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Effect of restricted feeding and realimentation periods on pork quality and fatty acid profile of *M. longissimus thoracis*

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ABSTRACT

An experiment with 94 fattening pigs (48 gilts and 46 barrows) was conducted to determine the effect of feeding 25% restricted diets at different body weights on meat quality and fatty acid profile of *M. longissimus thoracis* (LT). During the 84 days of the experiment (4 periods, 21 days each), animals with an initial weight of about 31 kg were fed in different periods of observation *ad libitum* (A) or restricted diets (R) in groups AAAA, AARA, RAAA and RARA. After 21 days of the experiment, the restricted-fed pigs, compared to those fed *ad libitum*, had a lower total fat content of *M. longissimus thoracis* ($P<0.05$), higher shear force ($P=0.068$), and lower proportions of SFA (C14:0, C18:0 $P<0.05$) and MUFA and higher proportions of PUFA (C20:4, C22:4 $P<0.05$) in the fatty acid profile. Three weeks after the restricted feed supply was lifted, the total fat content in LT muscle was higher than in animals fed *ad libitum* throughout (2.34 vs. 2.02), very close after the next 3 weeks of realimentation (3.16 vs. 3.15) and lower after another 3 weeks (3.19 vs. 3.49). Regardless of the time at which restricted feeding was started and the number of restricted feeding periods, the total fat content in the LT muscle at the end of the experiment was similar or lower in groups RAAA, AARA and RARA, compared to group AAAA. The coefficient of correlation between the total fat content in LT and the shear force was −0.36 ($P<0.01$). Colour, pH and drip loss did not depend on the level of nutrition. After 84 days of observation, animals from groups RARA and AARA, compared to pigs from groups AAAA and RAAA, were characterized by a slightly higher shear force of LT, lower SFA and MUFA ($P<0.001$), and higher n-6 PUFA ($P<0.01$) and n-3 PUFA ($P<0.01$) proportions in the fatty acid profile. The fatty acid profiles of AAAA pigs and pigs undergoing a 63-day realimentation period (RAAA) were similar. Regardless of the feeding scheme, the n-6:n-3 ratio exceeded 10 in all the groups.

1. Introduction

The main aim of pig production is a good balance between growth of the animals and meat quality. Research results to date have shown that pork quality can be modified in many ways. However, it is difficult to obtain pork that shows good technological and health-promoting qualities while also having a good taste (Riley, Enser, Nute, & Wood, 2000; Lebret, 2008; Więcek, Rekiel, & Skomiał, 2010). In addition to the genetics, product quality is also considerably influenced by the level of nutrition (Mason, Hogan, Lynch, O'Sullivan, Lawlor & Kerry, 2005; Skiba, 2010; Więcek et al., 2010).

Pigs fed below requirements are characterized by lower total carcass fatness and lower amount of intramuscular fat (IMF) (Kristensen et al., 2002; Mason et al., 2005; Skiba, 2010; Więcek et al., 2010), although it should be noted that considerable differences may also result, among others, from different muscle type (Bee, Calderini, Biolley, Guex, Herzog & Lindemann, 2007; Więcek, 2009). Greater accretion of fat in addition to greater deposition of protein is also reported in animals switched from restricted intake (Skiba, 2010). If the amount of deposited protein decreased during restricted feeding, the protein level will be restored in the first place during realimentation, even at the cost of fat deposition. The final chemical composition of the body depends on the duration of realimentation (Hornick, van Eenaeme, Gérard, Dufrasne, & Istasse, 2000).

According to Stolzenbach et al. (2009), the level of nutrition and the amount of fat deposition have an effect on meat tenderness, these factors being independent of each other. Kristensen, Therkildsen, Aaslyng, Oksbjerg, and Ertbjerg (2004) showed that compensatory growth after a period of feed restriction improves meat tenderness but only in gilts. Heyer and Lebret (2007) reported that a restriction/compensatory growth strategy considerably reduces intramuscular fat content without improving meat tenderness and juiciness.

The level of nutrition influences not only the amount of deposited fat but also its fatty acid profile. Daza, Rey, Menoyo, Bautista, Olivares and López-Bote (2007) demonstrated that inadequate supply of dietary energy lowers the activity of lipogenic enzymes, resulting in

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limited synthesis of saturated and monounsaturared fatty acids, which increases the proportion of unsaturated acids in their overall profile. Several authors (Mason et al., 2005; Daza et al., 2007; Więcek et al., 2010) reported inconsistent results regarding the effect of level of nutrition on the fatty acid profile. These differences were due to the level of restricted feeding and the type of tissues and lipids in which the fatty acid profile was determined.

The desirable ratio of PUFA to SFA is at least 0.4 and n-6:n-3 below 4 (Wood et al., 2003). Pork is characterized by a nutritionally undesirable profile of fatty acids. Polyunsaturated fatty acids cannot be synthesized in the pig's body and have to be supplied through diet in the parent form, i.e. as linoleic and linolenic acids (Enser, Richardson, Wood, Gill, & Sheard, 2000). Every effort aimed at improving the fatty acid profile of pork is justified on health grounds.

In studies on restricted feeding and compensatory growth, the period of limited feed intake was introduced once, most often during the initial stage of fattening (Kristensen et al., 2004; Heyer & Lebret, 2007; Skiba, 2010; Więcek et al., 2010). In the literature there are no references to the response of animals to feed restricted several times during fattening.

Results of this experiment can show if the changes in feed intake at different stages of growth affect the quality of pork.

The aim of this study was to determine the effect of restricted feeding at different stages of fattening and duration of realimentation period on pork quality and fatty acid profile of *M. longissimus thoracis*.

2. Materials and methods

2.1. Animals, experimental design and diets

The experiment design was accepted by the Local Ethical Commission. The experiment was carried out with 94 fattening pigs (48 gilts and 46 barrows; Polish Landrace × Polish Large White sows and Duroc boars). The initial body weight of the animals was 30.7 ± 2.8 kg. The experiment lasted 84 days (4 periods of 21 days each).

Animals were fed individually: *ad libitum* (A) or restricted diets (R) in different periods (Table 1). The restriction was to reduce the level of nutrition by 25% compared to the animals fed *ad libitum*. Pigs fed restricted diets started the experiment 3 days later than those fed *ad libitum*. During these days the feed intake was controlled and the restriction was calculated and applied for R group animals. In the first period 47 fatteners were fed *ad libitum* (groups AAAA and AARA) and other 47 restrictively (groups RAAA and RARA). After the first period of 21 days 7 fatteners fed *ad libitum* and 7 fed restrictively (4 gilts and 3 barrows) were slaughtered. The remaining 80 (gilts: barrows, 1:1) were fed *ad libitum* for the next 3 weeks and then from each group of animals fed according to the AA and RA regimen 8 pigs (gilts: barrows, 1:1) were slaughtered. The remaining 64 fatteners were fed again *ad libitum* or restrictively to achieve feeding sequences AAA, AAR, RAA, and RAR, and after 3 weeks 8 pigs from each group were slaughtered (total 32 fatteners). In the last period the remaining animals were fed *ad libitum* and after 3 weeks slaughtered.

In the experiment, two diets were used: grower diet from 1 to 42 days and finisher diet from 43 to 84 days (Table 2).

Table 1
The experimental design.

Period/days of experiment	Method of feeding[a]			
I/1–21	A	A	R	R
II/22–42	A	A	A	A
III/43–63	A	R	A	R
IV/64–84	A	A	A	A
Symbol of group	AAAA	AARA	RAAA	RARA

[a] A— *ad libitum*, R — restricted.

Table 2
Ingredients and chemical composition of the experimental diets.

	Diet	
	Growing period	Finishing period
Ingredients (%)		
Ground wheat	40.85	44.00
Ground barley	44.29	36.73
Wheat bran	–	7.00
Soyabean meal	12.20	10.00
L-lysine	0.25	0.20
DL-methionine	0.03	–
L-threonine	0.01	–
Limestone	1.47	1.25
Salt	0.40	0.32
Premix[a]	0.50	0.50
Chemical composition		
Metabolisable energy (MJ kg^{-1})	13.0	13.0
Crude protein (g kg^{-1})	172	157
Ether extract (g kg^{-1})	24.7	25.1
Crude fibre (g kg^{-1})	41.3	41.4

[a] Premix contained per kg (diet for growing period, values in parentheses refer to diet for finishing period): 1 800 000 (1 600 000) IU vit. A; 400 000 (300 000) IU vit. D_3; 6 000 (6 000) mg vit. E; 300 (200) mg vit. B_1; 700 (600) mg vit. B_2; 400 (300) mg vit. K; 600 (400) mg vit. B_6; 4 (3) mg vit. B_{12}; 4 (2) mg biotin; 4 009 (4 009) mg niacin; 50 (50) mg folic acid; 3 000 (2 000) mg calcium pantothenate; 12 000 (6 000) mg choline; 278 (285) g Ca; 3 (3) g Mg; 8 000 (8 000) mg Mn; 17 000 (17 000) mg Zn; 100 (100) mg Co; 60 (60) mg Se; 4 000 (4 000) mg Cu; 20 000 (20 000) mg Fe; 200 (100) mg I; 14 000 (8 000) mg betaine.

2.2. Measurements, sample collection and analysis

Slaughter of fattening pigs was consistent with the current meat industry practices using electrical stunning. Right half-carcasses were used for the measurements and determinations. Measurement of pH was performed 45 min and 24 h postmortem using a Hanna HI-98240 pH meter (Hanna Instruments) with an FC 231D puncture electrode. After 24-h chilling of carcasses (4 °C), a section of *Longissimus thoracis* (LT) was collected from the area of penultimate thoracic vertebra in the cranial direction to determine colour, drip loss, shear force, chemical composition and fatty acid profile.

Colour (L^* lightness, a^* redness, and b^* yellowness) was measured with a Minolta CR-200 chroma meter at five locations in a 2-cm slice of LT muscle. The values obtained were averaged.

Samples of LT muscle were weighed (approx. 300 g), sealed in a polyethylene bag and maintained under cold storage conditions (4 °C) for 24 h, after which time the exudate was collected and the amount of drip loss was expressed as a percentage of initial muscle weight.

For the shear test a Zwick 1120 tensile tester was used. Muscle samples weighing about 150 g were immersed for 24 h in a 1% NaCl solution under cold storage conditions (4 °C). After this time, samples were removed from the brine, immersed for 30 s in boiling water to denature meat surface layers and baked at 180 °C. Heat treatment was continued until the internal temperature in the geometric centre of the sample reached 76 °C. Ten minutes after reaching the desired temperature, the samples were removed from the oven, cooled at room temperature, and maintained under cold storage conditions (4 °C) for 24 h. Shear force was determined at room temperature using rectangular samples with a square cross-section (20 × 20 mm) and a Warner–Bratzler shear machine. Determinations were made perpendicular to the muscle fibres until the sample was cut completely. The result was the maximum force needed to shear the sample. Cross-head speed was 30 mm/min until an initial tension of 2 N was obtained and 50 mm/min during the test proper.

Chemical composition of the muscle was determined according to AOAC methods (2005). Dry matter was determined after the samples were dried in a laboratory drier (105 °C to constant weight). Protein and fat contents of LT were determined by Kjeldahl and Soxhlet methods respectively.