basic chemical components, except ash;
4. Statistically confirmed differences between the sexes of fattening pigs were found in the fatty acid profile;
5. Meat from boars was characterised by a higher UFA content;
6. Further research on the effect of sex on pork quality is warranted.

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SUMMARY

The aim of the study was to determine the effect of sex on individual quality and fatty acid (FA) profile in DanBred hybrid pigs. *Longissimus dorsi* (LD) muscle samples were collected from gilts and entire male pigs. Gender was used as the criterion of selection. During the fattening period, animals were kept separately in group pens and fed with complete feed mixtures. Four-phase feeding was used. Feed and water were available *ad libitum*. The slaughter was carried out in accordance with applicable regulations. *Longissimus dorsi* muscle samples were taken from the right half-carcass from the lumbar section between the 3rd and 4th vertebrae. The pH24 value was measured with a pH-meter and the meat colour was measured in the CIE L*a*b system. The following were measured: dry matter, crude protein (Kjeldahl method), crude fat (Soxhlet method) and ash contents (AOAC, 2007) as well as FA profile of the meat. The fatty acids were separated by gas chromatography. Fatty acid methyl esters (FAME) were prepared according to various Peisker methods. Fatty acids were identified by comparing their retention times with pure FAME standards (Sigma-Aldrich, St. Louis, Missouri, USA) and peaks in the analyzed samples. The degree of acidification did not differ by gender. Higher carcass meat percentage was noted for gilts. *Longissimus dorsi* muscle samples from gilts were characterized by a higher content of basic chemical components. Significant and highly significant differences between the sexes of the animals and the fatty acid profile were found.

Keywords: fatty acids, chemical composition, fatteners, sex, DanBred