Effects of Cysteamine on Carcass Traits and Meat Quality in Ningxiang Pigs (Postprint)

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Abstract

This study aimed to investigate the effects of dietary cysteamine supplementation on carcass traits and meat quality in Ningxiang pigs. Thirty Ningxiang barrows of similar age with a body weight of approximately 43 kg were randomly allocated into two groups, each comprising five replicates of three pigs. The control group was fed a basal diet, while the treatment group received the basal diet supplemented with 80 mg/kg cysteamine for an 8-week period. The results showed that: 1) Compared with the control group, the dressing percentage of the treatment group increased by 3.04% ($P<0.05$). 2) Compared with the control group, the drip loss of longissimus dorsi muscle in the treatment group decreased by 21.83% ($0.05 \leq P<0.10$). 3) Compared with the control group, the stearic acid content in saturated fatty acids of longissimus dorsi muscle decreased by 6.71% ($P<0.05$); the elaidic acid content in monounsaturated fatty acids decreased by 62.57% ($P<0.01$), and the eicosanoic acid content decreased by 28.02% ($P<0.01$); the polyunsaturated fatty acid content increased by 7.14% ($P<0.05$), among which the linoleic acid content increased by 7.89% ($P<0.05$), the eicosatrienoic acid content increased by 34.10% ($0.05 \leq P<0.10$), and the α-linolenic acid content decreased by 15.87% ($P<0.01$). It can be concluded that dietary cysteamine supplementation improved the dressing percentage of Ningxiang pigs and enhanced meat quality by reducing stearic acid content and increasing linoleic acid content.

Full Text

Effects of Cysteamine on Carcass Traits and Meat Quality of Ningxiang Pigs

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Abstract

This experiment aimed to investigate the effects of dietary cysteamine supplementation on carcass traits and meat quality of Ningxiang pigs. Thirty Ningxiang barrows of similar age with an average initial weight of approximately 43 kg were randomly divided into 2 groups, with 5 replicates per group and 3 pigs per replicate. The control group was fed a basal diet, while the experimental group received the basal diet supplemented with 80 mg/kg cysteamine for a period of 8 weeks. The results indicated that: 1) Compared with the control group, the experimental group exhibited a 3.04% increase in dressing percentage ($P<0.05$). 2) Drip loss in the longissimus dorsi muscle decreased by 21.83% ($0.05 \leq P<0.10$) compared with the control group. 3) Dietary cysteamine supplementation decreased stearic acid content in saturated fatty acids of the longissimus dorsi muscle by 6.71% ($P<0.05$); decreased elaidic acid content in monounsaturated fatty acids by 62.57% ($P<0.01$) and eicosenoic acid by 28.02% ($P<0.01$); increased polyunsaturated fatty acid content by 7.14% ($P<0.05$), including a 7.89% increase in linoleic acid ($P<0.05$), a 34.10% increase in eicosatrienoic acid ($0.05 \leq P<0.10$), and a 15.87% decrease in α-linolenic acid ($P<0.01$). These findings demonstrate that dietary cysteamine supplementation improves the dressing percentage and meat quality of Ningxiang pigs by reducing stearic acid content and increasing linoleic acid content.

Keywords: cysteamine; Ningxiang pig; carcass traits; meat quality

Introduction

Cysteamine (CS), also known as β-mercaptoethylamine, is a component of acetyl-coenzyme A and the decarboxylation product of cysteine. Due to its active sulfhydryl and amino groups, cysteamine exhibits various biological functions in animals, including promoting nutrient metabolism and improving carcass quality [1-2]. Numerous studies have reported the beneficial effects of cysteamine on carcass and meat quality in three-way crossbred pigs [3-5], while research on local breeds remains limited. Ningxiang pig is a renowned local breed in China, characterized by wide adaptability, easy fattening, strong fat deposition capacity, high dressing percentage, and tender meat quality. Previous research has indicated that cysteamine supplementation in the late fattening period can influence the growth performance of Ningxiang pigs [6]; however, the effects of cysteamine on carcass traits and meat quality in this breed have rarely been documented. This experiment was designed to investigate these effects and provide a theoretical basis for practical application in production.

Materials and Methods

1.1 Experimental Design This experiment employed a single-factor design. Prior to the trial, 30 Ningxiang barrows from the same building and batch, with an average weight of approximately 43 kg, were selected from a fattening farm and randomly divided into 2 groups: a control group and an experimental group. Each group consisted of 5 replicates with 3 pigs per replicate.

1.2 Experimental Diet and Management The basal diet was formulated according to NRC (2012) guidelines and conventional Ningxiang pig diet formulations, with composition and nutrient levels presented in Table 1 . The experimental group received the basal diet supplemented with 80 mg/kg cysteamine (64.5% purity, provided by Guangzhou Tianke Biotechnology Co., Ltd.). The experimental period lasted 8 weeks. During the trial, pigs were fed three times daily (08:00, 12:00, and 18:00), with disinfection and immunization conducted according to routine procedures. The experiment was carried out at Hunan Ningxiang Dalong Animal Husbandry Technology Co., Ltd.

Table 1 Composition and nutrient levels of the basal diet (DM basis), %

Item	Content
Ingredients	
Corn	70.00
Soybean meal	18.00
Wheat bran	8.00
Premix[1]	4.00
Total	**100.00**
Nutrient level[2]	
DE/(MJ/kg)	13.50
CP	14.50
EE	3.20
Ash	4.50
Ca	0.60
AP	0.28
TP	0.50
Lys	0.75
Thr	0.48
Met	0.20
Met+Cys	0.40

[1]The premix provides the following per kg of diet: VA 1,300 IU, VD_3 150 IU, VE 11 IU, VK_3 0.5 mg, VB_1 1.2 mg, VB_2 2 mg, VB_6 1.3 mg, VB_{12} 5 μg, folic acid 0.3 mg, pantothenic acid 7 mg, Cu 3.3 mg, I 0.14 mg, Se 0.15 mg, Zn 50 mg, Fe 40 mg, Mn 2 mg.
[2]DE is a calculated value and the others are measured values.

1.3.1 Meat Sample Collection Upon completion of the feeding trial, pigs were fasted for 24 hours with free access to water. One pig from each replicate was selected for slaughter, and the longissimus dorsi muscle between the 1st and 2nd thoracic vertebrae was collected as the meat sample.

1.3.2 Carcass Traits and Meat Quality Measurement Carcass traits and meat quality were determined according to NY/T 1333-2007 [7].

1.3.3 Long-Chain Fatty Acid Analysis in Longissimus Dorsi Muscle After freeze-drying, approximately 0.5 g of meat sample was weighed. Long-chain fatty acid content was determined using external standard gas chromatography-mass spectrometry [8] at the laboratory of the Institute of Subtropical Agriculture, Chinese Academy of Sciences.

1.4 Statistical Analysis Experimental data were initially processed using Excel 2010, and independent samples t-test in SPSS 21.0 software was used to compare differences between groups. Results are expressed as mean±standard error (mean±SE). P<0.05 was considered significant, P<0.01 highly significant, and 0.05≤P<0.10 marginally significant.

Results

2.1 Effects of Cysteamine on Carcass Traits of Ningxiang Pigs As shown in Table 2 , compared with the control group, the experimental group exhibited a 3.04% increase in dressing percentage (P<0.05). Eye muscle area and lean meat percentage increased by 2.39% and 1.41% respectively (P>0.05), while backfat thickness decreased by 3.78% (P>0.05).

Table 2 Effects of CS on carcass traits of Ningxiang pigs

Item	Control group	Experimental group	P-value
Backfat thickness/mm	36.00$±2.49|34.64±0.60| [illegible]	[illegible]	[illegible]

In the same row, values with no letter or the same letter superscripts indicate no significant difference (P>0.05), different lowercase letters indicate significant difference (P<0.05), and different uppercase letters indicate highly significant difference (P<0.01). The same applies to the following tables.

2.2 Effects of Cysteamine on Meat Quality of Ningxiang Pigs As shown in Table 3 , compared with the control group, drip loss in the longissimus dorsi muscle of the experimental group decreased by 21.83% ($0.05 \leq P < 0.10$). The experimental group also showed a 9.59% decrease in muscle ΔpH, 3.07% increase in cooking yield, 2.12% decrease in meat color lightness (L*), 9.15% increase in redness (a*), 2.71% decrease in yellowness (b*), and 10.80% increase in shear force, though these differences were not significant ($P > 0.05$).

Table 3 Effects of CS on pork quality of Ningxiang pigs

<table>
<tr><th>Item</th><th>Control group</th><th>Experimental group</th><th>P-value</th></tr>
<tr><td>Water-holding capacity/%</td><td colspan="3">86.48$±0.76|86.50±0.85|0.987||Droploss/±0.36|2.90±0.09|0.067||Cookedmeatrate/±1.74|64.82±2. |45.25±0.95|44.29±1.15|0.543||a* |6.45±0.51|7.04±0.38|0.383||b* |3.69±0.41|3.59±0.36|0.873||pH{1}_h|6.36±0.05|6.35±0.05|0.887||pH{48}_h|5.68±0.05|5.74±0.05|0.4</td></tr>
</table>

2.3 Effects of Cysteamine on Long-Chain Fatty Acid Content in Longissimus Dorsi Muscle As shown in Table 4 , compared with the control group, stearic acid content in saturated fatty acids of the experimental group decreased by 6.71% ($P < 0.05$). Elaidic acid content in monounsaturated fatty acids decreased by 62.57% ($P < 0.01$) and eicosenoic acid by 28.02% ($P < 0.01$). Polyunsaturated fatty acid content increased by 7.14% ($P < 0.05$), including a 7.89% increase in linoleic acid ($P < 0.05$), a 34.10% increase in eicosatrienoic acid ($0.05 \leq P < 0.10$), and a 15.87% decrease in α-linolenic acid ($P < 0.01$).

Table 4 Effects of CS on long chain fatty acid contents in longissimus dorsi muscle of Ningxiang pigs, %

<table>
<tr><th>Item</th><th>Control group</th><th>Experimental group</th><th>P-value</th></tr>
<tr><td>Myristic acid C14:0</td><td colspan="3">1.513$±0.068|1.446±0.044|0.453||PalmiticacidC16 : 0|29.560±0.158|29.652±0.427|0.843||HeptadecanoicacidC17 : 0|0.227±0.010|0.208±0.007|0.163||StearicacidC18 : 0|16.296±0.319^A|15.203±0.216^B|0.034||ArachidicacidC20 : 0|0.190±0.011|0.180±0.008|0.473||PalmitoleicacidC16 : 1|4.502±0.045|4.267±0.132|0.163||ElaidicacidC18 : 1t9|0.342±0.024^A|0.128±0.006^B| < 0.001||OleicacidC18 : 1c9|33.768±0.497|34.685±0.751|0.363||LinoleicacidC18 : 2c6|9.529±0.182^b|10.281±$0.249</td></tr>
</table>

Item	Control group	Experimental group	P-value
α-Linolenic acid C18:3	0.252±0.006^A	0.212±0.007^B	0.001
Eicosenoic acid C20:1	0.853±0.041^A	0.614±0.016^B	< 0.001
Arachidonic acid C20:4	2.712±0.119	2.834±0.086	0.453
Eicosatrienoic acid C20:3	0.217±0.017	0.291±0.030	0.067
SFA	47.826±0.438	46.689±0.526	0.163
MUFA	39.465±0.468	39[illegible]	

Discussion

3.1 Effects of Cysteamine on Carcass Traits of Ningxiang Pigs Cysteamine improves animal carcass quality by depleting somatostatin (SS), which increases growth hormone (GH) and insulin-like growth factor 1 (IGF-1) levels. GH promotes differentiation of muscle cell lines and preadipocyte lines, and these cells stimulate muscle protein synthesis and muscle growth under the action of IGF-1 [9]. SS initially attracted attention due to its inhibition of GH secretion and is widely distributed in the central and peripheral nervous systems, pancreas, and gastrointestinal tract [10]. Liu et al. [11] found that cysteamine elevates GH, IGF-1, and gastrin levels by altering SS configuration. Xue et al. [12] further demonstrated that cysteamine promotes fat decomposition and protein deposition by increasing insulin content, though the mechanism remains unclear. Previous studies have shown that dietary cysteamine supplementation in finishing pigs reduces backfat thickness [13-15], fat percentage [16-17], and sebum percentage [1], while increasing eye muscle area [18-19], lean meat percentage [20-21], and dressing percentage [17,22]. The present results showing increased dressing percentage and eye muscle area are consistent with Sirilaophaisan [23]. However, variable effects of dietary cysteamine on carcass traits in pigs have been reported, possibly related to breed, body weight, and dietary composition.

3.2 Effects of Cysteamine on Meat Quality of Ningxiang Pigs Studies have shown that cysteamine promotes protein deposition in vivo, thereby improving meat quality [11]. Dietary cysteamine supplementation in finishing pigs has been reported to increase muscle water-holding capacity [22], reduce drip loss [24] and shear force [25], and improve meat color [19,26] and marbling [18,26]. The a* value is primarily determined by myoglobin and hemoglobin contents in muscle, with the color manifestation resulting from heme iron binding with oxygen. Dietary cysteamine can increase muscle a* value and reduce the incidence of pale, soft, exudative (PSE) meat. The present study demonstrated that cysteamine supplementation increased water-holding capacity and cooking yield while decreasing drip loss and ΔpH in the longissimus dorsi muscle. Variations in the effects of dietary cysteamine on meat quality may be related to its stability, purity, and supplementation level.

3.3 Effects of Cysteamine on Long-Chain Fatty Acids in Longissimus Dorsi Muscle Fatty acids can be classified as saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) [27]. The present study found no significant differences in total SFA and MUFA contents between groups; however, stearic acid content in SFA, elaidic acid and eicosenoic acid contents in MUFA were significantly reduced, while PUFA content was significantly increased in the cysteamine group, including elevated linoleic acid and eicosatrienoic acid, and decreased α-linolenic acid. Close [28] reported that high unsaturated fatty acid content in muscle is associated with lower tenderness, juiciness, flavor, and overall sensory scores, whereas high SFA+MUFA content yields higher scores. Other studies have found that SFA and MUFA primarily affect meat flavor, while PUFA influences nutritional value; the regulation of pork quality essentially targets C16 and C18 fatty acids, with linoleic acid positively correlating with meat flavor [29]. Rat model studies have also shown that dietary cysteamine alters fatty acid composition in the longissimus dorsi muscle, reducing myristic acid, palmitic acid, and stearic acid contents while increasing oleic acid and linoleic acid contents and decreasing linolenic acid [30]. Studies in fish have demonstrated that arachidonic acid can enhance stress resistance and immunity while reducing eicosapentaenoic acid (EPA) content [31-32]. Stearoyl-CoA desaturase (SCD) is a rate-limiting enzyme that converts saturated fatty acids to monounsaturated fatty acids [33], specifically transforming stearic acid to oleic acid [34]. Research has shown that dietary cysteamine supplementation increases SCD gene expression in the semitendinosus muscle of fattening sheep [35]. Other studies suggest that cysteamine improves meat nutritional value by increasing linoleic acid content [36], which is consistent with our findings.

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