Relationships between *in vivo* Measurements of Backfat Thickness and Several Carcass and Ham Traits in Heavy Pigs

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Summary

This study investigated the relationships between ultrasound measurements of backfat thickness (UBF) taken on live heavy pigs and several carcass composition and ham quality traits. Before slaughter 240 pigs were weighed (average BW: 167 ± 10 kg) and assessed for UBF using an A-mode ultrasonic device (placed above the last rib at approximately 5.5 to 8.0 cm from midline, with increasing distance with increasing BW). At slaughterhouse backfat thickness and weight of carcass and of commercial lean and fat cuts were collected. After 24-h chilling, hams were trimmed, weighed, scored and measured for several quality traits. A sample of trimmed fat was taken to assess iodine number and linoleic acid content. All hams were cured, and weight losses during curing were recorded. The measures of UBF were correlated with all carcass and ham traits available. The strongest relationships with UBF were detected for backfat depth at loin (0.54), backfat weight and yield (0.69), overall yield of lean and fat cuts (-0.59 and 0.51, respectively), score or measure of ham fat covering thickness (0.62 and 0.53, respectively), and linoleic acid content of ham subcutaneous fat (- 0.48). Magnitude of correlations does not provide reliable prediction of carcass, but ultrasound assessment on live animals could be useful to support selection programs of heavy pigs aimed to dry-cured ham production. Further studies are needed to investigate genetic relationships between these traits and UBF.

Key words

heavy pigs, ultrasound backfat thickness, carcass traits, ham traits

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Aim

The ultrasound technology has been widely applied by the pig industry and by seedstock producers to evaluate carcass quality and composition on the live pig and to improve genetic merit for composition traits (Moeller, 2002; Magowan and McCann, 2006; Ayuso et al., 2013). However, the relationships between ultrasound measurements and carcass traits have been scarcely investigated on typical Italian heavy pigs intended for the production of Protected Designation of Origin (PDO) dry-cured hams. Furthermore, the role of ultrasound technology on live animals for the evaluation of quality traits of raw hams aimed to dry-curing process has not been examined. Therefore, this study aimed to investigate the relationships between ultrasound measurements of backfat thickness (UBF) taken on live heavy pigs prior to slaughter and several carcass composition and ham quality traits.

Material and methods

All experimental procedures were reviewed and approved by the Ethical Committee for the Care and Use of Experimental Animals (CEASA) of the University of Padova.

Animals

A total of 240 crossbred pigs (120 gilts and 120 barrows), grouped in three consecutive batches of 80 pigs each, were used in this study. Pigs were offspring of 12 boars of the C21 Goland sire line (Gorzagri, Fonzaso, Italy) mated to 32 Large White-derived crossbred sows. In each batch, pigs were housed in 8 pens of 10 animals each and received, from 90 kg BW onwards, one of four feed treatments differing for crude protein and lysine content. Pigs were fed on the basis of a restricted feeding regime where the daily amount of feed per pig increased from 2.4 to 3.2 kg/d from the first to the last week on feed, when the pigs were expected to weigh 90 and 165 kg BW, respectively.

Ultrasound backfat thickness collection

Approximately at 9 months of age and 36 h before slaughter pigs were weighed (average BW: 167 ± 10 kg) and assessed for backfat thickness using an A-mode ultrasonic device (Renco Lean-Meater series 12, Renco corporation, Minneapolis, USA). Ultrasound backfat thickness was collected above the last rib at approximately 5.5 to 8.0 cm from midline, with increasing distance with increasing BW, on pigs confined in a weighbridge, so that their movement was restricted and standing posture was maintained.

Carcass and ham data collection

Pigs were slaughtered in one day per batch in the same slaughterhouse. Hot carcasses were weighed and backfat thickness was measured on the half left carcass at the 1st thoracic and at the last lumbar vertebra using a caliper. One hour after slaughter, carcasses were processed according to Italian commercial procedure and weight of commercial lean (neck, shoulder, loin and ham) and fat cuts (backfat, belly and jowl) were collected. Hams were chilled (0–2 °C) for 24 h and thereafter trimmed to obtain the typical ham round-shape. After trimming, all left and right hams were weighed and scored by the same expert for round shape and marbling (from 0, low, to 4, high) and for fat covering thickness, (from - 4, low to 4, high). Fat covering thickness was also measured with a ruler in the external part of hams beneath the femur head near semimembranosus muscle ("sottonoce" position) and with ultrasound technology (Aloka SSD 500) in the "corona" position, near quadriceps muscle. To determine iodine value and fatty acid composition, a sample of trimmed fat including both outer and inner layer was taken from both left and right hams, frozen and stored at -20°C pending analysis.

All hams were cured according to the San Daniele procedure, and weight losses during curing were recorded.

Analysis of fat samples

Samples of subcutaneous fat tissue were chopped into small pieces and minced. About 25 g of minced fat were placed in a drying oven (100°C) until full fusion. The liquid fat obtained was filtered through anhydrous sodium sulphate. The fat samples were analysed for both iodine value and fatty acids composition. Iodine value was determined using the Wijs method (AOAC, 1980). The fatty acid profile was determined, after methylation (Chouinard et al., 1999), using a gas-chomatograph (8000 Serie Top, ThermoQuest, Milano, Italy) equipped with a split-splittless injector and a flame ionization detector. Individual fatty acid methyl esters were separated on a 30 m long capillary column with 0.25 mm of internal diameter and 0.25 μm film thickness (Omegawax 250, Supelco, Bellefonte PA, USA) containing a polar stationary phase. The gas chromatography conditions were as follows: detector and injector temperature: 250°C; oven initial temperature: 140°C, with an increase of 4°C/min until 220°C. The flow rate of the carrier gas (hydrogen) was 1.6 ml/min and 0.4 μl of solution was injected. Chromatografic data were recorded and integrated with a dedicated software (CE Chrom Card). Methylesters were identified by comparison of retention time with a standard mixture containing fifty-two pure fatty acids (#674, Nu-chek prep inc., MN, USA). The concentration of the various fatty acids, grouped into saturated, monounsaturated, polyunsaturated, n3 and n6, were calculated from their corresponding chromatographic areas, from the chromatographic area and the amount of methyl 12-tridecenoate used as internal standard (# U-35M, Nu-chek prep inc., MN, USA) and from the weight of the fat sample.

Editing and statistical analysis

Yield of commercial cuts was computed as the ratio between the weight of cuts and the weight of carcass including the head. Traits from left and right ham of each pig were averaged prior to statistical analysis. Descriptive statistics for ultrasound, carcass and hams traits and Pearson correlations were calculated using the procedures in SAS (SAS Inst. Inc., Cary, NC). Both rough correlations and partial correlations on residuals from a model accounting for batch, diet, gender and sire effects were run. As differences between the two sets of correlations were trivial, only rough correlations are presented in results.

Results and discussion

Descriptive statistics for weight of carcass and main cuts and Pearson correlation coefficients with in vivo UBF are given in table 1. Carcass and commercial cuts weight shown by experimental pigs were consistent with typical performance required to heavy Italian pigs (Bosi and Russo, 2004; Della Casa et al., 2010). Backfat depth measured on carcass averaged 38.5 and 23.7 mm at shoulder and loin, respectively. Both values were higher

Table 1. Descriptive statistics for weight of carcass and main cuts and Pearson correlation coefficients with in vivo ultrasound backfat estimates (UBF; mean: 18 mm, standard deviation: 3 mm)

	Mean	SD[1]	Correlation with UBF[2]
Carcass weight, kg	138	8.2	0.19
Backfat at 1st thoracic vertebra, mm	38.5	5.62	0.37
Backfat at last lumbar vertebra, mm	23.7	4.44	0.54
Loins, kg	18.13	1.49	ns
Trimmed hams, kg	30.00	2.08	ns
Shoulders, kg	16.65	1.53	- 0.21
Necks, kg	9.05	0.67	ns
Overall lean cuts, kg	73.81	5.01	ns
Backfat, kg	8.14	1.53	0.69
Belly, kg	17.42	2.48	0.27
Jowl, kg	7.56	0.74	0.31
Overall fat cuts, kg	33.11	3.95	0.49

[1] SD: standard deviation; [2] ns: P>0.01.

Table 2. Descriptive statistics for yield of main cuts on carcass weight and Pearson correlation coefficients with in vivo ultrasound backfat estimates (UBF; mean: 18 mm, standard deviation: 3 mm)

	Mean	SD[1]	Correlation with UBF[2]
Loins, %	13.20	0.76	- 0.40
Trimmed hams, %	21.84	0.91	- 0.32
Shoulders, %	12.12	0.85	- 0.44
Necks, %	6.60	0.33	- 0.39
Overall lean cuts, %	53.74	1.96	- 0.59
Backfat, %	5.92	1.04	0.69
Belly, %	12.67	1.55	0.23
Jowl, %	5.60	0.51	0.24
Overall fat cuts, kg	24.08	2.35	0.51

[1] SD: standard deviation; [2] ns: P>0.01.

than UBF. It has been reported that A-mode ultrasonic device frequently underestimated corresponding measurements on carcasses (Moeller, 2002; Wiseman et al., 2007), as a possible result of the inability of A-mode device to consistently define the third layer of fat covering the loin muscle of the pig. However, Ayuso et al. (2013) reported underestimated backfat measurements for heavy pigs also using real time ultrasound devices. Correlation between UBF and backfat depth assessed on carcass using caliper was higher when this measure was taken at loin (0.54) than when it was taken at shoulder (0.37). In general, relationships between UBF and backfat depth assessed on carcass observed in this study was lower than those reported by others (Cisneros et al., 1996; Kloareg et al., 2006; Ayuso et al., 2013). Correlations of UBF with weight of carcass or commercial lean cuts were very moderate (carcass and shoulder) or not significant at all (loin, ham, neck, overall lean cuts weight). Conversely, UBF appeared well correlated with weight of overall commercial fat cuts (0.49) and above all with backfat weight (0.69). Weak correlations between ultrasound live backfat assessment and weight of lean cuts have been found in the study of Ayuso et al. (2013).

Table 3. Descriptive statistics for ham quality traits and curing losses and Pearson correlation coefficients with in vivo ultrasound backfat estimates (UBF; mean: 18 mm, standard deviation: 3 mm)

	Mean	SD[1]	Correlation with UBF[2]
Trimmed hams evaluation score for:			
- round shape, (0, low to 4, high)	1.69	0.69	ns
- fat covering thickness, (- 4, low to 4, high)	0.02	1.64	0.62
- marbling, (0, low to 4, high)	1.50	0.71	0.16
Measured fat covering thickness (mm) at:			
- sottonoce[3]	21.9	6.35	0.53
- corona[4]	5.75	0.86	0.18
Fat covering chemical assessment:			
- iodine number	65.20	3.10	- 0.19
- linoleic acid, %	12.90	1.35	- 0.48
- saturated, %	37.04	1.61	0.17
- monounsaturated, %	47.17	1.55	0.23
- polyunsaturated, %	13.90	1.26	- 0.50
- n3, %	0.85	0.09	- 0.28
- n6, %	12.24	1.16	- 0.50
Curing losses (%) at the end of:			
- salting period	3.29	0.60	- 0.33
- resting period	18.04	1.52	- 0.23
- seasoning	27.95	2.01	- 0.28

[1] SD: standard deviation; [2] ns: P>0.01; [3]external part of hams beneath the femur head near semimembranosus muscle; [4]near quadriceps muscle

Descriptive statistics for yield of main cuts on carcass weight and Pearson correlation coefficients with in vivo UBF are shown in table 2. Commercial lean and fat cuts yielded nearly 54% and 24% on carcass weight. In general, correlations between UBF and yield of commercial cuts were always significant ($P < 0.01$) and constantly higher than those observed when UBF was correlated with weight of commercial cuts. The relationship between UBF and yield of overall lean cuts appeared stronger than that observed between UBF and yield of overall fat cuts. However, yield of backfat showed the highest correlation with UBF again. Correlations between UBF and yield of lean cuts from this study are comparable, albeit slightly higher, than those reported by Ayuso et al. (2013) in a trial involving Iberian pigs and a real time ultrasound device.

Descriptive statistics for ham quality traits and curing losses and Pearson correlation coefficients with in vivo ultrasound backfat estimates are reported in table 3. Average fat covering thickness of hams, iodine value and linoleic acid content of subcutaneous fat of hams were well within the values dictated by regulations governing PDO dry-cured ham production (Bosi and Russo, 2004). The strongest relationships between UBF and ham quality traits were found for score or measure of fat covering thickness (0.62 and 0.53, respectively) and for linoleic or total polyunsaturated fatty acids content (-0.48 and -0.50, respectively). Conversely, the relationship between UBF and iodine value, albeit significant, was weak (- 0.19). Last, UBF showed moderate relationships also with curing losses, particularly with salting (- 0.33) and with overall seasoning losses (- 0.28).

Conclusions

Backfat thickness assessed on live heavy pigs using an A-mode ultrasound device showed medium phenotypic relationships with some carcass and ham quality traits, particularly those related to fat tissues. Even if magnitude of correlations seems not big enough to provide reliable prediction of carcass composition for industry purposes, relationships found with ham quality traits are interesting. These traits are critical for DPO dry-cured ham chain and should be included in breeding schemes for DPO Italian heavy pigs, but direct collection of this type of data is expensive and time consuming. Ultrasound assessment on live animals could then provide cost effective informations to support selection. However, further studies are needed to investigate genetic relationships between these traits.

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