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RESEARCH ARTICLE

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The effect of immune stress on ideal amino acid pattern for piglets

Abstract Two nitrogen-balance experiments were conducted to determine the optimum balance pattern among four amino acids (lysine, methionine, tryptophan and threonine) on a digestible basis in the diet of piglets (10 kg) treated with lipopolysaccharide or saline as control. The method of amino acid deletion was adopted. All pigs were of a single genetic background and geographical origin. In each group, fifteen Landrance × Rongchang castrated piglets were allotted randomly to one of five groups of dietary amino acid regimens. The positive control group was supplemented with four amino acids. One of the four amino acids was reduced by about 25% in the respective treatment groups. After finishing the nitrogen-balance experiments, the slaughter technique was used to determine the ideal amino acid digestibility of the positive control by using chromium oxide (3 g/kg) as the indicator. The results showed that the ideal amino acid pattern of lysine/methionine/threonine/tryptopham on the digestible basis was 100:27:29:59 for 10 kg pigs under immune stress, and 100:30:21:61 for piglets under normal conditions.

Keywords ideal amino acid pattern, immunologic stress, piglets, lipopolysaccharide

1 Introduction

It is widely accepted that animals under intensive feeding often suffer immune stress. Under this circumstance, nutrients available for growth under normal conditions would be utilized for immune system metabolism instead. In the stressed state, the rates of basic metabolism, liver acute-phase proteins and antibody synthesis, and gluconeogenesis from amino acids and lymphocytes increase, but the rates of muscle protein retention decrease (Klasing et al., 1987; Fong et al., 1898; Waterlow, 1991; Singh and Pachauri, 2002). There are differences in the amino acid composition between constitutive and protective proteins and liver acute-phase and skeletal muscle proteins (Reeds et al., 1994), which means that such metabolic changes could play an important role in the requirements of amino acid pattern for piglets under the control of immunologic stress. Thus, the objective of this study was to compare the ideal amino acid pattern between control and immunologic stress group in piglets in order to provide a theoretical basis for promoting growth performance.

2 Materials and methods

2.1 Diets

The composition of the digestible amino acid (DAA)-based diets is shown in Table 1. The diets were isonitrogenous and contained the same level of digestible energy (DE) (14.23 MJ/kg). They were formulated according to the results of Williams et al. (1997a, b) and the feeding standards for meat-type pig in China. In brief, the basic amino acid pattern was based on the amino acid requirements in the Nutrient Requirements of Swine (NRC) (1998) for 5–10 kg piglets. The ratio of apparent DAA to lysine was close to the level of the NRC (1998) recommendation in the positive control group diet. One of four amino acids (lysine, methionine, tryptophan and threonine) was reduced by about 25% in the respective treatment groups (PC-Lys, PC-Met, PC-Try and PC-Thr).

2.2 Animals and experimental design

Thirty healthy Landrance × Rongchang castrated piglets (9.03 ± 0.63 kg) were used in this study. All pigs were of a single genetic background and geographical origin and were divided into two treatments (normal vs. stressed) according to Wang et al. (2001). Piglets in the stress treatment were distributed randomly to one of the five groups of dietary amino acid regimens: one for each replicate with three replicates in each

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Table 1 Composition of diets (%)

Ingredient	PC (Positive control)	PC-Lys	PC-Met	PC-Trp	PC-Thr
Corn	65.18	65.40	65.25	65.22	65.33
Soybean meal	10.13	10.13	10.13	10.13	10.13
Extruded soybean	4.58	4.58	4.58	4.58	4.58
Fish meal	1.50	1.50	1.50	1.50	1.50
Whey meal	8.00	8.00	8.00	8.00	8.00
Feather meal	1.57	1.57	1.57	1.57	1.57
Soy oil	2.43	2.43	2.43	2.43	2.43
Vitamin premix	0.05	0.05	0.05	0.05	0.05
Enzymepremix	0.05	0.05	0.05	0.05	0.05
Acidifier	0.30	0.30	0.30	0.30	0.30
Choline chloride	0.15	0.15	0.15	0.15	0.15
Mineral premix	0.30	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30	0.30
$NaHCO_3$	0.50	0.50	0.50	0.50	0.50
$CaCO_3$	0.77	0.77	0.77	0.77	0.77
$CaHPO_4$	0.995	0.995	0.995	0.995	0.995
Glu	2.00	2.00	2.00	2.00	2.00
Cys	0.07	0.07	0.07	0.07	0.07
Ile	0.111	0.111	0.111	0.111	0.111
L-Lys-HCl	0.57	0.25	0.57	0.57	0.25
DL-Met	0.07	0.07	0	0.07	0.07
L-Trp	0.05	0.05	0.05	0.01	0.05
Thr	0.17	0.17	0.17	0.17	0.02
L-His-HCl	0.04	0.04	0.04	0.04	0.04
Val	0.11	0.11	0.11	0.11	0.11

group. The amino acid deletion method described by Wang and Fuller (1989, 1990) was used in this study, including the nitrogen balance and digestion experiment. One day before and on the second, fourth and sixth days of the experiment, lipopolysaccharide (LPS) saline solution (200 g/kg BW) was injected into the stress group, while sterile saline was injected into the control group. All feces and urine were collected during the whole period of the test. Ileal apparent amino acid digestibility was measured by slaughtering and sampling chyme in the distal ileum.

2.3 Management

Piglets were fed a weaning diet (supplied by Zhengda Company) after weaning. All the piglets were divided into several groups according to body weight after the weaning period and fed with the respective test diets for three days. All the pigs were housed in individual metabolic cages in a room maintained at 20–23°C, and were allowed free access to feed and water.

2.4 Calculations and statistical analysis

Nitrogen intake and retention, apparent nitrogen digestibility and biovalue, and ileal apparent amino acid digestibility were calculated. Results were presented as means ± SEM. Levels of significance were set at $P < 0.05$. The data were subjected to the *t* test (SPSS 10.0), and were multi-compared among groups by Duncan method.

3 Results

3.1 Amino acid digestibility

The ileal apparent digestibilities of lysine, methionine, tryptophan and threonine in the diets were 73.28%, 73.83%, 74.29% and 59.51% respectively in the immunologic stress group with chromium oxide as the indicator. The corresponding values were 73.64%, 73.83%, 65.98% and 56.51% respectively in the positive control group.

3.2 Utilization of dietary nitrogen

Nitrogen intake and retention (both expressed as per kg $W^{0.75}$), apparent fecal nitrogen digestibility and biovalue are shown in Table 2.

3.3 Amino acid pattern

Intakes of digestible amino acid (DAA) and nitrogen retention (NR) per kg $W^{0.75}$ calculated according to the parameters from Table 2 are shown in Table 3. Following the method described by Wang and Fuller (1989, 1990), the patterns among digestible lysine (Dlys), methionine (Dmet), tryptophan (Dtrp) and threonine (Dthr) were estimated and are listed in Table 4.

4 Discussion

The balances of digestible Lys, Met, Trp and Thr under normal conditions were 100, 30, 21 and 61 respectively in Landrance × Rongchang castrated piglets weighing 10 kg. However, the contents of dietary cysteine and the ileal apparent cysteine digestibility were not measured in this study. On the assumption of the proper ratio of dietary Met to Cys (50:50), the balance of Dlys, Dmet, Dtrp and Dthr can be substituted by Lys (100), Met + Cys (60), Trp (21) and Thr (61). The results in this study were similar to those in the previous studies (Wang and Fuller, 1989; Chung and Baker, 1992; Zhang et al., 2000).

As shown in Table 4, the ratio of Dmet (27:30) and Dthr (59:61) was a bit lower than that in the control group. Hou et al. (2000) suggested that the pattern for Lys, Met and Thr should be 100:30:52 to achieve the optimal status of the immune system. Since the index for dietary NR was different from the one used in the previous study, data were different in this study. Thus, nutrient requirements estimated for high growth performance and the nutrient utilization efficiency are different from those needed to achieve the optimal immune status.

As the compositions of amino acids are different between muscle proteins and acute-phase proteins, under the control of immunologic stress, most amino acids released from muscle proteins are available for acute-phase protein

Table 2 Dietary nitrogen utilization

Group		N intake (g/kg$^{0.75}$/day)	N retention (g/kg$^{0.75}$/day)	N digestibility (%)	BV of N (%)
Challenged					
PC	3	2.506 ± 0.258^{bc}	1.331 ± 0.135^{c}	0.712 ± 0.047^{a}	0.746 ± 0.036^{ab}
PC-Lys	3	2.133 ± 0.187^{bc}	1.200 ± 0.080^{cd}	0.754 ± 0.016^{a}	0.746 ± 0.057^{ab}
PC-Met	3	2.167 ± 0.091^{bc}	1.233 ± 0.045^{cd}	0.797 ± 0.058^{a}	0.714 ± 0.049^{ab}
PC-Trp	3	1.773 ± 0.147^{c}	0.798 ± 0.131^{d}	0.748 ± 0.048^{a}	0.592 ± 0.025^{b}
PC-Thr	2	2.217 ± 0.046^{bc}	1.197 ± 0.165^{cd}	0.769 ± 0.091^{a}	0.702 ± 0.013^{ab}
Normal					
PC	3	3.309 ± 0.281^{a}	2.030 ± 0.153^{a}	0.742 ± 0.041^{a}	0.827 ± 0.019^{a}
PC-Lys	3	2.854 ± 0.070^{ab}	1.782 ± 0.107^{ab}	0.783 ± 0.010^{a}	0.796 ± 0.025^{a}
PC-Met	3	2.426 ± 0.328^{bc}	1.289 ± 0.050^{c}	0.727 ± 0.022^{a}	0.731 ± 0.081^{ab}
PC-Trp	3	2.505 ± 0.219^{bc}	1.322 ± 0.101^{c}	0.706 ± 0.072^{a}	0.748 ± 0.049^{ab}
PC-Thr	3	2.730 ± 0.098^{ab}	1.526 ± 0.258^{bc}	0.763 ± 0.059^{a}	0.733 ± 0.052^{ab}

Note: Different capital ($P < 0.01$) and small letters ($P < 0.05$) within a column denote significant differences, while the same letters denote no significant differences ($P > 0.05$).

Table 3 Intake of DAA and NR per W$^{0.75}$ per day

Group	DAA intake					Relative to positive control				
	NR	Lys	Met	Trp	Thr	NR	Lys	Met	Trp	Thr
Challenged										
PC	1.331	725	200	174	415	1	1	1	1	1
PC-Lys	1.200	494	172	150	356	0.902	0.681	0.859	0.859	0.859
PC-Met	1.233	642	132	154	368	0.908	0.886	0.661	0.886	0.886
PC-Trp	0.798	515	142	65	295	0.600	0.711	0.711	0.374	0.711
PC-Thr	1.197	631	174	152	289	0.899	0.871	0.871	0.871	0.696
Normal										
PC	2.028	961	244	204	517	1	1	1	1	1
PC-Lys	1.782	664	213	178	449	0.879	0.691	0.870	0.870	0.870
PC-Met	1.289	704	133	149	378	0.636	0.732	0.546	0.732	0.732
PC-Trp	1.322	731	186	82	393	0.652	0.760	0.760	0.399	0.760
PC-Thr	1.526	781	198	166	335	0.753	0.812	0.812	0.812	0.649

Note: NR and DAA represent N retention (g) per kg W$^{0.75}$ per day and DAAs intake (mg/ W$^{0.75}$/day) respectively.

Table 4 Balance of Dlys, Dmet, Dtrp and Dthr

Condition	Lys	Met	Trp	Thr
Normal	100	30	21	61
Challenged	100	27	29	59

synthesis, and cannot be incorporated into muscle proteins. Under the circumstances of infection and injury, acute-phase protein synthesis is considered to be an important pathway for amino acid utilization (Colley et al., 1983; Kushner et al., 1982). Waterlow (1991) reported that during the catabolic fastigium, the rate of acute-phase protein synthesis was 1.2 g/kg·day^{-1} (30% of total protein synthesis in healthy humans) in response to infection. When cattle were under stress conditions, plasma globulin level was 12 times higher than that in the control group, while the content of plasma albumin was markedly decreased (Williams et al., 1997a). Since there are differences in amino acid composition between muscle proteins and acute-phase proteins, the requirement of Phe and Trp for muscle protein synthesis exceeded that for acute-phase protein synthesis (Williams et al., 1997b) during the stress period. As a result, these two amino acids could be considered as the endogenous first and second limiting amino acid. According to the calculation by Reeds (Williams et al., 1997b), the content of Phe in 850 mg acute-phase protein equaled that contained in 1980 mg muscle protein. If there is no supply of extrinsic Phe, excessive amino acids are degraded, which in turn increase nitrogen excretion, so the ratio relative to Lys is increased. This condition is applicable to Trp when Phe and Tyr meet the requirements of acute-phase protein synthesis. In this study, the proportion of Phe + Tyr relative to Lys was higher than the recommended values in the NRC (1998). This study suggests that Trp could possibly be the first limiting amino acid, which might be the reason why the balance of Dtrp in the stress group is higher than that under normal conditions.

5 Conclusion

Immunologic stress could have an effect on the patterns of certain amino acids in piglets. The ideal amino acid pattern of Lys:Met:Thr:Trp on a digestible basis was 100:27:29:59 for 10 kg Landrance × Rongchang castrated piglets under LPS-induced immunologic stress, and 100:30:21:61 for piglets under normal conditions.

References

Chung T K, Baker D H (1992). Maximal portion of the young pig's sulfur amino acid requirement that can be furnished by cystine. J Anim Sci, 70: 1182–1187

Colley C M, Fleck A W, Muller B R, Myers M A (1983). Early time course of acute-phase protein response in man. J Clin Path, 36: 203–207

Fong Y, Moldawer L L, Lowry F (1989). Cachectin/TNF or IL-1 induces cachexia with redistribution of body proteins. Am J Physiol, 256(3): R659–R665

Hou Y Q, Huo Y M, Zhou M P (2000). The relationship between protein, amino acid nutrition and immune system of animal. Feed Industry, 21(8): 5–7 (in Chinese)

Klasing K C, Laurin D E, Peng R K, Fry D M (1987). Immunologically mediated growth depression in chicks: Influence of feed intake, corticosterone and interleukin-1. J Nutr, 117: 1629–1637

Kushner I (1982). The phenomenon of the acute phase response. Ann N Y Acad Sci, 389: 39–48

NRC (1998). Nutrient Requirements of Swine. 10th ed. Washington, DC: National Academy Press

Reeds P J, Fjeld C R, Jahoor F (1994). Do the differences between the amino acid compositions of acute-phase and muscle proteins have a bearing on nitrogen loss in traumatic states? J Nutr, 124: 906–910

Singh S V, Pachauri S P (2002). Acute phase proteins in bovine mastitis. Indian J Anim Sci, 72(1): 20–22

Wang J M, Chen D W, Zhang K Y (2001). Ideal amino acid patterns for growing and finishing pigs. Acta Veterinaria et Zootechnica Sinica, 32(3): 202–205 (in Chinese)

Wang T C, Fuller M F (1989). The optimum dietary amino acid pattern for growing pigs 1. Experiments by amino acid deletion. Br J Nutr, 62: 77–89

Wang T C, Fuller M F (1990). The effect of the plane of nutrition on the optimum dietary amino acid pattern for growing pigs. Anim Prod, 50: 155–164

Waterlow J C (1991). Protein-energy malnutrition: challenges and controversies. Proc Nutr Soc India, 37: 59–86

Williams N H, Stahly T S, Zimmerman D R (1997a). Effect of chronic immune system activation on body nitrogen retention, partial efficiency of lysine utilization, and lysine needs of pigs. J Anim Sci, 75: 2472–2480

Williams N H, Stahly T S, Zimmerman D R (1997b). Effect of chronic system activation on the rate, efficiency, and composition of growth and lysine needs of pigs fed from 6 to 27 kg. J Anim Sci, 75: 2463–2471

Zhang K Y, Chen D W, Luo X M (2000). The effect of ideal amino acid patterns on the nitrogen utilization of growing pigs. Acta Veterinaria et Zootechnica Sinica, 31(6): 576–578 (in Chinese)