The Thai Journal of Veterinary Medicine

Volume 50
Issue 4 *December, 2020*

Article 16

12-1-2020

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Original Article

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Abstract

The piglet pre-weaning mortality is a major problem in swine production. The objective of the present study was to determine the effect of dietary gel protein supplementation on pre-weaning mortality and growth in piglets. A total of 48 Landrace x Yorkshire crossbred sows were included in this study. On farrowing day, the sows were randomly allocated into two experimental groups by parity: Control (n=20) and Treatment (n=28). The piglets in the Control group sows (n=234) were not orally supplemented and the piglets in the Treatment group sows (n=316) were orally supplemented with gel protein (Porcistart®, Virbac. Co., Ltd., Loudeac, France). The piglets in the treatment group had ad libitum access to gel protein in a container placed in the creep area for the piglets. The feeding protocols were carried out from farrowing day until Day 7 after farrowing. The creep feed was provided from day 7 until weaning. On Day 7 after farrowing, 2 mL blood samples were obtained from 160 piglets (Control, n = 54 and Treatment, n = 106) randomly selected from sows included in the experiment for IGF-1 analysis. The piglet body weight was recorded at Days 3, 10 and weaning. The litter weight gains were calculated. The piglet pre-weaning mortality was determined at Days 3, 10 of life and at weaning. The lactation length, litter size at Days 3 and 10 and weaning were 25.5 ± 0.9 days, 11.5 ± 1.8 piglets/litter, 10.0 ±1.5 piglets/litter and 9.6 ± 2.1 piglets/litter, respectively. No effect of gel protein supplementation on piglet weaned weight and piglet pre-weaning mortality was found in the present study ($P > 0.05$). On average, the serum IGF-1 concentration was 128.1 ± 54.7 ng/ml (range 22.6-243.5 ng/ml) and piglet weaned weight was 6.7 ± 1.3 kilograms (range 4.4-8.9 kilograms). Serum IGF-1 concentration in the treatment group (140.3 ng/ml) was higher than in the control group sows (120.2 ng/ml, $P = 0.027$). In conclusion, dietary gel protein supplementation in the piglets increased piglet serum IGF-1 but had no effect on weight and pre-weaning mortality in piglets.

Keywords: Gel protein supplementation, IGF-1, Piglet, Pre-weaning mortality, Weight

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Received August 31, 2020.

Accepted November 13, 2020.

Introduction

Nowadays, genetic improvements in sows have been developed and have rapidly increased the number of total piglets born per litter. On the other hand, piglet pre-weaning mortality in commercial swine herds is still stable at about 10-20% (Nuntapaitoon and Tummaruk, 2015; ADHP, 2018; Hansen, 2018; Nuntapaitoon *et al*., 2018). Main nutrients for pre-weaning piglets are colostrum and milk. Colostrum is a main factor in piglet survival because colostrum contains a high amount of immunoglobulin protection in newborn piglets. Moreover, colostrum and milk are the high sources of energy that relates to growth rate in piglets (Nuntapaitoon *et al*., 2019b). Therefore, lack of energy in pre-weaning affects piglet survival and growth rate.

Oral protein supplementation is commonly used in commercial swine herds for improving piglet energy status and performance. Many natural extract ingredients for supplementation in piglets are used such as potato, whey and barley. (Smulders *et al*., 2011; Poolperm *et al*., 2012). Previous studies found that protein supplementation in piglets increases IGF-1 concentration and increased growth rate in piglets (Saleri *et al*., 2001; Poolperm *et al*., 2012; Muns *et al*., 2017). Moreover, other sources of protein other than whey and plant extract (i.e., Algae green tea) might be improved piglet performance.

Whey protein includes essential amino acid for the piglets (Gottlob *et al*, 2005). Furthermore, piglet intestines can digest this protein and absorb all amino acids by more than 90%. In addition, algae extract is a source of fatty acids that improve immune and neural functions (Wells *et al*, 2017). Alkaloids and caffeine in green tea extract stimulated infant activity (Abdel-Hady *et al*., 2015; Moschino *et al*., 2019; Chung *et al*., 2020). Recently, gel protein supplementation has improved piglet mortality and growth (Bousquet *et al*., 2019). However, the effect of the gel protein supplementation on piglet IGF-1 concentrations has not been elucidated. Therefore, the objective of the present study was to determine the effect of dietary gel protein supplementation on piglet IGF-1 concentration, pre-weaning mortality and growth in piglets.

Materials and Methods

The experiment followed the guidelines documented in "The Ethical Principles and Guidelines for the Use of Animals for Scientific Purposes" edited by the National Research Council of Thailand, and was approved by the Institutional Animal Care and Use Committee (IACUC) in accordance with the university regulations and policies governing the care and use of experimental animals (Approval number 1931033).

Experimental design: A total of 48 sows were included in this study. On farrowing day, the sows were randomly allocated into two experimental groups: Control (n=20) and Treatment (n=28) by parity. The piglets in the Control group sows (n=234) had no oral supplementation and the piglets in the Treatment group sows (n=316) were orally supplemented with gel protein (Porcistart®, Virbac. Co., Ltd., Loudeac, France) (400 KJ/100 g, 9.1% crude protein). The piglets in the treatment group had ad libitum access to gel protein in a container placed in the creep area for the piglets. The feeding protocols were carried out from farrowing day until Day 7 after farrowing and the gel protein intake was measured every day.

Animals, Housing, and Management: The study was carried out in a commercial swine herd located in the western part of Thailand. The breed of sows was crossbred Landrace x Yorkshire F1 female parities between 1 to 7 (mean 4.9 ± 1.5) . The productive sows were 2,500 sows. The gestating sows were kept in a conventional opened-housing system. The gestating sows were moved to the farrowing house approximately 1 wk before the predicted farrowing date. All sows were individually housed in crates until weaning in the same housing. Sows were kept in a conventional evaporative cooling system and fed a commercial lactation diet according to their requirements (Am-in *et al*., 2019). Lactating sows were fed twice a day with a dry corn-soy- bean meal diet that met or exceeded nutritional requirements (NRC, 2012). The amount of feed offered was increased daily until ad libitum feed was reached after 1wk of lactation. The farrowing facilities consisted of an evaporation housing system provided with fans and individual water sprinklers to reduce the impact of the high ambient temperature. Farrowing pens (2.95 m^2) were fully slatted with concrete at their center for the sows and with steel slats at both sides of the farrowing crate for the piglets. Each pen was provided with a creep area for the piglets (0.50 m^2) placed on the floor on 1 side and covered with a plastic plate without any heating source. Sows and piglets had ad libitum access to water via separated nipple drinkers.

The parturition process was carefully supervised. The sows and piglets were interfered with as little as possible. The farm's routine intervention was limited to visual supervision of the farrowing and removing placenta, mummified piglets or dead piglets. No extra management was performed on the newborn piglets. Routine procedures performed on the piglets included tail docking, tooth clipping and a 1 mL iron supplement administered intramuscularly (ABI-DEX 100, Charoen Pokaphand Enterprise Co.,Ltd and T.P. Drug Laboratories (1996) Co.,Ltd., Bangkok, Thailand) on the first day of life. Piglets were orally administered coccidiocide (Baycox, OLIC Ltd., Ayutthaya, Thailand) on the third day of age. Weaning took place at 28 d of age. During the entire experiment the animals were checked daily for health or eating problems.

Sow and piglet data: The following reproductive variables of the sows were recorded: number of piglets per litter at Days 3, 10 and weaning and lactation length. The piglets were weighed at Days 3 and 10 after farrowing and weaning.

The measurement of IGF-1 concentration: On Day 7 after birth, 2 mL blood samples were obtained from 160 piglets randomly selected from sows included in the experiment (Control, n = 54 and Treatment, n = 106). Samples were obtained by jugular venipuncture into 6 mL serum separated clot activator tubes (Vacuette,

Greiner Bio-One GmbH, Kremsmünster, Austria) and centrifuged at 2,000 × g for 10 min. The serum was stored frozen at -20°C until human IGF-I analysis. The IGF-1 was measured from serum samples using the Mediagnost IGF-I ELISA E20 kit (Mediagnost Gesellschaft für Forschung und Herstellung von Diagnostika GmbH. Reutlingen, Germany). Intraassay and interassay were 2.91 and 6.84%, respectively.

Statistical analysis: Statistical analyses were performed by using SAS (SAS version 9.0, Cary, NC, USA). Sow and piglet parameters were compared among groups by using general linear models. Least square means were compared by using least significant different test. $P < 0.05$ was regarded to be statistically significant. (SAS® program 9.4, Cary, NC, USA).

Results

Descriptive statistics: Descriptive statistics, including means, standard error, minimum and maximum of sow reproductive performance and newborn piglet traits are presented in Table 1. The lactation length, litter size at Days 3 and 10 and weaning were 25.5 ± 0.9 days, 11.5 ± 1.8 piglets/litter, 10.0 ±1.5 piglets/litter and 9.6 ± 2.1 piglets/litter, respectively.

Effect of gel protein supplementation on piglet growth performance and piglet pre-weaning mortality: No effect of gel protein supplementation on piglet weaned weight and piglet pre-weaning mortality was found in the present study ($P > 0.05$) (Table 2). The proportion of piglet pre-weaning mortality between Days 3-10 and Day 10-weaning in control and treatment group sows are presented in Figure 1.

Effect of gel protein supplementation on piglet serum IGF-1 concentration: On average, the serum IGF-1 concentration was 128.1 ± 54.7 ng/ml (range 22.6-243.5 ng/ml) and piglet weaned weight was 6.7 ± 1.3 kilograms (range 4.4-8.9 kilograms). The serum IGF-1 concentration in the control and treatment group sows are presented in Figure 2. As can be seen from the figure, serum IGF-1 concentration in the treatment group (140.3 ng/ml) was higher than in control group sows (120.2 ng/ml, $P = 0.027$).

Table 1 Descriptive statistic on sow and piglet performances

Parameters	Mean ± SD	Min	Max
Lactating days, day	25.5 ± 0.9	24.0	27.0
Supplemented day in treatment group, day	7.3 ± 0.5	7.0	8.0
Gel protein intake in treatment group, g	84.5 ± 14.6	52.6	101.3
Litter size, piglets/litter			
Day 3	11.5 ± 1.8	7.0	14.0
Day 10	10.0 ±1.5	7.0	13.0
Weaned piglet, piglets/litter	9.6 ± 2.1	6.0	14.0
Litter weight, kg			
Day 3	17.4 ± 3.7	11.0	24.2
Day 10	27.9 ± 7.9	16.9	41.6
At weaning	64.7 ± 20.7	35.0	100.0
Average Weaned Weight, kg	6.7 ± 1.3	4.4	8.9
Litter weight gain during Day 3-10, kg	1.4 ± 0.8	0.1	2.9
Mortality rate, %			
Day 3-10	12.2 ± 11.5	0	30.8
Day 10-weaning	6.9 ± 11.1	0	45.5
Day 3-weaning	16.5 ± 15.3	0	53.8

Table 2 Effect of gel protein supplementation on sow and piglet performances in Control and Treatment group sows (Least square mean ± SEM)

Parameters	Control	Treatment	*P*
Lactating days, days	26.3	24.9	
Weaned piglet, piglets/litter	9.9 ± 0.5	9.4 ± 0.4	0.418
Litter weight, kg			
Day 3	18.3 ± 0.7	16.8 ± 0.7	0.191
Day 10	30.1 ± 1.6	26.4 ± 1.5	0.110
At weaning	66.4 ± 4.6	63.6 ± 3.9	0.651
Average weaned weight, kg	6.7 ± 0.3	6.7 ± 0.2	0.916
Litter weight gain Days 3-10, kg	1.5 ± 0.2	1.4 ± 0.1	0.811
Mortality rate, %			
Days 3-10	9.9 ± 2.6	13.8 ± 2.2	0.257
Day 10-weaning	8.9 ± 2.5	5.4 ± 2.1	0.301
Day 3-weaning	15.6 ± 3.5	17.1 ± 2.9	0.745

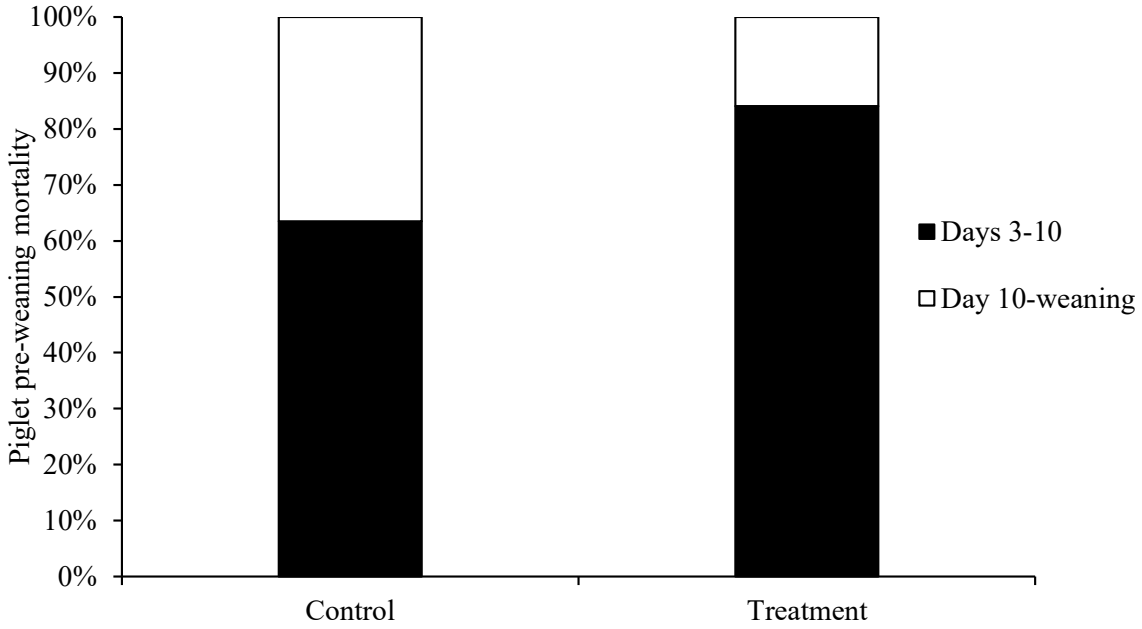

Figure 1 The proportion of piglet pre-weaning mortality between Days 3-10 and Day 10-weaning in the Control and Treatment group sows

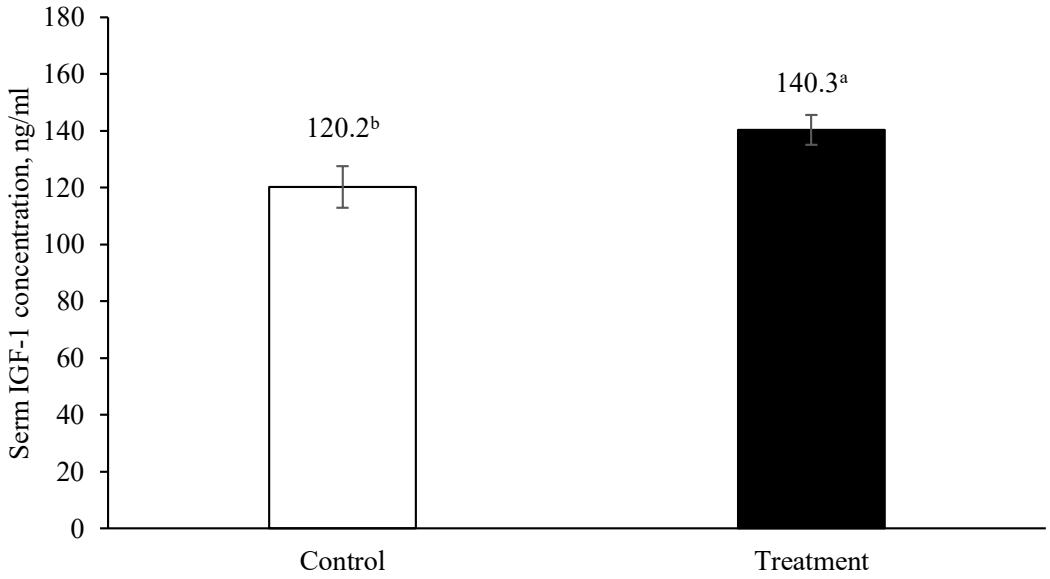

Figure 2 The serum IGF-1 concentration in piglet born from the Control and Treatment group sows

Discussion

The sow colostrum and milk play an important role in the vitality and average daily gain before weaning (Nuntapaitoon *et al*., 2019b). Moreover, colostrum and milk yield are highly variable among sows (Quesnel, 2011). The technique for reducing piglet mortality and enhancing piglet growth is feed supplementation (Muns and Tummaruk, 2016) and energy detection in the piglets by portable instrument (Nuntapaitoon *et al*., 2019a). This is the first original article on the effect of gel protein supplementation in piglets on IGF-1 concentration and piglet performance. In the present results show that the gel protein supplemented feeding in piglets increases piglet serum IGF-1 but had no effect on weight and pre-weaning mortality in piglets. This result agrees with the previous study (Muns *et al*., 2017) where feeding the protein enriched feed supplement to the piglet and improve piglet serum IGF-1.

At birth, glycogen reserve is a limiting factor on piglet vitality (Theil *et al*., 2014). Piglets should be received more than 400 g of colostrum for survival and growth in the first 24 h of life (Nuntapaitoon *et al*., 2019b). Moreover, high milk consumption increases piglet weaning weight. On average, sow milk production at days 10 to 17 of lactation as the peak of

production is 12.8 kg/day (Nuntapaitoon *et al*., 2020). It can be inferred that piglet milk intake is 900 g/day (at litter size 14). Piglet supplementation is performed to reduce the starvation problem. Therefore, supplementation should be applied to use in low colostrum in 24 h postpartum and milk producing sows throughout the lactation period.

Protein supplementation was used in both sows and piglets for improving reproductive and growth performance (Smulders *et al*., 2011; 2012; Poolperm *et al*., 2012; Kurachon *et al*., 2020). Many natural extract ingredients for supplementation in pigs were used such as potato, whey and barley (Smulders *et al*., 2011; 2012; Poolperm *et al*., 2012). The supplementation of fermented potato protein in gestating sows improved sow backfat loss during lactation (Kurachon *et al*., 2020) from high energy loss during late gestation and the lactation period (Theil *et al*., 2014). Protein supplementation had a declining effect of negative energy balance in gestating and lactating sows (Wavreille *et al*., 2010). Also, in piglets, the previous studies found that the fermented potatoes protein supplementation in piglets reduced the pre-weaning mortality rate and increased the growth rate in piglets (Saleri *et al*., 2001; Smulders *et al*., 2011; Wongtawan, 2018) from starvation in the suckling period. On the other hand, the present study found that the gel protein did not improved piglet mortality in piglet at weaning which is in agreement with Muns *et al*. (2017). However, the latter study found that protein supplementation improved pre- weaning mortality in the low birth weight piglets but found no effect on the normal birth weight piglets. Unfortunately, the present study has no data for low piglet birth weight. Therefore, the effect of gel protein supplementation in low piglet birth weight should be investigated in further study.

The active ingredients of gel protein that were used in the present study included whey protein, glucose, algae extract, green tea extract, butylate, amino acid and vitamins. Fatty acids improved immune and neural functions (Benzoni *et al*., 2013; Liu *et al*., 2014). Moreover, gel protein also included alkaloids and caffeine in green tea extract that stimulated activity (Abdel-Hady *et al*., 2015; Moschino *et al*., 2019; Chung *et al*., 2020). A recent study found that gel protein supplementation improved piglet mortality (Bousquet *et al*., 2019). Gel protein is an energy source for ingesting piglets that increases suckling activity and survival rate. On the other hand, no effect of gel protein supplementation on piglet pre-weaning mortality was observed in the present study. Therefore, the timing of exposure and amount of gel protein intake might not have been enough for improving piglet mortality and development in the present study.

Insulin-like growth factors plays an important role in the growth and development of piglets (Pas *et al*., 2004). Moreover, IGF-1 activates cell function and growth factor in anabolic and metabolic regulatory functions (Fernáundez *et al*., 2004). The IGF-1 concentration in the present study was measured by human IGF-1 ELISA kit. This kit was used to determine plasma IGF-1 in the previous study because the homology of the amino acid sequence of human and porcine IGF-1 had been reported (Tavakkol *et al*., 1998). The present study found that the gel protein supplementation increased serum IGF-1 concentration in the piglets. In agreement with previous studies found that protein supplementation in piglets increased IGF-1 concentration and increased growth rate in piglets (Saleri *et al*., 2001; Poolperm *et al*., 2012; Muns *et al*., 2017; Wongtawan, 2018). Enhancing IGF-1 from protein supplementation might have occurred because IGF-1 is the protein components. Moreover, protein enhances IGF-1 production in liver (Poltep *et al*., 2016). However, no effect on growth performance was found in the present study. The effect of IGF-1 on piglet growth performance is still a controversial. In conclusion, dietary gel protein supplementation in the piglets increases piglet serum IGF-1 but has no effect on weight and pre-weaning mortality in piglets.

Acknowledgements

Financial support for the present study was provided by the Faculty of Veterinary Science, Chulalongkorn University and the product trial was supported by Virbac (Thailand) Co., Ltd.

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