

The Effects of Iron Supplementation in Prewaning Piglets

Loh Teck Chwen¹, Leong Kah Heng², Too Heng Lee³, Mah Choew Kong⁴ and Choo Pow Yoon⁴

¹ *Department of Animal Science, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia. e-mail: tcloh@agri.upm.edu.my*

² *Alpharma A.S. Singapore Representative Office, 16 Raffles Quay, #27-05, Hong Leong Building, Singapore 048581*

³ *Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*

⁴ *Bayer (Malaysia) Sdn. Bhd., 19&20th Floor, Wisma MPSA, Persiaran Perbandaran, 40708 Shah Alam, Selangor, Malaysia*

ABSTRACT

The trial was carried out at a commercial pig farm in Bukit Pelanduk, Negeri Sembilan, Malaysia. The objective of the study was to assess the efficacy of supplemental iron in drinking water and iron in paste form in comparison with the iron dextran injection. A total of 12 litters were used divided into three treatments : iron dextran injection (ID), Fedexx[™] – iron in paste form (IP) and Opti-iron[™] - iron in drinking water (IW). Hemoglobin level and growth performance parameters were monitored weekly over a period of 28 days. ID piglets had significantly higher ($p < 0.05$) body weight and weekly weight gain compared with IW piglets at 21 and 28 days of age whereas no significant different ($p > 0.05$) results were found between IP and IW piglets. Hemoglobin level from days 0 to 28 showed statistical difference ($p > 0.05$) between piglets in IP and IW groups. Mild anemia was found in IP piglets but not for ID and IW piglets compared with normal value (> 9 g/dL). Hemoglobin (Hb) levels were positively correlated ($p < 0.05$, $r = .47$) with body weight at 28 days of age. In conclusion, pigs supplemented with iron in paste form and drinking water had poorer growth performance than iron dextran injection piglets. Piglets given iron in paste form had mild anemia. It is advisable to give multiple doses of oral iron to piglets in order to prevent iron deficiency anemia.

During the first 4 weeks of life, the body weights of the piglets increased by up to 5-fold. The dietary requirement for iron during this period is 7 mg per day but only 1 mg per day can be supplied by the sow's milk (Cunha, 1977; Miller & Ullrey, 1997; Roberts, 1998). The need to provide the piglets with an adequate amount of iron before weaning is therefore imperative because sow's milk alone will not meet the iron requirements of rapid growth and expanding blood volume (Hannan, 1971).

Several different methods can be used to offer iron to preweaning piglets. The most common administration method for iron in piglets is through an intramuscular injection of iron dextran complex at 3 days of age. A single dose of 200 mg/ml iron-dextran is effective against iron deficiency anemia. However, the method is very stressful to the piglets. They will suffer more pain if a greater dosage of iron is given intramuscularly. Furthermore, poor iron injection

techniques may cause considerable trauma to the muscles, staining of hams or create abscesses and lead to downgrading of the carcasses (Roberts, 1998).

Since there are several drawbacks to the iron injection, alternative methods need to be considered in intensive farming i.e. supply iron orally (Miller & Ullrey, 1997). The oral administration of iron has two advantages: cost and the fact that absorption is regulated by the intestinal mucosae. However, oral administration requires multiple doses. This is because a single dose may not be sufficient to protect the piglets from iron deficiency anemia for the first 4 weeks post-partum. The iron bioavailability in oral iron depends greatly on iron status of animals (Amine *et al.*, 1972; Susan & Wright, 1985). In addition, dietary factors such as amino acids and protein sources (Martinez *et al.*, 1981), pectin content, phytate (Morris & Ellis, 1982) and the other minerals (Elvehjem & Hart, 1932; Hedges & Kornegay, 1973; Suttle & Mills, 1966) may also influence the bioavailability of iron. Oral iron can be given as paste or drinking water. Early administration of oral iron within the first few days of life will meet the iron needs of the suckling pig. However, it is critical to administer early before gut closure to large molecules (Harmon *et al.*, 1974; Thoren-Tolling, 1975). This study was conducted to determine the efficacy of iron supplementation in drinking water or paste form in comparison with the injection of iron compounds in suckling pigs.

MATERIALS AND METHODS

The experiment was conducted at a commercial pig farm in Bukit Pelanduk, Negeri Sembilan, Malaysia, with a capacity of 800 sows. A total of twelve litters from Duroc X Yorksire X Landrace crossbreeds was used in this study. The litter size ranged from 8–12 piglets. All the sows used were in their second to sixth parity. Piglets were given free access to both creep feed and water and weaned at 28 days of age. The animals were assigned to three treatments with four litters per treatment. The treatments were (Table 1): ID, iron dextran injection (containing 200 mg iron per ml); IP, iron in paste form (with a concentration of 200 mg per ml) and IW, iron in drinking water (with a dosage of 32 mg per ml). In ID, the piglets were injected intramuscularly at neck region of the iron-dextran preparations with an amount of 1 ml. IP was applied at the caudal area of the tongue with a dose size of 1 ml, whereas IW was given in the drinking water. Only one dose of ID and IP were given on the third day after birth, while IW was given from the third day of birth until weaning.

In this experiment, all the treatment pens were installed with a piglet drinker (Selvan, manufactured by Nutrican, Denmark). Clean water was provided for all the treatment groups except IW. The drinker was placed 7 to 8 cm above the floor from 3 days of age until weaning.

The piglets were offered creep feed at 7 days of age containing 1g/kg of ferrous sulfate. The creep feed was offered twice daily and the same amount of feed was offered to all the litters. All new feed was provided in a clean feeder. The piglets were weighed individually at 1, 7, 14, 21 and 28 days of age.

Four piglets from each replicate of treatment groups (ID, IP and IW) were randomly selected and bled by the anterior vena cava route at days 1, 7, 14, 21 and 28 post-partum. The syringe and

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needle were flushed with 0.1 mL EDTA in order to prevent coagulation prior to collection of 1 ml of blood using a 21 or 23 gauge needle. The blood was collected into a 5 ml EDTA tube. The blood samples were analyzed for hemoglobin (Hb) concentrations. The Hb concentrations were determined using a Biochem Immuno Systems Haematology Analyser (Baker System 9120 CP).

Table 1. Iron administration in treatment groups according to iron source, route of entry, dosage and treatment period

Treatments	ID	IP	IW
Trade name	Iron dextran (Dexron 20 ^{''})	Fedexx ^{''}	Opti-iron ^{''}
Manufacturer	Delrose Veterinary Pharmaceuticals, Holland	Nutriscan a/s, Denmark	Nutriscan a/s, Denmark
Form	Iron-dextran (Dexron 20 ^{''})	Iron paste	Oral solution
Route of administration	Parenteral	Oral (on the tongue)	Oral (drinking water)
Dosage	1 ml (200 mg)	1ml (200 mg)	32 mg/ml
Time	3 days of age	3 days of age	From day 3 until weaning
Chemical form of iron	Iron-dextran	Amino acid chelated iron + iron dextran	Organic iron-II-lactate

Table 2. Growth performance of treatment groups

Parameters	Groups	Day(s)				
		1	7	14	21	28
Body weight ¹ , kg	ID (33)	1.64±0.13 ^a	2.47±0.20 ^a	3.65±0.24 ^a	4.96±0.46 ^a	6.05±0.28 ^a
	IP (37)	1.67±0.27 ^a	2.46±0.15 ^a	3.64±0.12 ^a	4.77±0.16 ^{ab}	5.59±0.28 ^{ab}
	IW (42)	1.54±0.26 ^a	2.33±0.44 ^a	3.40±0.55 ^a	4.38±0.36 ^b	5.14±0.64 ^b
Weekly live weight gain ¹ , kg	ID (33)		0.84±0.18 ^a	1.17±0.21 ^a	1.31±0.40 ^a	1.14±0.12 ^a
	IP (37)		0.79±0.36 ^a	1.19±0.21 ^a	1.12±0.12 ^{ab}	0.86±0.14 ^{ab}
	IW (42)		0.79±0.25 ^a	1.06±0.13 ^a	0.98±0.18 ^b	0.82±0.22 ^b

Values in the same column with different superscripts are significantly different (p<0.05). Values are presented as mean ± SD

Values in parenthesis indicate the number of piglets used in each treatment: 4 litters in each treatment groups.

¹ body weight and weekly live weight gain were measured based on individual piglets

Statistical analysis

The data were analyzed by analysis of variance (ANOVA) using the general linear model (SAS, 1988). The statistical model included the main effects of treatment groups, parity and their interaction. Litter size was used as a covariate for all the analyses. The significance of the

differences between means was tested using least significant difference (LSD). Relationships between body weight and Hb levels were analyzed by calculating Pearson's correlation coefficient. There was no significant ($p > 0.05$) result from parity effect. Therefore, the results and discussion will focus on the main effect of the treatment groups.

RESULTS

Growth performance

Growth performance results are presented in Table 2. The piglets in ID had significantly higher ($p < 0.05$) live weight and weekly weight gain compared to IW group of piglets at 21 and 28 days of age. There were no significant differences ($p > 0.05$) for body weight and weekly weight gain of IP and IW piglets. Creep feed intake for all the treatments groups were not significantly different ($p > 0.05$) for the whole experimental period (ID = 4.0 ± 1.2 g/day; IP = 4.5 ± 1.3 g/day and IW = 4.2 ± 1.5 g/piglet/day from days 7 to 28). In our study, there was a positive relationship between Hb concentration and body weight at 28 days of age ($r = .47$, $p < 0.05$). However, no relationship was found at 7, 14 and 21 days of age ($r = .15$, $p > 0.05$; $r = .27$, $p > 0.05$ and $r = .29$, $p > 0.05$, respectively).

Hemoglobin levels

Data on hemoglobin levels for different treatment groups of pigs is shown in Table 3. The initial Hb levels were not statistically significant ($p > 0.05$) for different groups of piglets at day one post-partum. At 14 days of age, the mean Hb levels for ID piglets were higher ($p < 0.05$) than the IP and IW piglets. The mean of Hb levels at 21 days of age was higher ($p < 0.05$) for ID piglets than the IP group of piglets. There were no significant differences ($p > 0.05$) for the hemoglobin levels of ID and IW piglets. The means of Hb concentrations at weaning showed a similar trend as found at 21 days of age.

Table 3. Effects of iron supplementation on hemoglobin levels of young pigs

Parameters	Groups	Day(s)				
		1	7	14	21	28
Hemoglobin level (g/dL)	ID	8.47 ± 1.40^a	9.64 ± 1.38^a	11.22 ± 0.19^a	9.37 ± 0.46^a	10.43 ± 0.43^a
	IP	8.06 ± 0.90^a	8.49 ± 0.81^a	9.42 ± 0.33^b	7.87 ± 0.31^b	8.49 ± 0.66^b
	IW	9.23 ± 1.60^a	8.36 ± 1.35^a	9.18 ± 0.17^b	8.75 ± 1.04^{ab}	9.20 ± 1.25^{ab}

Values in the same column with different superscripts are significantly different ($p < 0.05$). Values are presented as mean \pm SD

DISCUSSION

The total consumption of water was not reported herein due to water wastage as the piglets were fond of playing in water.

The piglets in IP and IW groups did not perform well after 21 and 28 days of age (Table 2), gaining an average of 120 g/day versus 162 g/d for ID piglets in the last week of the experiment. These results suggest that the growth rate was adversely influenced when injectable iron was completely replaced by the iron in paste form and iron in the drinking water.

According to iron absorption theory (Miller and Ullrey, 1997; O'Dell, 1989; Wood and Han, 1998), the absorption of iron is mainly regulated by the intestinal mucosae. Iron absorption occurs predominantly in the proximal small intestine. The uptake of iron by the mucosal cells is in one of three forms— ferrous, ferric or as part of an organic compound. The efficiency of iron absorption is normally regulated in accord with iron status. In iron-deplete conditions, both heme and non-heme iron absorption by the intestine is well regulated, while iron repletion results in reduced iron absorption. In our experiment, only one dose of iron in paste form was given to the IP piglets on day 3 postpartum. At this time, the iron status of the IP piglets was adequate. Thus, the absorption of the iron would be reduced, resulting in depletion of iron reserves as piglets grow up and this significantly reduces weight gain. Another suggestion can be made that the iron in paste form should be supplied more than as a single dose at different periods to the piglets. Moreover, for those systems that implement oral treatment routes, proper monitoring of Hb level from randomly selected piglets at age 2, 3 and 4 weeks is needed.

The amounts of creep feed consumption were similar for all the treatments groups. The results suggest that similar amounts of iron in feed were consumed by different groups of piglets and presumably this may have a similar effect of iron in feed on all the piglets. A previous study shows that continuous provision of iron in the feed to piglets weaned at 21 days of age repletes their Hb levels (Lewis *et al.*, 1996). The absorption of iron depends not only on body stores of iron but also on the molar ratio of iron with respect to the other essential trace elements such as copper and zinc. An adequate amount of copper is required for utilization of iron (Elvehjem & Hart, 1932). However, there are reports that a high level of copper may interfere with iron metabolism (Hedges & Kornegay, 1973). The interactions of iron-copper-zinc remain controversial (Elvehjem & Hart, 1932; Hedges & Kornegay, 1973; Suttle & Mills, 1966; O'Dell, 1989; Zinn *et al.*, 1997). In this study, zinc and copper contents and their interactions were not determined. Therefore, this subject will not be discussed further.

Murphy *et al.* (1997) reported that positive relationships between Hb level and body weight were found at 7, 14 and 28 days of age. The results could be due to a constant iron reserve in the body from the source of iron administered intramuscularly. In contrast, different supplementation methods used in our study and variations in uptake of iron into the body may have contributed to the non-significant relationship between Hb level and body weight at early ages.

Daykin *et al.* (1982) reported that the normal value of Hb concentration should be more than 9 g/dL. If the Hb level is less than the normal value, the piglets are deemed to be anemic. In this study, the average Hb concentration (8.49 gm/100ml) of IP pigs was slightly lower than the normal value at weaning (Table 3). The results indicate that the piglets had mild anemia, probably due to the occurrence of iron malabsorption through the guts despite adequate amount of iron (200 mg/ml) being given to this group of piglets. The occurrence of iron malabsorption may have resulted from the saturation of iron binding proteins in the intestinal wall (Teichmann & Stremmel, 1990). An excessive level of oral iron must be avoided because unbound serum

iron encourages intestinal bacterial growth and results in increased susceptibility to diarrhoea (Knight *et al.*, 1983; Kadis *et al.*, 1984).

The IW piglets did not show any anemic sign and their Hb levels were greater than the normal value (Table 3). The results suggest that providing iron in drinking water prevented anemia in this group of piglets. Providing iron in the drinking water may have many advantages; however this is only successful if the preweaning piglets can be encouraged to drink adequate quantities of water adequately supplemented with iron. Hansen (1998) reported that piglets were less stressed when supplemental iron orally and problems of induced sciatic nerve paralysis due to iron injection could be avoided. In addition, the iron source used in this study in drinking water contained electrolytes, organic acids and fructose. It can be offered as a supplement and a gut acidifier for the piglets which may enhance iron absorption for the piglets. In Denmark, it has been reported that 50% of the farmers practise iron administration in the drinking water (Hansen 1998) primarily due to problems of labor shortage and because of animal welfare issues. In another study, Holmgren (1996) found that a single injection of 200 mg iron dextran at day-old results in an iron overload. As iron is a good nutrient for most bacterial species to grow, excessive iron in the bloodstream and intestinal tract of preweaning piglets may be associated with the occurrence of polyarthritis, septicemia and colibacillosis. In addition, providing excess amounts of iron at one time may be toxic. For instance, supplying a single oral dose of ferrous sulfate, 600mg/kg of body weight produced signs of iron toxicity within 3 h (Miller & Ullrey, 1997).

CONCLUSIONS

Piglets supplemented with iron in paste form and drinking water had poorer growth performance than iron dextran injection piglets. The piglets in IP group developed mild anemia. Provision of iron through injection and drinking water was more efficient than in paste form in preventing iron deficiency anemia. The Hb concentrations at 28 days of age were correlated with body weight of the piglets. Oral administration of iron can be applied in a well managed farm but a proper monitoring of Hb level from randomly selected piglets at 2, 3 and 4 weeks of age is needed.

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