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A second look at the influence of birth weight on carcass and meat quality in pigs

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Abstract

To re-examine the relationship of birth weight with carcass and meat quality of pigs at market weight, offspring ($n = 378$) of 63 sows were assigned to three birth weight groups; 25% low weight (LW), 50% middle weight (MW), and 25% heavy weight (HW), with runts (<800 g) being excluded. LW pigs exhibited the lowest postnatal growth performance, the lowest lean mass and the greatest degree of fatness in terms of perirenal fat compared with MW and HW pigs. Only in females, but not in male castrates, the lean percentage was highest in HW pigs. Characteristics of *longissimus* muscle technological quality declined either in LW (pH, drip loss) or HW (conductivity, lightness) compared with MW pigs. In contrast, intramuscular fat percentage (IMF) was highest in LW pigs. The results suggest that the most desirable carcass composition is obtained with HW pigs, whereas optimum technological pork quality, except for IMF, is achieved with MW pigs.

Keywords: Birth weight; Carcass quality; Pork quality; Fat; Lean meat

1. Introduction

Birth weight and within-litter variation in birth weight are important economic traits in pig production. Genetic selection for large litters during the last decades has lowered mean birth weight, which mainly results from a higher competition of the foetuses *in utero* reflected also by an inverse correlation of birth weight and litter size (e.g. Milligan, Fraser, & Kramer, 2002; Quiniou, Dagorn, & Gaudre, 2002). Low birth weight, however, is associated with decreased survival and lower postnatal growth rates (e.g. Herpin, Damon, & Le Dividich, 2002; Milligan et al., 2002; Pond & Mersmann, 1988; Quiniou et al., 2002; Ritter & Zschorlich, 1990). In addition, pigs at market weight originating from piglets of low birth weight develop a lower carcass quality in terms of higher fat deposition and lower lean accretion compared with their middle or heavy weight littermates (Bee, 2004; Gondret et al., 2006; Hegarty and Allen, 1978; Kuhn et al., 2002; Poore & Fowden, 2004; Powell and Aberle, 1980, 1981; Rehfeldt and Kuhn, 2006). Low birth weight results from intrauterine growth retardation during gestation. It has been shown previously that small piglets form a lower total number of skeletal muscle fibres during prenatal development compared with their larger littermates (Gondret et al., 2006; Handel & Stickland, 1987; Wigmore & Stickland, 1983). From recent studies, it has been suggested that it is the low number of muscle fibres, which restricts the potential of postnatal lean growth and therefore allows to deposit increased amounts of fat (Rehfeldt & Kuhn, 2006). In addition, tendencies towards lower meat quality in terms of tenderness and water holding capacity have been observed at slaughter, when the piglets were small at birth (Gondret et al., 2005; Gondret et al., 2006; Rehfeldt & Kuhn, 2006), which may be associated with accelerated muscle fibre hypertrophy because of low fibre number. The studies on the influence of birth weight mentioned above have in common, that

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the number of animals used in the experiments were not very large (5–32 pigs per birth weight group born to 13–16 sows) and the variation in the traits of interest caused by the dam/litter has not always been considered in the statistical models. Therefore, this study was conducted using a larger set of pigs from 63 litters in total to re-examine the consequences of birth weight for ultimate carcass and meat quality.

2. Materials and methods

2.1. Experimental design

This experiment was conducted at the experimental station of the FBN Dummerstorf, Germany, under controlled environmental conditions. Sixty-three litters from German Landrace sows (bred by artificial insemination to German Landrace boars; 1st to 5th parity) in a total of seven temporally successive replicates were used. Birth weight was recorded, and runts exhibiting less than 800 g were excluded from this study. The mean litter size was 13.6 ± 3.1. In 6 of 7 replicates 2–3 piglets were removed from each litter for other studies. The remaining piglets ($n = 378$ in total) stayed with their dams, which received increasing amounts of a commercial diet for lactating sows (Trede & Pein GmbH & Co. KG, Itzehoe, Germany). Male piglets were castrated at five days of age, and all piglets were weaned at 28 days of age. During the whole growing-finishing period the offspring was fed *ad libitum* with a starter mixture from d 28 to 70, and with a universal mixture throughout finishing (Trede & Pein). The pigs were kept on flat-decks from d 28 to 70 and thereafter housed in groups. The pigs were weighed at 28, 70, 133 days of age, and before slaughter at approximately the same age (180 ± 8 days).

All procedures were in accordance with the guidelines set by the Animal Care Committee of the State Mecklenburg-Vorpommern, Germany, based on the German Law of Animal Protection.

2.2. Carcass and meat quality

At slaughter, the weights of the heart and of the perirenal fat were recorded. Muscle meat percentage, length and perimeter of the ham, loin muscle area, and back fat thickness were determined on the left carcass half. The length of the ham was taken as the straight distance from the cut of the pubic symphysis to the distal end of the ham cut; the perimeter was measured at the largest width of the ham. Muscle meat percentage was estimated by the FOM device (Fat-o-Meat'er, SFK-Technology A/S, Søborg, Denmark). Loin muscle area and back fat thickness were measured manually at the level of 13th/14th ribs. At the same position the following characteristics of meat quality were determined in the *longissimus* muscle: pH values (pH_{45}; pH_{24}) and conductivity (at 45 min and 24 h *postmortem*), impedance, colour, drip loss, and chemical composition (at 24 h *postmortem*). The pH_{45} and pH_{24} values were measured by electrode (pH-Star, Matthäus, Pöttmes, Germany). Likewise, for measurements of conductivity and impedance manual devices were used such as LF- Star (Matthäus, Pöttmes, Germany) or Meat Check 150 (Sigma electronic GmbH, Erfurt, Germany). Meat colour (lightness, L^*; redness, a^*; yellowness, b^*) was measured with the CR-200 (Minolta AG, Langenhagen, Germany). Drip loss was defined as the weight loss of a meat sample (50 g), placed on a flat plastic grid and wrapped in foil, after a storage time of 24 h (24–48 h *postmortem*) in a refrigerator (4 °C). The composition of *longissimus* muscle by water/dry matter, lipid, and ash was analysed according to standard methods (AOAC, 1990), and protein was estimated by difference (Kuhn, Ender, & Nürnberg, 1994).

2.3. Statistical analysis

All pigs were assigned to three birth weight groups: 25% to low weight ($LW \leqslant 1.22$ kg), 50% to middle weight (MW); and 25% to heavy weight ($HW \geqslant 1.54$ kg) according to the quantiles of frequency distribution with $n = 102$, $n = 180$, and $n = 96$, respectively. Birth weight ranged from 0.80 to 2.17 kg (1.37 ± 0.25 kg on average). The data set included 172 males (LW = 47; MW = 73; HW = 52) and 206 females (LW = 55, MW = 107, HW = 44). Data were subjected to analyses of variance, using the mixed classification model of SAS (SAS System for Windows Release 8 e; SAS Institute Inc., Cary, NC 27513, USA) including sex, replicate, birth weight group and corresponding interactions as fixed factors and sow within replicate as random factor. Data given in the tables are least squares means ± SE. Significance of differences between least squares means was tested by multiple *t*-test ($P < 0.05$).

3. Results

3.1. Growth and carcass composition

The LW pigs grew clearly slower than MW pigs, and the latter grew still slower than HW pigs (Fig. 1A). Following live weight development from birth to slaughter, weights were significantly different among LW, MW and HW pigs at all stages of age ($P < 0.05$) with the same ranking maintained from birth to slaughter. Though, before slaughter (d 180) live weight only tended to be different between MW and HW ($P = 0.07$). These differences in growth were also reflected by significant differences in live weight gain at all stages of age examined (Fig. 1B).

At slaughter, carcass weight differed correspondingly among LW, MW and HW pigs (Table 1). Absolute measures of lean mass, such as loin area or ham length and perimeter were lower ($P < 0.05$) in LW as compared to MW and HW piglets. Meat percentage measured by the FOM device was only numerically but not significantly lowest in LW piglets. However, there was a birth weight