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Use of low-protein diets for growing pigs to reduce fecal nitrogen excretion

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The increasing risks of environmental pollution by nitrogen of pig farms wastewater compel researchers to explore the possibility to reduce protein level in diets for growing-finishing pigs. The objective of this work was to evaluate the effect of low-protein diets balanced by the bioavailable essential amino acids, on the growth rate, efficiency of nutrient utilization and nitrogen excretion with urine and feces in growing-finishing pigs. The experiment was performed on three groups of Landras × Large White piglets, 12 piglets each, and included two periods, growing and fattening. Piglets in group I (control) were fed the complete feed with following levels of components: for growing period: crude protein and metabolizable energy - 172 g, 12.56 MJ and limiting amino acids, g/kg feed: lysine - 7.7 (true available for absorption in the intestine - 5 88), threonine - 4.83 (- 3.75), methionine 4.73 (- 3.82), and in the fattening period - 153 g, 12.34 MJ, 5.75 (- 5,08), 4.5, (- 3.49), 3.06, (- 2.47) g/kg respectively. In group II, the crude protein level was reduced to 151 g/kg in growing period and to 142 g/kg in fattening periods, and in group III - to 134 and 130 g/kg respectively. The content of true available lysine, methionine and threonine in the diets of groups II and III in both periods was adjusted to respective values in the control group by the addition of synthetic amino acids. The live weight gain during the finishing period in I and II groups was approximately the same (40.62 and 40.28 kg, 752 and 746 g, respectively); in group III it was by 6.2% less than in control group. The efficiency of using feed nitrogen in group II was higher by 6% compared with group I. Nitrogen excretion in II and III groups was reduced by 24.4 and 33.8% in urine and by 20.7 и 36.0% in feces respectively. The results of this study indicate that reducing the level of crude protein in the diet for growing-finishing pigs with the addition of synthetic essential amino acids, reduces the flow of nitrogen into the environment with urine and feces, without adversely affecting productive performance.

Key words: Environmental pollution by nitrogen; Growing-finishing pigs; Nitrogen of pig excreta; Low-protein diets; Supplements of essential amino acids

Introduction

The increasing risks of environmental pollution by nitrogen released from pig industry runoff compel researchers to explore the possibility to reduce protein level in diets for growing-finishing pigs. Studies on the scientific substantiation of the animal's requirements in essential amino acids are important for the development of pork production technologies that reduce environmental pollution with nitrogen excreted by the animals in the urine and feces (Kendall et al., 1999; Zervas & Zijlstra, 2000; Figueroa et al., 2002; Otto et al., 2003; Ryadchikov, 2006; Niyazov & Kal'nitskii, 2014). To ensure high productivity, animals require diets with a balanced composition of essential amino acids. On the other hand, it is impossible to reduce the quantity of "superfluous" amino acids entering the body beyond the need for maintaining the basic metabolism and growth, if the requirements of pigs in essential amino acids, including those assessed for their true availability for absorption in small intestine, are not known (Otto et al., 2003; Fastinger & Mahan, 2006; Stein et al., 2007). The aim of this work is to evaluate the effect of low-protein diets balanced by the bioavailable essential amino acids, on the rate of growth, efficiency of nutrient utilization and nitrogen excretion with urine and feces in growing-finishing pigs.

Material and Methods

After the equalizing period, 36 crossbreed pigs (Landrace × Large White) were randomly divided into three groups, by 12 animals each. The experiment included two periods - growing and finishing. Animals of group I (control) received complete feed with levels of components in growing period: crude protein (CP) and metabolizable energy (ME) - 172 g, 12.56 MJ and limiting amino acids, g/kg feed: lysine - 7.7 (true available for absorption in the intestine - 5 88), threonine - 4.83 (- 3.75), methionine - 4.73 (- 3.82), and in finishing period - 153 g, 12.34 MJ, 5.75 (- 5.08), 4.5, (- 3.49), 3.06, (- 2.47) g/kg, respectively. In group II, the crude protein level was reduced to 151 g/kg in growing and to 142 g/kg in finishing periods, and in group III - to 134 and 130 g/kg, respectively. The content of lysine, threonine and methionine in the diets of groups II and III in both periods was the same as in the control group, due to the addition of synthetic amino acids. In the course of the experiment, we controlled the consumption of feed, its chemical composition and consumption per unit of growth. Pigs weighing were performed at the beginning of the experiment and at the end of each age period. To determine the assimilation of feed nitrogen and the effectiveness of its use, balance trial was carried out at the end of the growing period on three animals from each group. To characterize the metabolism of nitrogenous substances, the concentration of urea and creatinine; activity of aspartate aminotransferase, alanine aminotransferase, creatine kinase, alkaline phosphatase were determined in the blood plasma. The analysis of feed for the content of dry matter, crude protein, total amino

acids, fat, crude fiber was carried out according to standard methods. Nitrogen content in urine and feces was determined according to Kjeldahl, on Kjeltek device.

Results and Discussion

The data obtained on piglets fed diets with different levels of protein and essential amino acids, suggests that changes in the quantitative and qualitative amino acid composition of mixed feed had an ambiguous impact on the growth of animals and feed conversion. The animals of the control group that received standard complete feed, at the end of growing period had the best values of live weight and daily live weight gains (LWG) (Table 1). In pigs of group II, in which the level of crude protein in feed was reduced to 151 g/kg and synthetic amino acids have been added, there was no significant decrease in average daily LWG, and animals of this group consumed less crude protein (by 50.8 g) per kg of LWG compared to control, which is a positive factor in this experiment.

Table 1. Live weight, average daily LWG, consumption of feed and crude protein in two periods of experience (M ± m, n = 12).

Indicators	Group		
	I (control)	II	III
Growing period			
Crude protein, g	172	151	142
Live weight at the beginning of the period, kg	16.83 ± 0.85	16.71 ± 0.87	16.73 ± 0.83
Live weight at the end of the period, kg	39.22 ± 3.21	38.29 ± 1.94	37.63 ± 1.35
Live weight gain, kg	22.41 ± 2.32	21.58 ± 1.38	20.90 ± 0.90*
Daily live weight gain, g	487.1 ± 50.8	469 ± 30	454 ± 19*
Consumed per 1 kg of LWG: feed, kg	3.37	3.50	3.61
crude protein, g	577.8	527.6	482.9
Fattening period			
Crude protein, g/kg	153	134	130
Live weight at the beginning of the period, kg	38.5 ± 4.46	37.89+2.57	37.81 ± 1.78
Live weight at the end of the period, kg	79.12 ± 7.49	78.17 ± 5.34	76.06 ± 2.84
Live weight gain, kg	40.62 ± 4.17	40.28 ± 3.12	38.25 ± 1.71
Daily live weight gain, g	752 ± 70	746 ± 56	708 ± 31*
Consumed per 1 kg of LWG: feed, kg	3.74	3.77	3.97
crude protein, g	568	534	516

Note: Here and in Table 2: *P<0.05 for the *t*-test vs control.

The decrease in the level of crude protein to 130 g/kg of feed (group III) with the addition of synthetic essential amino acids to the level of control group negatively affected the increase in LWG compared with control. In the studies of other authors (Ryadchikov, 2007), it has been noted that a decrease in the protein level in the feed by 3.8 abs.% causes an imbalance of essential and non-essential amino acids, which adversely affects the productivity of animals (Ryadchikov, 2007).

LWG and average LWG for the fattening period in the I and II groups were approximately the same (40.62 and 40.28 kg, 752 and 746 g, respectively), in the III group these indicators were 6.2% less (P<0.05) compared with the control group. Feed consumption per unit of LWG in group III was also higher compared with I and II groups. In animals of II and III groups, a decrease in the consumption of crude protein (g/kg LWG) was observed compared to control (by 6.3 and 10.1%, respectively).

The data obtained in the balance experiment confirm (Table 2) that a decrease in the level of crude protein with the addition of synthetic essential amino acids is an effective method of reducing nitrogen excretion. This decrease in nitrogen excretion with urine against the control group was 24.4% (P<0.05) in group II and 33.8% (P<0.05) in group III, i.e. these groups excreted nitrogen by 3-4 g/day less compared with control. Piglets of these groups were also excreted with feces less - by 20.7 and 26.0% (P <0.05) compared to control group. Animals of the II group more effectively used nitrogen feed t=in comparison with the animals of control group in terms of consumed (by 6.2%) and digested nitrogen (by 6.0%).

Table 2. The use of feed nitrogen during growing period, g/day (M ± m, n=3).

Indicators	Groups		
	I (control)	II	III
Consumed nitrogen with feed	43.49±0.09	38.24 ± 0.07	33.80 ± 0.06
Excreted with feces	10.52 ± 0.20	8.34 ± 0.36	7.78 ± 0.07*
with urine	12.25 ± 0.08	9.27 ± 0.46*	8.11 ± 0.23*
Digested:	32.97 ± 0.14	29.90 ± 0.17	26.02 ± 0.03
in %	75.81 ± 0.89	78.19 ± 0.38	76.98 ± 0.17
Deposited in the body:	20.72 ± 0.16	20.63 ± 0.61	17.91 ± 0.25
in % of consumed	47.64 ± 0.37	53.95 ± 1.96	52.99 ± 0.81
in % of digested	62.84 ± 0.27	68.99 ± 1.71	68.83 ± 0.90

The increase in the digestibility of feed protein by piglets in group II, apparently, is due to the optimal content of true available essential amino acids in the feed. At the same time, the piglets of the control group excreted the largest quantity of nitrogen with urine, since they consumed more nitrogen in the feed, and an excessive amount of non-limiting amino acids absorbed in the intestine. In pigs of I and II groups the deposition of nitrogen was almost the same, despite the difference in the percent of nitrogen digested and excreted with urine. The reason for this, apparently, was the optimal supply of amino acids and energy in piglets of group II, while in the control group there was some excess of non-essential amino acids and energy.

Our experimental data are consistent with studies (Tuitoek et al., 1997; Liu et al., 1999), in which the decrease in the concentration of crude protein by 2-3% vs norm with the supplements of essential synthetic amino acids did not reduce the average daily LWG in pigs. On the other hand, in those papers (Kendall et al 1999; Zervas & Zijlstra, 2000), in which the concentration of crude protein in

the diet was reduced by more than 3%, a decrease in LWG, digestibility and nitrogen deposition in the body was indicated, despite the supplement of synthetic essential amino acids.
The decrease in the content of crude protein in the diet of pigs in group III from 172 to 134 g with the addition of synthetic amino acids in the same amount as in group II, provided a significant decrease in the total excretion of nitrogen with feces and urine ($P<0.05$) on the background of a 10% reduction in nitrogen deposition in this group.
In other study (Otto et al., 2003), a decrease in the level of crude protein in the diet reduced the total loss of nitrogen, mainly due to its fecal excretion, on the background of slight decrease in nitrogen deposition in the body. However, this decrease in nitrogen deposition was not associated with a decrease in digestibility of non-limiting amino acids in the small intestine.
The coefficients of the apparent digestibility of lysine, threonine and methionine in the II and III groups were higher by 6-14% compared with control group (Table 3). This can be explained by the fact that synthetic analogs of these amino acids, the availability of which is about 100%, have been added to the diets of these groups. There were no significant inter-group differences on the coefficients of apparent digestibility of non-essential amino acids. The data on the apparent digestibility of total amino acids is generally consistent with the digestibility of nitrogen and crude protein in growing pigs (Gomez et al., 2002).
The decrease in the concentration of crude protein in the diet of pigs of group III from 172 to 142 g with the addition of synthetic amino acids in the same amount as in group II, provided a significant decrease in the total excretion of nitrogen with feces and urine ($P<0.05$) and 10% decrease in nitrogen deposition in the body of pigs of this group.
The effectiveness of the use of amino acids in biosynthetic processes can be indirectly judged by changes in the concentration of urea in the blood plasma. The urea level in the pigs of I, II, and III group was 5.21 ± 0.49, 5.04 ± 0.43, and 5.67 ± 0.04 mM respectively (n=12). A lower concentration of urea in the blood plasma in group II, compared with group III, may be associated with more efficient use of amino acids for protein biosynthesis.
Because the low-protein diets in this experiment were balanced for essential amino acids, macro - and microelements and vitamins, significant intergroup differences were not revealed in total protein concentration, albumin, creatinine, activity of creatinine kinase, AST, ALT, and alkaline phosphatase in blood plasma, and these parameters were within the physiological norm.

Table 3. The apparent digestibility of total amino acids at the end of growing period, %, (M ± m, n=3).

Amino acids	Groups		
	I (control)	II	III
Lysine	73.63 ± 0.54	79.38 ± 1.01**	80.09 ± 0.31***
Threonine	70.30 ± 3.22	77.02 ± 1.41	77.31 ± 0.20
Methionine	70.89 ± 1.41	84.89 ± 0.84	86.24 ± 0.27

Note: **P<0.01; ***P<0.001 for the *t*-test vs control.

The study of the composition of carcasses at slaughter at different periods of growth of pigs did not reveal significant differences in the morphological composition of carcasses between the control and experimental groups. However, in pigs of group II, during the periods of growing and fattening, the slaughter yield was slightly higher, the relative content of fat was lower and the amount of pulp in the carcass was higher compared with control group. Consequently, a reduction of the protein level in the diets for growing-finishing pigs does not adversely affect the quality of the meat provided it is balanced by the limiting amino acids absorbed in small intestine.

Conclusion

To reduce the excretion of nitrogen in growing-finishing pigs, the low-protein diets can be used with increased level of limiting amino acids lysine, threonine, methionine, taking into account the true availability of these amino acids for absorption in small intestine. The decrease in protein level in the diet for Landras × Large White pigs to 151 g/kg of feed during the growing and up to 142 g/kg of feed during the finishing period with supplements of synthetic essential amino acids provides the decrease in nitrogen excretion with urine by 24.4-33.8% and by 20.7-26.0% with feces, does not adversely affect the increase in body weight gain and reduces the consumption of crude protein per unit of live weight gain. The results of this study indicate that reducing the level of crude protein in the diet for growing-finishing pigs with the addition of synthetic essential amino acids, reduces the flow of nitrogen into the environment with urine and feces, without adversely affecting productive performance indicators.

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