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Changes in body content of iron, copper and zinc in Iberian suckling piglets under different nutritional managements

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ABSTRACT

Thirty-eight purebred Iberian sows were used in two consecutive trials to determine the influence of different nutritional strategies applied to the litters on body composition and retention of some trace minerals in the body of suckling piglets weaned at 35 d of age. Exclusively milk feeding (M), conventional suckling (CS) and intermittent suckling (IS) were studied. Only litters on CS and IS treatments had free access to creep feed from day 15 onwards. Those of the CS group had continuous access to their dams. Piglets on the IS treatment were progressively separated from the sow during 6 h, 8 h and 10 h on days 29–30, 31–32 and 33–34, respectively. Eight piglets at birth (4 per trial replicate) and one piglet per litter on day 35 of age were slaughtered and used to study whole-body content of Fe, Cu and Zn, and its distribution in the different body compartments. Mineral retention was calculated following the comparative slaughter procedure. Average contents of these trace elements in Iberian sows' milk were Fe 1.65, Cu 1.46 and Zn 11.10 mg/kg, whereas those analyzed in creep feed were Fe 240, Cu 170 and Zn 2900 mg/kg (as fed). The body concentration of Fe at weaning was unchanged between groups, although Fe stored in liver tended to be higher in IS piglets (32.3, 30.5 and 50.0 mg/kg for M, CS and IS piglets respectively, P=0.101). No differences (P>0.05) were observed in whole-body or liver concentration of Cu between groups, although Cu concentration was increased (P<0.01) in some body compartments (blood and head/feet/tail) in CS and IS compared to M piglets. Significant effect of the feeding regimen was found in body levels of Zn in weaned piglets, as retention and body content resulted progressively increased as follows: IS > CS > M groups (P<0.001), with significant differences for all body parts. Zn liver concentration increased around 3-fold in creep fed piglets compared to milk fed piglets (53, 149 and 157 mg/kg for M, CS and IS piglets, respectively, P=0.029). It may be concluded that stimulation of consumption of solid feed containing pharmacological levels of these trace elements in the suckling piglet may lead to some changes in body content of Fe and Cu at weaning, and increases greatly Zn body levels. Beneficial consequences of these nutritional practices warrant to be evaluated, as they cause substantial increase in environmental contamination.

1. Introduction

Trace minerals are essential for pigs, as they are related to key aspects of production, immune function, resistance to disease and growth promotion. Previous studies have shown positive effects of including additional quantities of trace minerals

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in pig diets on aspects other than preventing deficiencies. The addition of pharmacological levels of Zn (2000–4000 mg/kg) and Cu (125–250 mg/kg) to nursery pig diets is nowadays a common practice, due to the generally demonstrated beneficial response on health and growth performance of weanling piglets (Hill et al., 2000, 2001; Shelton et al., 2011). However, as the majority of trace minerals ingested by pigs is excreted in faeces and urine, feeding high levels of Zn and Cu increases the emission of these elements and becomes a potential environmental threat (Kornegay and Verstegen, 2001). Therefore, European regulations limited the Zn and Cu concentration authorized in pig diets to a maximum of 150 and 170 mg/kg, respectively (Official Journal of the European Union, No. 1334/2003).

Different nutritional strategies may be applied to suckling piglets in order to improve performance and efficiency of utilization of nutrients. To avoid negative implications derived from the drastic change from high digestible milk to a solid less digestible diet, pre-starter feed is usually offered to piglets before weaning. Moreover, a way to stimulate creep feed intake during lactation is the intermittent suckling practice, in which piglets are separated from dams during a number of hours daily in the second half of lactation (Kuller et al., 2004). Feeding piglets only on milk until weaning or combining milk and solid feed usually implies the intake of low to moderate levels of trace elements, especially Fe, Cu and Zn. It is known that sow's milk is a poor source of these minerals (Csapó et al., 1996) compared with solid nursery diets, which usually contain trace minerals beyond recommendations (NRC, 1998). Addition of dietary trace element affects mineral status in nursery pigs (Rincker et al., 2005), although information on whole-body composition of trace elements of piglets at weaning is very limited, and there is no information relating trace mineral body composition at weaning with previous nutritional management. An interrelationship exists between Cu, Fe and Zn due to their similar physical and chemical properties and, thus, an imbalance in one of them may have an antagonistic effect on the concentration of another (Rincker et al., 2005). Excess of Zn is known to induce a Cu deficiency, and Cu is essential for numerous enzymes involved in Fe transport and metabolism (Mateos et al., 2004).

The objectives of this research were to determine trace mineral balance and trace mineral body composition in Iberian piglets weaned at 35 d, under different nutritional strategies: exclusively milk feeding (M), conventional suckling including voluntary creep solid feed intake (CS), and intermittent suckling (IS). Whole-body content and the partition of Fe, Cu and Zn in body compartments were examined. Due to the relevance that trace mineral status may have in the viability of piglets, the information provided by this study may be useful to Iberian piglet producers.

2. Materials and methods

The experimental protocol was approved by the Bioethical Committee of the Spanish National Research Council (CSIC), Spain. The sows and piglets were cared for following Spanish Ministry of Agriculture guidelines (Boletín Oficial del Estado, 2005).

2.1. Animals and experimental design

Thirty eight purebred Iberian sows in their third pregnancy (Silvela strain) were involved in the study and used in two consecutive trials ($n = 19$ per replicate). In each trial, four sows were selected for milk sampling (nursing sows), and the other 15 to study litter performance and trace element balance measurements. One week before farrowing the sows were individually housed in farrowing crates (1.90 m × 0.60 m) within pens (2.40 m × 1.60 m) in a ventilated room. The environmental temperature of the farrowing room was 27 ± 2 °C in the first trial (Trial 1) and 22 ± 2 °C in the second one (Trial 2), during the subsequent 34 d of the lactation period. The pens were equipped with a thermo-regulated surface that maintained the temperature at 33–35 °C during the first week of life, declining progressively to 25–27 °C at the end of the third week. Once in the farrowing room, the sows were fed at 1% body weight (BW) a commercial lactation diet (Table 1). On the day of parturition the sows were offered 1.5 kg of this diet. Thereafter, the daily food allowance was increased by 0.6 kg to reach 4.5 kg/d on the fifth day of lactation, which was maintained onwards. No significant feed refusals were observed. The sows' live weight just after farrowing was in the range of 130–140 kg. Litter size at birth was equalized to six piglets by cross fostering, using additional sows submitted to identical conditions to those included in the assay, when necessary. Shortly after birth, the piglets were administered 200 mg Fe–dextran complex (Imposil Forte®; Alstoe Ltd., York, UK) via i.m. injection. Sows and litters had *ad libitum* access to water.

During each trial, milk samples were collected from the four nursing sows on day 5, 12, 19, 26 and 34 postpartum, in a similar way as described by Aguinaga et al. (2011) and stored in opaque plastic bottles at −20 °C until processed. Analysis of energy and nutrient composition of the Iberian sow's milk is shown in Table 2.

The remainder sows with their piglets were randomly distributed in three groups ($n = 10$ per group, 5 per trial replicate). The first group of piglets was fed exclusively with their mothers' milk over the 34 d lactation period (group M). From 15 d of age onwards, the other two groups of piglets had free access to solid feed, whose ingredients and nutrient composition are shown in Table 1. Pharmacological levels of Cu and Zn in the pre-starter feed were derived from the addition 140 mg/kg of Cu (as $CuSO_4 \cdot 5H_2O$) and 2500 mg/kg of Zn (as ZnO). At day 29 of age the litters followed either a conventional suckling (group CS) or an intermittent suckling schedule (group IS). The piglets in the CS treatment had free access to the sow 24 h per day. In the IS treatment, the piglets were separated from the sow according to the following schedule: day 29 and 30, from 08:00 h to 14:00 h (6 h); day 31 and 32, from 08:00 h to 16:00 h (8 h); day 33 and 34, from 08:00 h to 18:00 h (10 h). Weaning took place in the morning of 35 d of age. All piglets were weighed individually at birth and at 15, 28 and 35 d of