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Effects of Different Dietary Crude Fiber Levels on the Growth Performance of Finishing Su-Shan Pigs

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***Abstract*—**The utilization of dietary crude fiber in different breed pigs is not the same. Su-shan pigs are a new breed formed by crossing Taihu pigs and Yorkshire pigs. In order to understand the resistance of Su-shan pigs to dietary crude fiber, 150 Su-shan pigs with 60 kg of average body weight and similar body conditions were allocated to three groups randomly, and there are 50 pigs in each group. The percentages of dietary crude fiber were 8.35%, 9.10%, and 11.39%, respectively. At the end of the experiment, 15 pigs randomly selected from each group were slaughtered. The results showed as follows: average daily gain of the 9.10% group was higher than that of the 8.35% group and the 11.39% group; there was a significant difference between the 9.10% group and the 8.35% group ($p < 0.05$. Levels of urea nitrogen, total cholesterol and high density lipoprotein in the 9.10% group were significantly higher than those in the 8.35% group and the 11.39% group ($p < 0.05$). Ratios of meat to fat in the 9.10% group and the 11.39% group were significantly higher than that in the 8.35% group ($p < 0.05$). Lean percentage of 9.10% group was higher than that of 8.35% group and 11.39% group, but there was no significant difference in three groups ($p > 0.05$). The weight of small intestine and large intestine in the 11.39% group was higher than that in the 8.35% group, and the 9.10% group and the difference reached a significant level ($p < 0.05$). In conclusion, increasing dietary crude fiber properly could reduce fat percentage, and improve the ratio of meat to fat of finishing Su-shan pigs. The digestion and metabolism of dietary crude fiber promoted the development of stomach and intestine of finishing Su-shan pig.

***Keywords*—**Su-Shan pigs, dietary crude fiber, growth performance, serum biochemical indexes.

I. Introduction

CRUDE fiber is a relatively economical feed resource and has a special role in the nutrition and health of pigs. Dietary crude fiber is mainly lignin, cellulose and hemicellulose in the plant cell wall. Dietary crude fiber is fermented by a large number of microorganisms in the cecum and colon, and is decomposed into available volatile fatty acids such as acetic acid, propionic acid and butyric acid [1]. Excessively high levels of dietary crude fiber will reduce energy digestibility and decrease the digestibility of dry matter, crude protein, crude fat and starch [2], [3]. Different breed pigs have different degrees of tolerance and utilization to dietary crude fiber. Su-shan pigs are a new breed formed by crossing Taihu pigs and Yorkshire pigs. In production, Su-shan pigs are more resistant to dietary crude fiber than Yorkshire pigs [4]-[7].

In this study, through up-regulation and down-regulation of dietary crude fiber levels, we investigated growth performance, serum biochemical indicators, slaughter performance and internal organ weight, and we analyzed the effects of dietary crude fiber on the growth and metabolism of finishing Su-shan pigs. These results will provide theoretical basis and reference for the rational utilization of dietary crude fiber to improve the performance of finishing Su-shan pigs.

II. Materials and Methods

A. Animals

150 Su-Shan pigs, with 60.0±2.0 kg of average body weight and similar body conditions, were selected and randomly assigned to three groups (A, B and C), and there were 50 pigs in each group. The percentage of dietary crude fiber in each group was 8.35%, 9.10%, and 11.39% respectively. At the end of experiment, each pig was weighed again, and blood was collected. 15 pigs in each group were randomly selected and slaughtered.

B. Experimental Diet

According to "Chinese Feed Composition and Nutritional Values" (2013), NRC (1998) and "Chinese Feeding Standards for Pigs" (2004) [6]-[8], three different percentages of dietary crude fiber were prepared. Nutritional levels were shown in Table I.

C. Feeding Management

Experimental pigs were raised in the same pig house. Immunization, cleaning, and disinfection work were carried out according to the routine procedures of the farm. The temperature in pig house was controlled at 25~28 °C. The relative humidity was 65%~70%. Experimental pigs were fed three times every day. The feeding time was about 6:00, 12:00, and 18:00. Experimental pigs ate and drank water freely. The feeding and management conditions of three groups were the same.

D. Serum Biochemical Indexes

At the end of experiment, blood was collected from the experimental pigs' anterior vena cava, placed in a 10 mL centrifuge tube, and allowed to stand for 30 min at low temperature. After centrifuging at 3000 r/min for 15 min at 4 °C, the serum was dispensed at -20 °C. Serum glucose (GLU), urea nitrogen (UN), triglyceride (TG), total cholesterol (CHOL), high density lipoprotein (HDL) and low density

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lipoprotein (LDL) content were tested by automatic Hitachi 7180 biochemical analyzer.

TABLE I
COMPOSITION AND NUTRIENT LEVELS OF DIETS

Items	A	B	C
Corn (%)	53.00	51.50	50.00
Soybean meal (%)	9.00	9.00	9.00
Wheat bran (%)	26.00	22.00	17.50
Peanut bran (%)	9.50	15.00	21.00
$CaHPO_4$ (%)	0.50	0.50	0.50
Limestone (%)	0.50	0.50	0.50
NaCl (%)	0.50	0.50	0.50
Premix① (%)	1.00	1.00	1.00
Total (%)	100.00	100.00	100.00
Nutrient levels②			
DM (%)	87.98	86.90	87.96
Ash (%)	5.48	5.36	5.88
CP (%)	14.38	13.42	13.93
EE (%)	3.48	3.48	3.50
CF (%)	8.35	9.10	11.39
DE /(MJ/kg)	16.77	16.77	16.61
Ca (%)	0.54	0.54	0.54
P (%)	0.47	0.47	0.47

① Premix of per kg diet: Fe 100 mg, Zn 100 mg, Mn 30 mg, Cu 10mg, Se 0.3 mg, I 0.5 mg, VA 8000IU, VD 31000IU, VE 20IU, VK 3.0 mg, VB1 2.0 mg, VB2 6.0 mg, VB6 3.0 mg, VB12 30μ g, nicotinic acid 30 mg, pantothenic acid 30 mg, folic acid 1.0 mg. Biotin 0.2 mg, choline 300 mg.
② The digestive energy is the calculated value, and the other is the measured value.

E. Slaughter Performance

On the last day of experiment, 15 pigs were randomly selected from each group. Pigs were stopped feeding 24 h before slaughter. The live weight before slaughter of each pig was measured. Left half carcass was used to measure slaughter index. Stomach, small intestine, large intestine and cecum were weighed.

F. Statistical Analysis

All results were expressed as mean ± SEM. One-way analysis of variance was performed using ANOVA procedure in SPSS 16.0, and multiple comparisons were performed using LSD method. The difference was significant at P<0.05, and the difference was extremely significant at P<0.01.

III. RESULT

As shown in Table II, three groups of pigs had no significant difference in initial body weight. At the end of experiment, average daily weight gain in group B was the highest. Average daily weight gain in group C was the lowest. The difference between group B and group C was significant (P<0.05). The difference between group B and group A was not significant (P>0.05), and there was no significant difference between the C group and the A group (P>0.05).

A. Effects of Dietary Crude Fiber on Serum Biochemical Indexes of Finishing Su-Shan Pigs

As shown in Table III, the serum levels of GLU, UN, total CHOL, HDL, and LDL in group B are higher than those in group A and group C. There was significant difference in UN, total CHOL and HDL between group B and group C (P <0.05), and no significant difference between group B and group A (P> 0.05).

TABLE II
GROWTH PERFORMANCE OF FINISHING SU-SHAN PIGS

Items	A	B	C
Initial body weight (kg)	58.46±2.63	56.92±2.42	59.37±1.78
Finish body weight (kg)	89.50^{b}±8.70	92.08^{a}±8.87	88.58^{ab}±6.38
Average daily gain (g)	378.55$^{a\,b}$±46.87	428.86^{a}±95.29	356.30^{b}±72.43

Note: In the same row, values with no same letter superscripts mean significant difference, and with the same letter superscripts mean no significant difference. Values with different small letter superscripts mean significant difference ($P < 0.05$), and with different capital letter superscripts mean significant difference ($P<0.01$).

TABLE III
SERUM BIOCHEMICAL INDEXES OF FINISHING SU-SHAN PIGS (UNIT: MMOL/L)

Items	A	B	C
Glucose	3.96±0.83	4.24±0.64	4.01±0.53
Urea nitrogen	3.91^{ab}±0.57	4.17^{a}±0.48	3.05^{b}±0.43
Triglyceride	0.21±0.15	0.25±0.12	0.21±0.16
Total cholesterol	1.43^{ab}±0.32	1.57^{a}±0.26	1.32^{b}±0.22
High-density lipoprotein	0.70^{ab}±0.17	0.76^{a}±0.16	0.63^{b}±0.10
Low-density lipoprotein	0.65±0.10	0.75±0.15	0.69±0.17

B. Effects of Dietary Crude Fiber on Carcass Performance of Finishing Su-Shan Pigs

From Table IV, it can be seen that skin percentage and bone percentage showed an upward trend with the increase of dietary crude fiber. Carcass weight, slaughter rate, and ratio of meat to fat in group B were higher than those in group A and group C, and the difference of carcass weight reached significant levels (P<0.05). The ratio of meat to fat in group B and C was significantly higher than that in group A (P<0.05). Average fatback thickness in group B was lower than that in group A and C, and the difference was not significant (P>0.05).

TABLE IV
SLAUGHTER PERFORMANCE OF FINISHING SU-SHAN PIGS

Items	A	B	C
Live weight (kg)	89.75±8.70	96.07±8.87	89.83±6.38
Carcass weight (kg)	61.96^{b}±4.33	67.12^{a}±4.37	61.51^{b}±2.83
Slaughter rate (%)	69.04±1.34	69.92±2.02	68.48±0.69
Average fatback thickness (cm)	2.33±0.57	2.31±0.43	2.33±0.44
Lean percentage (%)	61.46±3.55	63.30±2.50	60.81±3.39
Skin percentage (%)	8.60^{b}±0.86	9.71^{b}±2.30	10.66^{a}±1.64
Bone percentage (%)	12.35±1.11	12.73±1.10	13.07±1.10
Fat percentage (%)	15.67^{a}±2.45	12.74^{b}±1.47	13.02^{b}±2.41
Ratio of meat to fat	3.83^{b}±0.88	5.02^{a}±0.54	4.53^{a}±1.23

C. Effects of Dietary Crude Fiber on the Weight of Digestive Organs in Finishing Su-Shan Pigs

As shown in Table V, the weight of stomach, small intestine, and large intestine increased with the increase of dietary crude fiber. The weight of small intestine and large intestine in group C was higher than that in group A and B, and the difference reached a significant level (P<0.05). The weight of small intestine in group B was lower than that in group A and C, and

the difference reached a significant level (P<0.05). With the increase of dietary crude fiber, the cecum weight showed a downward trend, but the difference in three groups did not reach a significant level (P> 0.05).

TABLE V
THE WEIGHT OF DIGESTIVE ORGANS IN FINISHING SU-SHAN PIGS (UNIT: KG)

Items	A	B	C
stomach	0.68±0.04	0.7±0.07	0.74±0.06
Small intestine	2.03^{b}±0.19	1.81^{c}±0.11	2.16^{a}±0.17
Large intestine	1.56^{b}±0.18	1.62^{b}±0.14	1.94^{a}±0.15
Cecum	0.24±0.05	0.22±0.02	0.23±0.02

IV. DISCUSSION

A. Effects of Dietary Crude Fiber on Growth Performance of Finishing Su-Shan Pig

Pigs utilize dietary crude fiber mainly through the fermentation and decomposition of microorganisms in large intestine to form volatile fatty acids (VFAs), some of which are absorbed by the intestinal wall and provide energy for pig growth [8], [9]. Numerous studies have shown that different breed pigs showed significant differences in the utilization of dietary crude fiber, and the resistance to dietary crude fiber in Chinese local pigs is significantly better than that in Yorkshire and Duroc pigs. Meixun et al. found that the intestinal flora of Duroc pigs obviously could not adapt to high crude fiber diets [10]. Cheng et al. found that the cellulose digestibility of Laiwu pigs was higher than that of Yorkshire pigs [11]. Rongqian et al. found that when the crude fiber level in the Huai pig diet increased, the average daily weigh gain decreased obviously [12]. Our results showed that when dietary crude fiber increased, the average daily weight gain increased first and then decreased. The above results indicated that the appropriate dietary crude fiber could improve the growth performance of finishing Su-shan pigs.

B. Effects of Dietary Crude Fiber on Blood Biochemical Indexes of Finishing Su-Shan Pigs

There was a significant correlation between blood GLU and fat deposition [13]. HDL reverses the transport of CHOL, reduces the deposition of lipids in the blood vessel walls, lowers the CHOL levels in plasma and blood vessel walls, and promotes the recycling or metabolism of CHOL. Johansen et al. found that cellulose could reduce blood GLU [14], while Serena et al. found that adding crude fiber within a certain range had no significant effect on GLU in serum [15]. Dietary crude fiber could bind to bile acids, and lower CHOL and malabsorption of lipids and CHOL [16]. UN was a product of protein metabolism, and could indirectly reflect feed conversion rates [17]. Holecek's research suggested that higher level of serum UN was associated with decreased protein utilization in animals [18]. Our results were consistent with those reports. Moderate dietary crude fiber could increase serum levels of GLU, UN, total CHOL, HDL and LDL. Appropriately increasing dietary crude fiber could promote the absorption and utilization of dietary crude protein in finishing Su-shan pigs.

C. Effects of Dietary Crude Fiber on Slaughter Performance of Finishing Su-Shan Pig

Slaughter rate is an important measure of animal performance and slaughter performance. Some studies have shown that adding sugar beet slag to diets could increase crude fiber levels and increase pig lean percentage [19], [20], and dietary crude fiber significantly reduced pig fatback thickness [21], [22]. Our studies showed that the increase of dietary crude fiber did not significantly reduce the slaughter performance of Su-shan pigs. Appropriate increase in dietary crude fiber could increase lean percentage, but the difference was not significant. These results indicated that increasing dietary crude fiber was beneficial to increase lean percentage and fat percentage of finishing Su-shan pigs.

D. Effects of Dietary Crude Fiber on Development of Digestive Organs in Finishing Su-Shan Pig

Internal organs are the basis of animal life activities. The weight of internal organs can be used as an approximate indicator of animal function [23]. The degree of development of animal digestive organs directly affects feed intake and digestion [24]. Hongquan et al. studied the effects of increased dietary fiber content on the development of digestive organs, and found that high-fiber diets significantly stimulated the development of stomach, liver, gastric, large intestine and small intestine [25]. Our studies indicated that when the level of dietary crude fiber increased, the weight of intestine and stomach increased. Our results indicated that digestion and metabolism of dietary crude fiber promoted the development of stomach and intestine of finishing Su-shan pig.

V. CONCLUSION

Dietary crude fiber could reduce blood lipid levels, and promote the absorption and utilization of crude protein in finishing Su-shan pigs. Moderate dietary crude fiber increased lean percentage, reduced fatback thickness, and affected the development of stomach and intestine of finishing Su-shan pigs.

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