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Behavior of suckling pigs supplemented with an encapsulated iron oral formula

Carolina Valenzuela, Gianfranco Lagos, Jaime Figueroa, Tamara Tadich*

Departamento de Fomento de la Producción Animal, Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Santiago, Chile

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ABSTRACT

Parental iron supplementation in neonatal piglets is a routine management to solve anemia but may cause welfare problems. The aim of this study was to assess behavior responses generated after oral or parenteral iron supplementation. Parenteral supplementation consisted of 200 mg of iron dextran intramuscular. The novel oral iron supplement was a combination of encapsulated nonheme/heme iron (252 mg of total iron) delivered orally. Two litters formed by 11, 2-day-old piglets were assigned to each treatment. The litters were video recorded for 6 hours, 3 before and 3 after iron supplementation. Scan sampling every 3 minutes was used to register the occurrence of 7 behaviors. The highest overall percentage of time was allocated to resting, 46.5% (167.4 minutes) for the parenteral group and 42.4% (152.6 minutes) for the oral group; and suckling 24.6% (88.6 minutes) for the parenteral group and 27.8% (100.1 minutes) for the oral group. Resting time was higher after 1 hour of iron supplementation in the parenteral group 51.9% (31.1 minutes) vs. 33.8% (19.7 minutes). In conclusion, the oral iron supplementation resulted in a higher behavioral disruption in neonatal pigs, probably associated to increased handling time and aversive flavor of the supplement.

Introduction

Iron-deficiency anemia is the most common mineral deficiency in swine, with a multicausal origin, and high morbidity in intensive pig farming systems (Lipiński et al., 2010). Within the first days of life, neonatal piglets are routinely subjected to parenteral iron supplementation (injection intramuscular of 100 to 200 mg of dextran iron), practice that can be stressful for piglets and sows (Brown et al., 1996). Alternative methods such as oral iron supplementation have also been proved to decrease iron deficiency (Quintero-Gutiérrez et al., 2008; Svoboda and Drábek, 2002). However, generally inorganic sources of nonheme iron, which have low bioavailability, are used as oral supplement. In contrast, Quintero-Gutiérrez et al. (2008) used sources of heme iron in pig supplementation, which showed a higher bioavailability than nonheme iron. The encapsulation method for iron has been widely used in human nutrition to prevent iron-deficiency anemia with good results (Zimmermann, 2004), but to our knowledge, this technology has not been applied for pig iron supplementation.

Current information on iron supplementation methods has focused on measuring the iron biomarkers in blood and serum, and the productive parameters of piglets (Lipiński et al., 2010; Quintero-Gutiérrez et al., 2008; Svoboda and Drábek, 2002). Any effects of parenteral and/or oral iron supplementation on behavior and welfare of pigs have been little studied compared with other stressful husbandry practices such as castration, tail docking, teeth resection, ear notch, and identification. The few studies in this area have focused on measures of vocalization, stress-related hormones, and escape attempts (Brown et al., 1996; Marchant-Forde et al., 2009, 2014). To date, there are no assessments of the effects of supplementation on the behavioral time budget of piglets.

One disadvantage of obtaining blood or saliva samples for measuring stress hormones is that the amount of restraint required might be a stressor itself (Blackshaw and Blackshaw, 1989). Saliva can be considered less invasive, but sampling time can take as long as 5 minutes in piglets (Blackshaw and Blackshaw, 1989), time that could have an effect on results. Kobelt et al. (2003) reported that up

* Address for reprint requests and correspondence: Tamara Tadich, Departamento de Fomento de la Producción Animal, Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Santiago, Chile. Tel.: +56229785572; Fax: +56222214030.
E-mail address: tamaratadich@u.uchile.cl (T. Tadich).

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to 4 minutes can be taken to collect a saliva sample from dogs without producing an effect on the cortisol measured (Kobelt et al., 2003).

Assessment of behaviors such as vocalization may require special equipment for acoustic analysis and to discriminate vocalizations associated with pain, such as screams (Marx et al., 2003).

The aim of this study was to evaluate the general behavioral effects on the time budget of piglets associated with 2 iron supplementation methods: parenteral versus oral.

Materials and methods

Animals and housing

The experiment was conducted in a commercial pig farm (Región Metropolitana, Santiago, Chile). A total of 22 male and 22 female 2-day-old piglets, weighing 1.61 ± 0.09 kg were used. The 4 sows used were hybrid commercial pigs that had the same parity (third) and litter size. All experimental procedures were approved by the Bioethics Committee of the Faculty of Veterinary and Animal Sciences, University of Chile, certificate N° 05-2015.

Iron supplements

Oral iron supplement

A novel oral iron supplement was developed by encapsulating in a maltodextrin matrix heme and nonheme iron. Nonheme iron (iron sulfate heptahydrate, Merck S.A) at 30% w/v was suspended in maltodextrin solution (40% w/v in deionized water), and spray-dried (Buchi Mini Spray Dryer B-290, Switzerland), producing a nonheme iron encapsulated. Porcine blood cells (Lican Alimentos S.A, Chile) at 30% w/v were suspended in maltodextrin solution (40% w/v in deionized water), and spray-dried, producing heme iron encapsulated. Both iron encapsulated forms were blended at 10:2 (nonheme iron encapsulated:heme iron encapsulated) ratio, and suspended into distilled water (2 mL), obtaining a total iron content of 252 ± 12 mg per dose.

Experimental design

At day 2 after birth, 2 litters of 11 piglets each were assigned to each group as follows:

Parenteral group

Piglets received an intramuscular injection of 200 mg of dextran iron (2 mL) (Veterquímica, Chile) into the thigh muscles. For this, the operator stretched back one of the hind legs of the piglets while they were standing or nursing and applied the injection. The time between picking up the hind leg and final release was recorded as handling time in seconds.

Oral group

Piglets were supplemented orally with 2 mL of the novel iron supplement with a blunt-tipped applicator. For administration, piglets were held up by an operator with both hands by the belly and taken from the farrowing cage to allow a second operator to open the mouth, introduce the applicator, and deliver the supplement. Once the piglet had swallowed the supplement, it was returned into the cage with the sow. Handling time (seconds) was calculated from the moment the piglet was held up by the operator until it was replaced in the farrowing cage.

A control group without iron supplementation was not included because according to the commercial farm managers, no piglets could be left without iron supplementation.

Behavioral observations

Two days before the piglets' probable date of birth, 4 double infrared video cameras (IM-CIR50600NS IR Outdoor Cameras 700tvl 1/3 cmos Sony, SENKO SA, Santiago, Chile) were installed, one in each farrowing cage. The video information was captured and stored using a digital video recording system and an external memory drive. The cameras began with the recording mode 3 hours before (H-3, H-2, and H-1) to iron supplementation and up to 3 hours after (H1, H2, and H3) as described in Leslie et al. (2010). All video images were analyzed by 1 observer with the Observer XT 2011 (Noldus software, version 11, Noldus Information Technology, The Netherlands). Scan sampling every 3 minutes was used, which allowed us to capture the briefest behavioral state of interest. The number of piglets performing each of the 7 behaviors described in Table 1 was registered at each sampling point (144 sampling points). The number of piglets and time spent out of sight was also registered.

Statistical analysis

For the time budget, minutes and percentages of time allocated to each behavior before and after supplementation were calculated. For differences between treatments, for each behavior, and differences between handling times, the Wilcoxon test was applied. Kruskal-Wallis and the post hoc multiple pairwise comparison tests were applied for the analysis between hours within treatments. A significance level of $P < 0.05$ was applied.

Results and discussion

Time budgets

Rest and suckling behaviors occupied the major part of the overall time budget of neonatal pigs (Table 2), with an overall average allocation of time to resting of 167.4 minutes (46.5%) and 152.6 minutes (42.4%) for parenteral and oral groups, respectively; and 25% and 28% in parenteral and oral groups for suckling. These values are in accordance with the literature, where it has been reported that, together, resting and suckling can occupy over 70% of newborn pigs' daily time budget (Fraser and Broom, 1997, Leslie et al., 2010).

The others studied behaviors showed a low expression for both groups (Table 2) with an overall average of 3.4 and 6.8 minutes (1.7 and 1.9%) for normal locomotion, 4 minutes (1%) for exploration, and 5.8 and 1.4 minutes (1.6% and 0.4%) for positive interaction in both parenteral and oral groups, respectively. This information is also in accordance to the literature because newborn piglets present the highest resting rates among farm animals during their

Table 1
Description of behaviors of 2-day-old piglets according to Fraser and Broom (1997) and Leslie et al. (2010)

Behaviors	Description
Suckling	Teat in the mouth. Vigorous rhythmic movements.
Positive interactions	Includes allo-grooming behavior between piglets or between piglet and sow, play behavior such as locomotor play (run, jump, spin) between piglets or directed toward the sow or parts of the crate by a piglet.
Rest	Recumbent position, resting or sleeping with head up or legs and head outstretched.
Sitting	Body weight supported by hind-quarters and front legs.
Standing	Body weight supported by all 4 legs.
Normal locomotion	Forward movement in a 4-time gait from point A to point B, all 4 limbs are involved.
Exploration	Piglet extends neck toward part of the environment and looks at or sniffs at an object.