Effects of Carbohydrase Supplement on Lactation Performance of Primiparous Sows Fed Corn-Soybean Meal Based Lactation Diet

F. Ji and S. W. Kim*
Department of Animal and Food Sciences, Texas Tech University, Lubbock, TX 79409, USA

ABSTRACT : The experiment was conducted to test the hypothesis that supplementing diets of lactating first parity sows with a mixture of carbohydrases (CS) improves lactation performance and second parity reproductive performance. The CS used in this study contained 7 units/g of α-1,6-galactosidase, 22 units/g of β-1,4-mannanase, β-1,4-mannosidase and trace amounts of other enzymes. Twenty primiparous sows (Newsham Hybrid) were allotted to either the control group (no CS supplement) or the CS group (0.1% CS supplement) and fed the experimental diets during 21 d lactation period. Sows and nursing pigs were weighed at birth and weekly until weaning. Days of weaning-to-estrus were recorded. Sows had free access to feed and water. Feed intake of sows was measured daily. During the second parity gestation and lactation, all the sows were fed the same gestation and lactation diets and their reproductive performance was measured. During the second parity, there were 14 sows (7 sows per group) remained productive. For the first lactation, maternal body weight loss of the CS group was smaller ($p<0.05$) than that of the control group. There was no difference in litter weight gain between two groups. Voluntary feed intake of sows did not differ between the two groups. Days of weaning-to-estrus of the CS group were smaller ($p<0.05$) than those of the control group. In the second parity, there was no difference in the reproductive performance between the two groups. In conclusion, supplementing CS in the diet of lactating sows during the first parity decreased body weight loss and days of weaning-to-estrus of sows. However, these effects of the CS supplementation in the first parity were not successfully carried over to the second parity. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 4 : 533-537)***

Key Words : Carbohydrases, Flatulence Producing Compounds, Soybean Meal, Sows

INTRODUCTION

Modern lean type sows often lose body tissues during lactation due to high milk production and low voluntary feed intake (Easter and Kim, 1998). High body weight loss of sows during lactation may prolong weaning-to-estrus interval, decrease the rate of return to estrus, decrease conception rate, and finally increase culling rate. One way to reduce lactation sow weight loss is to improve the utilization of dietary nutrients. Soybean meal, one of the major protein sources in lactation diets, contains anti-nutritional factors. One is flatulence producing compounds (FPC), such as β-galactomannans and α-1,6-galactosides. Most of anti-nutritional compounds in soybeans can be eliminated through extraction, soaking and germination (East et al., 1972; Ku et al., 1976). However, FPC are heat stable (Liener, 1994) and those β-galactomannans and α-1,6-galactosides still exist after soybean meal processing (Rackis, 1981; Hartwig et al., 1997). Trugo et al. (1995) reported that soybean meal contained 5.6% α-1,6-galactosides (1.0% raffinose and 4.6% stachyose) and 1.2% β-galactomannans. Pigs lack of endogenous enzymes in the intestine mucosa to cleave FPC (Pluske and Lindemann, 1998; Veum and Odle, 2001). These oligosaccharides are utilized by hind-gut microorganisms producing flatulence including carbon dioxide and methane (Calloway et al., 1966; Mayhara et al., 1988; Krause et al., 1994) and reducing energy and protein digestibilities (Veldman et al., 1993; Gdala et al., 1997). Use of exogenous enzymes, such as α-1,6-galactosidase, β-1,4-mannanase and β-1,4-mannosidase, hydrolyzed these anti-nutritional factors in soybean meal and improved digestibilities of energy and amino acids in young pigs (Sugimoto and Van Buren, 1970; Gdala et al., 1997; Kim et al., 2003). The objective of this study is to test the hypothesis that supplementing carbohydrase in lactation diets improves reproductive performance of primiparous sows.

* Corresponding Author: S. W. Kim. Tel: +1-806-742-2532, Fax: +1-806-742-2335, E-mail: sungwoo.kim@ttu.edu
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MATERIALS AND METHODS

Animals and design

Twenty primiparous sows (Newsham Hybrid, Colorado Springs, CO) were used. Sows were housed in gestation stall and fed 2.0 kg/day gestation diet. On day 109 of gestation, sows were transferred to farrowing crates and paired with similar body weight at farrowing. Each of paired sows was randomly allotted to one of two dietary treatments: control and carbohydrase (CS) treatments. Carbohydrases (Endopower®), containing 7 units/g of α-1,6-galactosidase (one unit is the enzyme activity required to hydrolyze 1 μmol p-nitrophenyl-β-D-galactopyranoside (pNPG) within 1 min at 30°C and pH 4.0), 22 units/g of β-1,4-mannanase and β-1,4-mannosidase (one unit is the enzyme activity required to release 1 mg total reducing sugars-glucose equivalent within 1 min at 30°C and pH 4.0),

Table 1. Composition of gestation and lactation diets during the second parity

Ingredient	Gestation diet	Lactation diet
Corn grain	60.25	59.20
Soybean meal, duhulled	11.45	28.00[a]
Molasses cane[b]	5.00	3.65
Potassium chloride	0.25	0.10
Salt	0.35	0.35
Vitamin mixture[c]	1.50	1.50
Fat, vegetable	0.50	4.00
Dicalcium phosphate	2.20	2.50
Limestone	0.50	0.70
Beet pulp	6.00	
Rice hull	5.00	
Alfalfa meal	7.00	
Total	100.00	100.00
Chemical composition		
Dry matter, %	90.7	90.8
ME, Mcal/kg	2.90	3.36
Crude protein, %	12.0	18.1
Lysine, %	0.58	1.00
Cystine+Methionine, %	0.41	0.60
Tryptophan, %	0.13	0.22
Threonine, %	0.45	0.69
Calcium	0.97	1.01
Available phosphorus	0.47	0.55
Total phosphorus	0.66	0.79

[a] For the CS treatment, 0.1% of soybean meal of lactation diet was replaced by the CS.
[b] DYNA-K (IMC Global, Lake Forest, Illinois).
[c] The vitamin premix provided the following per kilogram of complete diet: 6,613.8 IU vitamin A as vitamin A acetate, 661.4 IU vitamin D_3, 88.2 IU vitamin E, 4.4 IU vitamin K as menadione sodium bisulfite, 7.3 μg vitamin B_{12}, 1.8 mg riboflavin, 5.0 mg D-pantothenic acid as calcium pantothenate, 6.8 mg niacin and 49.9 mg choline as choline chloride.

and trace amounts of other enzymes, were obtained from EasyBio System, Inc. Sows were fed *ad libitum* from farrowing to weaning for 21 days. Feed intake of the sows was measured daily. Litter size was set to 9 pigs. No creep feed was offered. Body weights of sows and nursing pigs were measured weekly. All litters were weaned and sows were returned to gestation stalls on day 21 of lactation. Days of weaning-to-estrus were measured. During the second lactation, litter size and body weights of sows and nursing pigs were measured at farrowing and weaning. Sow feed intakes were measured daily.

Animal care

The animal care protocol was approved by Animal Care and Use Committee of Texas Tech University (# 01096).

Experimental diets

All the sows were fed the same gestation diet during gestation. Gestation diet contained corn as a major energy source and soybean meal as a major protein source providing 2.90 Mcal/kg, 12.0% CP and 0.58% total lysine (Table 1). After the farrowing, sows were fed one of two lactation diets during 21 days according to their allotment. Both the control and the CS diets contained corn and vegetable oil as a major energy source and soybean meal as a major protein source providing 3.36 Mcal/kg, 18.1% CP, and 1.0% total lysine (Table 1). For the CS diet, 0.1% of soybean meal was replaced by CS. After 21 d lactation, all sows in both the control and the CS groups were fed the same gestation and actation diets during the second parity lactation.

Table 2. Performance of sows and litters during first lactation

	Control	Carbohydrase	SE[a]
No. of sows	10	10	
Litter size	8.77	8.67	0.160
Daily litter weight gain, kg			
Week 1	1.56	1.49	0.159
Week 2	1.82	1.93	1.088
Week 3	1.70	1.75	0.103
Overall	1.69	1.71	0.088
Sow weight at farrowing, kg	164.7	163.8	3.64
Sow weight change, kg			
Week 1	-7.44[b]	+1.1[c]	1.644
Week 2	-3.20	-0.25	1.743
Week 3	-2.16	-2.96	0.974
Overall	-12.80[d]	-2.11[e]	3.351
Daily sow feed intake, kg/d			
Week 1	4.50	4.62	0.295
Week 2	5.78	6.26	0.485
Week 3	6.48	6.70	0.442
Overall	5.59	5.86	0.285
Weaning-to-estrus, day	5.94[d]	4.68[e]	0.358

[a] Standard error of the means. [b, c] $p<0.01$. [d, e] $p<0.05$.

Statistical analysis

The statistical analysis was performed with the General Linear Models procedure (PROC GLM) in SAS/STAT® software (SAS Inst. Inc., Cary, NC). Least-squares means, probability of differences, and standard errors were used to evaluate the differences between the control group and the CS group.

RESULTS AND DISCUSSION

The first parity

Litter size and litter weight gain : After cross-fostering, litter sizes did not differ between the control group (8.8±0.16) and the CS group (8.7±0.16) (Table 2). Litter weight gain (kg/d) during lactation was not affected by the supplementation of CS. Because there was no creep feed offered to the nursing pigs and no diseases affected the growth of the nursing pigs, litter weight gain during lactation was attributed mainly to milk intake. Litter weight gain can be used to estimate milk yield. Clowes et al. (1998) reported a linear relationship between the pig weight gain and milk intake and one gram of pig weight gain attributed to 3.88 g milk intake. In the current study, therefore, milk production of sows was not influenced by the CS supplement. Litter weight gains of the second week were the highest in both groups. The result from Tilton (1999) also shown that the highest litter weight gains were in the second week for the first and second parity sows. Toner et al. (1996) reported similar result that milk yield peak of first-litter sows was at day 11 to 14 of lactation for litter size 7 to10. However, Garst et al. (1999) reported that milk yields as the highest at day 17 to 19 of lactation. This may be because the data were from multiparous sows.

Feed intake of sows : Voluntary feed intake did not differ between the control group and the CS group. The effects of dietary nutrients on the voluntary feed intake of sows are still not very clear. Pollmann (1980) reported lactating sows had less feed intake when fed high energy diet and tend to have similar energy intake whereas O'Grady et al. (1985) reported sows ate 3% more of high energy diet. The CP level of gestation diet affected the feed intake during lactation only when the CP level of lactation diet was lower than 18% (O'Grady et al., 1985). The CP level of lactation diet affected the feed intake of lactation only when the CP level of gestation diet was lower than 9% (Mahan and Grifo, 1975). However, NCR-42 (1978) observed that average daily feed intakes during lactation were not influenced by either gestation or lactation CP level. As we will discuss later, supplementing CS could increase the utilization of dietary nutrients as shown from the study with nursery pigs (Kim et al., 2003). Providing more digestible nutrients could provide similar consequences as increasing dietary nutrient level. In this study, the energy and CP levels of the control and CS diets were in the normal level. Thus, the effect of dietary nutrients on feed intake may be rather limited**.** The amount of increased digestible nutrients by the CS supplement did not affect feed intake of sows during lactation, even though the CS group had numerically higher voluntary feed intake than the control group (5.86 vs 5.59 kg/d). Feed intake of the sows during the first week were the lowest. Sows often experience feed intake depression for the first few days after farrowing. This depression may affect the subsequent reproductive ability of sows (Revell et al., 1998). The voluntary feed intake of sows increased as lactation progressed and this trend was similar with the report by Revell et al. (1998).

Body weight changes of sows : There was no difference in body weights at farrowing between the control group and the CS group. Comparing the body weight loss of sows, the CS group (2.11 kg) had lower ($p<0.05$) body weight loss than the control group (12.8 kg). Sows can use both dietary nutrients and tissue protein/fat storage for milk production. For lactating primiparous sows, feed intake capacity is a limiting factor for the milk production. In most cases, sows lost body weight to support milk production during the first parity. In the current study, two groups had similar litter weight gain meaning they used similar amount of nutrients for milk production. The reason that the CS group had less body weight loss can be because the CS group obtained more nutrients from improved utilization of dietary nutrients. This opinion is supported by our previous study with nursery pigs. In that study, apparent ileal digestibility of gross energy, lysine, threonine, tryptophan and total amino acids increased 6.52, 1.25, 5.45, 3.88 and 2.89%, respectively when the control diet was supplemented with the carbohydrases (0.1%) in young pigs (Kim et al., 2003). Gdala et al. (1997) also reported that dietary supplementation of α-1,6-galactosidase improved digestibility of gross energy, threonine, methionine and branched chain amino acids by 2.7, 4.8, 5.0 and 2.8%, respectively. Wiggins (1984) found that FPC in the small intestine increased fluid retention by osmotic effects, and thus increased the passage rate of digesta that could affect the nutrient absorption. It may also be possible that sows could utilize α-1,6-galactosides and β-galactomannan as additional energy sources. During the first week, body weight loss of the control group (7.44 kg) was higher ($p<0.01$) than that of the CS group (-1.1 kg). The difference was 8.54 kg. During the second week, sow body weight loss of the control group (3.2 kg) was numerically 2.95 kg higher than the CS group (0.25 kg). During the third week, body weight loss of the control group (2.16 kg) was numerically 0.8 kg lower than the CS group (2.96 kg). The major effect of the CS supplement occurred during the first week of lactation.

Weaning-to-Estrus Interval : The CS supplementation to sow diets reduced ($p<0.05$) weaning-to-estrus interval. The etiology of estrus inhibition in response to feeding or metabolic status is not clear (Kirkwood et al., 1987). It may involve interaction of the adrenal axis hormones with GnRH release (Rivier and Vale, 1984; Moberg, 1991). Brain function could be modified by altering the supply of amino acids that are precursors for synthesis of neurotransmitters (Wurtman, 1982). Inadequate energy or amino acid supply during lactation resulted in lower LH secretion and increased weaning-to-estrus interval and nonproductive days of sows (King and Dunkin, 1986; Tokach et al., 1992; Jones and Stahly, 1999). Weaning-to-estrus interval is positively related to sow body weight loss. In the current experiment, the CS supplementation decreased sow body weight loss from 12.8 to 2.1 kg and weaning-to-estrus interval from 5.9 to 4.7 days. Johnston et al. (1993) reported similar results that weaning-to-estrus interval increased from 4.9 to 5.3 d as sow body weight loss increased from -0.8 to 9.1 kg. Failing to express estrus shortly after weaning will affect reproduction of sows for subsequent parity. How long will weaning-to-estrus affect the

Table 3. Performance of sows and litters during second lactation as affected by first lactation carbohydrase supplementation

	Control	Carbohydrase	SE[a]
Number of sows	7	7	
Litter size at birth	8.92	8.08	0.81
Litter size at weaning	8.47	7.24	0.69
Pig birth weight, kg/pig	2.11	2.28	0.12
Pig weaning weight, kg/pig	6.68	7.41	0.33
Daily weight gain, g/pig	217.6	244.0	13.8
Sow weight at farrowing, kg	184.6	193.0	3.6
Sow weight at weaning, kg	185.6	186.4	4.0
Sow daily feed intake, kg	5.93	5.61	0.13

[a] Standard error of the means.

reproductive performance? Generally, sows express estrus between 3 and 8 day after weaning. Tubbs (1995) observed that sows mated between 3 and 6 day had increased farrowing rates and litter size after weaning than sows mated between 7 and 15 day whereas other studies showed that when the weaning-to-estrus interval increased from 4 to 10 d, the subsequent litter size and farrowing rate were decreased (Vesseur et al., 1994; Steverink et al., 1999). In the current study, although days of weaning-to-estrus were different ($p<0.05$) between two groups, the difference of 1.26 d did not affect the litter size during the second parity. The results from King and Dunkin (1986a) showed that when sow body weight loss increased from 9.0 to 44.5 kg, weaning-to-mating interval increased from 7.8 to 29.8 d and the number of sows exhibiting estrus within 8 days-of-weaning decreased from 83.3 to 8.3%. In the current study, the average weaning-to-estrus interval of the control group was 5.9 d and their lactation weight loss was 12.8 kg suggesting that the sows in the control group performed normally.

The second parity

Two sows from each group were excluded because they did not return to estrus within 21 days postweaning. One sow from each group was excluded because they were not pregnant. Therefore, data for the second parity performance were from seven sows in each group.

The results show that there was no difference in reproductive performance during the second parity between the two groups (Table 3). Body weights of the control group and the CS group were 151.9 and 161.7 kg at weaning of the first lactation and they were 184.6 and 193.0 kg at farrowing of the second lactation, respectively. Weight gains of the control group and the CS group were 32.7 and 31.3 kg during the second gestation, respectively. The CS supplement during the first lactation did not affect weight gains of sows during the second gestation and the reproductive performance during the second lactation. There are lack of data showing the effect of reducing sow body weight loss during the first parity on the performance of sows and litters during the second parity. In this study, the results show that the improvement of sow body weight loss by 10.7 kg during the first lactation did not improve the reproductive performance during the second parity. It may benefit from having the CS supplement during the second lactation.

In conclusion, supplementing CS during the first lactation improved reproductive performance of sows by reducing body weight loss and days of weaning-to-estrus. However, this improvement was not successfully carried over to the second parity.

IMPLICATION

Supplementation of CS during first lactation can reduce body weight loss and weaning-to-estrus days during the first parity but the effect of CS did not last to the second parity. It may be more beneficial if the CS supplement is also exerted during the second lactation.

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