# Energy Balance Estimated from Individual Measurements of Body Weight and Backfat Thickness of Heavy Pigs of Four Genetic Lines Fed Different Diets

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**Summary**

Pigs of four genetic lines (GL): Anas (A), DanBred (D), Goland (G) and Topigs received either a conventional (140 g CP/kg and 46 g lysine/kg CP; C-CP) or a low protein diet (106 g CP/kg and 46 g lysine/kg CP; L-CP). Body weight (BW) and backfat depth (P2) were individually measured at the start and the end of two growing periods and individual feed intake (FI) was recorded daily. Body protein and lipid mass at the start and at the end of each period were estimated from BW and P2, and hence protein (Pr) and lipid (Lr) retention were computed. Energy requirement for maintenance ($ME_m$), and growth ($ME_g$) were estimated according to National Research Council guidelines, while ME intake (MEI) was computed from measured FI and ME content of the diets. The MEI/($ME_m$ + $ME_g$) ratio was used as index of efficiency. Differences among GL (P<0.001) were observed for Pr, which averaged 103, 113, 108 and 101 g/d for A, D, G and T, respectively, and Lr which averaged 204, 186, 194 and 172 g/d for A, D, G, and T, respectively. The L-CP diet reduced (P = 0.014) Pr by 8% compared to C-CP, but not Lr. The MEI/($ME_m$+$ME_g$) index was influenced by GL (P<0.001) being 0.99, 0.96, 0.99 and 1.03 for A, D, G and T, respectively.

Measurements of BW and P2 permits to achieve acceptable quantification of Pr and Lr. In this range of BW (90 to 165kg), gain composition is influenced more by GL than by the substantial reduction of CP and essential amino acids dietary density used in this trial.

**Key words**

heavy pig, genetic line, growth performance, low-protein diets

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## Aim

This work aimed to test the effects of a 25% reduction of dietary crude protein and essential amino acids, with respect to 145 g CP/kg of conventional diets, on growth performance of pigs from 90 to 165 kg BW belonging to four genetic lines and to evaluate the use of simple body measurements (BW and backfat depth) as predictors of body composition, body status changes and energy balance.

## Material and methods

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

**Pigs, diets and experimental design**. In two batches a total of 184 gilts and barrows were reared at the experimental farm of the University of Padova. The pigs belonged to three genetic lines commonly used in the Italian pig industry for high quality dry-cured ham production (DOP), Anas (A), Goland (G) and Topigs (T), and an additional line the DanBred (D) with an higher potential lean growth compared to the others. Within each batch, the piglets, barrows and gilts equally represented in each genotype and born in the same week, were moved to the experimental farm at an average weight of 30 kg. The pigs were housed in 8 pens (10 to 12 pigs/pen) equipped with a feeding station (Compident Pig – MLP, SchauerAgrotronic, Austria) recording individual daily FI, and raised on a conventional feeding regime till about 80 kg BW. Starting from 80 kg BW, the experimental diets were introduced and all pigs received a restricted feeding regime adjusted every 2 weeks. The amount of pellet diet per pig increased from 2.4 to 3.2 kg/d from the first to the last week on trial, when the pigs were about 90 and 165 kg BW, respectively. During early (90 to 120 kg BW) and late (120 to 165 kg BW) finishing the conventional diet (C-CP) contained 147 and 132 g CP/kg, respectively, whereas the low-protein and low-essential amino acids diet (L-CP) contained 112 and 100 g CP/kg, respectively. Both C-CP and L-CP diets contained 50 and 41 g lysine/kg CP in early and late finishing, respectively. The L-CP diets were formulated from C-CP by replacing soybean with wheat meal, and diet compositions are given in Table 1. Water was freely available from a nipple drinker. Every 3 weeks pigs were individually weighed and backfat thickness was measured at the P2 point (last rib, 6 to 8 cm from midline, left side) with an ultrasound device (Renco Lean-Meater series 12, Renco corporation, Minneapolis, USA). The ME intake (MEI) was computed from measured feed intake and ME content of dietary ingredients (Sauvant et al., 2004).

**Body and gain composition and ME requirements**. According to Schiavon et al. (2007), at the start and the end of each finishing period body lipid mass (L) was estimated as $L = (9.17 + 0.70 \times P2) \times BW/100$, fat free empty BW (FFEBW) was estimated as $FFEBW = (BW \times 0.95 - L)$ and protein mass (P) was estimated as $P = 0.1277 \times FFEBW^{1.11}$. Within period, the mean daily protein (Pr) and lipid (Lr) retentions were computed from changes of body chemical status and period duration. The mean protein mass was computed within period and the ME need for maintenance ($ME_m$) was calculated as $ME_m = 1.85 \times P^{0.78}$ (NRC, 1998). The ME need for growth ($ME_g$), were computed assuming to be necessary 44.4 and 52.3 MJ ME/kg of Pr and Lr, respectively (NRC, 1998). The $MEI/(ME_m+ME_g)$ ratio was considered as an index of energy efficiency.

**Chemical analysis**. During manufacturing, 10 samples of each diet were collected on line, pooled and sampled to achieve 1 kg of feed sample and sub-sampled. Sub-samples were analysed in 3 independent replications for their proximate composition (AOAC, 2003) and NDF content (Van Soest et al., 1991). Starch content was determined, after its hydrolysis to glucose (AOAC, 2003), by liquid chromatography (Bouchard et al., 1988). The ME and amino acid contents were assessed from dietary ingredient composition and tabled values of ingredients (Sauvant et al., 2004).

**Statistical analysis**. Statistical analysis of performance and simulated N balance traits was based on the following linear model using the statistical package of SAS (SAS Inst. Inc., Cary, NC, USA):

**Table 1.** Chemical composition (g/kg as fed, unless otherwise indicated) of early (90 to 120 kg average BW) and late finisher diets (over 120 kg average BW)[1]

| | Early finisher diets | | Late finisher diets | |
|---|---|---|---|---|
| | C-CP | L-CP | C-CP | L-CP |
| Analysed nutrient composition[2]: | | | | |
| DM | 881 | 882 | 885 | 889 |
| CP (N × 6.25) | 147 | 112 | 132 | 100 |
| Starch | 423 | 478 | 450 | 501 |
| NDF | 162 | 163 | 151 | 152 |
| Ether extract | 39 | 38 | 38 | 35 |
| Computed nutrient composition | | | | |
| ME[3], MJ/kg | 13.0 | 13.0 | 13.1 | 13.1 |
| Lysine[4] | 7.3 | 5.6 | 5.6 | 4.1 |
| Methionine[4] | 2.3 | 1.8 | 2.1 | 1.6 |
| Threonine[4] | 5.2 | 4.0 | 4.6 | 3.7 |
| Tryptophan[4] | 1.8 | 1.4 | 1.6 | 1.2 |

[1] C-CP: conventional feeds; L-CP: low protein feeds.[2] Analytical results (AOAC, 2003) obtained fromthree independent replications.[3] Computed from chemical composition of feeds according to NRC (1998). [4] Computed from tabulated values of dietary feed ingredients (Sauvant et al., 2004).

$Y_{ijklmn} = \mu + batch_i + GL_J + diet_k + sex_l + pen\ (batch\times diet)_{ikm} + (GL\times diet)_{jk} + (GL\times sex)_{jl} + (diet\times sex)_{kl} + (batch\times GL)_{ij} + (batch\times\ diet)_{ik} + e_{ijklmn}$

Where $y_{ijklmn}$ is the single observation; μ is the intercept, batch is the fixed effect of round (i = 1, 2); GL is the fixed effect of the genetic line (j = 1,…,4); diet is the fixed effect of the feeding treatment (k = 1, 2); sex is the effect of gender (l = 1, 2); pen is the effect of pen (m = 1,…, 8) within batch×diet; GL×diet is the interaction effect between GL and diet, GL×sex is the interaction effect between GL and gender; diet×sex is the interaction effect between diet and gender, batch×GL is the interaction effect between batch and GL; batch×diet is the interaction effect between round and diet and is the random residual. The effect of the diet was tested using the pen (batch×diet) as error line.

## Results and discussion

Significant GL effects were observed for almost all the growth traits considered, except for MEI intake as the pigs received restricted amounts of feed (Table 2).

The greater ability for lean growth of the D pigs was reflected by greater initial and final BW, and thinner backfat thickness, so that the resulting Pr was greater and Lr was smaller compared to the pigs of other GL. Across GL, in early and late finishing periods Pr averaged 120 and 98 g/d, respectively, and Lr averaged 157 and 210 g/d, respectively. The effects of feed were much smaller than those observed for GL, and indicated that the reduction of dietary CP only slightly decreased Pr in the late finishing period (P = 0.022), and consequently over the entire trial (P = 0.014). The MEI/($ME_m$ + $ME_g$) ratio averaged 0.993, and it was lower for D (0.96), greater for T (1.03) and intermediate for the A and G pigs (0.99). The reduction of the dietary CP level slightly worsened energy efficiency from 0.98 to 1.00 (P = 0.044).

Overall, the growth performance obtained in this trial was in agreement with that commonly observed in the heavy pig production system and described elsewhere (e.g. Xiccato et al. 2005; Ceolin et al., 2005; Tagliapietra et al., 2005). Energy requirements indirectly computed from individual body measurements, using the NRC (1998) relationship to quantify the needs of ME for maintenance and growth, were in good agreement with the values of ME intake based on measured feed intake and ME dietary contents. Even though such approach can be biased both on the side of the prediction of body chemical status and

**Table 2.** Body composition and energy balance of heavy pigs of four genetic lines[1] fed conventional (C-CP) or low-protein diets (L-CP)[2]

| | Genetic Line (GL) | | | | SEM | Diet | | SEM | *P* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | D | G | T | | C-CP | L-CP | | GL | Diet |
| Body weight (kg) | | | | | | | | | | |
| Initial | 86 | 92 | 87 | 87 | 0.9 | 88 | 88 | 0.9 | <0.001 | 0.82 |
| Intermediate | 118 | 125 | 119 | 116 | 1.2 | 119 | 119 | 1.2 | <0.001 | 0.98 |
| Final | 164 | 172 | 166 | 159 | 1.9 | 167 | 163 | 1.9 | <0.001 | 0.14 |
| Backfat depth (mm) | | | | | | | | | | |
| Initial | 10.0 | 8.3 | 9.2 | 8.5 | 0.22 | 9.1 | 8.9 | 0.18 | <0.001 | 0.60 |
| Intermediate | 12.9 | 10.3 | 11.9 | 10.7 | 0.28 | 11.2 | 11.8 | 0.26 | <0.001 | 0.13 |
| Final | 19.4 | 15.9 | 17.7 | 16.2 | 0.44 | 17.1 | 17.5 | 0.32 | <0.001 | 0.33 |
| Body protein (kg) | | | | | | | | | | |
| Initial | 13.7 | 15.1 | 14.0 | 14.1 | 0.16 | 14.2 | 14.3 | 0.16 | <0.001 | 0.73 |
| Intermediate | 18.9 | 20.7 | 19.4 | 19.0 | 0.21 | 19.6 | 19.5 | 0.19 | <0.001 | 0.68 |
| Final | 25.5 | 28.0 | 26.4 | 25.6 | 0.31 | 26.8 | 25.9 | 0.30 | <0.001 | 0.05 |
| Body lipid (kg) | | | | | | | | | | |
| Initial | 14.0 | 13.8 | 13.5 | 13.1 | 0.23 | 13.6 | 13.6 | 0.22 | 0.015 | 0.90 |
| Intermediate | 21.4 | 20.5 | 20.9 | 19.3 | 0.36 | 20.3 | 20.8 | 0.40 | <0.001 | 0.39 |
| Final | 37.3 | 35.1 | 35.7 | 32.8 | 0.79 | 35.4 | 35.1 | 0.69 | <0.001 | 0.75 |
| Protein retention (g/d) | | | | | | | | | | |
| 0 to 44 d on feed | 119 | 128 | 123 | 111 | 3.2 | 122 | 118 | 3.1 | <0.001 | 0.35 |
| 45 to 115 d on feed | 93 | 103 | 99 | 95 | 3.1 | 103 | 92 | 2.9 | 0.032 | 0.022 |
| 0 to 115 d on feed | 103 | 113 | 108 | 101 | 2.3 | 111 | 102 | 2.1 | <0.001 | 0.014 |
| Lipid retention (g/d) | | | | | | | | | | |
| 0 to 44 d on feed | 170 | 151 | 166 | 140 | 6.1 | 151 | 163 | 5.9 | <0.001 | 0.19 |
| 45 to 115 d on feed | 228 | 207 | 213 | 192 | 8.6 | 215 | 204 | 6.9 | 0.022 | 0.28 |
| 0 to 115 d on feed | 204 | 186 | 194 | 172 | 6.2 | 190 | 188 | 5.5 | 0.001 | 0.79 |
| $ME_m$ requirement[4], MJ/d | 18.8 | 20.3 | 19.3 | 19.0 | 0.16 | 19.5 | 19.2 | 0.15 | <0.001 | 0.17 |
| $ME_g$ requirement[4], MJ/d | 15.3 | 14.7 | 15.0 | 13.5 | 0.39 | 14.8 | 14.4 | 0.36 | 0.002 | 0.36 |
| $ME_m$+$ME_g$[4], MJ/d | 34.1 | 35.0 | 34.2 | 32.5 | 0.50 | 34.4 | 33.6 | 0.47 | <0.001 | 0.25 |
| ME intake (MEI)[5], MJ/d | 33.7 | 33.6 | 33.8 | 33.6 | 0.46 | 33.7 | 33.6 | 0.45 | 0.99 | 0.88 |
| MEI/($ME_m$+$ME_g$) | 0.99 | 0.96 | 0.99 | 1.03 | 0.77 | 0.98 | 1.00 | 0.71 | <0.001 | 0.044 |

[1] Data are from pigs (281 ± 3.6 old at slaughter) of 4 GL, Anas (A), DanBred (D), Goland (G) and Topigs (T) fed C-CP diets [147 and 132 g CP/kg in early and late finishing, respectively] or L-CP diets [112 and 100 g CP/kg in early and late finishing, respectively]; [2] Presented are the least square mean based on 46 and 92 observations for GL and feed, respectively. [3] Body composition and nutrient retentions were estimated from BW and backfat depth measurements (Schiavon et al., 2007). [4] $ME_m$ and $ME_g$ are requirement for maintenance and growth according to NRC (1998); [5] MEI = measured feed intake× dietary ME content.

on the dietary ME content, it offers the advantage to be easily and cheaply applied *in vivo* on a large number of pigs. Slaughter experiments are certainly accurate in the determination of body chemical status, but they cannot be repeated under different production circumstances. Thus, the approach proposed would be useful for a proximate estimation of protein and lipid retentions of heavy pigs, and offer the opportunity to modulate the diet characteristics according to the production aim of this production system.

Protein restriction permits to achieve a strong reduction of N excretion (37%) which would increase the pig production/ha in areas where the N load is fixed by law (Schiavon et al., 2012). Evaluations about the slurry volume in which N excreted is diluted are desirable (Schiavon et al., 2009).

## Conclusions

During this trial the reduction of dietary CP did not influenced the growth performance of the pigs and reduced slightly the protein retention and the efficiency of ME use. These results confirm the opportunity for farmers to reduce the N excretion respecting the actual legislation without compromising production efficiency.

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