# Variability in growth performance, carcass characteristics, and meat quality is partly related to litter size and birth weight of pigs

J. Bérard[1], M. Kreuzer[2], G. Bee[1]

[1]Agroscope Liebefeld-Posieux, Research Station ALP, 1725 Posieux, Switzerland
[2]ETH Zurich, Institute of Animal Science, 8092 Zurich, Switzerland

## Introduction

There is some evidence that, within litter, low birth weight pigs not only grow slower and have fatter carcasses but also meat quality traits like drip loss or shear force are impaired compared to their high birth weight siblings (Gondret et al., 2005; Rehfeldt and Kuhn, 2006). Because the variability of the body weight (BW) at birth is greater in large compared to small litters, the aim of the present study was to test the hypothesis that effects of birth weight on growth performance, carcass characteristics and meat quality differ when pigs originate from small or large litters. As reviewed by Huff-Lonergan and Lonergan (2005), the extent of cytoskeletal protein degradation post-mortem affects tenderness and water-holding capacity of pork. Therefore in the present study, we investigated whether birth weight of the pig or litter size is related to post-mortem proteolysis of various proteins such as titin, nebulin and integrin, and how the degree of degradation is related to pork quality traits.

## Material und Methods

The 60 Swiss Large White barrows used in this study originated from 20 litters with either less than 10 (S) or more than 14 (L) piglets born per litter. Within each of the S- and L-litters, three barrows were selected per litter at birth: the lightest (L-BtW), the heaviest (H-BtW), and the one with a birth weight nearest to the average birth weight of the litter (M-BtW). At weaning the barrows were individually penned and they had free access to standard starter (9 – 27 kg BW), growing (27 – 63 kg BW), and finishing diets (63 - 105 kg BW) until slaughter. The BW and total feed intake was determined each week. At slaughter, the weights of the hot carcass, heart, liver, and kidney were assessed. The carcass was dissected 24 h post-mortem according to the Swiss Pig Performance Testing Station procedure (Suisag, Sempach, Switzerland). The pH 24 h post-mortem, the L*a*b*-values, the drip loss after 48 h, the thaw loss, and the shear force were measured in chops of the longissimus muscle (LM) collected from between the $10^{th}$ to $12^{th}$ rib.

In tissue samples from the LD collected at 30 min, 24 and 72 h post-mortem, proteolysis of intact titin and nebulin as well as of integrin was determined by SDS-PAGE and Western-Blot technique, respectively. Sample preparation was carried out as described by Bee et al. (2006b). Results are expressed as the intensity of the intact protein band of each sample over the intensity of the intact protein band in the internal designated densitometry standard.

Data were analyzed using the MIXED procedure of SAS (version 9.1 Inst. Inc., Cary, NC). The model included BtW, litter size and the respective interaction as fixed effects and litter as random effect. Pearson correlation coefficients were calculated to determine the relationship between different meat quality parameters.

## Results and discussion

### *Growth performance*

The L-BtW (1.2 vs. 1.6 kg) and M-BtW barrows (1.6 vs. 1.9 kg) from L-litters were lighter than from S-litters whereas no differences in birth weight were observed in H-BtW barrows (1.9 vs. 2.0 kg) (litter size × birth weight interaction; $P < 0.01$). In agreement with our findings, Quiniou et al. (2002) reported that average birth weight of the litter is lower in large compared to small litters. The main reasons are that with increasing litter size the percentage of L-BtW pigs is higher and the birth weight of small piglets is markedly lower. Therefore, the present data suggested that in L-litters, L- and M-BtW barrows were more affected by lower nutrient supply during gestation than H-BtW barrows. Nevertheless, postnatal growth performance was mainly affected by birth weight rather than by litter size. The L-BtW barrows grew slower (0.81 vs. 0.90 kg; $P < 0.01$), ingested less feed (2.30 vs. 2.42 kg; $P = 0.03$), and were still less efficient (2.84 vs. 2.71 kg feed/kg gain; $P < 0.01$) than H-BtW- and M-BtW barrows. The observed differences in growth performance among the L- and H-BtW barrows were in agreement with results of previous studies (Bee et al., 2006a; Gondret et al., 2005; Rehfeldt and Kuhn, 2006).

### *Carcass characteristics and meat quality*

In accordance to Rehfeldt and Kuhn (2006), the carcass yields were higher (82 vs. 81%; $P < 0.01$) and livers (1.58 vs. 1.74 kg), and kidneys (0.31 vs. 0.34 kg) were lighter ($P \leq 0.01$) in L-BtW compared to H-BtW barrows. Regardless of the BW, barrows from S-litters had higher percentages of shoulder (12.4 vs. 12.1%; $P = 0.02$) and lower percentages of omental fat (1.8 vs. 2.1%; $P = 0.06$) than barrows from L-litters. These results suggest that barrows from L-litters have a lower protein and a higher fat deposition rate than barrows from S-litters regardless of their birth weight. Previous studies reported similar results when comparing pigs of different birth weight classes (Rehfeldt and Kuhn, 2006). They also showed that L-BtW are born with a significantly lower number of muscle fibers which are of greater size than those found in H-BtW pigs. They suggested that the potential of muscle fiber hypertrophy is reached earlier in L- compared to H-BtW pigs and therefore a part of dairy nutrients are used for fat rather than protein accretion.

Litter size and birth weight had only a small impact on meat quality traits. The LM of L-BtW was redder (a* value: 6.9 vs. 6.0; $P = 0.01$) than the LM of H-BtW barrows. In contrast, drip and thaw loss percentages, pH 24 h post-mortem and shear force were neither affected by litter size nor by birth weight of the barrows.

Table 1 Correlations between the relative abundance of intact integrin, intact titin, intact nebulin and pH after 24 h, drip loss after 48 h, thaw loss percentage and shear force values [a]

| | pH 24 h | | Total drip loss | | Thaw loss | | Shear force | |
|---|---|---|---|---|---|---|---|---|
| **Integrin**[a] | | | | | | | | |
| 0.5 h | 0.10 | (*P*=0.44) | -0.12 | (*P*=0.37) | -0.13 | (*P*=0.31) | -0.16 | (*P*=0.22) |
| 24 h | 0.22 | (*P*=0.09) | -0.34 | (*P*<0.01) | -0.26 | (*P*=0.05) | -0.01 | (*P*=0.93) |
| 72 h | 0.02 | (*P*=0.89) | -0.16 | (*P*=0.23) | -0.09 | (*P*=0.48) | 0.21 | (*P*=0.10) |
| **Titin**[a] | | | | | | | | |
| 0.5 h | -0.03 | (*P*=0.83) | -0.01 | (*P*=0.96) | -0.06 | (*P*=0.71) | -0.01 | (*P*=0.95) |
| 24 h | 0.11 | (*P*=0.42) | -0.20 | (*P*=0.13) | -0.21 | (*P*=0.08) | 0.22 | (*P*=0.09) |
| 72 h | -0.03 | (*P*=0.83) | -0.14 | (*P*=0.29) | -0.06 | (*P*=0.90) | 0.23 | (*P*=0.07) |
| **Nebulin**[a] | | | | | | | | |
| 0.5 h | -0.07 | (*P*=0.62) | -0.11 | (*P*=0.38) | -0.18 | (*P*=0.30) | -0.14 | (*P*=0.30) |
| 24 h | 0.07 | (*P*=0.58) | -0.01 | (*P*=0.92) | -0.08 | (*P*=0.91) | 0.05 | (*P*=0.69) |
| 72 h | -0.07 | (*P*=0.60) | -0.20 | (*P*=0.12) | -0.14 | (*P*=0.23) | 0.27 | (*P*=0.04) |

[a]Ratios are calculated as the intensity of the intact protein band of each sample over the intensity of the intact protein band in the internal designated densitometry standard.

*Post-mortem proteolysis*

Regardless of the litter size, the extent of proteolysis of titin at 24 h post-mortem (1.40 vs. 2.57; $P = 0.06$) and nebulin at 72 h post-mortem (0.15 vs. 0.25; $P = 0.07$) was greater in the LM of H-BtW than the LM of L-BtW barrows. Even if shear force was not affected by the BtW, the relative abundance of titin at 24 and 72 h post-mortem and nebulin at 24 h post-mortem was positively correlated ($P \leq 0.09$; Table 1) with shear force, suggesting that tenderness scores could be impaired by low birth weight, which is in line with recent observations of Gondret et al. (2005). Unexpectedly, higher titin proteolysis at 24 h post-mortem was negatively correlated with thaw loss ($P$=0.08).

At 72 h post-mortem intact integrin of the LM was less degraded (0.17 vs. 0.08; $P = 0.08$) in barrows originating from S- than from L-litters. Furthermore, the present results indicated that the relative abundance of the intact integrin band at 24 h post-mortem was negatively correlated ($P \leq$

0.05) with the percentage drip and thaw loss (Table 1). These findings are in line with recent results reported by Zhang et al. (2006) who showed that greater integrin proteolysis was associated with the formation of drip channels. Although birth weight and litter size had only a small impact on meat quality the degree of proteolysis of cytoskeletal proteins suggested that prenatal events might have an impact on biochemical and structural changes occurring post-mortem.

## Conclusions

The present results confirm the marked effect of birth weight on growth performance and carcass characteristic. However, the hypothesised impact on meat quality traits could only be partly demonstrated. Although litter size affected average birth weight of the L-BtW and M-BtW barrows, its impact on growth performance, carcass characteristics and meat quality was minor. In accordance with previous observations, the present study confirms the relationships between protein degradation, and some of the important meat quality parameters. Furthermore, the present findings revealed that the extent of proteolysis influenced differently meat quality traits.

## Literature

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