ORIGINAL ARTICLE

EUBIOTIC LIGNOCELLULOSE SUPPLEMENTATION IN SOWS REDUCED DRY PERIOD AND PREWEANING MORTALITY OF PIGLETS

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ABSTRACT

A feeding trial was conducted to evaluate the efficacy of supplementing eubiotic lignocellulose on reproductive performance of breeder sows. Seventy female pigs (average parity: 2.62 ± 0.19, Landrace x Large White) were allotted to two dietary treatments following randomized complete block design, with parity as blocking factor. Eubiotic lignocellulose supplementation was given at 25 and 10kg/ton add-on at gestating and lactating diets, respectively. Eubiotic lignocellulose supplementation during gestation and lactation reduced preweaning mortality of piglets (P<0.01) and dry period of sows (P=0.0775). However, supplementation had no significant effect on other variables measured. This indicates that increasing the fiber content of the diet by adding eubiotic lignocellulose during gestating and lactating stages enhances piglet survival and indirectly improves the reproductive performance of sows by shortening the dry period.

Keywords: eubiotic lignocellulose, gestation, lactation, pig, reproduction

INTRODUCTION

Feed restriction in gestating sows is generally practiced to avoid excessive weight gain that could lead to reproductive problems. However, this often results to stressful constant hunger pains that can lead to incidence of still birth, low piglet birth weight, high pre-weaning mortality and longer weaning to estrus interval (Meunier-Salaün *et al*., 2001). A number of studies reviewed by Guillemet *et al*. (2007) on beneficial effects of increasing fiber in sow diets include reduced constipation, shorter farrowing duration, increased litter size and higher piglet survival. Oliviero *et al*. (2008) showed that sows fed diets with higher fiber stimulated water intake which resulted to higher milk production, which is beneficial because 60% of water intake accounts for milk production. Among the general benefits of using dietary fiber are improved intestinal health, welfare and reproductive performance (Johnston *et al*., 2003). In contrast, some reports have either negative results or had no significant effect at all (Johnston *et al*., 2003; Guillemet *et al*., 2007; Reese *et al*., 2008). Further, modern livestock breeds are commonly fed with high nutrient density diets which often limits fiber inclusion in feed formulation. Provision of low-inclusion and good quality fiber source might be necessary to meet physiological requirements of the animal and its overall welfare.

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Eubiotic lignocellulose is a second generation lignocellulose product derived from fresh wood. Compared to traditional fiber sources, it has higher crude fiber content (>55%), low inclusion rate (0.5%-3%), sanitized and free from mycotoxins. First generation lignocellulose contains only 100% non-fermentable fiber. Eubiotic lignocellulose is composed of balanced and standardized combination of fermentable and non-fermentable fiber with additional prebiotic functions for physiological health benefits. The non-fermentable fiber has high water binding capacity which increases the bulkiness of feed, thereby prolonging satiety (Jorgensen *et al.*, 2010). It also reduces the transit time of the digesta to reach the distal part of the large intestine, where the fermentable fiber component produces short chain fatty acids (SCFAs) namely acetate, propionate, butyrate and lactate (Bach Knudsen, 2001). These acids lower the pH which inhibits the proliferation of disease-causing microorganisms (Bach Knudsen, 2001; Montagne *et al.*, 2003). Individual SCFAs once produce will be rapidly absorbed in the intestinal lumen; which will be used by the body in different ways. Acetate is carried to the liver to act as energy substrate for muscle tissue in the form of acetyl-coA. Propionate and lactate can be converted in the liver to oxaloacetate, an intermediate for gluconeogenesis. Butyrate is used mainly by the colonocytes to provide substantial amount of energy for its metabolic activities, increase cell proliferation of villi and crypt, stimulate water and sodium absorption and enhance nutrient absorption (Noblet and Le Goff, 2001; Bach Knudsen, 2001; Montagne *et al.*, 2003; Wang *et al.*, 2003; Jorgensen *et al.*, 2007; Urriola *et al.*, 2013). Overall, eubiotic lignocellulose maintains well-balanced gut microflora (eubiosis) which promotes gut health and improves performance of animals (Kroismayr and Roberts, 2009).

Previous trials showed that addition of eubiotic lignocellulose in gestating and lactating diets of sows prevented stress as evidenced by decrease in urinary cortisol level, reduced length of parturition, decreased mastitis, metritis and agalactia (MMA) incidence as well as pre-weaning mortality that resulted to additional pigs weaned per sow per year (Kroismayr and Roberts, 2009; Ziggers, 2011).

Currently, there are limited studies on the use of eubiotic lignocellulose in gestating and lactating sow's diets and the corresponding effect on its reproductive performance. The objective of this study is to determine the effect of supplementing eubiotic lignocellulose during gestation and lactation periods on gestation length, length of parturition, litter size at birth, litter size born alive, mummified fetus, stillbirth, birth weight, pre-weaning mortality, adjusted 30-day weaning weight and length of dry period in sows.

MATERIALS AND METHODS

The effect of eubiotic lignocellulose supplementation was tested through an on-farm feeding trial in a commercial swine farm located at Biñan, Laguna from March 1 to September 20, 2013. A total of 70 Landrace x Large White female pigs (average parity 2.62 ± 0.19) were randomly assigned to treatments following randomized complete block design, with parity as blocking factor. The dietary treatments were Control (Treatment 1, n=44) and with eubiotic lignocellulose (Treatment 2, n=26). Eubiotic lignocellulose supplementation was given at 25 and 10kg/ton add-on at gestating and lactating diets, respectively. Ingredient composition and calculated nutrient analysis of basal diets are described in Table 1.

Gestating diets were provided after the first insemination until two weeks before

Table 1. Ingredient composition and nutrient analysis of basal diets supplemented with eubiotic lignocellulose in sows.

Ingredients, %	Gestating	Lactating
	Composition, %	Composition, %
Wheat	57.914	68.151
Pollard, hard	25.000	0.000
Soya, Argentina	9.060	19.871
Coconut oil	0.000	3.927
Molasses	4.000	3.000
Limestone	1.675	2.198
MDCP	1.476	1.664
Salt	0.500	0.500
Mineral premix[1]	0.100	0.100
Vitamin breeder premix[2]	0.100	0.100
Toxin binder	0.100	0.100
Choline chloride, 60%	0.075	0.075
L-lysine sulfate, 65%	0.000	0.226
DL-methionine	0.000	0.028
L-threonine	0.000	0.030
Total	100.000	100.000
Calculated Analysis:		
Metabolizable energy, kcal/kg	3,083.902	3,435.766
Crude protein, %	14.200	16.100
Crude fat, %	1.758	5.000
Crude fiber, %	4.389	2.651
Calcium, %	1.000	1.200
Total phosphorus,%	0.805	0.729
Available phosphorus, %	0.500	0.500
Total lysine, %	0.700	0.966
Total met + cys, %	0.507	0.579
Total threonine, %	0.475	0.628
Total tryptophan, %	0.188	0.214

[1]Per kg vitamin premix contains : Vitamin A (10,000,000 IU), Vitamin D_3 (2,000,000 IU), Vitamin E (20,000 IU), Vitamin K_3 (750 mg), Vitamin B_1 (500 mg), Vitamin B_2 (3,500 mg), Vitamin B_6 (3,000 mg) Vitamin B_{12} (12 mg), Niacin (25,000 mg), pantothenic acid (10,000 mg), folic acid (500 mg), biotin (50 mg), antioxidant (25,000 mg).

[2]Per kg mineral premix contains: iron (115,000 mg), manganese (50,000 mg), iodine (850 mg), selenium (150 mg), zinc (50,000 mg), copper (10,000 mg).

expected date of farrowing. Diets were supplied by automated feeders which were connected through tubes that drop the feed in each gestating stall. Feeds that fall outside the stall were swept back while sows were eating. Lactating diets were provided 14 days before expected date of farrowing, after sows were moved to the farrowing house until the next insemination after weaning. Each sow was provided pre-weighed feed three times a day (6:00 AM, 4:00 PM and 11:00 PM). Average gestating and lactating feed intake based on farm records were 2.51 kg and 5.56 kg, respectively. Controlled feeding was practiced and no feed refusal was observed throughout the feeding trial. Sows on both treatments were allocated to consume equal amount of feed to test the physiological and nutritional effect of eubiotic lignocellulose on sows that receive the same volume of feed. In this way, the response in reproductive performance will not be influenced by the difference in feed intake throughout the duration of the experiment.

Sows confirmed pregnant 60 days after breeding were transferred to individual gestating stalls measuring 2.27 x 0.61 m. Two rows of gestating stalls were assigned for each treatment. Farrowing crates were equipped by slatted floor and measured 2.27 x 1.56 m. The area available for the sow measured the same size as gestating stalls. Each farrowing crate has a feeding through measuring 0.61 x 0.38 m, with an opening of 0.25 m wide and 0.15 m deep. Sows in heat were detected by daily boar exposure. Gilts identified in heat were inseminated at once while sows were inseminated 12 hours after heat detection. Artificial insemination was done twice with 12 hr interval.

Data gathered in the experiment were gestation length, length of parturition, litter size at birth, litter size born alive, mummified fetus, stillbirth, birth weight, pre-weaning mortality, adjusted 30-day weaning weight and length of dry period. Gestation length (in days) was defined as the interval between the first insemination and the day of parturition. Length of parturition (in minutes) was measured from the birth of the first piglet until the expulsion of placenta. Parturition was induced using commercially available prostaglandin F2-alpha, administered two days before expected date of farrowing. Litter size at birth is the average number of piglets born per sow. The percentages of live, mummified or stillborn piglets were obtained from the total number of litters per sow. Piglets were weighed (kg) at birth and at weaning. Weaning weight was adjusted to 30 days. Estrus after weaning was detected by daily boar exposure. Dry period (days) was the interval between weaning and first insemination after weaning.

Gathered data were subjected to analysis of variance following a Randomized Complete Block Design, with parity as blocking factor. Comparison of treatment means was done using Least Significant Difference test. Count data expressed in percentage namely litter size born alive, stillbirth, mummified and preweaning mortality were transformed using square root function. Data were checked for outliers, normality (Wilk-Shapiro test) and homogeneity of variance (Bartlett's test). All the data gathered were subjected to PROC MIXED analysis using Statistical Analysis Software. Level of confidence used in testing for significance of the differences was 5%.

RESULTS AND DISCUSSION

Eubiotic lignocellulose supplementation reduced preweaning mortality of piglets ($P<0.0091$) and dry period of sows ($P=0.0775$), as shown in Table 2. Result on reduction in preweaning mortality ($P<0.05$) was in agreement with the reports of Kroismayr and Roberts (2009) and Ziggers (2011). This may be due to less constipation of sows that promotes

ease in parturition. Difficulty in farrowing can lead to asphyxia of last born piglets brought about by successive contractions or rupture of umbilical cord that can reduce survivability of neonatal pigs for the first ten days of life (Schenkel *et al*., 2001). The extension of satiety due to increase in bulkiness of diet with eubiotic lignocellulose might also reduce frequency of postural changes of sows during and after farrowing that increases incidence of piglet crushing (Weary *et al*. as cited by Danielsen and Vestegaard, 2001). In addition, the shift of fermentation to distal colon results to production of short chain fatty acids (SCFAs), mainly butyric acid which is rapidly absorbed in the colon to serve as an energy source for its metabolic activities, increase cell proliferation of villi and crypt, stimulate water and sodium absorption and enhance nutrient absorption (Noblet and Le Goff, 2001; Bach Knudsen, 2001; Montagne *et al*., 2003; Wang *et al*., 2003; Jorgensen *et al*., 2007; Urriola *et al*., 2013). The SCFAs produced in the distal colon will be utilized by the body several hours after absorption of nutrients in the small intestine (Bach Knudsen, 2001) resulting to "glucomodulation", which prevents "spikes and falls" of blood glucose level in the body in between meals. Moreover, Oliviero *et al*. (2008) reported that increasing fiber in the diet increases chewing time of sows that stimulates water intake. This results to higher milk production of sows that can reduce preweaning mortality of piglets.

Table 2 also shows that sows supplemented with eubiotic lignocellulose have a tendency to reduce dry period ($P=0.0775$). Low body reserves at weaning delays dry period of sows (Schenkel *et al*., 2010). During farrowing, the energy utilized in this activity was mainly from internal body reserves (fat and muscle) and not from the diet (Oliviero *et al*., 2009). The additional stress brought by constant hunger and constipation has high energy cost (Noblet and Le Goff, 2001). These might have been reduced in sows supplemented with eubiotic lignocellulose that prevented body reserve mobilization of sows, which may have prevented return to heat of sows. Therefore, reduction in dry period and preweaning mortality can be considered as indirect effect of supplementing eubiotic lignocellulose in the diet. On the other hand, no significant differences were noted for other variables measured in the present study. This conforms to previous studies (Johnston *et al*., 2003; Guillemet *et al*., 2007; Reese *et al*., 2008). Although different breeds as well as nutrient composition and crude fiber content of experimental diets used varied, significant effect on reproductive performance was not realized.

Previous studies reported shorter gestation period (Kurcman-Przedpelska as cited by Guillemet *et al*., 2007) and length of parturition (Van Rens and Van Der Lende as cited by Guillemet *et al*., 2007) when fiber was increased in sow's diet. Recent studies showed that supplementation of eubiotic lignocellulose shortened length of parturition due to prevention of stress as evidenced by a decrease in urinary cortisol level (Kroismayr and Roberts, 2009; Ziggers, 2011).

Other experiments reported increase in litter size of sows fed diets with additional fiber (Johnston *et al*., 2003; Renteria-Flores *et al*., 2008). The increased amount of fiber in gestating diets improved litter size due to increased ovulation rate which is enhanced by increasing postprandial insulin level (Renteria-Flores *et al*., 2008). The present experiment introduced eubiotic lignocellulose supplementation after insemination of the sows detected in heat; while recruitment of pre-ovulatory follicles occurs at day 14 to 16 of estrus cycle (Renteria-Flores *et al*., 2008). In this present study, the timing of administration of eubiotic lignocellulose (*i.e.* start of gestation period) may be the reason why litter size did not differ between treatments. Moreover, Reese *et al*. (2008) who studied 20 published reports dating from 1975 to 2007 to determine overall effects of additional fiber on gestating diets on reproductive performance of sows found that greater response can be achieved in

Table 2. Reproductive performance of sows fed diets with and without eubiotic lignocellulose supplementation.

Variable	Control	With eubiotic lignocellulose	P-Value
Gestation length (days)^{ns}	112.85 ± 0.31	112.22 ± 0.37	0.1652
Length of parturition (minutes)^{ns}	212.64 ± 21.73	197.24 ± 26.19	0.6330
Litter size (heads)^{ns}	11.51 ± 0.39	11.38 ± 0.47	0.8223
Litter size born alive (%)^{ns}	87.49 ± 0.31	97.53 ± 0.37	0.2558
Mummified (%)^{ns}	1.58 ± 0.34	0.33 ± 0.41	0.2989
Stillbirth (%)^{ns}	0.79 ± 0.18	1.55 ± 0.21	0.9774
Average birth weight (kg)^{ns}	1.37 ± 0.03	1.38 ± 0.04	0.8568
Pre-weaning mortality (%)*	23.08 ± 0.41	9.55 ± 0.51	0.0091
Average weaning weight (kg)^{ns}	7.52 ± 0.16	7.62 ± 0.19	0.6793
Length of dry period (days)*	9.16 ± 1.35	5.18 ± 1.89	0.7775

^{ns}Not significant (P>0.10)

*Significant (P<0.10)

multiple-cycle studies than in single-cycle studies. He also suggested increasing dietary fiber in the diet prior to mating or breeding. In addition, the digestive utilization of pigs depend on the type and quality of fiber used (Noblet and Le Goff, 2001; Danielsen and Vestegaard, 2001).

The study provided data on the potential of eubiotic lignocellulose supplementation in sow's diet particularly in increasing piglet survivability and reducing dry period in sows. Further investigations involving a greater number of sows with multiple cycles are recommended. In addition, measurement of body weight gain or loss, body condition score and backfat thickness of sows at the start and end of trial can also be determined to generate a holistic perspective regarding the role of fiber supplementation in gestating and lactating sows.

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