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Non-GMO beet pulp and canola meal corn-soybean meal diet ingredient has comparable effects as that of GMO corn-soybean meal diet on the performance of sows and piglets

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Abstract

This study was done to compare the effects of the dietary supplementation of non-genetically modified organism (non-GMO) beet pulp and canola meal on reproduction performance in gestation-lactation sows. A total of 16 lactating sows (Landrace × Yorkshire) were randomly allotted to 1 of 2 dietary treatments with 8 replicates per treatment. Treatments consisted of genetically modified organism (GMO) basal diet (CON) and GMO basal diet supplemented with Non-GMO beet pulp and canola meal (NO). The experiment lasted from 4 weeks prior to farrowing, to day 21 of lactation. The ambient environments in the dry sow accommodation and the farrowing house were kept at a fairly constant temperature of 19 - 21°C, and 60% relative humidity. In the current study, inclusion of non-GMO feed ingredients diets showed comparable effects on the reproductive performance of the sows as that of the basal diet. There was no difference in reproduction performance in sows fed the non-GMO diets compared with CON diets when the feed ingredients were replaced with the feed by-product sugar-beet pulp (SBP) and canola meal (CM). In addition, there was also no significant difference in the growth performance of the piglets fed Non-GMO diets compared with the CON diet ($p > 0.05$). In conclusion, the results of the current study indicate a comparable effect of non-GMO sugar-beet pulp, and canola meal diet with basal diet on reproduction performance in gestation-lactation sows.

Keywords: canola meal, gestation-lactation sows, non-GMO, sugar-beet pulp

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Introduction

The first international and national provisions for the safety assessment and regulation of genetically modified organisms (GMO), including genetically modified crops and derived foods were drawn up by scientific experts in the mid-1980s (OECD, 1986; US OSTP, 1986). Then, the first successful transformation experiment in plants (tobacco) in 1988 and the International Food Biotechnology Council (IFBC) published the first report on the issue of safety assessment of these new varieties after two years (IFBC, 1990). Other organizations, such as the Organization for Economic Cooperation and Development (OECD), the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) and the International Life Sciences Institute (ILSI) have developed further guidelines for safety (Kuiper et al., 2001). However, many people question the potential benefits and risks of genetically modified crops (Fernandez-Cornejo et al., 2014). If without direct tangible benefits to the consumer, the foods produced with GMO ingredients may be perceived as being inferior to their non-GM counterparts (Chern and Rickertsen, 2001). Moreover, some food industry non-GMO by-products can be used as feed ingredient substitutes to reduce feed costs.

Sugar-beet pulp (SBP) is a botanically diverse by-product of the food industry, which contains substantial amounts of non-starch polysaccharide (NSP) (600 to 700 g NSP per kg dry matter [DM]) (Yan et al., 1995). It can be used as bulking materials in a diet for pregnant sows since the daily allowance for concentrated grain diets is much lower than the potential appetite of sows (Kay et al., 1990; Gill et al., 1992). Canola meal (CM) is a good source of available calcium, iron, manganese, selenium, and many of the B vitamins (Newkirk, 2009). Although high in phytate, CM is also one of the richest sources of non phytate (available) phosphorus (Khajali and Slominski, 2012).

Consumers concern about the increase of GMO has been increasing. We try to use non-GMO by-products from the food industry to replace GMO dietary ingredients to avoid potential risks and reduce costs. Consequently, the objectives of this experiment were to compare the effect of dietary supplementation of non-GMO SBP and CM with GMO basal diets on reproduction performance in gestation-lactation sows.

Materials and Methods

The experiment was conducted at the swine experimental unit of Dankook University (Cheonan, Korea). The protocol for the current experiment was approved by the Animal Care and Use Committee of Dankook University.

Test and control sugar-beet pulp and canola meal

Non-GMO SBP and CM sample were sent to independent laboratory Kogenebiotech Co., Ltd. (Seoul, Korea) for GMO Analysis. GMO qualitative analysis of SBP was performed by PCR with the specific primer pairs of H7-1 gene respectively. GMO qualitative analysis of CM was performed by PCR with the specific primer pairs of T45, GT73, Ms8, Rf3, and MON88302 gene respectively. The results are shown in Table 1. The results confirmed that the SBP and CM were non-GMO.

Experimental design, animals and housing

A total of 16 lactating sows (Landrace × Yorkshire), were randomly allotted to 1 of 2 treatments with 8 sows per treatment. Treatments consisted of GMO basal diet (CON) and GMO basal diet supplemented with Non-GMO SBP and CM (NO). Gestating sows were housed on a slat floor, in an environmentally regulated building.

The experiment lasted from 4 weeks prior to farrowing, to day 21 of lactation. The ambient environments in the dry sow accommodation and the farrowing house were kept at a fairly constant temperature of 19 - 21℃, and 60% relative humidity. A nursery box equipped with an infrared spotlight and heating mat was provided to meet the requirements of piglets. Sows were individually fed, using specially installed troughs and nipple drinkers. The diets were formulated to meet or exceed NRC (2012) recommendations for all nutrients (Table 2). The temperature in the farrowing house was maintained at a minimum of 20℃. Supplemental heat was provided for piglets using heat lamps. All diets of sows were provided in meal form, and sows and piglets were provided with free access to water throughout the experimental period. Piglets were treated according to routine management practices that included teeth clipping, tail docking, and ear notching.

Sampling and measurements

The backfat thickness of sows was measured 6 cm off the midline at the 10th rib using a real-time ultrasound instrument (Piglet 105, SFK Technology, Herlev, Denmark) 4 day before farrowing, 1 day after farrowing, and during weaning. Values from the two measurements were averaged to obtain a single backfat measurement. The measurement of backfat was done as per the method described by Song et al. (2012). The amount of feed consumed during the lactation periods was recorded and used to calculate the average daily feed intake (ADFI). Detection of estrus was conducted twice per day from weaning onwards, at 8 am and 4 pm every day. A sow was considered to return to estrus when exhibiting a standing response induced by a back pressure test when in the presence of a boar. Number of piglets borne and weaned pigs was also recorded to calculate the survival rate. Individual piglet body weight (BW) and litter weights were assessed on days 0, and 26 to calculate average daily gain (ADG).

Statistical analysis

All data were subjected to the GLM procedures of SAS (2013) as a randomized complete block design (SAS Inst. Inc., Cary, USA). The individual sow or litter of piglets was used as the experimental unit. Differences among all treatments were separated by using the Tukey's test. The variability in the data was expressed as standard error (SE). A probability level of $p < 0.05$ was considered to be statistically significant.

Results

GMO qualitative analysis

The GMO qualitative analysis results are presented in Table 1 and 2. H7-1 gene was not detected non-GMO SBP. T45, GT73, Ms8, Rf3, MON88302 gene were not detected in non-GMO CM. Those results confirmed that the SBP and CM, which applied in non-GMO meal, were non-GMOs.

Table 1. GMO qualitative analysis results of beet pulp.

Analysis item[z]	Result
Non-beet pulp	
Sugar Beet reference gene (GruA3)	Detected
Inhibition test	No Inhibition observed
H7-1 qualitative test	Not detected
Canola meal	
Canola reference gen (BncruA)	Detected
Inhibition test	No Inhibition observed
T45 qualitative test	Not detected
GT73 qualitative test	Detected
Ms8 qualitative test	Not detected
Rf3 qualitative test	Not detected
MON88302 qualitative test	Not detected

[Z] Independent laboratory Kogenebiotech (2017).

Table 2. Ingredient composition of experimental diets (as-fed basis).

Items	Gestation		Lactation	
	CON	NO	CON	NO
Ingredients (%)				
Corn	56.47	48.09	59.49	46.87
Beet pulp (Non-GMO)	-	19.61	-	13.92
Soybean bran	27.77	14.16	13.09	9.18
Soybean meal	10.49	10.68	21.13	17.95
Canola meal (Non-GMO)	-	3.0	-	5.0
Calcium hydrogen phosphate (16.5%)	1.46	1.50	1.43	1.58
Limestone	1.67	0.85	1.04	0.58
Salt	0.41	0.41	0.31	0.31
L-Lysine –HCl (98.5%)	0.28	0.24	0.39	0.40
Sodium bicarbonate (99%)	0.20	0.20	0.20	0.20
Choline (50%)	0.16	0.16	0.16	0.16
Vitamin premix[y]	0.5	0.5	0.5	0.5
Mineral premix[z]	0.5	0.5	0.5	0.5
L-Threonine (98.5%)	0.06	0.06	0.13	0.14
DL-Methionine (98.5%)	0.01	0.02	0.11	0.12
Phytase	0.02	0.02	0.02	0.02
Soy oil	-	-	1.50	2.57
Calculated composition				
Metabolizable energy (kcal/kg)	2.97	2.97	3.22	3.22
Crude protein (%)	14.00	14.00	17.00	17.00
Crude fat (%)	7.06	7.03	6.00	6.00
Crude fiber (%)	6.9	7.2	2.1	3.2
Ash (%)	6.16	6.16	5.90	5.90
Calcium (%)	0.90	0.90	0.80	0.80
Phosphorus (%)	0.69	0.69	0.71	0.71
Lysine (%)	0.70	0.70	1.00	1.00

CON, GMO basal diet; NO, non-genetically modified organism wheat-based diet.

[y] Provided per kilogram of complete diet: vitamin A, 10 000 IU; vitamin D3, 2000 IU; vitamin E, 48 IU; vitamin K_3, 1.5 mg; riboflavin, 6 mg; niacin, 40 mg; d-pantothenic, 17 mg; biotin, 0.2 mg; folic acid, 2 mg; choline, 166 mg; vitamin B_6, 2 mg; vitamin B_{12}, 28 mg.

[z] Provided per kilogram of complete diet: Fe (as $FeSO_4 \cdot 7H_2O$), 90 mg; Cu (as $CuSO_4 \cdot 5H_2O$), 15 mg; Zn (as $ZnSO_4$), 50 mg; Mn (as MnO_2), 54 mg; I (as KI), 0.99 mg; Se (as $Na_2SeO3 \cdot 5H_2O$), 0.25 mg.

Reproduction performance of lactation sows

The replacement of feed ingredients with feed by-product SBP and CM on reproduction performance in sows fed non-GMO diets compared with CON diets (Table 3).

Table 3. Effect of dietary supplementation of non-GMO on reproduction performance in lactation sows.

Items	CON	NO	SEM	p-value
Parity	2.4	2.4	-	-
Litter size (head)				
Total birth piglet	13.8	14.0	0.6	0.79
Live piglet	12.9	12.8	0.7	0.90
Stillbirth	0.3	0.6	0.1	0.08
Mummification	0.6	0.6	0.3	1.00
SUR 1[x] (%)	93.7	91.2	2.1	0.44
Body weight (kg)				
Initial	217.9	220.2	2.2	0.48
Before farrowing	246.5	248.9	2.4	0.50
After farrowing	226.1	229.2	2.4	0.41
Weaning	216.2	219.9	2.4	0.31
Body weight difference1[y]	28.6	28.7	0.7	0.88
Body weight difference2[y]	20.3	19.7	0.8	0.61
Body weight difference3[y]	10.0	9.2	0.6	0.37
ADFI (kg)				
Lactation	6.7	6.5	0.1	0.19
Backfat thickness (mm)				
Initial	18.2	17.8	0.2	0.13
Before farrowing	20.4	20.3	0.1	0.76
After farrowing	20.0	20.1	0.1	0.76
Weaning	18.9	18.5	0.2	0.14
Back fat thickness difference1[z]	2.2	2.6	0.1	0.08
Back fat thickness difference2[z]	0.4	0.3	0.1	0.35
Back fat thickness difference3[z]	1.1	1.6	0.2	0.11
Body condition score				
Initial	2.3	2.4	0.06	0.08
Before farrowing	3.0	2.9	0.04	0.35
After farrowing	3.0	2.9	0.04	0.35
Weaning	2.3	2.3	0.09	1.00
Estrus interval	4.8	4.9	0.2	0.68

CON, GMO basal diet; NO, non-genetically modified organism wheat-based diet; SEM, standard error of means.
[x] Survival rate at farrowing.
[y] 1, initial to before farrowing; 2, before farrowing to after farrowing; 3, after farrowing to weaning.
[z] 1, initial to before farrowing; 2, before farrowing to after farrowing; 3, after farrowing to weaning.

Growth performance of sucking piglets

No significant difference effects ($p > 0.05$) were detected on growth performance in piglets fed non-GMO diets compared with CON diets (Table 4).

Table 4. Effect of dietary supplementation of non-GMO on growth performance in sucking piglets.

Items	CON	NO	SEM	p-value
Litter size (head)				
Initial	12.0	12.0	-	-
Final	11.3	11.3	0.21	0.68
SUR 2[z] (%)	94.8	93.8	1.72	0.73
Body weight (kg)				
Initial	1.09	1.07	0.02	0.55
Final	8.03	7.82	0.24	0.56
Average daily gain (g)	248	241	8.58	0.58

CON, GMO basal diet; NO, non-genetically modified organism wheat-based diet; SEM, standard error of means.
[Z] Survival rate at weaning.

Discussion

Dried SBP contains a large quantity of NSP, of which 15% to 30% is pectin (Pilnik and Voragen, 1992). Sugar-beet pectin has been shown to be extensively degraded in the caecum (Robertson et al., 1987). Therefore if sugar-beet pectin is available for fermentation in the caecum, it may replace protein fermentation and associated harmful by-products will be reduced. Longland et al. (1994) has also demonstrated that the incorporation of SBP into the diet enhances the fermentation of the cell wall carbohydrates in pigs. Although piglets (Longland et al., 1994) and growing pigs (Longland et al., 1993) have been reported to be able to digest and utilize the NSP fraction of SBP, pig studies on dietary ingredients rich in NSP are mainly focused on finishing and breeding animals. Because of their ability to digest and ferment fiber is thought to be greater than that of the newly weaned piglet (Gill et al., 2000) and it has been demonstrated that digestibility of the dietary fiber fraction increases with BW of the pig with a particularly important difference between growing pigs and adult sows (Noblet and Shi, 1994). In consistent with our research, the gestating mature sow has the ability to utilize fibrous feeds because of a larger digestive tract capacity, particularly the hindgut, and lower nutrient requirements compared with the lactating sow or the growing pig. Pond (1981) suggested that feeding fibrous feeds to sows could be greatly increased.

Canola meal is known for its lower and less consistent amino acid digestibility than soya-bean meal (SBM) (Khajali and Slominski, 2012). The results of a series of experiments indicated that when growing pigs are allowed feed ad libitum, the substitution of the major part of SBM by CM significantly reduced feed intake and had a slightly negative effect on daily weight gain (McKinnon and Bowland, 1977; Bell and Shires, 1980). Nevertheless, contradictory reports are available in the literature regarding the CM were used in the sows. Clowes et al. (2003) reported that 8.1% CM did not have any adverse effect on maternal growth, piglet birth weight, and litter growth in lactation, wean-to-breeding interval, or subsequent litter size. King et al. (2001) evaluated the effect of diets containing up to 20% of solvent-extracted canola meal on sow performance; results indicated that average sow performance and piglet weight were not affected by the different levels of CM in the diets. Quiniou et al. (2012) studied the effects of feeding 10% of low-glucosinolate rapeseed meal (*B. napus*) during gestation and lactation, over three reproductive cycles, on the performance of hyper prolific sows and their litters and found no differences when compared to diets containing no rapeseed meal. These reports are consistent with our research results. In addition, these contradictory reports convince us that the stage of pig growth may be an important factor that must be considered.

Conclusion

In conclusion, the results of the current study indicate the supplementation of non-GMO beet pulp, and canola meal do not have any adverse effect on reproduction performance in gestation-lactation sows. In this experiment, non-GMO ingredients can be added to the feed as an alternative ingredient.

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