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Effects of Different Dietary Levels of Glutamic Acid and Aspartic Acid on Organ Indices, Serum Biochemical Parameters, and Hormone Content in Piglets (Postprint)

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Abstract

This experiment aimed to investigate the effects of different dietary glutamic acid and aspartic acid levels on organ indices, serum biochemical indices, and hormone content in piglets. Forty-two healthy 35-day-old three-way cross (Duroc × Landrace × Large White) weaned piglets were selected and randomly allocated into 6 groups with 7 replicates per group and 1 pig per replicate. The control group (NC group) had dietary glutamic acid and aspartic acid levels of 2.9% and 1.5%, respectively, while the other groups were adjusted based on the NC group as follows: 2.9% and 1.3% (LA group), 2.9% and 1.7% (HA group), 2.6% and 1.5% (LG group), 3.2% and 1.5% (HG group), and 3.5% and 1.5% (HHG group). The experimental period lasted 21 days. At the end of the experiment, organ indices, serum biochemical indices, and hormone content in piglets were measured. The results showed: 1) Different dietary glutamic acid and aspartic acid levels had no significant effects on various organ indices in piglets ($P>0.05$). 2) Serum triglyceride content in the LA and NC groups was significantly lower than in the HA group ($P<0.05$), serum triglyceride content in the HG and HHG groups was significantly lower than in the LG group ($P<0.05$), serum albumin content in the LG group was significantly lower than in the NC and HG groups ($P<0.05$), and serum glucose content in the LG and HG groups was significantly lower than in the HHG group ($P<0.05$). 3) Serum gastrin content in the HA group was significantly lower than in the LA group ($P<0.05$), serum insulin content in the LG and HG groups was significantly higher than in the HHG group ($P<0.05$), serum glucagon content in the LG and HG groups was significantly lower than in the HHG group ($P<0.05$), and serum growth hormone content in the LG and NC groups was significantly lower than in the HHG group ($P<0.05$). In conclusion, different dietary glutamic acid and

aspartic acid levels affected serum biochemical indices and hormone content in piglets, but had no significant effect on organ development.

Full Text

Effects of Dietary Different Glutamate and Aspartate Levels on Organ Indexes, Serum Biochemical Parameters, and Hormone Contents in Piglets

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Abstract: This study investigated the effects of dietary glutamate (Glu) and aspartate (Asp) levels on organ indexes, serum biochemical parameters, and hormone contents in weaned piglets. Forty-two healthy crossbred (Duroc × Landrace × Yorkshire) piglets at 35 days of age were randomly allocated into six groups with seven replicates per group and one pig per replicate. The control group (NC) received a diet containing 2.9% Glu and 1.5% Asp. The other five groups were fed diets with modified Glu and Asp levels: 2.9% Glu + 1.3% Asp (LA group), 2.9% Glu + 1.7% Asp (HA group), 2.6% Glu + 1.5% Asp (LG group), 3.2% Glu + 1.5% Asp (HG group), and 3.5% Glu + 1.5% Asp (HHG group). The 21-day feeding trial concluded with measurements of organ indexes, serum biochemical parameters, and hormone concentrations.

The results demonstrated that dietary Glu and Asp levels did not significantly affect any organ indexes ($P > 0.05$). However, serum triglyceride (TG) content in the LA and NC groups was significantly lower than in the HA group ($P < 0.05$), while the HG and HHG groups showed significantly lower TG than the LG group ($P < 0.05$). Serum albumin (ALB) content in the LG group was significantly lower than in the NC and HG groups ($P < 0.05$), and serum glucose

(GLU) content in the LG and HG groups was significantly lower than in the HHG group ($P < 0.05$). Regarding hormones, serum gastric inhibitory polypeptide (GIP) content in the HA group was significantly lower than in the LA group ($P < 0.05$). The LG and HG groups exhibited significantly higher serum insulin (INS) content compared to the HHG group ($P < 0.05$), while showing significantly lower serum glucagon (GC) content ($P < 0.05$). Additionally, serum growth hormone (GH) content in the LG and NC groups was significantly lower than in the HHG group ($P < 0.05$). These findings indicate that dietary Glu and Asp levels influence serum biochemical parameters and hormone contents without significantly affecting organ development in piglets.

Keywords: acidic amino acids; glutamate; aspartate; piglets; organ indexes; serum biochemical parameters; hormone

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Glutamate (Glu) and aspartate (Asp) are acidic amino acids with isoelectric points below 7. Traditionally considered non-essential amino acids [1], they also function as excitatory neurotransmitters in the nervous system and are classified as excitatory amino acids [2]. Recent research has revealed their important roles as functional amino acids in the body [3-4]. As primary energy sources for tissues and organs, Glu and Asp can be converted into other nutrients through decarboxylation or transamination, producing glutamine, glutathione, citrulline, -ketoglutarate, and carbon dioxide. These metabolic pathways play crucial roles in improving tissue structure and function [5] and alleviating stress responses [3, 6].

Previous studies have demonstrated protective effects of these amino acids. Shi et al. [5] reported that adding 0.5% or 1.0% Asp to basal diets significantly mitigated LPS-induced reductions in average daily gain in piglets. Wu et al. [7] found that dietary supplementation with 2% Glu alleviated deoxynivalenol (DON)-induced decreases in average daily feed intake and significantly improved average daily gain while reducing feed-to-gain ratio in DON-challenged piglets. Duan [8] similarly showed that 1% Asp and 2% Glu supplementation significantly relieved stress-induced growth inhibition. Our previous research indicated that dietary Asp levels of 1.3%-1.5% and Glu levels of 2.6%-2.9% promoted growth and amino acid utilization in weaned piglets, whereas Glu levels of 3.2%-3.5% or Asp levels of 1.7% inhibited growth. Using Ussing chamber techniques, we also observed that high Glu or Asp concentrations inhibited the absorption of each other during transport [9], suggesting their functional importance. However, few studies have examined how different dietary Glu and Asp levels affect organ indexes, serum biochemical parameters, and hormone contents in healthy weaned piglets. Therefore, this experiment was conducted to explore these effects and provide scientific guidance for the rational use of Glu and Asp in piglet diets.

1.1 Experimental Design

Forty-two healthy crossbred (Duroc × Landrace × Yorkshire) weaned piglets at 35 days of age (half male and half female, body weight 13.24 ± 0.25 kg) were randomly divided into six groups with seven replicates per group, one pig per replicate, housed individually. The dietary treatments were designed with standardized ileal digestible Glu and Asp levels as follows: control group (NC) with 2.9% Glu and 1.5% Asp; low Asp group (LA) with 2.9% Glu and 1.3% Asp; high Asp group (HA) with 2.9% Glu and 1.7% Asp; low Glu group (LG) with 2.6% Glu and 1.5% Asp; high Glu group (HG) with 3.2% Glu and 1.5% Asp; and highly high Glu group (HHG) with 3.5% Glu and 1.5% Asp. The composition and nutrient levels of experimental diets are shown in Table 1 .

1.2 Feeding Management and Slaughter

The experiment was conducted at the animal housing facility of the Institute of Subtropical Agriculture, Chinese Academy of Sciences. The fully enclosed pig house featured slatted metal flooring, stainless steel adjustable feeders, and nipple drinkers. Piglets were housed individually and followed standard farm procedures for deworming and vaccination. They had ad libitum access to water and feed provided as powder. The facility used natural ventilation, maintained cleanliness, and underwent periodic disinfection throughout the trial. After the 21-day experimental period, six piglets were randomly selected from each group (totaling 42 piglets) and slaughtered after a 24-hour fast.

1.3.1 Organ Index Determination

On day 21, after a 24-hour fast, piglets were weighed to obtain pre-slaughter live weight before slaughter and dissection. The heart, liver, spleen, and kidneys were removed and weighed after surface moisture was blotted dry. Organ index was calculated using the formula: Organ index (%) = organ weight (g) / [live weight (kg) × 10].

1.3.2 Serum Biochemical Parameter Analysis

At the end of the feeding trial, 10 mL of fasting blood was collected from the anterior vena cava. Serum was separated by centrifugation at 3,000 rpm for 10 minutes at 4°C and stored at -20°C. Serum total protein (TP), albumin (ALB), urea nitrogen (UN), glucose (GLU), and triglyceride (TG) concentrations were measured using a CX4 automatic biochemical analyzer (Beckman, USA) following the kit protocols (Nanjing Jiancheng Bioengineering Institute).

1.3.3 Serum Hormone Content Determination

Serum insulin (INS), glucagon (GC), gastric inhibitory polypeptide (GIP), glucagon-like peptide-I (GLP-I), growth hormone (GH), and insulin-like growth factor-I (IGF-I) concentrations were determined by enzyme-linked

immunosorbent assay (ELISA) (Nanjing Hua Dong Electronic Group Medical Equipment Co., Ltd.) following the ELISA kit protocols (Nanjing Jiancheng Bioengineering Institute).

1.4 Statistical Analysis

All data were compiled using Excel 2010 and analyzed by one-way ANOVA using SPSS 18.0 software. Duncan' s multiple comparison test was used to assess significant differences. Results are expressed as means ± standard error, with $P < 0.05$ considered statistically significant.

2 Results

2.1 Effects of Dietary Glu and Asp Levels on Organ Indexes in Piglets

As shown in Table 2 , dietary Asp levels did not significantly affect heart, liver, spleen, or kidney indexes ($P > 0.05$). Similarly, Table 3 demonstrates that dietary Glu levels had no significant effects on these organ indexes ($P > 0.05$).

2.2 Effects of Dietary Glu and Asp Levels on Serum Biochemical Parameters in Piglets

Dietary Asp levels did not significantly affect serum TP, ALB, UN, or GLU concentrations ($P > 0.05$). However, serum TG content in the LA and NC groups was significantly lower than in the HA group ($P < 0.05$) (Table 4). Regarding Glu levels, dietary treatment did not significantly affect serum TP or UN concentrations ($P > 0.05$). The LG group showed significantly lower serum ALB content compared to the NC and HG groups ($P < 0.05$), while the LG and HG groups had significantly lower serum GLU content than the HHG group ($P < 0.05$). Additionally, the HG and HHG groups exhibited significantly lower serum TG content than the LG group ($P < 0.05$) (Table 5).

2.3 Effects of Dietary Glu and Asp Levels on Serum Hormone Contents in Piglets

Dietary Asp levels did not significantly affect serum INS, GC, GLP-I, GH, or IGF-I concentrations ($P > 0.05$), though the HA group showed significantly lower GIP content than the LA group ($P < 0.05$) (Table 6). For Glu levels, dietary treatment did not significantly affect GIP, GLP-I, or IGF-I concentrations ($P > 0.05$). However, the LG and HG groups displayed significantly higher serum INS content than the HHG group ($P < 0.05$), while showing the opposite trend for GC, with significantly lower concentrations compared to the HHG group ($P < 0.05$). The LG and NC groups also had significantly lower serum GH content than the HHG group ($P < 0.05$) (Table 7).

3 Discussion

3.1 Effects of Dietary Glu and Asp Levels on Organ Indexes in Piglets

Organ index, representing the relative weight of visceral organs, serves as an intuitive indicator of animal health status [10]. Chen [10] reported that 2% Glu supplementation in mold-contaminated diets provided significant organ protection, while Wu et al. [7] demonstrated protective and reparative effects of Glu on the liver, kidneys, pancreas, and spleen. In the current study, the lack of significant effects on organ indexes may be attributed to the piglets' age (35 days), as their visceral organs had already passed the peak developmental stage and were normally developed, making them less responsive to dietary modifications [11].

3.2 Effects of Dietary Glu and Asp Levels on Serum Biochemical Parameters in Piglets

Serum biochemical parameters reflect nutritional metabolism and physiological function, with serum ALB content directly indicating protein synthesis and metabolism [12-13]. Serum GLU typically remains stable under normal conditions but fluctuates during pathology or stress [14], while TG participates directly in cholesterol synthesis as a major blood lipid component [15]. Wu et al. [16] found that dietary glutamine supplementation at 306.64 mg/kg increased serum ALB in rats, and Wu et al. [7] showed that 2% Glu alleviated DON-induced serum GLU elevation. In our study, 1.7% Asp significantly reduced serum TG content, while 3.2% Glu significantly increased serum ALB and decreased both GLU and TG. However, our previous research indicated that 3.2% Glu or 1.7% Asp inhibited growth performance, possibly because these amino acids, as important energy substrates, were extensively oxidized to maintain intestinal health [17] without promoting body growth.

3.3 Effects of Dietary Glu and Asp Levels on Serum Hormone Contents in Piglets

Gastric inhibitory polypeptide (GIP) is a crucial satiety hormone released postprandially that enhances glucose-dependent INS synthesis and secretion while suppressing GC release, delaying gastric emptying and reducing gastrointestinal motility and acid secretion [18]. Our study observed decreased serum GIP with increasing dietary Asp levels, consistent with our previous findings showing parallel trends between growth performance and serum GIP content. Glu can act as a messenger to induce INS secretion [19], and Peng [11] reported that 1% Glu supplementation significantly increased serum GH. In this experiment, 3.5% Glu reduced serum INS while increasing GC and GH, aligning with Peng's [11] results and similar to Matsunaga et al. [20], suggesting that elevated dietary Glu promotes GH secretion while reducing serum GLU and INS concentrations.

4 Conclusion

Dietary Glu and Asp levels did not significantly affect organ indexes in piglets.

Dietary Asp at 1.7% significantly reduced serum TG content, while dietary Glu at 3.2% significantly increased serum ALB content and decreased serum GLU and TG contents.

Increasing dietary Asp level reduced serum GIP content, and dietary Glu at 3.5% decreased serum INS content while increasing serum GC and GH contents.

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