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In large litters birth weight and gender is decisive for growth performance but less for carcass and pork quality traits

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ABSTRACT

This study aimed to examine whether growth performance, carcass and meat quality traits differed among high (H), medium (M) and low (L) birth weight (BtW) gilts and barrows born from large litters (>16 piglets born alive). Regardless of gender, H pigs grew faster ($P<0.05$) during the suckler period than L and M pigs. From weaning to slaughter at 113 kg catch-up growth was observed in M barrows. In gilts and barrows percentage ham was greater ($P<0.05$) and percentage total subcutaneous fat was lower ($P<0.10$) in H compared to M and L pigs. Compared to L and M pigs, H pigs displayed in general better quality in the longissimus muscle whereas the opposite was observed in the semitendinosus muscle. The superiority of H compared to M and L BtW littermates regarding carcass and meat quality appears to be less evident when pigs originate from large litters.

1. Introduction

Current breeding strategies place great emphasis on the number of piglets born per litter because of the perception that greater litter size equals greater profit. However, there is clear evidence that with increasing litter size the average birth weight (BtW) decreases and the proportion of low BtW pigs markedly increases (Quiniou, Dagorn, & Gaudré, 2002). Compared to smaller litters (≤10 piglets), it was found that low and medium but not high BtW piglets originating from larger litters (≥14 piglets) were markedly lighter (Bérard, Kreuzer, & Bee, 2008). One explanation for this finding is that compared to pigs from small litters prenatal development of offspring from larger litters is impaired to a greater extent by intra uterine crowding (Foxcroft et al., 2006; Town, Putman, Turchinsky, Dixon, & Foxcroft, 2004). Recent results showed that low BtW negatively affects postnatal growth of pigs, their carcass composition at slaughter and to some extent pork quality (Gondret, Lefaucheur, Juin, Louveau, & Lebret, 2006; Rehfeldt, Tuchscherer, Hartung, & Kuhn, 2008). However, Bérard et al. (2008) found only small effects of BtW on these traits when using Swiss Large White barrows originating either from larger or small litters. In the latter, different from the aforementioned studies, only barrows were used and it has been suggested that the impact of BtW on postnatal growth and body fatness was more pronounced in female than male pigs (Poore & Fowden, 2004). Furthermore, current data suggest that BtW effects on muscle characteristics and pork quality differ among muscles (Bérard et al., 2008; Gondret et al., 2005). Thus, in this study the impact of BtW and gender on growth performance, carcass traits and technological as well as sensory pork quality of two muscles was assessed. Because it was hypothesized that the effects of interest were affected by intra uterine crowding and would be therefore more pronounced in large litters only offspring originating from litters with more than 16 pigs born alive were considered.

2. Materials and methods

2.1. Animals and treatments

All procedures involving animals were approved by the Swiss Cantonal Committee for Animal Care and Use.

A total of 60 Swiss Large White pigs originating from 10 litters with a litter size of >16 piglets born alive were used (mean ± s.e. number of pigs alive = 18.0 ± 1.75). From each litter and gender one light (L) < 1.2 kg, one heavy (H) > 1.6 kg, and one medium with BtW around 1.4 kg (M) were selected at birth. Piglets with a BtW lower than 800 g were excluded because they were considered runts. Male piglets were castrated within 4 d of birth. During the experiment 1 L and 1 M gilt died. From weaning (35 d of age; mean ± s.e. body weight (BW) = 9.5 ± 0.49 kg) through to slaughter (113 kg BW) females and barrows were individually penned (2.6 m^2/pig) on a concrete floor in an environmentally controlled building (22 °C and 60–70% relative humidity). They had

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free access to standard starter (9.5–28 kg BW), grower (28–63.5 kg BW) and finisher diets (63.5–113 kg BW) (Table 1). Feed analysis for proximate contents were quantified according to AOAC (1995). The BW and total feed intake were determined weekly.

During 1 wk in the grower and 1 wk in the finisher period, 4 g/kg of Cr_2O_3 were mixed into the respective diets as an undigestible marker. In these wk, over 5 d, about 100 g of feces were collected daily from each pig. The feces were pooled, dried at 60 °C for 48 h and ground (1 mm sieve). Gross energy was determined in the feed and the feces using an adiabatic bomb calorimeter. The Cr_2O_3 concentration was determined in the diets and feces by inductively coupled plasma optical emission spectrometry (ICP-OES) using an Optima 2000 DV ICP-OES (PerkinElmer Waltham, Massachusetts, USA) after samples had been dry-ashed at 550 °C for 4 h and mineralized at 340 °C for 15 min with 4 ml of 4.5% $KBrO_4$ and 3 ml of 80% H_3PO_4. Digestibility of energy (dE) was calculated.

2.2. Slaughter procedure and carcass measurements

Feed was withheld from the pigs 15 h before they were walked in groups (100 m) to the research station abattoir, which is equipped with a CO_2 stunner (MPS meat processing systems Lichtenvoorde, The Netherlands). The pigs were stunned with a gas mixture of 87% CO_2 and 13% air for 100 s. Subsequently they were exsanguinated, scalded, mechanically de-haired and eviscerated. Thirty min after exsanguination, the hot carcass weights as well as the weights of the heart, liver and kidney were assessed. Dissection of the left carcass sides at 1 d postmortem (pm) were carried out as described previously (Bee, Gebert, & Messikommer, 2002).

Table 1
Ingredient and nutrient composition of the starter, grower and finisher diets.

Item	Starter diet	Grower diet	Finisher diet
Ingredient composition, g/kg			
Barley	287.4	68.0	100.0
Corn	60.0	140.0	140.0
Wheat	474.0	436.0	494.0
Dried sugar beet pulp	16.0	100.0	100.0
Soybean meal	4.0	236.0	146.0
Potato protein	85.0	–	–
Rapeseed	24.0	–	–
NaCl	4.3	3.0	3.2
Dicalcium phosphate	15.5	0.9	2.2
Calcium carbonate	–	7.3	7.0
Calcium formate	14.2	–	–
L-lysine HCl	5.3	1.4	1.5
DL-Methionine	1.1	0.2	–
L-Threonine	1.5	0.3	–
L-Tryptophan	0.7	–	–
Vitamin-mineral-premix[a]	4.0	4.0	4.0
Pellan[b]	3.0	3.0	3.0
Analyzed chemical composition, g/kg DM			
Total ash	53	50	45
Crude fiber	28	50	47
Crude protein	173	209	180
Ether extract	37	27	25
NFE[c]	708	664	703
Calculated nutritional value			
DE, MJ/kg DM	16.1	15.6	15.6

[a] Supplied the following nutrients per kilogram of diet: 20,000 IU of vitamin A, 200 IU of vitamin D_3, 39 mg of vitamin E, 2.9 mg of riboflavin, 2.4 mg of vitamin B_6, 0.01 mg of vitamin B_{12}, 0.2 mg of vitamin K3, 10 mg of pantothenic acid, 1.4 mg of niacin, 0.48 mg of folic acid, 199 g of choline, 0.052 mg of biotin, 52 mg of Fe as $FeSO_4$, 0.16 mg of I as $Ca(IO)_3$, 0.15 mg of Se as Na_2Se, 5.5 mg of Cu as $CuSO_4$, 81 mg of Zn as ZnO_2, and 15 mg of Mn as MnO_2.
[b] Binder that aids in pellet formation (Mikro-Technik, GmbH & Co. KG, Germany).
[c] Nitrogen-free extract, calculated as DM – total ash – crude protein – ether extract – crude fiber.

2.3. Morphometric muscle and meat quality measurements

In the longissimus dorsi muscle (LM), pH and temperature were determined 30 min pm, using a pH meter (WTW pH197-S, WTW, Weilheim, Germany) equipped with a Eb4 electrode (WTW, Weilheim, Germany). Measurements were done at the 10th rib level of the right carcass side by insertion of the pH and temperature probe between the ribs from the inside of the carcass. Furthermore, a chop was collected for the determination of the loin eye area. In addition, the semitendinosus muscle (ST) of the right carcass side was excised 30 min pm and the weight and girth determined. Subsequently, the pH as well as temperature was measured in the dark portion of the ST (ST_{dark}).

At 24 h pm the LM (10 to 13th rib level) and the ST of the left carcass were excised and the pH was determined at the 10th rib level and in the ST_{dark}, respectively. Subsequently, six 1.5-cm thick LM chops without subcutaneous adipose tissue were prepared and labelled A, B, C, D, E and F. Two longitudinal slices of the ST_{dark}, weighing approximately 70 g each, were prepared and labelled G and H. From the LM chops labelled A and C and from the ST_{dark} labeled G, drip loss was determined as the amount of purge formed during storage at 4 °C for 48 h (Honikel, 1998). From the LM chops B and D and the ST_{dark} sample H, light reflectance coordinates (L*: lightness, a*: redness and b*: yellowness) of the muscle surface were determined in triplicates following 10 min blooming, using a Chroma Meter CR-300 with a D65 light source (Minolta, Dietikon, Switzerland). After colour measurements were made, samples B, D and H were vacuum-packed and stored at −20 °C until Warner Bratzler shear force measurements were performed.

Frozen samples were thawed for 24 h at 2 °C and then weighed to determine thaw loss. Afterwards, samples were kept at room temperature for 1 h, weighed and cooked on a preheated (190 to 195 °C) grill plate (Beer Grill AG, Zurich, Switzerland) to an internal temperature of 69 °C. Samples were then re-weighed to calculate cooking loss. Finally, shear force was determined using a Stable Micro System TA.XT2 Texture Analyzer (Godalming, Surry, UK) equipped with a 2.5-mm-thick Warner-Bratzler shear blade. Chops E and F and 2 slices of the light portion of the ST (ST_{light}) were vacuum-packed and aged for 48 h at 4 °C. Subsequently the LM and ST_{light} samples were stored at −20 °C for sensory analysis.

2.4. Sensory analysis

The day prior to analysis, LM and ST_{light} samples were thawed for 24 h at 2 °C. Samples were then kept at room temperature for 1 h and cooked as described for shear force measurements. After removing the borders, 6 rectangular samples (approximately $1 \times 1 \times 2$ cm) were prepared from the middle of each chop and ST_{light} slice. Ten sessions each for the LM and for the ST_{light} were carried out always serving 1 cooked sample per BtW group and gender (total of 6 animals per session). The sensory test was carried out by a trained 8 member panel. Prior to the testing, panellists were trained using pork originating from pigs of the same genetic background as the present study, which were raised under the same conditions and fed similar diets. Tenderness, juiciness and perception of specific pork flavor were scored on a continuous scale from 0 (tender, low, absent) to 10 (tough, high, strong) using the Fizz Network data acquisition system and software (Version 2.0, Biosystems, Couternon, France).

2.5. Statistical analysis

Data were analyzed using the MIXED procedure of SAS (version 9.1 Inst. Inc., Cary, NC). The statistical model included BtW, gender, and the BtW × gender interactions as fixed and litter as random effects. For the sensory analysis panellists were additionally included as a random effect. Least square means were compared using the PDIFF option,