Effects of Addition of Amino Acids or Soybean Phospholipid in Diet on Slaughter Performance and Meat Quality of Pigs

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Abstract [**Objectives**] The study aims to discuss the effects of addition of arginine and glutamic acid or soybean phospholipid, vitamin E and yeast selenium in diet on the slaughter performance and meat quality of long (white) × large (York) binary hybrid pigs. [**Methods**] 27 long × large castrated hybrid boars with the body weight of (54.4 ± 0.15) kg were randomly divided into 3 groups, with 3 replicates per group and 3 pigs per replicate. Group A was the control group, in which the pigs were fed basal diet; in group B, 0.8% arginine and 0.60% glutamate were added to the basal diet; in group C, 75 g of soybean phospholipid, 20 g of vitamin E and 8 g of yeast selenium were added to every 100 kg of the basal diet. The trial period was 60 d. After the experiment was ended, one test pig with similar body weight was selected from each replicate for slaughter and meat determination. [**Results**] The average weight gain and eye muscle area of the pigs in group B were significantly higher than those in group C ($P < 0.05$), and also showed an increasing trend compared with group A, but there was no statistically significant difference ($P > 0.05$); there was no significant difference between group B or C and group A in the average weight gain and eye muscle area ($P > 0.05$). There was no significant difference in other slaughter performance between the three groups ($P > 0.05$). Besides, there was also no significant difference in the content of various amino acids, total amino acids and total umami amino acids between the three groups ($P > 0.05$). The inosine content in the longissimus dorsi muscle and muscle cooking loss of binary hybrid pigs in group C were significantly better than those in group B ($P < 0.05$), and also had a tendency to be better than those in group A, but there was no significant difference ($P > 0.05$); there was no significant difference between group B or C and group A in the inosine content and muscle cooking loss of the pigs ($P > 0.05$). In addition, there was no significant difference in other meat traits and chemical composition of the longissimus dorsi muscle between group B or C and group A ($P > 0.05$). [**Conclusions**] The addition of arginine and glutamic acid or soybean phospholipid, vitamin E and yeast selenium in diet had no significant effect on the growth rate, slaughter performance and meat traits of long × large binary hybrid pigs.

Key words Slaughter performance, Meat quality, Arginine, Glutamic acid, Soybean phospholipid, Long × large binary hybrid pigs

1 Introduction

Quality pork, which is a brand new concept proposed in recent years, refers to pork with good color, water retention, intramuscular fat content, tenderness, *etc*[1]. With the continuous improvement of living standards, people's pursuit of eating high-quality pork and brand pork is also improving in recent years[2]. The physiological basis of high-quality pork is that fat cells in the endomysium and perimysium are fully developed to surround delicate muscle fibers, so that the flavor of pork can remain in the meat and not be lost during cooking[3]. Therefore, it has become a focus of current research to regulate the growth of meat fat pigs and improve their body fat deposition by adding exogenous substances to adjust the dietary nutrient structure, so as to produce new pork products with tender muscle and good taste.

Arginine, as a semi-essential amino acid, stimulates glucose oxidation in a cell-specific manner, and regulates lipid metabolism in a tissue-specific manner. Glutamic acid, which is a kind of amino acid with umami flavor, can bind with umami receptors in the body, and plays a very important role in the body as a non-essential amino acid[4]. Dietary supplementation of 1.0 g/kg L-arginine is helpful in improving the meat quality of hybrid pigs (Landrace × Yorkshire × Duroc)[5]. Dietary supplementation of 0.83% L-arginine can increase lean meat percentage, decrease fat percentage, enhance body oxidation function, and improve some meat quality indexes of Huanjiang mini-pigs[6]. Dietary supplementation of glutamic acid has no significant effect on fatty acid composition in pig muscle, but can significantly increase the expression of LPL gene in longissimus dorsi muscle, that is, meat flavor can be improved by increasing the content of meat flavor amino acids and the expression of genes related to the formation of flavor substances, thus improving meat quality[7].

Soy phospholipid is rich in lecithin, cephalin, inositol phospholipid, serine phospholipid, *etc*. In its fatty acid composition, unsaturated fatty acids account for 60%, and it contains rich vitamins and trace elements. Besides supplementing essential nutrients for human body, soy phospholipid has unique physiological activities and plays an important role in regulating the biological activity of biofilm and normal metabolism of the body[8]. Therefore, soy phospholipids are gradually used as dietary additives for

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fattening pigs due to their unique nutritional and physiological functions[9]. This study aims to observe the effects of the added arginine and glutamic acid or soy phospholipid and vitamin E in conventional diet on slaughter performance and meat quality of long (white) × large (York) hybrid pigs.

2 Materials and methods

2.1 Experimental animals and design 27 long × large castrated hybrid boars with the body weight of (54.4 ± 0.15) kg were randomly divided into 3 groups, with 3 replicates per group and 3 pigs per replicate. Group A was the control group, in which the boars were fed basal diet; groups B and C were the experimental groups. For group B, 0.8% arginine and 0.60% glutamate were added to the basal diet. For group C, 75 g of soybean phospholipid, 20 g of vitamin E and 8 g of yeast selenium were added to every 100 kg of the basal diet. The formal trial period was 60 d, and the preliminary period was 7 d.

2.2 Composition of experimental basal diet The basal diet consisted of 64.5% corn, 24% soybean meal, 2% fish meal, 3% wheat bran, 2.5% golden milk and 4% premix. Nutritional level was 13.096 MJ/kg digestible energy, 18.11% crude protein, 3.99% crude fat, 2.82% crude fiber, 0.64% calcium, and 0.43% phosphorus.

2.3 Feeding management The experiment was conducted in the breeding experimental base of Guangxi Vocational University of Agriculture. The test pigs were immunized according to farm procedures, and routine cleaning and disinfection were carried out. During the experiment, the pigs took food and water freely, and feed was added four times at 08:30, 12:00, 14:30 and 17:30 each day. Feeding and management conditions of the treatments were consistent. The piggery was kept clean and hygienic.

2.4 Determination indexes and methods

2.4.1 Growth performance index. At the beginning and end of the experiment, the pigs were weighted before early feeding to measure their daily average weight gain.

2.4.2 Carcass indexes. After the experiment was ended, one test pig with similar body weight was selected from each replicate for slaughter and meat determination. During slaughter, the carcass was divided according to the *Technical Regulation for Testing of Carcass Traits of Lean-type Pig* (NY/T 825-2004)[10]. The carcass weight was determined and the slaughter rate was calculated. In addition, the left half of the carcass was conventionally taken to measure the carcass oblique length, backfat thickness, eye muscle area, *etc*[11].

The width and thickness of the cross-section of longissimus dorsi muscle were measured with a caliper at the cross section of the thoracolumbar junction of the left body, and then eye muscle area was calculated as follows: Eye muscle area (cm^2) = Eye muscle width (cm) × Eye muscle thickness (cm) × 0.7.

2.4.3 Meat quality indexes. After slaughter, longissimus dorsi muscle was taken backward from the penultimate third to fourth thoracic vertebrae of the left half of the carcass and placed at room temperature for 45 min to determine pH. After it was placed at 4 ℃ for 24 h, pH_{24} (PHS—3C precision pH meter produced by Shanghai Jinma Instrument Table Co., Ltd.) was measured, and shear force (digital muscle tenderness meter developed by College of Engineering, Northeast Agricultural University), flesh color and water holding capacity (intelligent flesh color detector OPTO-STAR and intelligent conductivity detector LF-STAR; Maites, a German company) were measured; the psoas major muscle was taken to measure cooking loss[12]. In addition, the content of dry matter, protein and muscle fat was also determined[13]. The content of amino acids and inosinic acid in longissimus dorsi muscle was determined by Guangxi Analysis and Testing Center according to the *Determination of Organic Acids in Foods* (GB/T 5009.157-2003) and *Determination of Amino Acids in Foods* (GB/T 5009.124-2003).

2.5 Data processing and statistical analysis After the experimental data were statistically processed by Excel 2007 and SAS 8.2, and then their variance analysis was conducted by SPSS 12.0 for Windows. Duncan's method was used for multiple comparisons. Results are expressed as mean ± standard deviation ($\bar{x} \pm s$).

3 Results and analysis

3.1 Daily average weight gain and slaughter performance of test pigs As can be seen from Table 1, the daily average weight gain and eye muscle area of pigs in group B were significantly higher than those of group C ($P < 0.05$), and also showed an increasing trend compared with group A, but there was no significant statistical difference ($P > 0.05$), and there was no significant difference between groups B or C and group A in the daily average weight gain and eye muscle area ($P > 0.05$). Besides, there was no significant difference between the three groups in premortem live weight, carcass weight, slaughter percentage, carcass length and back fat thickness ($P > 0.05$). In conclusion, the addition of arginine and glutamic acid or soybean phospholipid, vitamin E and yeast selenium in diet had no significant effect on daily gain weight and slaughter performance of long × large binary hybrid pigs.

Table 1 Daily average weight gain and slaughter performance of the binary hybrid pigs

Group	Daily average weight gain//kg	Premortem live weight//kg	Carcass weight//kg	Slaughter percentage//%	Carcass length//cm	Back fat thickness//cm	Eye muscle area//cm^2
A	0.85 ± 0.01^{ab}	110.67 ± 9.71	82.54 ± 7.61	75.00 ± 0.85	91.66 ± 1.15	2.31 ± 0.51	56.61 ± 4.73^{ab}
B	0.89 ± 0.11^{a}	113.93 ± 10.13	86.45 ± 8.75	76.00 ± 1.00	94.33 ± 6.66	2.42 ± 0.27	63.96 ± 6.80^{a}
C	0.79 ± 0.06^{b}	102.83 ± 3.69	76.06 ± 4.56	74.00 ± 0.02	91.33 ± 4.19	2.62 ± 0.51	51.59 ± 1.69^{b}

Note: Different lowercase letters in the same column indicate significant difference ($P < 0.05$), while others indicate no significant difference ($P > 0.05$). The same as below.

3.2 Meat quality traits of the binary hybrid pigs As shown in Table 2, there was no significant difference between the three groups in the shear force, flesh color, water holding capacity, $pH_{45\ min}$ and $pH_{24\ h}$ of the pigs ($P>0.05$). However, the cooking loss of the pigs in group C was significantly lower than that of group B ($P<0.05$), and was also lower than that of group A, but the difference was not statistically significant ($P>0.05$). Meanwhile, there was no significant difference between group B or C and group A in the cooking loss of the pigs ($P>0.05$).

Table 2 Meat traits of the binary hybrid pigs

Group	Shear force//N	Flesh color	Water holding capacity//ms	$pH_{45\ min}$	$pH_{24\ h}$	Cooking loss//%
A	58.13 ±19.27	81.60 ±4.76	2.67 ±0.09	6.05 ±0.19	5.36 ±0.09	29.00 ±1.0^{ab}
B	57.72 ±15.03	83.82 ±1.61	2.56 ±0.23	6.00 ±0.17	5.25 ±0.12	30.00 ±2.0^{a}
C	56.52 ±7.02	83.36 ±2.75	2.62 ±0.18	6.01 ±0.17	5.32 ±0.15	27.00 ±1.0^{b}

Seen from Table 3, there were no significant differences in various amino acids, total amino acids and total umami amino acids among the three groups ($P>0.05$), but the inosinic acid content in group C was significantly higher than that in group B ($P<0.05$) and slightly higher than that in group A, but there was no statistically significant difference ($P>0.05$). However, the inosine content in groups B and C was not significantly different from that in group A ($P>0.05$).

Table 3 Content of amino acids and inosinic acid in the longissimus dorsi muscle of the binary hybrid test pigs %

Item	Group A	Group B	Group C
Glutamic acid	3.14 ±0.14	3.21 ±0.20	3.26 ±0.13
Glycine	0.87 ±0.01	0.87 ±0.04	0.88 ±0.03
Alanine	1.15 ±0.04	1.02 ±0.06	1.20 ±0.06
Aspartic acid	1.90 ±0.05	1.94 ±0.11	1.96 ±0.08
Threonine	0.91 ±0.05	0.93 ±0.07	0.95 ±0.06
Serine	0.76 ±0.04	0.77 ±0.06	0.80 ±0.05
Proline	0.63 ±0.03	0.66 ±0.03	0.68 ±0.03
Cystine	0.15 ±0.04	0.15 ±0.02	0.10 ±0.66
Valine	1.08 ±0.04	1.09 ±0.05	1.08 ±0.03
Lysine	1.84 ±0.07	1.85 ±0.11	1.82 ±0.10
Histidine	0.93 ±0.03	0.95 ±0.06	0.94 ±0.03
Arginine	1.29 ±0.05	1.35 ±0.10	1.29 ±0.11
Methionine	0.58 ±0.02	0.57 ±0.04	0.57 ±0.04
Isoleucine	1.00 ±0.03	1.02 ±0.04	1.01 ±0.05
Leucine	1.66 ±0.04	1.71 ±0.08	1.69 ±0.11
Tyrosine	0.73 ±0.04	0.73 ±0.04	0.73 ±0.05
Phenylalanine	0.80 ±0.02	0.83 ±0.04	0.85 ±0.05
Total amino acids	19.44 ±0.60	19.85 ±1.08	19.82 ±0.90
Total umami amino acids	15.32 ±0.48	15.67 ±0.86	15.67 ±0.72
Inosine acid//mg/100 g	325.17 ±9.56^{ab}	310.27 ±18.75^{b}	341.80 ±2.36^{a}

As can be seen from Table 4, there were no significant differences in the contents of dry matter, crude protein and intramuscular fat in the longissimus dorsi muscle of pigs in the three groups ($P>0.05$).

Table 4 Contents of other chemical components in the longissimus dorsi muscle of the test pigs (dry matter basis) %

Group	Dry matter	Crude protein	Intramuscular fat
A	28.42 ±0.62	85.18 ±2.87	9.15 ±2.55
B	28.09 ±0.21	84.75 ±1.69	8.75 ±2.32
C	28.32 ±0.40	85.26 ±2.04	7.12 ±1.20

In conclusion, the addition of arginine and glutamic acid or soybean phospholipid, vitamin E and yeast selenium in diet had no significant effect on the meat traits of long × large binary hybrid pigs.

4 Discussion

The daily average weight gain and eye muscle area of pigs in group B supplemented with arginine and glutamate were significantly better than those of group C supplemented with soy phospholipid, vitamin E and yeast selenium, and also showed an increasing trend compared with the control group, but it was not statistically significant. Inosinic acid content in the longissimus dorsi muscle of pigs in group B was significantly higher than that in group A and slightly higher than that in control group, but it was not statistically significant. The cooking loss of muscle in group C was also better than that in group B, and slightly better than in the control group, but it was not statistically significant either. However, there were no significant differences in daily average weight gain, slaughter performance or meat traits between group B or C and the control group. In conclusion, the addition of arginine and glutamic acid or soybean phospholipid, vitamin E and yeast selenium in diet had no significant effect on the daily average weight gain, slaughter percentage and meat traits of long × large binary hybrid pigs.

Studies have shown that arginine is the amino acid with the most functions in animal cells found so far, and it has become a hot research topic that arginine affects the body's metabolism through the regulation of gene expression[14]. The addition of arginine in high-energy diet is helpful to increase intramuscular fat content, reduce shear force and improve meat quality, while the addition of arginine in normal energy diet has no significant effect on meat quality[15]. Zhou Xiaoli *et al.* added 3% monosodium glutamate to the basal diet to improve meat flavor by increasing carcass fat percentage, IMF (intramuscular fat) and leg-hip ratio, thus improving meat quality; however, the addition of the same monosodium glutamate in the high-fat diet reduced the leg-to-hip ratio, IMF and unsaturated fatty acid content, and increased the content of saturated fatty acid[16]. It can be seen that the addition of arginine or glutamic acid (sodium) to different diets will produce different effects. Therefore, different dietary composition is an important factor affecting the function of amino acids. In this study, although both arginine and glutamic acid were added to the basal diet, there was no significant effect on the daily weight gain, slaughter performance and meat traits of long × large hybrid pigs. It is due to the composition of the diet, the interaction of two different amino acids or some other factors, and further research is needed. Soybean phospholipid is a by-product produced in the refining process of soybean oil. Because it contains a large number of unsaturated fatty acids, choline, inositol and other nutrients, it has biological functions of promoting animal growth, regulating fat metabolism and enhancing body immunity, and is widely used in medicine, food industry and feed industry[17]. Dietary supplementation of soy phospholipid can significantly improve the body weight, carcass weight, leg muscle weight and leg muscle percentage of broilers, and increase palatability[18]. Diets supplemented with 0.5 mg/kg selenium yeast and 260 mg/kg vitamin E can significantly increase the average daily gain, feed conversion rate and slaughter percentage, and effectively improve meat quality and antioxidant capacity of experimental pigs[19-20]. In addition, selenium and vitamin E have a synergistic effect in the body, and they have the same biological function, but the mechanism of action is different. Both of them can effectively prevent the lipid oxidation reaction of the liver centrioles and microsomes. The addition of a certain amount of selenium in diet can save vitamin E, and acts as a synergistic antioxidant[21-22]. Although no successful studies have been reported on the application of soy phospholipids in diet to improve the slaughter performance or meat quality of pigs, this study aims to improve the slaughtering performance or meat quality of the binary hybrid pigs by adding soy phospholipids (due to the unique nutritional and physiological functions), vitamin E and yeast selenium in diet. Inosinic acid is a very important umami substance in muscles, and plays an important role in improving meat flavor. In this study, inosinic acid content in the muscles of test pigs showed an increasing tend, and the cooking loss of meat also showed a decreasing tend, but the difference was not significant; there was no significant difference in other slaughter performance and meat traits. Therefore, the effect is not ideal. Since the three additives were added in the diet at the same time, there are many factors involved. Hence, more research is needed to obtain the expected effect.

5 Conclusions

(i) The average weight gain and eye muscle area of long × large hybrid pigs fed with arginine and glutamate were significantly higher than those supplemented with soy phospholipid, vitamin E and yeast selenium, and also showed an increasing trend compared with those fed with basal diet, but there was no significant difference. (ii) The inosine content in the longissimus dorsi muscle and muscle cooking loss of binary hybrid pigs supplemented with soy phospholipid, vitamin E and yeast selenium were significantly better than those supplemented with arginine and glutamic acid, and had some advantages over those supplemented with only basal diet, but there was no significant difference. (iii) The addition of arginine and glutamic acid or soybean phospholipid, vitamin E and yeast selenium in diet had no significant effect on the growth rate, slaughter performance and meat traits of long × large binary hybrid pigs.

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