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

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Abstract

This study was conducted to investigate the effects of dietary cysteamine supplementation on carcass traits and meat quality in Ningxiang pigs. Thirty Ningxiang barrows of similar age with an average body weight of approximately 43 kg were randomly allocated into 2 groups, each consisting of 5 replicates with 3 pigs per replicate. The control group received a basal diet, whereas the experimental group received the basal diet supplemented with 80 mg/kg cysteamine for a duration of 8 weeks. The results demonstrated that: 1) Compared with the control group, the dressing percentage of the experimental group increased by 3.04% ($P<0.05$). 2) Compared with the control group, the drip loss of longissimus dorsi muscle in the experimental group decreased by 21.83% (0.05 $P<0.10$). 3) Compared with the control group, the stearic acid content in saturated fatty acids of longissimus dorsi muscle in the experimental group decreased by 6.71% ($P<0.05$); the elaidic acid content in monounsaturated fatty acids decreased by 62.57% ($P<0.01$), and the eicosenoic 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 $P<0.10$), and the -linolenic acid 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 study investigated the effects of dietary cysteamine (CS) supplementation on carcass traits and meat quality of Ningxiang pigs. Thirty Ningxiang barrows with an average initial body weight of 43 kg were randomly allocated into two groups, each consisting of five replicates with three pigs per replicate. Pigs in the control group were fed a basal diet, while those in the experimental group received the basal diet supplemented with 80 mg/kg CS for eight weeks. The results showed that: (1) compared with the control group, CS supplementation increased dressing percentage by 3.04% ($P<0.05$); (2) CS supplementation decreased drip loss by 21.83% (0.05 $P<0.10$); and (3) CS supplementation decreased stearic acid (C18:0) content in saturated fatty acids of the longissimus dorsi muscle by 6.71% ($P<0.05$), decreased trans-oleic acid (C18:1 t9) content in monounsaturated fatty acids by 62.57% ($P<0.01$) and eicosenoic acid (C20:1) by 28.02% ($P<0.01$), while increasing polyunsaturated fatty acid content by 7.14% ($P<0.05$), linoleic acid (C18:2 c6) by 7.89% ($P<0.05$), eicosatrienoic acid (C20:3) by 34.10% (0.05 $P<0.10$), and decreasing -linolenic acid (C18:3) by 15.87% ($P<0.01$). These findings indicate that dietary CS supplementation can improve 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 -mercaptoethylamine, is a component of coenzyme A. Due to its active sulfhydryl and amino groups, CS exhibits multiple physiological functions in animals, including promoting nutrient metabolism and improving carcass and meat quality [**?**]. Numerous studies have reported the effects of CS on carcass traits and meat quality of three-way crossbred pigs [**?**], but research on local breeds remains limited. Ningxiang pig is one of China' s famous indigenous pig breeds, characterized by wide adaptability, high reproductive performance, strong disease resistance, and excellent meat quality. Previous research has shown that CS supplementation in growing-finishing diets can affect production performance [?], but its effects on carcass traits and meat quality of Ningxiang pigs have not been reported. Therefore, this study aimed to investigate the effects of CS on carcass traits and meat quality of Ningxiang pigs to provide a scientific basis for its practical application in production.

Materials and Methods

Experimental Design This experiment employed a single-factor design. Thirty Ningxiang barrows with similar genetic background and an average initial weight of 43 kg were randomly divided into two groups: a control group and an experimental group. Each group comprised five replicates with three pigs per replicate.

Dietary Treatments and Feeding Management The basal diet was formulated according to NRC (2012) recommendations and conventional feeding standards for Ningxiang pigs. The composition and nutrient levels of the basal diet are presented in Table 1 . The experimental group received the basal diet supplemented with 80 mg/kg CS (purity 64.5%, provided by Guangzhou Tiannong Biotechnology Co., Ltd.). The experiment lasted for eight weeks. During the trial, pigs were fed three times daily (at 08:00, 12:00, and 18:00) and had free access to water. All management and immunization procedures followed conventional practices. The experiment was conducted at the Ningxiang Datang Agricultural Technology Co., Ltd. in Hunan Province.

Sample Collection and Measurements **Meat Sample Collection.** After the feeding trial, pigs were slaughtered following a 24-hour fasting period. One pig from each replicate was selected for slaughter. The longissimus dorsi muscle was collected between the 1st and 2nd lumbar vertebrae for meat quality analysis.

Carcass Traits and Meat Quality Analysis. Carcass traits and meat quality parameters were determined according to the Chinese agricultural standard NY/T 1333-2007 [?].

Long-Chain Fatty Acid Analysis. Meat samples were freeze-dried and approximately 0.5 g was used for fatty acid extraction. Fatty acid composition was determined by gas chromatography-mass spectrometry [?] at the Laboratory of the Institute of Subtropical Agriculture, Chinese Academy of Sciences.

Statistical Analysis Data were initially processed using Excel 2010 and then analyzed using SPSS 21.0 software. Independent samples t-tests were performed to determine differences between groups. Results are expressed as mean ± standard error (mean±SE). Significance was declared at P<0.05, highly significant at P<0.01, and a trend was considered at 0.05 P<0.10.

Results

Effects of Cysteamine on Carcass Traits of Ningxiang Pigs As shown in Table 2 , compared with the control group, CS supplementation significantly increased dressing percentage by 3.04% (P<0.05). Eye muscle area and cutability increased by 2.39% and 1.41% respectively, while backfat thickness decreased by 3.78%, though these differences were not statistically significant (P>0.05).

Table 2 Effects of CS on carcass traits of Ningxiang pigs

Items	Control group	Experimental group	P-value
Backfat thickness (mm)	36.00±2.49	34.64±0.60	>0.05
Dressing percentage (%)	70.14±0.47b	72.27±0.65a	<0.05
Carcass length (mm)	78.80±3.53	76.00±1.52	>0.05
Eye muscle area (cm^2)	17.15±1.92	17.56±1.90	>0.05
Cutability (%)	34.03±1.24	34.51±0.95	>0.05
Fat percentage (%)	42.43±0.51	44.16±1.45	>0.05

Note: 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 notation applies below.

Effects of Cysteamine on Meat Quality of Ningxiang Pigs Table 3 shows that CS supplementation decreased drip loss by 21.83% (0.05 P<0.10) compared with the control group. The experimental group also exhibited a 9.59% decrease in ΔpH, a 3.07% increase in cooked meat percentage, a 2.12% decrease in lightness (L*), a 9.15% increase in redness (a*), a 2.71% decrease in yellowness (b*), and a 10.80% increase in shear force, though none of these differences reached statistical significance (P>0.05).

Table 3 Effects of CS on pork quality of Ningxiang pigs

Items	Control group	Experimental group	P-value
Water-holding capacity (%)	86.48±0.76	86.50±0.85	>0.05
Drop loss (%)	3.71±0.36	2.90±0.09	0.05 P<0.10
Cooked meat rate (%)	62.89±1.74	64.82±2.85	>0.05
Lightness (L*)	45.25±0.95	44.29±1.15	>0.05
Redness (a*)	6.45±0.51	7.04±0.38	>0.05
Yellowness (b*)	3.69±0.41	3.59±0.36	>0.05

Items	Control group	Experimental group	P-value
pH h	6.36±0.05	6.35±0.05	>0.05
pH h	5.68±0.05	5.74±0.05	>0.05
ΔpH (%)	10.64±1.13	9.62±0.91	>0.05
Shearing force (N)	32.51±2.30	36.02±2.71	>0.05

Effects of Cysteamine on Long-Chain Fatty Acid Composition in Longissimus Dorsi Muscle As presented in Table 4 , CS supplementation significantly decreased stearic acid (C18:0) content in saturated fatty acids by 6.71% ($P<0.05$). In monounsaturated fatty acids, trans-oleic acid (C18:1 t9) and eicosenoic acid (C20:1) contents decreased by 62.57% ($P<0.01$) and 28.02% ($P<0.01$), respectively. Polyunsaturated fatty acid content increased by 7.14% ($P<0.05$), with linoleic acid (C18:2 c6) increasing by 7.89% ($P<0.05$), eicosatrienoic acid (C20:3) increasing by 34.10% (0.05 $P<0.10$), and -linolenic acid (C18:3) decreasing by 15.87% ($P<0.01$).

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

Items	Control group	Experimental group	P-value
Myristic acid (C14:0)	1.513±0.068	1.446±0.044	>0.05
Palmitic acid (C16:0)	29.560±0.158	29.652±0.427	>0.05
Margaric acid (C17:0)	0.227±0.010	0.208±0.007	>0.05
Stearic acid (C18:0)	16.296±0.319a	15.203±0.216b	<0.05
Arachidic acid (C20:0)	0.190±0.011	0.180±0.008	>0.05
Palmitoleic acid (C16:1)	4.502±0.045	4.267±0.132	>0.05
Trans-oleic acid (C18:1 t9)	0.342±0.024A	0.128±0.006B	<0.01

Items	Control group	Experimental group	P-value
Oleic acid (C18:1 c9)	33.768±0.497	34.685±0.751	>0.05
Linoleic acid (C18:2 c6)	9.529±0.182b	10.281±0.249a	<0.05
- Linolenic acid (C18:3)	0.252±0.006A	0.212±0.007B	<0.01
Eicosenoic acid (C20:1)	0.853±0.041A	0.614±0.016B	<0.01
Arachidonic acid (C20:4)	2.712±0.119	2.834±0.086	>0.05
Eicosatrienoic acid (C20:3)	0.217±0.017	0.291±0.030	0.05 P<0.10
Saturated fatty acids (SFA)	47.826±0.438	46.689±0.526	>0.05
Monounsaturated fatty acids (MUFA)	39.465±0.468	39.694±0.826	>0.05
Polyunsaturated fatty acids (PUFA)	12.709±0.118b	13.617±0.302a	<0.05

Discussion

Effects of Cysteamine on Carcass Traits Cysteamine reduces somatostatin (SS) levels in the body, thereby increasing growth hormone (GH) and insulin-like growth factor-1 (IGF-1) concentrations. GH promotes the differentiation of muscle and adipose precursor cells, while these cells stimulate protein synthesis and muscle growth under the action of IGF-1, consequently improving animal carcass traits [?]. SS initially attracted attention due to its inhibition of GH secretion and its wide distribution in the central nervous system, peripheral tissues, pancreas, and gastrointestinal tract [?]. Liu et al. [?] found that CS could alter SS conformation and increase GH, IGF-1, and insulin levels. Xue et al. [?] further demonstrated that CS promotes protein synthesis and muscle growth by increasing insulin content, though the underlying mechanism remains unclear. Previous studies have shown that dietary CS supplementation can reduce backfat thickness [?], fat percentage [?], and carcass fat content [?], while increasing eye muscle area [?], cutability [?], and dressing percentage [?, ?]. In the present study, CS supplementation increased dressing percentage and eye muscle area while reducing backfat thickness, consistent with the findings of Sirilaophaisan [?]. The variable effects of CS on carcass traits across studies may be attributed to differences in pig breeds, body weight, and dietary composition.

Effects of Cysteamine on Meat Quality Research has demonstrated that CS can promote protein synthesis in vivo, thereby improving meat quality [?]. The current study found that CS supplementation enhanced water-holding capacity and cooked meat percentage while reducing drip loss and ΔpH. Previous studies have reported that CS improves meat color [?, ?] and tenderness [?, ?]. The redness value (a*) is primarily determined by myoglobin and hemoglobin contents in meat, as these proteins display different colors depending on the oxidation state of their heme iron groups. Dietary CS supplementation can increase the a* value and reduce the incidence of pale, soft, and exudative (PSE) meat. In this study, CS supplementation improved water-holding capacity and cooked meat rate while decreasing drip loss and ΔpH, though most differences were not statistically significant. The variation in CS effects on meat quality among studies may be related to CS stability, purity, and supplementation level.

Effects of Cysteamine on Fatty Acid Composition Fatty acids are classified as saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) [?]. The present study revealed that while total SFA and MUFA contents in longissimus dorsi muscle were not significantly different between groups, CS supplementation significantly reduced stearic acid content in SFAs and decreased trans-oleic acid and eicosenoic acid contents in MUFAs. Conversely, PUFA content increased significantly, with elevated linoleic acid and eicosatrienoic acid levels and reduced -linolenic acid content. Close [?] reported that higher unsaturated fatty acid content in meat is associated with lower tenderness, juiciness, flavor, and overall sensory scores, whereas increased SFA+MUFA content improves sensory scores. Other research indicates that SFAs and MUFAs primarily affect meat flavor, while PUFAs influence nutritional value. For pork quality, the key fatty acids are palmitic acid and stearic acid, with linoleic acid content negatively correlating with flavor [?]. Studies in Large White pigs have shown that CS supplementation alters muscle fatty acid composition by reducing myristic, palmitic, and stearic acid contents while increasing oleic and linoleic acids and decreasing linolenic acid [?]. Additionally, arachidonic acid can enhance immune response and reduce eicosapentaenoic acid (EPA) content in tissues [?]. Stearoyl-CoA desaturase (SCD) is the key enzyme converting SFAs to MUFAs by desaturating stearic acid to oleic acid [?]. Dietary CS supplementation has been shown to upregulate SCD gene expression in muscle [?]. Therefore, CS may improve the nutritional value of pork by increasing linoleic acid content, which aligns with our findings.

Conclusion

Dietary supplementation with cysteamine at 80 mg/kg increased the dressing percentage of Ningxiang pigs and improved meat quality by reducing stearic acid content while increasing linoleic acid content in muscle.

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Note: Figure translations are in progress. See original paper for figures.