Effects of glutamine on growth performance of weanling piglets

X.T. Zou, G.H. Zheng, X.J. Fang, J.F. Jiang

Feed Science Institute, Zhejiang University, Hangzhou, China

ABSTRACT: An experiment was conducted to investigate the effects of glutamine on growth performance of weanling piglets. Sixty piglets weaned at 21 days of age were randomly assigned to two groups (10 piglets per pen, 3 pens per group). The control group received a maize-soybean meal-based diet. The treatment group received a maize-soybean meal-based diet supplemented with 1.0% free L-glutamine. Piglets were fed the diets for 20 days. Results showed that piglets fed the glutamine diet had lower diarrhoea ratio and shorter diarrhoea duration than those fed the control diet during 20 days after weaning. During the first ten days after weaning, pigs supplemented with glutamine had a 12.05% lower feed:gain ratio than those fed the control diet ($P < 0.05$). During the second ten days after weaning, they had a 27.75% higher average daily gain than those fed the control diet ($P < 0.05$); there were no differences in the feed:gain ratio and average daily feed intake. During the first ten days after weaning, the serum urea nitrogen of pigs supplemented with glutamine was reduced by 17.36% ($P > 0.05$) compared to the control. During the second ten days after weaning, serum urea nitrogen was reduced by 4.27% and serum concentrations of total protein increased by 18.70% in pigs supplemented with glutamine compared to the control ($P > 0.05$). There were no differences in albumin, T_3, T_4 and growth hormone.

Keywords: weaning piglets; glutamine; growth performance; biochemical parameters

L-glutamine is a protein amino acid found in proteins of all life forms. It is classified as a semi-essential or conditionally essential amino acid. This means that under normal circumstances the body can synthesize sufficient L-glutamine to meet physiological demands. However, there are conditions when the body cannot do so. Recently, L-glutamine has come to be regarded as one of the most important amino acids when the body is subjected to such metabolic stress situations as trauma (including surgical trauma), cancer, sepsis and burns. Under such conditions, L-glutamine becomes an essential amino acid, and it is therefore very important to ensure adequate intakes of the amino acid in order to meet the increased physiological demands created by these situations (Bowtell and Bruce, 2002).

Research (Elia and Peter, 1997) indicated that under the stress of gastrointestinal disorders supplementation of glutamine had improved intestinal functions in man. The small intestinal mucosa atrophy caused by early weaning is the most frequent reason that depresses piglets' growth performance (Hampson, 1986). This study investigates the effects of glutamine on weanling piglets to find a good additive to improve growth performance of weanling piglets.

MATERIAL AND METHODS

Experimental animals and sample collection

Sixty Duroc-Landrace-Yorkshire piglets weaned at 21 days of age (30 barrows and 30 gilts) of similar initial body weight (about 5 kg) were randomly allotted to two treatments. Each treatment consisted of 3 replications with 5 barrows and 5 gilts per replication. The treatments received the same basal diet (Table 1) and supplemented with 0, 1.0% free L-glutamine provided by Xinrui Biotech Co., Ltd.,

Supported by National Natural Science Foundation of China (Project No. 30471260).

Table 1. Ingredients and composition of experimental diet

Ingredients	Composition	Nutrient levels	
Corn	55.7	DE/(MJ/kg)	14.02
Extruded soybean (%)	12.0	CP	19.54
Bean oil (%)	2.0	Lys	1.21
Soybean meal (%)	18.3	Met + cys	0.62
Fish meal (%)	4.0	Ca	0.82
Whey powder (%)	4.0	P	0.45
Premix[1]	4.0		

[1]the premix was provided by the Feed Institute of Zhejiang University

Hangzhou, China. The piglets were given *ad libitum* access to diet and water during the experiment. The experiment lasted for 20 days. Feed intake was recorded daily and each piglet was weighed every 10 days to determine average daily gain, average daily feed intake and feed/gain ratio. The piglets were examined for diarrhoea every morning. The diarrhoea ratio was determined as the number of diarrheic piglets/total number of piglets × 100%. All procedures were approved by the Institutional Animal Care and Use Committee of Zhejiang University.

Blood samples of two piglets (one barrow and one gilt) randomly selected from each replication were taken via the vena cava puncture at 0, 10, 20 days after weaning, respectively. The piglets were fasted for 24 h with *ad libitum* access to water. Blood samples were centrifuged for 15 min (3 000 × g), the serum separated from blood was packed in Eppendorf centrifuge tubes, and then kept at –70°C until analysis.

Analysis of serum biochemical parameters and hormone analysis

The concentrations of serum urea nitrogen, total protein, albumin and enzymatic activity of alkaline phosphatase were analysed on an ERBA CHEM-5 semi-automated bio-chemistry analyzer (Tranasasia Biochemical LTd., Mumbai, India). The assay kits were provided by Ningbo Cicheng Biochemistry Reagent Factory.

Thyroxine and growth hormone were analysed by the method of radioimmunoassay on a Packard Cobra Gamma Counter (GMI, Inc. Minnesota, USA). The assay kits of thyroxine and growth hormone were provided by Beijing North Institute of Biological Technology.

Statistical analysis

All the data were analyzed by ANOVA using the GLM procedure of SAS (Version 6.13).

RESULTS

Effects of glutamine on diarrhoea of weanling piglets

Figure 1 shows changes in the diarrhoea ratio of piglets in the control and treated groups from 5 to 18 days after weaning. Both groups had a higher diarrhoea ratio during 7–9 days after weaning, while the diarrhoea ratio in the two groups dropped significantly from the 10th day after weaning. Diarrhoea nearly disappeared till day 12 after weaning. During the whole experiment the control group had a higher diarrhoea ratio and longer diarrhoea duration than the group supplemented with glutamine. The piglets in the control group maintained a 50%–60% diarrhoea ratio during 8–11 days after weaning and there was still a 20–30% diarrhoea ratio during 12–15 days after weaning in the control group.

Effects of glutamine on growth performance of weanling piglets

From day 1 to 10 after weaning, the feed:gain ratio decreased by 12.05% ($P < 0.05$) in the treated group compared with the control group. There were no significant differences in average daily gain and average daily feed intake between the two groups, but there was a trend of improving the average

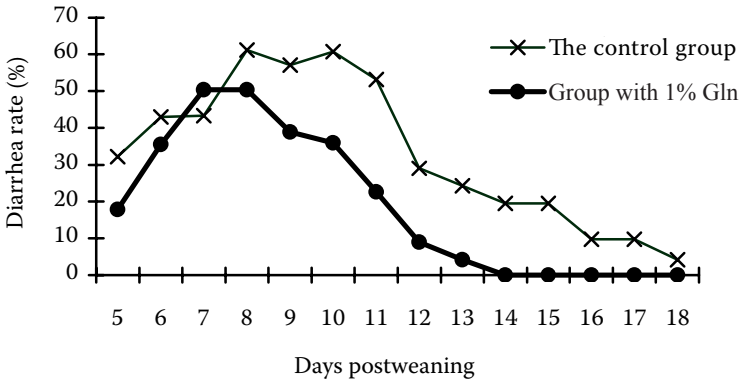

Figure 1. Effects of glutamine on the diarrhoea ratio of weanling piglets

daily gain in the group with 1% glutamine. During 11–20 days after weaning there was a significant difference in the average daily gain between the two groups, and the average daily gain increased by 27.75% ($P < 0.05$) in the group with 1% glutamine; glutamine supplementation had no significant effects on the average daily feed intake and feed:gain ratio (Table 2).

Effects of glutamine on biochemical parameters in serum of weanling piglets

Glutamine supplementation had a trend of decreasing serum urea nitrogen in piglets. Compared with the control group the concentration of BUN in the treated group decreased by 17.36% ($P > 0.05$) and 4.26% ($P > 0.05$) at day 10 and day 20 after weaning, respectively. The serum total protein concentration in the treated group increased by 18.70% ($P > 0.05$). The serum albumin concentration was not influenced significantly by weaning stress (Table 3).

Effects of glutamine on hormone concentration in serum of weanling piglets

Glutamine supplementation had no significant effects on the concentration of T_3 and T_4, but it increased the concentration of growth hormone. Compared with the control group, the concentration of growth hormone in the treated group increased by 12.18% ($P > 0.05$) and 14.93% ($P > 0.05$) at day 10 and day 20 after weaning, respectively (Table 4).

DISCUSSION

Effects of glutamine on growth performance of weanling piglets

Hampson (1986) reported that diarrhoea and the small intestinal mucosa atrophy caused by early weaning stress were the main reasons for a decrease in growth performance in piglets. The causes of piglets' diarrhoea are as follows: 1. Piglets' intestine directly absorbs vegetal protein from the diet, which causes hypersusceptibility of the intestinal lymphatic tissue and consequently induces the intestinal mucosa oedema. 2. Piglets do not have a good adaptability to the change from milk to solid diet, then physical damage to the intestine occurs. 3. Infection by pathogenic bacteria or rotavirus. Diarrhoea accelerates the apoptosis of intestinal mucosal cells. If the proliferation of intestinal mucosal cells cannot maintain the rebirth of intestinal mucosa efficiently, the intestinal mucosa will be atrophied, thus the growth of piglets will be de-

Table 2. Effects of glutamine on the growth performance of weanling piglets

Item	10 days after weaning		20 days after weaning	
	control	1.0% Gln	control	1.0% Gln
Average daily feed intake (kg)	0.110 ± 0.005[1]	0.103 ± 0.004	0.307 ± 0.002	0.346 ± 0.020
Average daily gain (kg)	0.0218 ± 0.001	0.0230 ± 0.007	0.173 ± 0.017[a]	0.221 ± 0.016[b]
Feed : gain	4.93 ± 0.120[a]	4.40 ± 0.210[b]	1.55 ± 0.230	1.54 ± 0.150

[a,b]different superscripts with a main effect indicate a significant difference ($P < 0.05$)
[1]treatment Mean ± SD

Table 3. Effects of glutamine on biochemical parameters in the serum of weanling piglets

Item	Before weaning	10 days after weaning		20 days after weaning	
		control	1.0% Gln	control	1.0% Gln
BUN (mmol/l)	5.59 ± 0.84[1]	8.93 ± 1.84	7.38 ± 1.08	7.27 ± 0.68	6.96 ± 0.58
Total protein (g/l)	50.28 ± 4.67[a]	42.34 ± 3.27[ab]	40.87 ± 3.83[ab]	33.64 ± 2.44[b]	39.93 ± 1.84[ab]
Albumin (g/l)	27.36 ± 2.62	28.20 ± 3.13	25.14 ± 2.27	28.22 ± 4.56	29.22 ± 1.24
Alkaline phosphatase (IU/l)	143.04 ± 23.34[a]	73.09 ± 6.86[bc]	58.34 ± 7.39[b]	111.80 ± 14.66[a]	108.94 ± 15.79[ac]

[a–c]different superscripts with a main effect indicate a significant difference ($P < 0.05$)
[1]treatment Mean ± SD

Table 4. Effects of glutamine on hormone concentrations in the serum of weanling piglets

Item	Before weaning	10 days after weaning		20 days after weaning	
		control	1.0% Gln	control	1.0% Gln
T_3 (ng/ml)	0.64 ± 0.05[a1]	0.73 ± 0.02[b]	0.70 ± 0.02[ab]	0.81 ± 0.01[c]	0.83 ± 0.02[c]
T_4 (ng/ml)	55.16 ± 1.54[ab]	51.02 ± 1.11[a]	53.47 ± 1.19[a]	57.07 ± 2.64[b]	59.39 ± 1.41[b]
GH (ng/ml)	2.69 ± 1.01[bc]	1.56 ± 0.14[a]	1.75 ± 0.31[ab]	2.21 ± 0.15[abc]	2.54 ± 0.26[c]

[a–c]different superscripts with a main effect indicate a significant difference ($P < 0.05$)
[1]treatment Mean ± SD

pressed. This experiment showed that in the group with glutamine the diarrhoea ratio was reduced, duration of diarrhoea was also shortened and the diarrhoea ratio dropped significantly since day 9 after weaning, which indicated glutamine had the function of accelerating the recovery of piglet's intestinal mucosa from weaning stress.

Glutamine supplementation improved average daily feed intake and average daily gain to some extent during 10 days after weaning. The feed:gain ratio decreased significantly during 10 days after weaning, which may be caused by the fact that glutamine reduced the damage to piglets' intestine by weaning stress and protected the digestive and absorbable function of the intestine. Average daily gain of piglets significantly increased by adding 1% glutamine during 20 days after weaning. Liu and Pen (1999) demonstrated that 1% glutamine supplementation improved average daily gain during 2 weeks after weaning in piglets weaned at 28 days of age.

Possible reasons for glutamine improvement of the growth performance of weanling piglets are as follows: 1. Glutamine is the major energy source for the small intestinal epithelial cells and lymphocytes which proliferate rapidly (Krebs, 1980). On the other hand, glutamine is also the maximum amino acid utilized by the intestine (Windmueller and Spaeth, 1980), which maintains many metabolic processes depending on ATP. 2. Glutamine is a necessary precursor for the macromolecular synthesis of e.g. DNA and protein (Ardawi and Newsholme, 1983), therefore it is very important for the proliferation of small intestinal epithelial cells and recovery of damaged intestinal mucosa (Peng et al., 2004). 3. As a metabolite of glutamine, arginine fulfils an important function as the precursor for NO synthesis, and NO plays an important role in regulating the secretion of the intestine and maintaining its integrity.

Effects of glutamine on biochemical parameters in serum of weaning piglets

Malmolf (1988) and Holecek (2002) reported that the serum BUN concentration was related with the status of protein metabolism and balance of amino acids in the animal. The serum BUN concentration decreases when amino acids are well balanced. This research indicated that weaning stress increased the concentration of serum BUN, glutamine supplementation decreased the serum BUN concentration to some extent. This reason may be that during the period of weaning the feed intake of piglets declined, the functions of digestion and absorption were restrained and piglets could not get enough nutrition, the ability of protein synthesis decreased, and then N losses occurred. Glutamine can synthesize many kinds of amino acids to accelerate protein synthesis through the process of deamination and transamination (Boza et al., 2001), therefore glutamine supplementation can decrease the serum BUN concentration to some

extent. The serum total protein concentration is a parameter that reflects the ability of liver to synthesize protein. This study showed that the serum total protein concentration decreased under weaning stress; this may be related to reduced nutrition intake and unbalanced status of amino acids after weaning. Glutamine supplementation had a trend of improving the serum total protein concentration. The serum albumin concentration is a critical parameter to measure the hepatic function and body's nutritional status. This experiment indicated that weaning stress did not reduce the serum albumin concentration of the control group. Glutamine supplementation did not have any significant effects on the serum albumin concentration. Alkaline phosphatase (AKP) is an enzyme that can catalyze many kinds of lecithoid compounds to release inorganic phosphorus, which is extensively present in animal tissues, exerting its important function in the formation of skeleton and fat. Results showed that the activity of alkaline phosphatase was high in piglets weaned at 21 days of age, however its activity decreased significantly at day 10 after weaning and increased significantly at day 20 after weaning, the mechanism for which needs to be further discussed.

Effects of glutamine on hormone concentration of weanling piglets

This research indicated that there was no significant change in serum T_3, T_4 concentrations during the experiment. The level of serum growth hormone at day 10 after weaning was significantly lower than before weaning, which indicated that the weaning stress restrained piglets to grow. Glutamine weakened the negative effects of weaning stress on the growth hormone secretion, and the growth hormone concentration increased significantly at day 20 after weaning, which indicated that glutamine supplementation improved the serum growth hormone concentration.

REFERENCES

Ardawi M.S.M., Newsholme E.A. (1983): Glutamine metabolism in lymphocytes of the rat. Biochem. J., *212*, 835–842.

Bowtell J.L., Bruce M. (2002): Glutamine: an anaplerotic precursor. Nutrition, *18*, 222–224.

Boza J.J., Turini M., Moennok D. (2001): Effect of glutamine supplementation of the diet on tissue protein synthesis rate of glucocorticoid-treated rats. Nutrition, *17*, 35–40.

Elia M., Peter G. (1997): The use of glutamine in the treatment of gastrointestinal disorders in man. Nutrition, *13*, 743–747.

Hampson D.J. (1986): Attempts to modify changes in the piglet small intestine after weaning. Res. Vet. Sci., *40*, 313–317.

Holecek M. (2002): Relation between glutamine, branched-chain amino acids, and protein metabolism. Nutrition, *18*, 130–133.

Krebs H. (1980): Glutamine metabolism in the animal body [A]. In: Glutamine: Metabolism, Enzymology and Regulation. New York, Academic Press, 319–329.

Liu T., Pen J. (1999): Effects of glutamine and glutamic acid on growing performance of weaning piglets. Acta Agric. Univ. Huangzhong. *18*, 457–460.

Malmolf K. (1988): Amino acid in farm animal nutrition metabolism, partition and consequences of imbalance. J. Agric. Res., *18*, 191–193.

Peng X., Hong Y., You Z.Y. (2004): Effects of enteral supplementation with glutamine granules on intestinal mucosal barrier function in severe burned patients. Burns, *30*, 135–139.

Windmueller H.G., Spaeth A.E. (1980): Respiratory fuels and nitrogen metabolism in vivo in small intestine of fed rats. J. Biol. Chem., *255*, 107–112.

Received: 2006–04–25
Accepted after corrections: 2006–06–21

Corresponding Author

X.T. Zou, Feed Science Institute, Zhejiang University, Qiaotao North Road 164, Hangzhou, Zhejiang, 310029, China
Tel. +86 0571 86994963, fax +86 0571 86091802, e-mail: xtzou@zju.edu.cn