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# Performance and body composition of light and heavy early-weaning piglets subject to different dietary energy levels

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ABSTRACT

This study aimed to evaluate the effects of dietary metabolizable energy (ME; 3.40, 3.60, or 3.80 Mcal/kg) and weaning weight (WW; 4.5 ± 0.4 and 6.7 ± 0.5 kg) on growth performance, body composition, and energy utilization in early-weanling piglets. The diet with 3.40 Mcal/kg was formulated based on standard energy and nutrient recommendations in Brazil, and amino acids, Ca, P, and lactose levels in diets containing 3.60 and 3.80 Mcal/kg were adjusted for the increased ME to maintain constant nutrient to ME ratios. Thirty-two male piglets were housed in metabolic cages individually for 28 d in a 2 × 3 factorial arrangement of treatments with 5 barrows per treatment, except light and 3.8 ME and heavy and 3.4 ME/kg treatments, which had 6 barrows per treatment. Body composition, nutrient deposition rates, and energy efficiency were measured through a comparative slaughter procedure. There were no WW × ME interactions for any of the response criteria. Heavy piglets had 15% greater average feed intake, 16% average daily gain, and 19% body weight on d 28 than the light piglets ($P=0.021$), but there was no effect of WW on energy and nutrient digestibility. Dietary ME content did not affect growth performance, but increased digestibility of dry matter, gross energy, and crude protein ($P<0.001$). Heavy piglets had greater carcass weight (20%) and empty body weight (18%) than the light piglets ($P<0.001$). Energy efficiency was not influenced by WW or dietary ME content. Heavy piglets at weaning consumed more ME ($P<0.022$) and had greater body protein accretion in the carcass and empty body weight ($P<0.05$), but fat deposition was not affected. There was no interaction between WW and ME content of post-weaning diets, and increasing dietary energy level did not affect the post-weaning performance of light piglets at weaning. The results of this study did not support the hypothesis that light piglets at weaning do not exhibit compensatory growth because of limitations in energy and nutrient intake.

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## 1. Introduction

Pigs have been submitted to intensive selection pressure for the increase in the number of piglets born per sow per year, which, however, led to an increase in the number of stillborn piglets and to low birth weight (Fix et al., 2010). Light pigs at weaning seldom show compensatory growth in subsequent rearing phases (Beaulieu et al., 2010; Bérard et al., 2008; Gondret et al., 2006), and usually require more days to reach market weight. This lack of compensatory growth is because of a combination of factors that compromise the ability of those piglets to reach the same performance results compared with piglets weaned at heavier weights.

Low birth weight is related to the intrauterine competition for nutrients (Bérard et al., 2008), which results in different degrees of restriction of embryo growth (Nissen and Oksbjerg, 2011; Pardo et al., 2013b), resulting in lower number of total muscle fibers (Foxcroft et al., 2006) and low capacity of lean tissue accretion (Rehfeldt and Kuhn, 2006). However, piglets born with weights within the normal weight range may be light at weaning because of insufficient suckling, as well as to poor management practices and poor environmental and health conditions (Mahan and Lepine, 1991; Wolter and Ellis, 2001; Wolter et al., 2002). Many factors related to poor performance of weaned piglets have not been yet determined or defined (Wu et al., 2006).

The poor performance of weaning piglets could be compensated by supplying high-energy density diets, as protein accretion in growing pigs is limited by energy intake when diet formulation is based on Lys to energy ratios. However, previous studies did not show any performance improvement when dietary energy density was increased (Arnaiz et al., 2009; Beaulieu et al., 2006; Oresanya et al., 2008) only greater body fat deposition was observed (Oresanya et al., 2008).

The objective of the present study was to evaluate the effect of dietary energy concentration and weaning weight on performance

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and body composition of weaned piglets in order to determine if there is any interaction between these factors, i.e., if light piglets at weaning could show compensatory growth when fed an energy- and nutrient-dense diet when compared with heavy piglets at weaning.

## 2. Material and methods

### 2.1. Animals, treatments, and experimental design

The experiment was conducted in the Laboratório de Ensino Zootécnico of Universidade Federal do Rio Grande do Sul (UFRGS), located in Porto Alegre, Brazil. All procedures used in this experiment were approved by the Ethics Committee on Animal Use from UFRGS (Protocol no. 21121).

Thirty-two weanling barrows (21–24 d of age) housed in individual metabolism crates were assigned to weaning weight (WW; light: $4.5 \pm 0.4$ kg and heavy: $6.7 \pm 0.5$ kg) and metabolizable energy (ME: 3.4, 3.6, and 3.8 Mcal/kg) in a $2 \times 3$ factorial arrangement of treatments with 5 barrow per treatment, except light and 3.8 ME and heavy and 3.4 ME/kg treatments, which had 6 barrows per treatment. Piglets were categorized to light and heavy at the commercial facility. Metabolism crates (0.48 $m^2$) were located in an environmentally-controlled room and equipped with a feeder and a drinker. The experiment was conducted in two nursery phases: I, between 0 and 14 d after weaning, and II, between 15 and 28 d after weaning. Piglets were offered ad libitum access to feed and water throughout the study.

### 2.2. Dietary treatments

Diets with three ME levels were formulated (3.4, 3.6 or 3.8 Mcal/kg) and fed as mash (Table 1). The control diet (3.40 Mcal ME/kg) was formulated with standard energy and nutrient recommendations (Rostagno et al., 2011), whereas indispensable and dispensable amino acid, calcium, phosporus, and lactose levels in the diets 3.6 and 3.8 Mcal/kg were adjusted for the increased ME to maintain constant nutrient to ME ratios. Ratios of 4.14 and 3.91 g of digestible Lys/Mcal of ME and 14.8% and 8.5% lactose were supplied in phases I and II, respectively. Milk replacers and swine plasma were added to stimulate feed intake and to ensure that diet digestibility was high. Piglets were given a pre-starter diet during the first 14 d and a starter diet during the subsequent 14 d of the experiment.

### 2.3. Performance, ultrasound analysis, and apparent total tract digestibility

Pig body weight (BW) and feed consumption were determined weekly. Loin-eye area (LEA) and last rib backfat were measured by ultrasound on d 27 of the experiment. Images were collected using a portable unit (Model DDD500; ALOKA, São Paulo-SP, Brazil) with a 3.5 MHz and 11-cm long linear transducer, and subsequently analyzed by the software program Lince (M&S Consultoria Agropecuária Ltda., Pirassununga-SP, Brazil). During manufacture of feeds, five samples of each diet were collected, pooled, mixed, and sampled to achieve a 500 g of feed. All samples were stored at −20 °C until required for analysis. The feed samples were analyzed in two replications for their proximate composition (AOAC, 1995). The digestibility assay consisted of seven d of adaptation, during phase I, followed by total fecal and urine collection for seven and 14 d during phases I and II, respectively. The collection of feces and urine was performed once a day. Ferric oxide at 0.1% was used as a marker just before the first and last meal to establish the exact period of feces collection (Adeola, 2001). Feces were weighed daily then placed in labeled plastic bags. Urine was drained into plastic buckets with 5 mL of $H_2SO_4$ to prevent the nitrogen (N) loss. The volume was weighed daily and the entire volume was kept in freezers at −15 °C until analysis. Fecal and urine samples were subsequently thawed and homogenized for the collection of two subsamples weighing 500 g and 100 mL per replicate, respectively, for analyses.

**Table 1**
Composition of experimental diets (as-fed basis).

| Item | Phase I[a] | | | Phase II[b] | | |
|---|---|---|---|---|---|---|
| | 3.40 | 3.60 | 3.80 | 3.40 | 3.60 | 3.80 |
| Ingredient (g/kg) | | | | | | |
| Corn | 353.2 | 312.0 | 270.7 | 351.2 | 366.9 | 382.4 |
| Soybean meal | 180.0 | 195.0 | 210.0 | 220.0 | 221.5 | 223.0 |
| Soybean oil | 7.30 | 31.20 | 55.00 | 29.30 | 39.60 | 50.00 |
| Milk whey | 158.6 | 148.1 | 137.6 | 109.6 | 72.90 | 36.30 |
| Sugar | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 |
| Swine plasma | 40.00 | 42.50 | 45.00 | 10.00 | 10.00 | 10.00 |
| Corn gluten (64% CP) | 35.70 | 43.90 | 52.00 | 62.00 | 66.00 | 70.00 |
| Powdered whole milk | 60.60 | 99.70 | 138.8 | 0.00 | 79.40 | 158.7 |
| Full-fat rice bran | 100.00 | 62.30 | 24.60 | 150.00 | 75.00 | 0.00 |
| Dicalcium phosphate | 9.80 | 11.00 | 12.20 | 10.40 | 11.20 | 12.00 |
| Limestone | 9.50 | 9.40 | 9.20 | 11.50 | 11.30 | 11.10 |
| Salt | 0.00 | 0.10 | 0.10 | 2.40 | 2.40 | 2.50 |
| Vitamin premix[c,d] | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| Mineral premix[e,f] | 0.80 | 0.80 | 0.80 | 0.70 | 0.70 | 0.70 |
| DL-Met | 1.40 | 1.50 | 1.50 | 1.40 | 1.60 | 1.70 |
| L-Lys · HCL | 4.20 | 4.00 | 3.80 | 5.70 | 5.70 | 5.70 |
| L-Thr | 0.80 | 0.70 | 0.60 | 1.30 | 1.30 | 1.30 |
| L-Trp | 0.20 | 0.20 | 0.20 | 0.40 | 0.40 | 0.40 |
| Zinc oxide | 2.70 | 2.70 | 2.70 | 0.00 | 0.00 | 0.00 |
| Copper sulfate | 0.40 | 0.40 | 0.40 | 0.30 | 0.30 | 0.30 |
| Acidifier[g] | 4.00 | 4.00 | 4.00 | 3.00 | 3.00 | 3.00 |
| Halquinol(60%)[h] | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Ethoxyquin[i] | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Calculated composition | | | | | | |
| ME (Mcal/kg) | 3.40 | 3.60 | 3.80 | 3.40 | 3.60 | 3.80 |
| CP (g/kg) | 210.0 | 225.0 | 240.0 | 210.0 | 221.5 | 233.0 |
| Fat (g/kg) | 57.80 | 84.60 | 111.50 | 72.50 | 91.80 | 111.20 |
| Ca (g/kg) | 8.20 | 8.70 | 9.20 | 8.30 | 8.80 | 9.30 |
| P (g/kg) | 4.90 | 5.20 | 5.50 | 4.50 | 4.80 | 5.10 |
| Ca:P | 1.67 | 1.67 | 1.67 | 1.84 | 1.83 | 1.83 |
| Dig Lys (g/kg) | 14.10 | 14.90 | 15.80 | 13.30 | 14.10 | 14.90 |
| Lactose (g/kg) | 140.0 | 148.0 | 156.0 | 80.0 | 85.0 | 90.0 |
| Lys:ME (g/Mcal) | 4.14 | 4.14 | 4.14 | 3.91 | 3.91 | 3.91 |
| Analyzed composition | | | | | | |
| ME (Mcal/kg) | 3.46 | 3.60 | 3.79 | 3.47 | 3.58 | 3.83 |

[a] Phase I (0–14 d).
[b] Phase II (15–28 d).
[c] Added per kilogram of diet (Phase I): vitamin A, 14,400 IU; vitamin $D_3$, 2700 IU; vitamin E, 32.40 mg; vitamin K, 3.60 mg; vitamin B1, 2.88 mg; vitamin B2, 9.18 mg; vitamin B6, 2.79 mg; vitamin B12, 34.20 mg; pantothenic acid, 23.40 mg; niacin, 46.80 mg; folic acid, 0.81 mg; and biotin, 162 μg.
[d] Added per kilogram of diet (Phase II): vitamin A, 11,280 IU; vitamin $D_3$, 2400 IU; vitamin E, 28.80 mg; vitamin K, 3.20 mg; vitamin B1, 2.56 mg; vitamin B2, 8.16 mg; vitamin B6, 2.48 mg; vitamin B12, 30.4 mg; pantothenic acid, 20.80 mg; niacin, 41.60 mg; folic acid, 0.72 mg; and biotin, 144 μg.
[e] Added per kilogram of diet (Phase I): Se, 0.48 mg; I, 0.56 mg; Fe, 64.0 mg; Cu, 12.80 mg; Zn, 128.0 mg; and Mn, 48.0 mg.
[f] Added per kilogram of diet (Phase II): Se, 0.42 mg; I, 0.49 mg; Fe, 56.0 mg; Cu, 11.20 mg; Zn, 112.0 mg; and Mn, 42.0 mg.
[g] Ultracid Plus (14.4 mg/kg, INVE Technologies, Dendermonde, Belgium).
[h] 120 mg/kg (Novartis, Barueri, São Paulo, Brazil).
[i] 66 mg/kg (Novus Int., Mississauga, ON, Canada).

### 2.4. Comparative slaughter measurements and chemical analyses

Another six piglets from the same weaning group (3 lights and 3 heavy) were sacrificed at the beginning of the experiment to

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