THE USE OF PROTEIN AND LIPID DEPOSITION TO DETERMINE SELECTION GOALS AND THEIR ASSOCIATION WITH CARCASS CUTS IN SWINE

S. Landgraf[1], R. Roehe[1], A. Susenbeth[2], U. Baulain[3], P.W. Knap[4], H. Looft[4], G.S. Plastow[4] and E. Kalm[1]

[1] Institut für Tierzucht und Tierhaltung, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany
[2] Institut für Tierernährung und Stoffwechselphysiologie, Universität Kiel, D-24098 Kiel, Germany
[3] Institut für Tierzucht und Tierverhalten, Bundesforschungsanstalt für Landwirtschaft (FAL), D-31535 Neustadt-Mariensee, Germany
[4] PIC Deutschland, Ratsteich 31, D-24837 Schleswig, Germany

INTRODUCTION

Biological growth models are of increasing interest in animal breeding. For example, De Vries and Kanis (1992) developed a biological growth model to optimise selection for feed intake capacity. For this biological growth model the input parameters of maximum protein deposition rate and minimum lipid to protein deposition ratio have to be known. In order to optimise the feed intake curve based on this biological growth model, the input parameters have to be known for each stage of growth. Different methods can be used for measuring protein and lipid deposition rate on live animals (e.g. deuterium dilution technique, magnetic resonance tomography (MRT)) or on slaughter animals in a serial slaughter trial with the entire body chemically analysed. All these techniques are very expensive and can only be obtained in an experimental trial. Therefore, indicator cuts to estimate the protein and deposition in different stages of growth are of high interest. For selection of feed intake over the entire growth period, the maximum protein deposition rate and minimum lipid to protein deposition ratio have to be known. Knap (2000) showed that the Gompertz function can be used to estimate these parameters. The use of the Gompertz function is only possible when the animals were tested over a long period as in the present study. Therefore, the objectives of this study were to obtain indicator cuts for protein deposition and lipid deposition rate and to obtain parameters for maximum protein and lipid deposition estimated by using nonlinear Gompertz function, which can be used for selection to optimise feed intake curve based on a biological model.

MATERIAL AND METHODS

Data were obtained in a three generation full-sib design, which will be used finally to identify the genomic regulation of protein and lipid deposition rate. However, the first goal was to obtain protein, lipid and ash deposition during growth and its association with carcass characteristics. The base generation (F_0) consisted of 8 unrelated boars of a sire line and 32 unrelated sows of a dam line, which were mated to get the F_1 generation. Animals not used to create the F_2 generation were tested on station to obtain protein, lipid and ash deposition at 15, 30, 60, 90, 120, 140 kg. Protein and lipid deposition was measured on all tested animals by deuterium dilution technique. As first reference method, chemical analysis of the entire body was used in a serial slaughter trail with 8 animals slaughtered at each of the 6 weight classes. MRT on another 8 animals was done for the same weight classes. In the present analysis the data of the chemical analysis and the MRT was used to estimate protein and lipid deposition and its association to carcass cuts. As carcass cuts, the weight of the main cuts, ham, shoulder, loin, belly and neck was measured. Thereafter, each cut was dissected to obtain further information about its composition concerning lean meat, fat and bones. Data were analysed using SAS procedures, in particular the PROC NLIN procedure for estimation of parameters of the Gompertz function.

RESULTS AND DISCUSSION

The protein and lipid mass of the carcass were closely correlated with fat traits measured at the 13./14. rib (table 1). This was not the case for ash mass.

Table 1. Correlations between carcass cuts and protein, lipid and ash composition of the entire body at the live weight of 120 kg

Carcass cut	Protein (kg)	Lipid (kg)	Ash (kg)
Ham total (kg)	0.45	- 0.19	- 0.46
Ham trimmed (kg)	0.71	- 0.47	- 0.34
Fat area (cm^2)	- 0.92	0.80	0.01
Loin area (cm^2)	0.46	- 0.68	0.11

As shown in table 2, there is a change in correlation between carcass cuts and protein or lipid mass during growth. Whereas, the weight of ham was a good estimate for protein mass in pigs of 15 kg weight, the association at weight classes 60 to 90 kg was only moderate with an increase in correlation at higher weight classes. For lipid mass, the highest correlation was found at early growth with ham trimmed, whereas at high weights the fat and loin area were highly associated with lipid mass. In general, the estimated correlations are very variable so that an estimation of lipid and protein deposition by a single carcass cut is difficult. Therefore, functions of carcass cuts may be developed the obtain higher association over the entire growth period.

The change of protein deposition rate during growth is presented in table 3. High protein deposition rate was obtained between 60 and 90 kg live weight. Eissen (2000) also reported the highest protein deposition rate at these weights. Within this weight range, Roehe *et al.* (1994) and Schulze *et al*. (2002) found the highest heritabilities of feed intake, which may indicate the close association between protein deposition and feed intake. In this weight range also lipid deposition showed its first height, which again agreed with results reported by Eissen (2000). After the reduction of lipid deposition rate in the range of 90-120 kg live weight, an exponential increase in lipid deposition was obtained.

Table 2. Change of correlation between carcass cuts and protein and lipid composition of the entire body during the growth period

	Weight class					
Carcass cut	15 kg	30 kg	60 kg	90 kg	120 kg	140 kg
	Correlation with protein mass (kg)					
Ham total	0.96	0.81	0.77	0.50	0.45	0.18
Ham trimmed	0.90	0.77	0.54	0.41	0.70	0.71
Fat area	0.56	0.30	-0.62	0.13	-0.92	-0.33
Loin area	0.74	0.63	0.31	0.36	0.46	0.62
	Correlation with lipid mass (kg)					
Ham total	0.86	0.51	0.12	-0.11	-0.19	-0.07
Ham trimmed	0.90	0.66	0.02	-0.24	-0.47	-0.31
Fat area	0.52	0.52	0.52	0.48	0.80	0.76
Loin area	0.75	0.52	-0.59	0.04	-0.68	-0.84

Table 3. Protein, lipid and ash deposition rate in different weight ranges measured in chemical analysed pigs of a serial slaughter trial

Fraction	Weight range				
	15-30 kg	30-60 kg	60-90 kg	90-120 kg	120-140 kg
Protein (g/d)	112	102	134	100	155
Lipid (g/d)	61	163	243	215	629
Ash (g/d)	17	19	26	25	17

The parameter estimates of protein, lipid and ash deposition fitting a Gompertz function over the entire growth period are presented in table 4. In the present study, mature protein mass was at the lowest level of values (24.5 to 38.5 kg) reported by Knap (2000) based on several studies obtained from the literature. This may be due to the Pietrain genotype which was involved in the F1 crosses. It may indicate that mature body mass is reduced due to selection on high lean content in Pietrain. It may also be concluded that reduced feed intake capacity in Pietrain is related with low mature protein mass.

The estimates of maximum protein deposition using Gompertz function were slightly lower than the linear protein deposition rate presented in table 3. In comparison to the literature study of Knap (2000), these estimates were in the range of values obtained from the data described by Noblet *et al.* (1994). For lipid deposition, the Gompertz function did not fit well, because of the extensive increase in lipid deposition at the end of the test period. Therefore, maximum lipid deposition was substantially lower than highest lipid deposition rate during growth within 120-140 kg live weight. In contrast, maximum ash deposition agreed well with the linear ash deposition at the weight range of 60-90 kg.

Table 5 shows the estimates of muscle and fat tissue using MRT by which the volume of the tissue is measured. The Gompertz rate, which is independent from the scale, was lower than obtained for serial slaughtered animals. The difference in maximum muscle tissue deposition and protein deposition is mainly a function of water content.

Table 4. Estimates of mature (∞) , maximum (max) and Gompertz rate (Gomp) for protein (P), lipid (L) and ash (A) deposition in serial slaughtered animals

Item	P_∞ (kg)	P_{max} (g/d)	P_{Gomp} (kg/d*kg)	L_∞ (kg)	L_{max} (g/d)	L_{Gomp} (kg/d*kg)	A_∞ (kg)	A_{max} (g/d)	A_{Gomp} (kg/d*kg)
Males	24.73	126	0.0139	48.79	285	0.0159	5.04	23	0.0126
Females	24.98	125	0.0136	29.40	226	0.0209	4.58	26	0.0153
Both	24.73	126	0.0138	48.55	259	0.0145	5.01	24	0.0128

Table 5. Estimates of mature (∞), maximum (max) and Gompertz rate (Gomp) for muscle (M) and fat (F) tissue deposition using magnetic resonance tomography

Item	M_∞ (kg)	M_{max} (g/d)	M_{Gomp} (kg/d*kg)	F_∞ (kg)	F_{max} (g/d)	F_{Gomp} (kg/d*kg)
Males	125.4	415	0.0090	62.43	204	0.0089
Females	125.6	416	0.0090	65.78	276	0.0114
Both	125.6	416	0.0090	59.50	243	0.0111

CONCLUSION

Based on the present results, indicator cuts for estimation of protein and lipid deposition were very variable during the growth period and thus had no high value to predict chemical body composition. Combination of carcass cuts to predict protein deposition may have a higher value. Maximum protein deposition rate during growth agreed well with estimates given by Eissen (2000) using enhanced breeds, and can therefore be used to optimise feed intake within a biological growth model. Selection for higher mature protein mass seems also necessary in the given population, because mature protein mass may limit protein deposition during growth and is closely associated with feed intake. Further reduction in mature protein mass may also result in extensive fat deposition as given for the weight range of 120-140 kg .

ACKNOWLEDGEMENTS

The authors wish to acknowledge financial support by Deutsche Forschungsgemeinschaft and PIC.

REFERENCES

De Vries, A.G. and Kanis, E. (1992) *Anim. Prod*. **55** : 241-246.

Eissen, J.J. (2000) PhD Thesis, Wageningen University, The Netherlands.

Knap, P.W. (2000) *Anim. Sci.* **70** : 39-49.

Noblet, J., Karege, C. and Dubois, S. (1994) *J. Rech. Porcine France* **26** : 267-276.

Roehe, R., von Felde, A., Looft, H., Krapoth, J. and Kalm, E. (1994) *Proc. 5th WCGALP* **19** : 185-188.

Schulze, V., Roehe, R., Lorenzo Bermejo, J., Looft, H. and Kalm E. (2002) *Livest. Prod. Sci.* **73** : 199-211.