Short Note

Effects of genotype, diet and sex on backfat depth in pigs measured physically at different carcass sites and ultrasonically at different liveweights

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Summary. Pigs of both sexes, from a line selected for low backfat depth and an unselected line, were grown on 3 diets. Backfat depths were measured by ultrasonics at 3 liveweights during growth and by optical probe and scale at 5 sites on and off the midline of the carcass after slaughter.

Ultrasonics and carcass measurements were equally effective at detecting the effects of line, diet and sex on fat depth. Average fat depth was higher in females than males, higher in the unselected line than in the selected line, and increased with dietary energy–lysine level. The difference between sexes, lines and diets increased with liveweight. Changing diets affected carcass fat depths at different sites of measurement uniformly, but both line and sex varied in their effects on fat depth at different sites.

Introduction

The lean content of pig carcasses is an economically important trait which can be manipulated by nutritional (SCA 1987) and genetic means (McPhee *et al.* 1988). A measurement of subcutaneous fat depth over the M. longissimus dorsi is an accurate and low cost predictor of carcass lean content (Kempster and Evans 1979). A number of probes and ultrasonic devices have been developed for measuring fat depth on the carcass (Kempster *et al.* 1985) and on the live pig (Hudson and Payne-Crostin 1984). Important decisions made on the basis of a single backfat measurement include carcass grading, breeding stock selection and the evaluation of experimental treatments aimed at modifying fatness.

Issues of concern which this practice raises are (i) the agreement between live ultrasonic and carcass measurement of fat depth, (ii) variation in fat depth at unmeasured carcass sites, and (iii) variation in the ranking of pigs on fat depth at different liveweights. This study examined these issues in 2 genetic lines of pigs, one selected for low backfat depth and the other an unselected control, grown on diets varying in energy and lysine levels.

Materials and methods

Source of lines

The data were drawn from a study reported by McPhee *et al.* (1991) in which pigs of both sexes from a selected (S) and an unselected control (C) line were compared on a range of diets varying in energy and lysine content. Both lines had a common Large White x Landrace foundation, but the S line had undergone 5 generations of selection for high growth rate and low depth of backfat as measured by ultrasonics, while the C line had been maintained as an unselected control.

Diets and ration

The diets and ration fed to the trial pigs were fully described by McPhee *et al.* (1991). Data from pigs given diets of varying lysine levels within a common energy level were combined so that the effect of nutrient density (low, medium and high) could be examined in the present study. Diets were fed over 2 phases, each of 6 weeks duration. For the first and second phases of the low, medium and high diets, the digestible energy (DE) levels were 14 and 13 MJ/kg, 15 and 14 MJ/kg and 16 and 15 MJ/kg. The corresponding lysine DE levels for the same diets averaged 0.75 and 0.6 g/MJ, 0.85 and 0.7 g/MJ, and 0.9 and 0.75 g/MJ. The main ingredients of the diets were wheat or barley, fish meal and soybean. The energy and lysine specifications were met by varying the soybean and wheat portions, with very minor adjustments by the addition of vegetable oil and synthetic lysine. The ration scale was designed to supply all pigs with the same weight of food over the trial period.

Fat measurement

Pigs commenced the trial at 25 kg liveweight and were weighed weekly until consigned for slaughter. Ultrasonic (Meritronics, U.K.) fat depths were measured on the growing pigs at the P2 position (65 mm ventral to the mid backline and level with the last rib), at liveweights which averaged 25.3, 51.4 and 80.5 kg. There was an interval of 1 week between final ultrasonic measurement and slaughter. After slaughter, fat depths were measured at P2 on the hot hanging carcass, using an optical probe (Intrascope, Denmark).

Table 1. Effects of line, diet and sex on backfat depths (mm) at the P2 position, measured at 80 kg liveweight on the live pig by ultrasonics and on its carcass by optical probe

Values are least square means ± s.e.

Technique	Line		Diet			Sex		Mean
	S	C	Low	Medium	High	Male	Female	
Ultrasonic	12.59 ± 0.61	14.66 ± 0.66	12.53 ± 0.51	13.78 ± 0.47	14.56 ± 0.61	13.11 ± 0.44	14.14 ± 0.44	13.63 ± 0.53
Optical probe	13.34 ± 0.73	15.49 ± 0.60	13.69 ± 0.51	14.47 ± 0.48	15.10 ± 0.61	14.10 ± 0.46	14.73 ± 0.43	14.42 ± 0.54
Mean	12.96 ± 0.53	15.08 ± 0.53	13.11 ± 0.43	14.12 ± 0.42	14.83 ± 0.51	13.61 ± 0.40	14.43 ± 0.40	14.02 ± 0.38

Carcasses were chilled at 5°C for 25 h, and backfat depths (including skin) were measured by vernier calipers along the midline of the split carcass at the shoulder (maximum), mid back (minimum) and loin (minimum) positions. Fat depths were also taken at the C and K positions on the exposed cross-section of the side when cut through at the head of the last rib. Position C covers the greatest depth of the muscle cross-section, and K the dorso-lateral corner of the muscle cross-section (Buck 1963).

Statistical analysis

The trial was performed on 432 pigs, 24 of each sex from 9 successive batches of farrowings. The pigs were the progeny of 35 sires of the S line and 32 sires of the C line. Analyses of variance were carried out on the fat depths according to Harvey (1985). Fixed effects were line (S, C), sex, diet (low, medium, high nutrient density), carcass measurement site (shoulder, mid back, C, K, loin), technique (optical probe, ultrasonics), batch (1–9) and liveweight at measurement (25, 50, 80 kg). Random effects were sire and residual. To correct for possible liveweight gain in the week between the 80 kg ultrasonic and optical probe measurements, a covariate on liveweight was used in comparing these traits. Dressed weight was used as a covariate for the comparison of carcass site measurements.

Results

Measurement technique

Analysis of variance of fat measurements taken ultrasonically at the P2 site on the 80 kg liveweight pigs before slaughter and by optical probe on their carcasses after slaughter showed that the main effects were all significant: C > S ($P<0.01$); high and medium diets > low diet ($P<0.05$); female > male ($P<0.01$) (Table 1). Probe measurements of carcass fat depth at P2 were significantly ($P<0.01$) higher than live measurements at the same site. There were no significant interactions. Ultrasonics and probe gave the same ranking of the lines, diets and sexes.

Site of carcass measurement

There were a number of significant interactions between site and the other main effects. The difference between the S and C lines was greatest at the K site and least at the mid back site (line x site, $P<0.01$), and the difference between the sexes was greatest at the loin and least at the K site (site x sex, $P<0.01$). Sire had a significant effect on average carcass fat depth and this varied with the site of measurement (sire x site within line, $P<0.01$). The sex difference was greater in the C than the S line (line x sex, $P<0.01$), with mean (± s.e.) backfat depths for males and females in the C line being 20.7 and 23.0 ± 0.5 mm, compared with 18.9 and 20.1 ± 0.5 mm in the S line.

Averaged over all sites, backfat depths ranked similarly to those given above for the ultrasonic and probe readings for the different levels of line ($P< 0.01$), diet ($P< 0.01$) and sex ($P< 0.01$) (Table 2). Measurement sites in declining order of depth were shoulder, mid back, K, loin and C ($P< 0.01$).

Table 2. Effects of line, diet and sex on backfat depths (mm) at five sites on the carcasses of 80 kg liveweight pigs

Values are least square means ± s.e.

	Measurement site					Mean
	Shoulder	Mid back	C	K	Loin	
Line						
S	34.40 ± 0.48	20.92 ± 0.48	12.24 ± 0.48	15.51 ± 0.48	14.31 ± 0.48	19.48 ± 0.48
C	37.00 ± 0.47	21.32 ± 0.47	14.87 ± 0.47	18.82 ± 0.47	17.06 ± 0.47	21.82 ± 0.47
Diet						
Low	34.59 ± 0.78	19.98 ± 0.78	12.01 ± 0.78	15.46 ± 0.78	13.82 ± 0.78	19.18 ± 0.46
Medium	35.98 ± 0.59	21.06 ± 0.59	13.80 ± 0.59	17.72 ± 0.59	16.42 ± 0.59	21.00 ± 0.46
High	36.54 ± 0.73	22.32 ± 0.73	14.85 ± 0.73	18.37 ± 0.73	16.82 ± 0.73	21.78 ± 0.49
Sex						
Male	34.84 ± 0.47	20.03 ± 0.47	12.94 ± 0.47	17.03 ± 0.47	13.94 ± 0.47	19.76 ± 0.39
Female	36.57 ± 0.47	22.22 ± 0.47	14.18 ± 0.47	17.33 ± 0.47	17.43 ± 0.47	21.55 ± 0.39
Mean	35.71 ± 0.46	21.12 ± 0.46	13.56 ± 0.46	17.18 ± 0.46	15.69 ± 0.46	20.65 ± 0.37

Table 3. Effects of line, diet and sex on P2 backfat depths (mm) measured ultrasonically at three liveweights

Values are least square means ± s.e.

Liveweight (kg)	Line		Diet			Sex		Mean
	S	C	Low	Medium	High	Male	Female	
25	7.32 ± 0.16	8.41 ± 0.16	7.78 ± 0.22	7.99 ± 0.21	7.82 ± 0.30	8.00 ± 0.19	7.73 ± 0.19	7.86 ± 0.17
50	9.61 ± 0.16	11.10 ± 0.16	9.81 ± 0.22	10.43 ± 0.21	10.82 ± 0.30	10.21 ± 0.19	10.49 ± 0.19	10.35 ± 0.17
80	12.27 ± 0.16	14.36 ± 0.16	12.34 ± 0.22	13.43 ± 0.21	14.16 ± 0.30	12.81 ± 0.19	13.82 ± 0.19	13.31 ± 0.17
Mean	9.73 ± 0.19	11.29 ± 0.29	9.98 ± 0.17	10.62 ± 0.21	10.93 ± 0.21	10.34 ± 0.16	10.68 ± 0.68	10.51 ± 0.15

Liveweight at measurement

Liveweight interacted significantly with the other main effects. The increase with liveweight was greater in the C than the S line (line x liveweight, $P<0.01$), greater in the high than the medium and low diets (diet x liveweight, $P<0.05$), and greater in females than in males (sex x liveweight, $P<0.01$). Other significant ($P<0.01$) interactions were line x diet and line x sex.

Average fat depth increased ($P<0.01$) with liveweight at measurement. The rankings of lines, diets and sexes on ultrasonic measurements at 3 liveweights (Table 3) were consistent with those reported above: C > S ($P<0.01$); high and medium diet > low diet ($P<0.01$); female > male ($P<0.01$). Sire within line was a significant ($P<0.01$) effect.

Discussion

The absence of statistical interaction between measurement technique and line, diet or sex (Table 1) indicates that a single equation for predicting carcass fat depth by ultrasonics on the live pig could be applied across a range of genotypes and environments, and that either technique would be effective for monitoring changes in fat depth brought about by genetic or non-genetic means. Hudson and Payne-Crostin (1984) reported that ultrasonic measurements of fat depth on the live pig were lower than the corresponding optical probe measurements on the carcass. They attributed this difference, in part, to an increase in body weight and fatness in the time between ultrasonic recordings and slaughter. This effect, though, was largely removed from the present study by correcting recordings from both techniques for liveweight on the day of measurement. Sather *et al.* (1988), who took fat depth measurements by ultrasonic and probe on the same day, attributed their higher probe measurements to compression of the fat layers along the longitudinal axis, which increases the apparent fat thickness when the carcass is dressed and hung.

There was some variation between carcass sites in the effects of line and sex, but not diet, on fat depth (Table 2). The difference between the S and the C line indicated that selection had reduced ultrasonic fat depth at P2 in the S line by 2.2 mm. This compared with reductions on the carcass ranging from 3.3 mm at K to 0.4 mm at the midback site. In an earlier selection study for low backfat, McPhee (1981) also found that response in fat depth was greatest at K, while the other sites including the midback showed similar responses. Wood *et al.* (1983) examined site variation in backfat depth in a line of Large Whites selected for a combination of backfat depths at different sites, with major emphasis on P2. The change in backfat measured at P2 was 3 mm, similar to the present study, as was the absence of change at the mid back site. Variation in fat depth response between sites after selection at a single site would have been expected in the S line of the present study from the sire x site interaction revealed by the analysis of variance. It may be partly responsible for observations by processors (R. Attwood pers. comm.) of variation in 'fat cover' adversely affecting appearance of meat cuts. Variation between studies in the correlated selection responses of fat at different carcass sites probably reflects the action of chance, to which small populations are subject (Hill 1971).

Sex differences in fat depth at the shoulder, mid back and loin sites of measurement are consistent with the finding that the male pig deposits a greater proportion of its subcutaneous fat in the shoulder, neck and fore parts than the female (Fortin *et al.* 1987). It is difficult to explain, other than by chance, the similarity of the sexes in K fat depth found in this study.

Ultrasonic measurements of P2 fat depth at the 3 liveweights (Table 3) revealed that the effects of line, diet and sex were similar to those found for the carcass fat measurements; however, there was an increase in the effects with liveweight. In the case of lines, selection has caused a uniform change in the rate of fat deposition with age in the S line. This is reassuring to those who may wish to vary the weight of turn-off according to market demand. As the interactions show, the class of pig exhibiting the greatest rates of increase in fat depth with liveweight were C line females on the high energy–lysine diet. This supports the findings of Campbell and Taverner (1988) that selection and maleness enhance a pig's ability to make use of high energy–lysine diets to deposit lean rather than fat tissue.

In conclusion, genetic and non-genetic factors causing variation in subcutaneous fat depth at P2 are

detected equally well by ultrasonics on the live pig and by optical probe on its carcass. Ultrasonics are also effective in detecting the influence of these factors on the rate of increase in fat depth with gain in liveweight. Selection for low fat depth at P2 also reduces subcutaneous fat depth, to a lesser degree at lower liveweights and variably at other carcass sites.

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