EFFECT OF FERMENTED EXTRUDED CORN STOVER ON NUTRIENT DIGESTIBILITY AND MILK COMPOSITION IN COLOSTRUM OF PREGNANT SOWS

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Abstract. The study was conducted to determine the effect of fermented extruded corn stover on nutrient digestibility and milk composition in colostrum of pregnant sows. A total of 48 pregnant sows (24 Landrace and 24 Yorkshire) were randomly assigned into four experimental treatment groups (0, 10%, 15%, 20% fermented extruded corn stover). The results of nutrient digestibility (*Table 2*) showed that in crude protein and neutral detergent fibre, there were no significant differences between the control group and 10% fermented extruded stover ($P > 0.05$). However, these results in energy and acid detergent fibre showed a significant differences between control group and all the experimental groups ($P > 0.05$), respectively. In fat, lactose and non-fat solids, there were no significant differences between control group and experimental groups ($P > 0.05$), respectively. There was a significant difference in protein between control group and experimental group ($P < 0.05$). Our findings suggest that with the increase of fiber content in feed, protein and lactose content are increased in colostrum of pregnant sows and there is little effect on digestibility.
Keywords: *dietary fiber, corn stover, pregnant sows performance, digestibility, lactation*

Introduction

Dietary fiber is well recognized to affect digestive functions in the small intestines with result of digestion and absorption of nutrients, also in pigs it is the main substrate for bacteria in the gastro-intestinal tract and its inclusion has shown to promote bacterial growth resulting in higher fecal excretion (Metzler and Mosenthin, 2008). The high interest to use dietary fiber in pig's diets is an economical point and animal welfare perspective, also feedstuff with high content of dietary fiber could be supplied as cheap by products as roughage (Banino, 2012). Kim et al. (2018) stated that during pregnancy, sow feed intake is not adequate to meet the nutrient requirements for maintenance, fetal growth and lactation which leads to mobilization of body reserves. According to Krogh et al. (2015) high fiber diets that are greater than 7% crude fiber, during sow's gestation period have increased growth performance of new born piglets, also increased sow feed intake during lactation and reduced constipation. Sows performance has been improved over the last decades by which energy and nutrients intake has become critical and nutritional factors such as metabolic status, energy supply during lactation may affect the milk production while feed intake and dietary fibre content may affect heat energy of reproductive sows (Theil et al., 2004). Ngalavu et al. (2018) recommended that supplementation is required for feeding during sow's gestation period to improve

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performance. There is little information on dietary fiber supplementation on milk composition in colostrums of pregnant sows. Hence, we hypothesized that the dietary fiber supplementation such as fermented corn stover might be the supplement to improve nutrient digestibility and milk composition of pregnant sows.

The objective of the present study was to investigate the effects of dietary fiber supplementation on nutrient digestibility and milk composition in colostrums of pregnant sows. This study will provide basic scientific knowledge of dietary fiber such as fermented corn stover as supplement during the pregnant stage of sows.

Materials and methods

Study site

This experiment was conducted in a research area of Jilin Agricultural University, Changchun city of the People's Republic of China. Jilin Province is located at latitude 43° 42' N and longitude 126° 12' E whereas Changchun city is found at latitude 43° 88' N and longitude 125° 35' E. The average annual rainfall ranges between 350-1000 mm during rainy seasons between March and August, while the dry season is between September and February. Average daily temperatures in winter (Nov- Mar), ranges between -8 °C (17 ºF) to -20 °C (-4.6 °F, and in summer (May-July) between 16 °C (61.4 °F) and 28 °C (81.2 °F) respectively.

Corn stover preparation and fermentation

Corn stover leaves were removed and dried at a temperature of 70 °C until the constant weight was achieved. Corn stover was completely dried and further cut into 10 cm, thereafter crushed into fine powder to allow passing through a 3.5 mm mesh mini laboratory sieve to determine the level of dry matter. Corn stover fermentation for the current study was prepared using the method indicated by Chang et al. (2012) and Ngalavu et al. (2018). In the current study, the Commercial baking yeast was used as *Saccharomyces cerevisie* for the microbial fermentation process. The yeast was then inoculated into medium, containing glucose 50 gL^{-1}, peptone 5 gL^{-1}, MgSO4.7H2O 1 gL^{-1}, K2HPO2 and 5gL^{-1} of yeast. The medium was autoclaved at 121 °C (249 °F) for 15 min. After autoclaved, the yeast was inoculated on the orbital shaker for a period of 18 h at 30 °C, 50 rmp.

Experimental design and sows feeding management

Experiment was conducted in completely randomized design; forty eight pregnant sows (24 Landrace and 24 Yorkshire) were randomly assigned into 4 experimental treatment groups (0%, 10%, 15% and 20% fermented extruded corn stover) for with 12 replicates per group and were selected on the basis of genetics, weight and parity similar to binary hybrid sow (long x large). In addition, pigs live body weights were ranged between 17.5-20.5 kg (average 19 kg). Daily feed intakes, health conditions of pigs and free access to drinking water were carefully checked and recorded. The duration of the trial included 3 days of pre-feeding; from mating to sow delivery 114 days, sows 7 days after delivery to 28 days after weaning, up to a to a total number of 145 days. Pigs' immunization and disinfection of piggery and experiments were according the conventional method of pigs.

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Table 1 shows the experimental diets contained corn and soybean meal as raw material were prepared according the NRC (1998) pig's nutritional requirements. All the procedures involved pigs were approved by Animal Research Ethics Committee of the Jilin Agricultural University, China.

Table 1. *Fodder during pregnancy and lactation formula*

Experimental diet				
Ingredients	**Percentage per group**			
	(Control)	10%	15%	20%
Corn	76	67	62	59
Soybean meal	14	15	15	16
Wheat bran	5.2	3.2	3.2	0.2
$CaHPO_4$	2	2	2	2
Limestone	1	1	1	1
NaCl	0.2	0.2	0.2	0.2
Fermentation puffed straw	0	10	15	20
$NaHCO_3$	0.6	0.6	0.6	0.6
Premix	1	1	1	1
Total	100	100	100	100
Nutrient levels	**Percentage**			
DE/(MJ/kg)	13.75	13.42	13.21	13.13
CP	12.91	12.92	12.81	12.87
NDF	10.50	15.75	18.58	20.76
ADF	3.40	8.55	11.20	13.63
Ca	0.88	0.88	0.88	0.88
P	0.71	0.70	0.66	0.63
Na	0.15	0.15	0.15	0.15
Cl	0.12	0.12	0.12	0.12

$CaHPO_4$: Calcium Hydrogen Phosphate; NaCl: Sodium Chloride; $NaHCO_3$: Sodium bicarbonate; DE: Digestible Energy; CP: Crude Protein; NDF: Neutral Detergent Fibre; ADF: Acid Detergent Fibre; Ca: Calcium; P: Phosphorus; Na: Sodium; Cl: Chloride

Nutrient digestibility and milk composition analysis

Total of 300 g fecal samples were collected from each pen every morning (9:00 am) for seven days and stored at -20 °C immediately after collection. Frozen dried samples of feces were ground through 1 mm screen in a Wiley Mill model 4; Thomas Scientific, Swedesboro, NJ. The chromium concentration in fecal samples was determined using an ICP procedure (Method 990.08, AOAC Int., 2007). Samples were prepared using nitric acid. Colostrum samples were collected in a 50 ml centrifuge tube immediately after sows had delivered, and the stored at -40 °C refrigerator for cryopreservation tests. The samples were analysed using FOSS multi-functional milk composition analyzer for milk fat, milk protein and non-fat solids.

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Chemical analysis and statistical analysis

The procedure of AOAC (2005) was used to analyze the digestible energy (DE) and crude protein (CP). Van Soest (1994) method was followed to analyze the acid detergent fibre (ADF) and neutral detergent fibre (NDF). All the experimental diets including Calcium (Ca), phosphorus (P), Sodium (Na) and Chloride (Cl) were analyzed according the procedure explained by Chang et al. (2015). One-way analysis of variance (ANOVA) was used for data analysis with Duncan multiply range test for comparing difference among the means using statistical package for social sciences (Version 10.0 for windows, SPSS Inc., Chicago, IL). All the results were expressed as mean ± standard deviation (mean ± SD). Alpha 0.05 was the significance level of the study.

Results and discussion

Effects of fermented extruded corn stover on digestibility

The results of nutrient digestibility (*Table 2*) showed that in crude protein and neutral detergent fibre, there were no significant differences between the control group and 10% fermented extruded stover ($P > 0.05$). However, these results in energy and acid detergent fibre showed a significant differences between control group and all the experimental groups ($P > 0.05$), respectively. It can be seen that with the increase of fiber content in diets, the apparent digestibility of fiber level showed a significant decrease trend. The apparent digestibility of energy and the apparent digestibility of protein decreased with the increase of fiber content. Through the results of this experiment, it can be seen that the addition of fermented extruded stover during pregnancy to improve the level of fiber in sow diets will reduce the apparent digestibility of its energy without affecting the sow during pregnancy. Digestibility, apparent digestibility of acidic detergent fibers, and apparent digestibility of neutral detergent fibers were negatively correlated with increased fiber levels in diets. Sows have high utilization capacity for high fiber diets, mainly because adult sows have a relatively complete intestinal digestion environment. The fiber can be in the intestine through the role of micro-organisms, resulting in short-chain fatty acids (acetic acid, propionic acid, butyric acid) and other volatile fatty acids to supply energy for the sow and other energy needs (Jha and Berrocoso, 2015). The energy digestibility of the test group was not significant, mainly due to the longer metabolic time of the fiber, due to the structural characteristics of the fiber, resulting in sow satiety, thereby reducing the sow physical activity so as to reduce the need to maintain the purpose. The mechanism of protein digestion and absorption in the sow is mainly due to the physical properties of the fiber, to prevent the digestive enzymes in the intestine as well as to digest the nutrient, so that parts of the nutrients are not absorbed by the fiber composition of a membrane and material, which is wrapped up by the sow through the form of feces discharged. Johnston et al. (2003) stated that fibrous feed typically have not been used for non-ruminants due to the reported depression of digestibility, however, some type of fiber do not apply such negative effects on nutrient digestibility. Recent study (Jiang et al., 2016) on Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) digestibility was improved and Gross Energy (GE) digestibility was improved, which may be the reason for an improved Average Daily Feed Intake (ADFI) compared with pigs fed control diets. Declining Metabolic Energy (ME) intake plus observation that dietary fibre decrease digestibility of energy and other nutrient (Renteria-Flores et al., 2015).

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Table 2. *Effects of fermented extruded corn stover on digestibility in sows*

Digestibility parameters	Experimental groups			
	Control	10% fermented extruded straw	15% fermented extruded straw	20% fermented extruded straw
Crude protein	85.03±0.02[a]	83.12±1.00[a]	81.18±0.80[b]	80.52±0.36[b]
Energy	87.42±1.33[a]	84.26±0.05[b]	83.46±1.31[b]	83.14±2.35[b]
Acid detergent fibre	82.42±0.76[a]	76.77±1.51[b]	61.70±1.62[c]	54.58±1.24[d]
Neutral detergent fibre	87.04±0.24[a]	84.94±1.86[a]	78.30±2.50[b]	68.09±4.53[c]

[a, b, c, d]Means in rows with different superscripts differ significantly ($p \leq 0.05$)

Effects of fermented extruded stover on milk components and composition in sows' colostrum

Effect of corn stover on pregnant sow's colostrum ingredients is portrayed on *Table 3*. The results discovered that in fat, lactose and non-fat solids, there were no significant differences between control group and experimental groups ($P > 0.05$). There was a significant difference in protein between control group and experimental group ($P < 0.05$), respectively. In addition, Devillers et al. (2004) indicated that piglet body weight gain increases concurrently with colostrum intake during the first 24 h after birth and a weight gain of 50 g during the weaning on average is allowed by 250 g of colostrum ingested.

Table 3. *Effects of fermented extruded corn stover on milk components in sows' colostrum*

Milk components	Experimental groups			
	Control	10% fermented extruded straw	15% fermented extruded straw	20% fermented extruded straw
Protein	16.73±0.55[c]	17.79±1.12[ab]	18.53±0.07[ab]	16.38±0.03[a]
Fat	5.18±0.96[a]	5.29±0.56[a]	4.98±0.06[a]	5.37±0.06[a]
Lactose	2.53±0.01[a]	2.61±0.04[a]	2.55±0.06[a]	2.80±0.01[b]
Non-fat solids	21.35±1.43[a]	22.37±0.97[a]	22.41±0.46[a]	20.53±0.54[a]

[a, b]Means in rows with same superscripts are the same significantly ($p \leq 0.05$)

As shown in *Table 4*, there was no significant difference in the total solid content between the control group and the colostrum ($P > 0.05$). There was significant difference between the control group and the experimental groups in colostrum composition ($P < 0.05$). There was no significant difference between the control group and the 20% fermented extruded stover group ($P > 0.05$). The control group and 10% fermented extruded stover group had no significant difference ($P > 0.05$). The results has shown that the amount of protein and lactose in the milk composition of the colostrum of each group increased with the increase of the fiber content in the sow diets, and the difference was significant. Similar results were also reported by Kim et al. (2018), who found that sows fed high energy diet had higher concentration of lactose in milk. The content of free fatty acid (FFT), non-fat solid (NFS), freezing point (FP) and total solid (TS) were not significantly different; however, there was a difference in the decrease free fatty acids. Studies have shown that feeding high-fiber diets can increase the content of volatile fatty acids in sows, while some of the volatile fatty acids play an

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important role in the milk production of sows, and therefore have a higher effect on milk fat content in milk. Quesnel et al. (2009) study have shown that high-fiber diet than the control group increased milk production, but the difference was not significant, no significant difference in milk composition, which is slightly different from the current study results, which may be related to the type of feeding fiber inconsistencies. According to Quesnel et al. (2009), the great appetite of lactating sows fed a high fiber diet during gestation may be slightly indicated by decreased secretion of leptin and does not seem to have connection with change in glucose and insulin metabolism. The reduction in part of the milk composition in the 20% fermented puffed straw group may be related to excessive fiber intake. This also shows that the fiber cannot rely too much on the low energy use effect. Feed ingredients, such as fermented liquid and yeast extracts has shown to cause change in colostrum composition (Farmer and Quesnel, 2009).

Table 4. *Effects of fermented extruded corn stover on milk composition in sows' colostrum*

Milk composition	Experimental groups			
	Control	**10% fermented extruded straw**	**15% fermented extruded straw**	**20% fermented extruded straw**
Total solids	30.43±0.15^{a}	28.96±0.08^{a}	27.35±0.12^{a}	27.10±0.17^{a}
Freezing point	1.50±0.03^{a}	1.24±0.12^{ab}	1.24±0.11^{b}	1.26±0.01^{b}
Acidity	63.41±4.01^{a}	55.15±5.10^{b}	54.19±4.62^{b}	51.95±0.23^{b}
Free fatty acid	71.84±2.59^{a}	68.14±4.76^{a}	66.27±4.28^{a}	66.11±0.30^{a}

$^{a, b}$Means in rows with different superscripts differ significantly ($p \leq 0.05$)

Conclusion

Fermented extruded corn stover which is a dietary fiber supplement can be used to slightly improve performance of pregnant sows. Our findings suggest that with the increase of fiber content in feed, protein and lactose content are increased in colostrum of pregnant sows and there is little effect on digestibility. There is great potential to develop different methods of feed processing that will increase the effect of fiber supplementation in pig's performance.

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