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RESEARCH ARTICLE

DIGESTIBILITY OF TOTAL, INSOLUBLE AND SOLUBLE DIETARY FIBER OF SOWS DURING GESTATION

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ABSTRACT

When the level of fiber is increased, it is important to evaluate the impact of this addition upon the nutrients digestibility. The present study evaluated the effect of variation in the amount of total dietary fiber in sow diets, provided from 74 to 87 days of gestation, on the digestibility of nutrients. Thirty-three sows were used in a randomized experimental design. The amounts of total dietary fiber in three treatment diets were 15.6; 22.3 and 28.2%. To increase the amount of dietary fiber, rice grain and soybean meal were partially substituted for defatted rice bran and soybean hulls. The daily consumption of nutrients and energy was similar between the 74 to 87 days of gestation, differing only in the volume of ration consumed, which was 2.1; 2.2 and 2.4 kg/day. During gestation, the increase in total dietary fiber resulted in a significant decrease in the apparent total tract digestibility of total dietary fiber, insoluble dietary fiber e soluble dietary fiber. Increasing the amount of total dietary fiber reduced the digestibility of nutrients, mainly of the total dietary fiber and insoluble dietary fiber.

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INTRODUCTION

The addition of fiber to the diet of sows helps to control weight and minimize the stress associated with confinement of sows in gestation crates and feed restrictions that pregnant females endure (Ramonet *et al.,* 1999; Danielsen and Vestergaard, 2001; Gentilini *et al.,* 2003). Besides, the fiber utilized during pregnancy may affect positively in the weight of piglets by birth and sow's feed consumption along lactation, reflecting in the piglet's weaning weight (van der Peet-Schwering *et al.,* 2003; Veum *et al.,* 2009). However, by increasing the level of fiber in the diet, it is important to evaluate the impact of this addition upon the nutrients' digestibility, since increasing the level of fiber in the diet there is a decrease in nutrients digestibility and energy (Le Gall *et al.,* 2009).Nutritionists must understand the effects of dietary fiber on nutrient digestibility of diets to properly feed high-fiber diets to sows (Renteria-Flores, 2008). Despite the substantial debate over the use of fiber in the diet of pregnant sows, there remain uncertainties over its use (Reese *et al.,* 2008), mainly in relation to the level of total dietary fiber (TDF) to be used. According to the National Research Council (2012), the main challenge in measuring TDF is its implementation in nutrition laboratories. In addition, it is important to evaluate the digestibility of the soluble and insoluble fractions of dietary fiber. The present study evaluated the digestibility of soluble dietary fiber, insoluble and total fiber from 82 to 87 days of pregnancy of sows fed with diets containing different levels of TDF.

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MATERIALS AND METHODS

All procedures conducted on sows were approved by the Ethics Committee on the Use of Animals (Protocol number 006/2014) of the Federal University of Pampa (UNIPAMPA). Thirty-three sows (commercial breeders Fertilis 20 from Généticporc Company, Yargo Piggery of Itaqui – Rio Grande do Sul – Brazil), weighing on average 232.1 ± 23.4 kg (mean ± residual standard deviation) at 74 days of gestation, were used in a completely randomized experimental design, with 11 replicates per treatment. During the gestation period, the environmental temperature ranged between 17.5 ± 2.7 °C and

24.8 ± 3.4 °C. All sows received the same diet up to 73 days of gestation, with 13.2 MJ/kg of digestible energy (DE), 14.8% of crude protein (CP), 5.2% of ash, and 4.3% of crude fiber (CF). Rations were given in one meal per day at 0800 h in the following quantities: 2 kg/day from 0 to 7 days and 2.4 kg/day from 8 to 73 days of gestation. From 74 to 87 days of gestation, sows were subjected to one of the dietary treatments shown in Table 1. The treatment dietary rations were given in one meal per day at 0800 h. The diets during gestation were formulated in accordance with National Research Council (2012). The daily gestation ration (Table 1) was adjusted based on the amounts of energy and lysine in the diets, so that sows would consume the same quantity of nutrients per day. To increase the amount of fiber in the diet, rice grain and soybean meal were partially substituted for defatted rice bran (DRB) and soybean hulls (SH). Water was available ad libitum for sows throughout the experimental period. The chemical composition of the diets was determined using the techniques described by AOAC (1990), except fiber (total, insoluble, and soluble), which was determined according to the enzymatic method described by Lee *et al.,* (1992) using the enzymes alpha-amylase**,** glucoamylase and protease, at 240 KNU-T/g, 300 AGU/mL and 2.4 AU-A/g, respectively. From 74 days of gestation, 0.35% of the indicator chromium oxide (Cr_2O_3) was included in all the diets and a partial collection of feces was performed daily from 82 to 87 days of gestation. Feces were analyzed to measure the levels of chromium oxide, insoluble dietary fiber (IDF), soluble dietary fiber (SDF) and total dietary fiber (TDF). To determine the apparent total tract digestibility (ATTD) of the nutrients, the following equation, described by Sun *et al.* (2014), was used: ATTD (%) = 100 - {100 × [(% of the indicator in the diet/% of the indicator in the faeces) × (% of the nutrient in the faeces/% of the nutrient in the diet)]}.

Table 1. Ingredients, chemical composition and daily consumption of gestation and lactation diets in sows

Item	Level of total dietary fiber[1]		
	15.60%	22.30%	28.20%
Ingredients (%)			
Defatted rice bran	32.0	34.8	37.6
Rice grain	57.0	44.2	31.4
Blood and bone meal	4.0	4.0	4.0
Soybean meal	4.2	2.1	0.0
Soybean hulls	-	12.2	24.4
Limestone	1.29	1.17	1.05
Salt	0.220	0.23	0.240
Rice oil	1.00	1.00	1.00
Vitamin and mineral premix[2]	0.274	0.274	0.274
Copper sulfate	0.024	0.024	0.024
Analyzed composition (%)[3]			
Crude protein	15.6	13.9	12.9
Ashes	6.6	8.1	9.6
Ether extract	1.28	2.06	2.28
Crude fiber	3.3	7.0	10.1
Insoluble dietary fiber	10.6	16.9	20.7
Soluble dietary fiber	5.0	5.4	7.5
Total dietary fiber	15.6	22.3	28.2
Dry matter (% in the diets)	86.2	88.3	87.7
Gross energy (MJ/kg of NM)	14.36	15.06	15.47
Digestible energy (MJ/kg of NM)	12.54	12.24	11.92
Daily ration consumption (kg)			
74 to 87 days of gestation	2.10	2.21	2.40

[1]Amounts of total dietary fiber in gestation diets. [2]Guarantee levels: Vitamin A, 4 750000 UI/kg; Vitamin D3, 950000 UI/kg; Vitamin E, 17500 UI/kg; Vitamin K3, 550 mg/kg; Vitamin B1, 1000 mg/kg; Vitamin B2, 3188 mg/kg; Vitamin B6, 1590.50 mg/kg; Vitamin B12, 9000 mcg/kg; Niacin, 14068 mg/kg; Pantothenic acid, 8500 mg/kg; Folic acid, 700 mg/kg; Biotin, 300 mg/kg; Choline chloride, 104.14 g/kg, B.H.T, 250 mg/kg; Calcium, 60 g/kg; Manganese, 45 g/kg; Zinc, 170 g/kg; Iron, 80 g/kg; Copper, 12 g/kg; Iodine, 750 mg/kg; Selenium, 300 mg/kg. [3]As fed.

Data were analyzed using the MIXED procedure of SAS software, and LSmeans were compared using the Fisher's (LSD) test. Fixed effect of fiber level was included in all the models of analysis. Linear and quadratic effects of fiber level were also investigated.

RESULTS AND DISCUSSION

The ATTD of TDF, IDF and SDF presented a linear decrease ($P < 0.05$) with a higher TDF level in the diet (Table 2). There was not any statistical difference ($P>0.05$) between the treatments with 22.3% and 28.2% of TDF, to the variables studied.

Table 2. Effect of the amount of total dietary (TDF) fiber in the diet of sows (74 to 114 days of gestation) on the apparent total tract digestibility (%)

Variables	Total dietary fiber level			d.p.	P-value	
	15.6%	22.3%	28.2%		Diets	L[1]
TDF	70.5a	58.4b	55.8b	7.5	<0.001	<0.001
Insoluble dietary fiber	57.6a	50.0b	47.1b	6.01	<0.001	<0.001
Soluble dietary fiber	92.2a	86.7ab	82.3b	7.63	0.006	<0.001

Values in the row with different superscripts differ significantly at $P < 0.05$, after analysis of variance and comparison using the LSD test. d.p. = standard deviation. [1]Linear response for the fiber level.

This study aimed to meet the nutritional requirements of sows, despite the variation in diet composition. The daily energy consumption from 74 to 87 days of gestation was 26.8; 26.0 and 26.9 MJ/kg of DE, and 327; 306 and 308 g of CP, for the 15.6; 22.3 and 28.2% TDF treatments, respectively. When the levels of fiber were increased in the diet there was a decrease in the digestibility of TDF, IDF and SDF. By adding higher amounts of fiber in the diet, the digestibility of dry matter, nitrogen and energy decrease for sows (Holt *et al.,* 2006; Le Gall *et al.,* 2009) and growing swines (Zhang *et al.,* 2013). The greater amount of fiber in the diet leads to important physiological changes, such as an increased viscosity of the diet (Kim *et al.,* 2005) and reduced time for the passage of chyme (Jorgensen *et al.,* 1996; Lattimer and Haub, 2010), which decreases the fermentation time in the large intestine (Wilfart *et al.,* 2007). However, Zhang *et al.* (2013) observed that as TDF in diets is increased there is a linear increase ($P<0.01$) in ATTD of TDF, IDF and SDF of growing swines. Similarly, Le Gall *et al.* (2009) observed an increase in ATTD ($P<0.05$) by increasing TDF from 12.6% to 21.4%. Although, with higher TDF values (30.5% and 38.2%) and lower ATTD values ($P<0.05$). Renteria-Flores *et al.* (2008), when working with pregnant sows that consumed diets with different concentrations of soluble and insoluble fiber, observed a decrease ($P<0.01$) in nitrogen digestibility. However, these authors noted that by increasing only the amount of soluble fiber in the diet, nitrogen digestibility remained the same ($P>0.01$). In contrast, with low levels of the soluble fraction, if the amount of insoluble fiber in the diet is increased, nitrogen digestibility decreases ($P<0.01$).

The variation that occurs in digestibility of TDF, IDF and SDF may be due to the different sources of fiber used in the diets (Zhang *et al.,* 2013). In this study, the sources of fiber chosen were rice bran and soybean hull, and the digestibility of nutrients decreased as higher amount of these ingredients were added to the diets. A similar effect was observed by Le Gall *et al.* (2009) when working with diets containing soybean hulls, wheat bran and beet pulp. Conversely, Zhang *et al.* (2013) when working with diets for growing pigs based on rice starch, casein and beet pulp, noted that as TDF in diets was increased, the levels of TDF's ATTD, IDF and SDF also increased, the authors assigned this response to the ingredients used, the presence of components from endogenous secretions, that are analysed as TDF, though they are not, and also to a higher fermentation of SDF in large intestine.

Conclusion

The higher levels of TDF, IDF and SDF in diet, obtained by the addition of higher amounts of defatted rice bran and soybean hulls cause a decrease in the ATTD of these nutrients. These effects are more expressive upon TDF and IDF digestibility as TDF is increased in diets, because the addition of up to 22.3% of TDF in diet, reached by the insertion of 34.8% of defatted rice bran and 12.2% of soybean hulls did not affect SDF digestibility.

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