Real-time control of pig growth through an integrated management system (IMS)

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Introduction Integrated management systems (IMS) for pigs offer the prospects of optimising meat production and minimising nitrogenous pollution through closed-loop control of pig growth by nutritional control (Whittemore, *et al*., 2001). Such an IMS requires a real-time sensor system, a nutritional model which is optimised in response to data collected in by the sensor system, and a control system which uses forward predictions of the model to predict the nutritional regime required to satisfy growth and pollution targets. An experiment was carried out to determine the accuracy to which a novel IMS system can direct pig weight gain and fatness towards preset targets through nutritional control.

Materials and methods A total of 144 pigs of a commercial breed were reared in controlled environment facilities in twelve pens. Pigs were fed *ad libitum* diets that varied in crude protein (CP) content between pens, produced by blending two source diets of 140 and 190 g / kg CP. Live weight estimated by a visual image analysis (VIA) system (Marchant and Schofield, 1999) and feed intakes were recorded for individual pigs on a daily basis. Manual weights and P2 back fat depth measurements were also taken. The system was based on the model described by Green and Whittemore (2003). From the daily live weight and intake data, two model parameters (one controlling efficiency of use of dietary supplied nutrients, the other maximum protein retention rate) were optimised for each pig using the Revised Simplex Method (Nelder and Mead, 1965). The same algorithm was used to control dietary CP content for each pen, reappraised weekly, according to the following growth targets (two pens for each target): a) 50 kg and b) 60 kg weight gain; and c) 12 mm and d) 16 mm final P2 back fat depth. The final two pairs of pens were fed on the two extreme CP levels throughout.

Results Model optimisation results are given in Table 1. Optimising the parameters using VIA data for the first 39 days, or for the whole growth period, resulted in a good model fit without bias. In addition, prediction to the end of the trial using parameters estimated from the data for the first 39 days produced good model predictions. RMSEP values were within the range of measurement error of live weight by VIA. The system controlled the average weight in three out of four pens to within 3 kg of the target; in the fourth, a change in growth rate at the end of the trial resulted in a deviation of -5.8 kg (Table 2). For fat depth, control produced results close to the lower target of 12 mm. The achievement of the higher target lay beyond the capability of the system given the range of possible diets and *ad libitum* feeding, but these pens achieved the highest P2 fat depth in the trial.

Table 1 Observed and modelled live weight (kg). Root mean squared errors of predictions (RMSEP) are given in parentheses

Observed weight	Model weight – unoptimised	Model weight - optimised
Optimisation to day 39		
74.0	70.0	73.2
Optimisation to day 39, prediction to end		
96.5	90.3 (8.4)	97.0 (6.3)
Optimisation to end of trial		
		96.8 (5.0)

Table 2 Growth targets for each pen, with mean final deviation from target. Standard errors are given in parentheses

Target		Deviation
Weight gain (kg)	49.3	2.1 (2.4)
	49.3	2.3 (0.9)
	59.1	-5.8 (1.5)
	59.1	2.0 (2.4)
Final P2 back fat depth (mm)	12	-0.9 (0.53)
	12	0.2 (0.60)
	16	-2.1 (0.72)
	16	-2.4 (0.68)

Conclusions The present study has shown that pig growth model optimisation can be performed in real time using VIA data, and that weight gain in pigs can be controlled through an integrated management system using *ad libitum* feeding and a range of diet CP content. Some control of fat depth may also be possible.

Acknowledgements The support of the sponsors: DEFRA LINK SLP, MLC, BOCM PAULS Ltd, PIC Ltd, and Osborne Ltd is gratefully acknowledged. Experiments were conducted at ADAS Terrington, Norfolk.

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