Effect of Dietary Fiber Level during Gestation on Reproductive Performance and Serum Reproductive Hormone Levels in Shenxian Sows (Postprint)

Authors: Lu Chunlian, Cao Hongzhan, Miao Yutao, Tension ring, Li Tongzhou, Li Juanjuan, Li Shang, Xie Youzhi, Li Sai

Date: 2017-10-10T00:00:00+00:00

Abstract

This experiment was conducted to investigate the effects of dietary fiber levels during gestation on reproductive performance and serum reproductive hormone levels in Shenxian sows. Thirty first-parity pregnant Shenxian sows were randomly assigned to 3 groups with 5 replicates per group and 2 sows per replicate. The experimental period spanned from the onset of gestation to the end of lactation. Sows in groups 1, 2, and 3 were fed diets with crude fiber (neutral detergent fiber) levels of 10% (31.58%), 12% (31.96%), and 14% (32.65%) during gestation, respectively, while all groups received the same diet during lactation. The results showed: 1) The litter size and number of live-born piglets in groups 2 and 3 were extremely significantly higher than those in group 1 ($P<0.01$). The stillbirth rate in group 2 was significantly lower than that in group 1 ($P<0.05$). The litter birth weight, individual birth weight, litter weaning weight, and individual weaning weight in group 2 were extremely significantly higher than those in groups 1 and 3 ($P<0.01$). The litter weaning weight of piglets from group 3 sows was extremely significantly higher than that of group 1 ($P<0.01$), while the litter birth weight and individual weaning weight were significantly higher than those of group 1 ($P<0.05$). 2) Dietary fiber level had no significant effect on serum estradiol, progesterone, and prolactin levels on day 85 of gestation ($P>0.05$); however, serum progesterone and prolactin levels on day 114 of gestation in groups 2 and 3 were significantly higher than those in group 1 ($P<0.05$), while serum estradiol levels showed no significant differences among groups ($P>0.05$). Based on comprehensive analysis of all indicators, the optimal crude fiber (neutral detergent fiber) level in gestation diets for Shenxian sows was 12% (31.96%) for achieving the best reproductive performance.

Full Text

Effects of Dietary Fiber Level during Pregnancy on Reproductive Performance and Serum Reproductive Hormone Levels of Shenxian Sows

**LU Chunlian[1], CAO Hongzhan[1]*, MIAO Yutao[2], ZHANG Liquan[3], LI Tongzhou[1], LI Juanjuan[1], LI Shang[1], XIE Youzhi[1], LI Sai **

[1]College of Animal Science and Technology, Agricultural University of Hebei, Baoding 071000, China
[2]Livestock Station of Hebei Province, Shijiazhuang 050000, China
[3]Bureau of Animal Husbandry and Veterinary of Hebei Province, Shijiazhuang 050000, China
Zhengnong Husbandry Co. Ltd. of Xinji City in Hebei Province, Xinji 052360, China

Abstract

This experiment was conducted to investigate the effects of dietary fiber level during pregnancy on reproductive performance and serum reproductive hormone levels in Shenxian sows. Thirty first-parity pregnant Shenxian sows with similar health status and body condition were randomly divided into three groups, with five replicates per group and two sows per replicate. The experimental period spanned from the start of pregnancy through the end of lactation. Groups 1, 2, and 3 were fed diets containing 10% (31.58%), 12% (31.96%), and 14% (32.65%) crude fiber (neutral detergent fiber) during pregnancy, respectively, while all groups received the same diet during lactation. The results showed: (1) The litter size and number of piglets born alive in groups 2 and 3 were extremely significantly higher than in group 1 ($P<0.01$). The stillbirth rate in group 2 was significantly lower than in group 1 ($P<0.05$). Group 2 exhibited extremely significantly higher litter weight at birth, individual birth weight, litter weight at weaning, and individual weaning weight compared to groups 1 and 3 ($P<0.01$). Group 3 showed extremely significantly higher litter weaning weight ($P<0.01$) and significantly higher litter birth weight and individual weaning weight compared to group 1 ($P<0.05$). (2) Dietary fiber level had no significant effect on serum estradiol, progesterone, and prolactin levels on day 85 of pregnancy ($P>0.05$). On day 114 of pregnancy, serum progesterone and prolactin levels were significantly higher in groups 2 and 3 compared to group 1 ($P<0.05$), while serum estradiol levels did not differ significantly among groups ($P>0.05$). Based on comprehensive analysis of all indicators, the optimal dietary crude fiber (neutral detergent fiber) level for Shenxian sows during pregnancy was 12% (31.96%).

Keywords: dietary fiber level; Shenxian sows; reproductive performance; serum reproductive hormone levels

Introduction

Dietary fiber plays a crucial role in animal nutrition due to its unique physicochemical properties, including adsorption characteristics, fermentability, water-holding capacity, viscosity, and cation exchange capacity [1]. Recent studies both domestically and internationally have found that dietary fiber level influences reproductive performance in animals [2-3], making it a current research hotspot. Most research on dietary fiber effects on porcine reproductive performance has focused on lean-type pig breeds, with limited reports on local breeds, particularly on Shenxian pigs from Hebei Province. Shenxian pig is the only local pig breed in Hebei Province with a long history, characterized by high reproductive performance, roughage tolerance, and excellent meat quality [4], offering significant development potential. Therefore, this study used Shenxian sows to investigate the effects of dietary fiber level throughout pregnancy on reproductive performance and changes in serum reproductive hormone levels, aiming to explore the regulatory mechanisms of dietary fiber on sow reproductive performance and determine the optimal dietary fiber level for Shenxian sows during pregnancy, thereby providing theoretical basis for local pig production in China.

1.1 Experimental Animals and Grouping

Thirty healthy first-parity pregnant Shenxian sows with similar body condition and comparable breeding timing and expected delivery dates were selected and randomly divided into three groups using a single-factor completely randomized design. Each group comprised five replicates with two sows per replicate. The experimental period extended from the start of pregnancy through the end of lactation. Groups 1, 2, and 3 were fed experimental diets containing 10% (31.58%), 12% (31.96%), and 14% (32.65%) crude fiber (neutral detergent fiber) during pregnancy, respectively, while all groups received the same diet during lactation.

1.2 Experimental Diet Composition and Management

The experimental diets for pregnant and lactating sows were formulated according to the Chinese Meat-Type Pig Feeding Standards and Feed Composition Tables [5]. The composition and nutrient levels are presented in and . During the experiment, sow pens were kept clean with adequate ventilation, and sows were provided with winter warmth protection. Sows were fed twice daily: 1.60 kg/day during early pregnancy and 2.25 kg/day during late pregnancy, with free access to water and routine vaccination. Lactating sows were fed ad libitum, and piglets were weaned at 30 days of age. Manure was cleaned twice daily, and experimental sows were closely monitored with timely recording of behavioral states and health conditions.

1.3.1 Reproductive Performance Indicators

Litter size (LS), number born alive (NBA), number of stillbirths, stillbirth rate, litter weight at birth (LBW), and individual birth weight (BW) were recorded in detail within 12 hours after farrowing, with accurate weighing of each piglet. Total litter size included the sum of healthy, weak, stillborn, mummified, and malformed piglets. Stillbirth rate (%) was calculated as (number of stillbirths/total litter size) × 100. Litter weight at weaning (WAA) and individual weaning weight (WW) were recorded and measured accurately when piglets were weaned at 30 days of age.

1.3.2 Serum Reproductive Hormone Level Determination

On days 85 and 114 of pregnancy, five sows were randomly selected from each group for blood collection. Five milliliters of blood was drawn from the jugular vein into capped centrifuge tubes, centrifuged at 3,000 r/min for 10 minutes, and the serum was separated and stored at -20°C for determination of estradiol, progesterone, and prolactin levels. Enzyme-linked immunosorbent assay (ELISA) kits from Shanghai Enzyme-Linked Biotechnology Co., Ltd. were used according to the manufacturer' s instructions.

1.4 Data Processing

Data were first organized using Excel 2013 and then subjected to one-way ANOVA using SPSS 17.0 statistical software, with multiple comparisons performed using the LSD method. Results are expressed as mean ± standard deviation.

2.1 Effects of Dietary Fiber Level during Pregnancy on Reproductive Performance of Shenxian Sows

The effects of dietary fiber level during pregnancy on reproductive performance are shown in . When dietary crude fiber (neutral detergent fiber) levels were 12% (31.96%) and 14% (32.65%), litter size and number of piglets born alive were extremely significantly higher than at 10% (31.58%) ($P<0.01$), increasing by 41.67% and 37.50%, respectively. The stillbirth rate of sows fed 12% crude fiber (neutral detergent fiber) was 41.42% lower than that of the 10% group ($P<0.05$). No significant differences were observed in litter size, number born alive, or stillbirth rate between the 12% and 14% fiber groups ($P>0.05$), and dietary fiber level had no significant effect on the number of stillbirths ($P>0.05$).

Sows fed 12% crude fiber (neutral detergent fiber) during pregnancy produced piglets with the highest litter birth weight and individual birth weight at 9.73 kg and 0.98 kg, respectively, which were extremely significantly higher than those in both the 10% and 14% groups ($P<0.01$). The 14% group showed significantly higher litter birth weight compared to the 10% group ($P<0.05$),

while no significant difference was observed in individual birth weight between the 14% and 10% groups (P>0.05).

The 12% crude fiber (neutral detergent fiber) group also achieved the highest litter weaning weight and individual weaning weight at 52.47 kg and 5.27 kg, respectively, which were extremely significantly higher than those in both the 10% and 14% groups (P<0.01). The 14% group exhibited extremely significantly higher litter weaning weight (P<0.01) and significantly higher individual weaning weight compared to the 10% group (P<0.05).

3.3 Effects of Dietary Fiber Level during Pregnancy on Serum Reproductive Hormone Levels of Shenxian Sows

As shown in , dietary fiber level during pregnancy had no significant effect on serum estradiol, progesterone, or prolactin levels on day 85 of pregnancy (P>0.05).

3.1 Effects of Dietary Fiber Level during Pregnancy on Reproductive Performance

Research findings on the effects of dietary fiber level on sow reproductive performance have been inconsistent. Several studies have reported that dietary fiber level affects reproductive performance [6-8]. Veum et al. [7] found that adding 13.35% ground wheat straw as a fiber source to corn-soybean meal diets during gestation significantly improved litter size and extremely significantly increased litter birth weight and weaning weight across three successive reproductive cycles. Feng [3] demonstrated that appropriate dietary fiber levels improved reproductive performance, with the best results observed when first-parity sows were fed diets containing 10.8% neutral detergent fiber, showing optimal litter size, number born alive, and piglet weights on day 22 of lactation. Zhang et al. [9] reported that increasing dietary crude fiber level during pregnancy extremely significantly improved litter size and significantly increased litter weaning weight at day 28, with optimal effects at 9% crude fiber, though higher levels reduced reproductive performance. Conversely, Renteria-Flores et al. [10] found that increasing insoluble fiber levels in gilt diets significantly reduced embryo survival rates, while increasing both soluble and insoluble fiber in multiparous sow diets had no significant effect on litter size but significantly increased lactation feed intake and extremely significantly reduced lactation weight loss. Shan et al. [11] observed that increasing dietary crude fiber levels from 4% to 8% during pregnancy resulted in corresponding decreases in litter size and number of healthy piglets.

The present study indicates that appropriate dietary crude fiber levels significantly improved reproductive performance, including litter size, number born alive, litter birth weight, individual birth weight, litter weaning weight, and individual weaning weight, consistent with reports by Feng [3] and Zhang et al. [9]. However, the optimal dietary crude fiber (neutral detergent fiber) level of 12%

(31.96%) for Shenxian sows during pregnancy differs from previously reported optimal levels, possibly due to variations in sow breed, parity, diet composition, and fiber type.

3.2 Effects of Dietary Fiber Level during Pregnancy on Serum Reproductive Hormone Levels

Previous studies have reported that dietary fiber level influences blood reproductive hormone levels, with estradiol, progesterone, and prolactin having significant effects on reproductive performance. Yang et al. [12] found that varying dietary crude fiber levels (4.14%, 5.27%, and 6.06%) during early pregnancy had no significant effect on serum estradiol and progesterone levels in multiparous sows. Huang et al. [13] reported that sows fed 9% dietary fiber showed significantly higher mRNA expression of progesterone and prolactin receptors compared to those fed 3%, 5%, 7%, and 11% fiber, with the 9% group exhibiting the best reproductive performance. Feng [3] found that dietary fiber level did not affect plasma estradiol and progesterone levels in first-parity sows, though levels were significantly lower in groups fed 15.8% and 20.8% crude fiber compared to 10.5%.

The present study shows that dietary fiber level did not affect serum estradiol, progesterone, or prolactin levels in early pregnancy (day 85) but significantly increased serum progesterone and prolactin levels in late pregnancy (day 114). First-parity Shenxian sows fed 12% (31.96%) and 14% (32.65%) crude fiber (neutral detergent fiber) during pregnancy had significantly higher serum progesterone and prolactin levels in late pregnancy compared to those fed 10% (31.58%), while serum estradiol levels did not differ significantly among groups. These results partially differ from previous reports, possibly due to variations in sow breed, parity, dietary fiber level, and fiber source.

Conclusions

Under the conditions of this experiment:

1. Dietary fiber level during pregnancy affected reproductive performance in first-parity Shenxian sows. The 12% (31.96%) crude fiber (neutral detergent fiber) group exhibited extremely significantly higher litter size and number born alive compared to the 10% (31.58%) group, and extremely significantly higher litter birth weight, individual birth weight, litter weaning weight, and individual weaning weight compared to both the 10% and 14% groups.
2. Dietary fiber level during pregnancy significantly affected serum progesterone and prolactin levels in late pregnancy, with the 12% (31.96%) and 14% (32.65%) groups showing significantly higher levels than the 10% (31.58%) group.

3. Based on comprehensive evaluation of all indicators, the optimal dietary crude fiber (neutral detergent fiber) level for first-parity Shenxian sows during pregnancy is recommended to be 12% (31.96%).

References

[1] ARRIGONI E, CAPREZ A, AMADÒ R, et al. Chemical composition and physical properties of modified dietary fibre sources[J]. Food Hydrocolloids, 1986, 1(1): 57-64.
[2] CHE L, FEND D, WU D, et al. Effect of dietary fibre on reproductive performance of sows during the first two parities[J]. Reproduction in Domestic Animals, 2011, 46(6): 1061-1066.
[3] 冯冬冬. 日粮纤维水平对妊娠母猪繁殖性能的影响 [D]. 硕士学位论文. 雅安: 四川农业大学, 2010: 29-31.
[4] 胡英新, 褚素乔, 芦春莲, 等. 深县猪种质特性研究 [J]. 畜牧与兽医, 2015, 47(7): 58-60.
[5] 熊本海, 张宏福. 国内外畜禽饲养标准与饲料成分表 [M]. 北京: 中国农业科学技术出版社, 2010: 15-17.
[6] REESE D E. Dietary fiber in sow gestation diets reviewed[J]. Feedstuffs, 1997, 23(6): 1-15.
[7] VEUM T L, CRENSHAW J D, CRENSHAW T D, et al. The addition of ground wheat straw as a fiber source in the gestation diet of sows and the effect on sow and litter performance for three successive parities[J]. Journal of Animal Science, 2009, 87(3): 1003-1012.
[8] HOLT J P, JOHNSTON L J, BAIDOO S K, et al. Effects of a high-fiber diet and frequent feeding on behavior, reproductive performance, and nutrient digestibility in gestating sows[J]. Journal of Animal Science, 2006, 84(4): 946-955.
[9] 张虎, 黄大鹏, 李姝超, 等. 日粮粗纤维水平对妊娠母猪繁殖性能的影响 [J]. 黑龙江八一农垦大学学报, 2012, 24(1): 35-38.
[10] RENTERIA-FLORES J A, JOHNSTON L J, SHURSON G C, et al. Effect of soluble and insoluble dietary fiber embryo survival performance[J]. Journal of Animal Science, 2008, 86(10): 2576-2584.
[11] 单妹, 凌宝明, 蓝天, 等. 妊娠期饲粮不同粗纤维水平对母猪生产性能的影响 [J]. 养猪, 2015(2): 35-37.
[12] 杨玉芬, 葛德军, 王长康. 饲粮纤维水平对妊娠母猪粪便指标、血清激素和生化指标的影响 [J]. 动物营养学报, 2010, 22(6): 1529-1535.
[13] 黄大棚, 张虎, 李传锋. 纤维水平对母猪繁殖性能及生殖激素受体 mRNA 表达量影响 [J]. 中国畜牧杂志, 2015, 51(3): 47-50.

Note: Figure translations are in progress. See original paper for figures.