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Effects of dietary *Acremonium terricola* culture supplementation on the quality, conventional characteristics, and flavor substances of Hortobágy goose meat

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Abstract

This study aimed to determine the effect of dietary supplementation with *Acremonium terricola* culture (ATC) on the quality, conventional characteristics, and flavor substances of Hortobágy goose meat. A total of 720 one-day-old goslings were divided into four dietary treatments, each consisting of six cages of 30 goslings. The dietary conditions consisted of the control group and three treatment groups supplemented with 3, 5, or 7 g/kg ATC. In male geese, supplementation with 3 g/kg ATC elevated the crude ash (CA) content of the thigh muscle compared to the control group, and the CA content of the pectoralis major was significantly elevated when geese were supplemented with 5 g/kg ATC ($p < 0.05$). In females, compared with the control group, supplementation with 7 g/kg ATC enhanced the crude protein (CP) content of the pectoralis major. Supplementation with 7 g/kg ATC also increased the crude fat (CF) content of the pectoralis major in females as well as in both sexes; moreover, this supplementation dose increased the inosinic acid content of the thigh muscle in males and in both sexes. In contrast, supplementation with 5 g/kg ATC decreased the pH of the thigh muscle at 12 h postmortem ($p < 0.01$). No significant changes in meat color, water loss rate, shear force, moisture content or amino acid (AA) levels were observed after ATC supplementation ($p > 0.05$). Levels of saturated fatty acids (SFAs) and polyunsaturated FAs (PUFAs) in the pectoralis major and levels of SFAs, monounsaturated FAs (MUFAs), and PUFAs in the thigh muscle were not affected by the supplementation. Overall, ATC supplementation had positive effects on the pH, and CA, CP, CF, inosinic acid contents as well as on the FA composition of gosling meat. The optimal level of ATC supplementation was 7 g/kg in goslings from 1 to 70 days of age.

Keywords: *Acremonium terricola* culture, Hortobágy geese, Flavor substances, Conventional characteristics, Meat quality

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Competing interests
The authors declare they have no potential conflicts of interest relevant to this article.

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Availability of data and material
Upon reasonable request, the datasets of this study can be available from the corresponding author.

Authors' contributions
Conceptualization: Xie K.
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Writing - review & editing: Guo Y, Chen J, Liu S, Zhu Y, Gao P, Xie K.

Ethics approval and consent to participate
The procedures of this experiment were reviewed and approved by the Institutional Animal Care and Use Committee of the Animal Welfare Committee of Yangzhou University (permit number: SYXK (Su) IACUC 2012-0029).

INTRODUCTION

With the improvement in living standards and the gradual adoption of a healthy diet by the majority of consumers, people strive to achieve a low-fat, low-cholesterol, high-protein diet and balanced nutrition. Goose meat is popular with consumers, especially Chinese consumers, for its nutritional content and unique flavor; additionally, goose meat was listed as one of the critical developments of green foods in the 21st century by the Food and Agriculture Organization of the United Nations in 2002. Hortobágy geese originated in the Hortobágy steppe areas of the Hungarian Great Plain, northeastern Hungary. This species tolerates a wide range of feeding conditions and exhibits high adaptability to grazing or free-range rearing. Hortobágy geese have a high feather yield, good feather elasticity, high down content and loft; they have excellent egg-laying and reproductive performance, and their meat is flavorful and tender with a high nutritional value. Although the Hortobágy goose has gained a reputation for its high-quality down, it has other merits, such as its large size, easy management, short production cycles, low cost and high profit, that have made it widely popular and market competitive [1]. Therefore, the quality, conventional characteristics, and flavor substances of its meat merit further study.

Antibiotic additives have been banned in many nations because of residual harm, antibiotic resistance and the transmission of antibiotic resistance genes caused by the long-term use of antibiotics as feed additives and therapeutic drugs. According to Implementing Regulations 1831/2003 and 1463/2004 of the European Commission, the EU has prohibited the use of antibiotics in animal feed since 2006. *Cordyceps* and *Cordyceps* fungal cultures, which are rich in a wide range of bioactive substances, have attracted substantial attention as potential health complements and antibiotic alternatives. *Cordyceps* is one of the largest genera of reported entomopathogenic fungi. *Cordyceps sinensis* (*Berk.*), *C. militaris* (*Berk.*) and *C. gunnii* (*Berk.*) and other *Cordyceps* species have wide applications, including as herbs, medicinal mushrooms, health tonics, and feed additives, in regions of Asia. *C. gunnii* (*Berk.*) is a *Cordyceps* species parasitized by *Acremonium terricola* on Hepialidae larvae; this species has only lately been commercially developed but has considerable market competitiveness. Furthermore, *C. gunnii* (*Berk.*) can adapt to varied geography, elevations, and climatic circumstances; hence, its artificial cultivation has been actively investigated. Owing to the rarity and insufficient yield, including the recentness of its artificial cultivation, the broader applications of *C. gunnii* (*Berk.*) are limited. However, *Acremonium terricola* was isolated from *C. gunnii* (*Berk.*) and placed on an artificial medium to produce *Acremonium terricola* culture (ATC) using artificial liquid–solid two-phase fermentation technology. To date, several studies have investigated the use of ATC as a feed additive in weaned calves [2], dairy cows [3,4], transition dairy cows [5], and rats with mastitis [6]; however, the test materials and target indicators differed from those used in this study. The studies mentioned above show that ATC supplementation has functional benefits, such as growth promotion [2], production improvement [4,5], blood metabolism regulation [3], antioxidant and immune enhancement [2,4–6] and anti-inflammatory effects [6]. ATC supplementation in chickens [1] and geese [7] has demonstrated its potential as a dietary supplement for poultry. ATC supplementation has been explored to replace supplementation with the expensive and rare *C. gunnii (Berk.)* and other *Cordyceps* species because it contains similar functional bioactive components, namely, adenosine, cordycepin (3'-deoxyadenosin) and ergosterol. ATC contains a variety of compounds, of which adenosine is the most explored nucleoside, and ergosterol is a sterol unique to fungi [8] that can be converted to vitamin D_2 under ultraviolet irradiation. These three active ingredients (adenosine, cordycepin, and ergosterol) can exert an anti-inflammatory effect and reduce tissue damage caused by inflammation. Adenosine, as an intermediate metabolite of adenosine triphosphate (ATP) degradation, plays a variety of

physiological regulatory functions. Cordycepin, which is similar in structure to adenosine but lacks only a 3' hydroxyl group, acts as a nucleoside analog [9]. Cordycepin is more potent than adenosine in terms of its biochemical and molecular activity [10]. Ergosterol is available in two forms, free and esterified; these forms influence different physiological functions [11]. According to Hurn [12], the adenosine content in the fruiting body and corpus of *C. militaris* (*Berk.*) was 0.18% and 0.06%, respectively, and the cordycepin content was 0.97% and 0.36%, respectively. The contents of adenosine, cordycepin and ergosterol in *C. gunnii* (*Berk.*) and ATC have not been reported, and it is difficult to produce precise values due to variation induced by factors such as strain, growing stage, and geographic location. Considering the above facts, studying the effect of ATC as a feed supplement for Hortobágy geese has practical importance.

In summary, the main active components of ATC are nucleosides (adenosine), nucleoside analogs (cordycepin), and sterols (ergosterol); thus, the use of ATC as a feed supplement for Hortobágy geese is novel, advantageous, and generalizable. The objective of the present study was to investigate the effects of dietary ATC supplementation in Hortobágy geese, as assessed by meat quality, conventional characteristics, and flavor substances.

MATERIALS AND METHODS

Animal care

The present experiment was reviewed and approved by the Institutional Animal Care and Use Committee of the Animal Welfare Committee of Yangzhou University (permit number: SYXK (Su) IACUC 2012-0029). All the experimental processes related to animal feeding and slaughter were carried out in strict accordance with the recommendations of the Guide for Ethical Review of Laboratory Animal Welfare issued by the National Technical Committee for Standardization of Laboratory Animals and the Guide for the Care and Use of Laboratory Animals of Jiangsu Province. All efforts were made to minimize the suffering of the laboratory animals as recommended by directive no. 2010/63/EU and the ARRIVE guidelines 2.0 (https://arriveguidelines.org).

Animals, housing, diets, and experimental design

The study utilized Hortobágy geese. A total of 720 one-day-old goslings were obtained from a commercial hatchery (Xiangtiange Poultry, Maanshan, Anhui, China), randomly divided into 4 groups of dietary treatments (control group: fed a basal diet; and three treatment groups fed a basal diet supplemented with 3, 5, and 7 g/kg ATC, respectively), with 6 replicate pens per treatment. Each replicate consisted of 30 goslings (half male and half female) that were fed separately in an enclosure containing a playground and pond and with a feeding density of 5 birds per square meter. The treatment groups were labelled the low-dose group, moderate-dose group, and high-dose group depending on the dosage of ATC (3, 5, and 7 g/kg ATC, respectively). Up to the age of 28 days, the goslings were kept indoors; subsequently, they were fully exposed to natural light and temperature and were free to roam and socialize during the day. The basal diet was formulated based on the National Research Council nutrient requirements for growing geese [13], and the ingredients and results of the chemical composition analysis of the basal diets are shown in Table 1. All individuals developed healthily under the same rearing conditions and had *ad libitum* and uncompetitive access to food and water.

The ATCs used in the present study were purchased from Metdo Biotechnology (Yangzhou, Jiangsu, China).

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Table 1. Ingredients and analyzed chemical compositions of the control diet (air-dried basis)

Item	Days 1 to 14	Days 15 to 70
Composition (%)	100	100
Corn	58	58
Soybean meal	16	5
Wheat bran	10	16
Corn gluten meal	2	2
Rice bran meal	9	16
Premix[1)]	5	3
Nutrient levels[2)]		
ME (MJ/kg)	11.04	10.96
Crude protein (%)	15.80	13.02
Crude fat (%)	4.05	4.22
Crude fiber (%)	4.07	4.35
Calcium (%)	0.17	0.15
Available phosphorus (%)	0.51	0.62
Lysine (%)	0.74	0.53
Methionine (%)	0.27	0.23

[1)]Premix for 1 to 14 days of age provided per kg of diet: vitamin A, 120 kilo international units (KIU); vitamin D_3, 24.5 KIU; vitamin E, 500 mg; vitamin K_3, 50 mg; vitamin B_1, 45 mg; vitamin B_2, 185 mg; vitamin B_6, 72 mg; vitamin B_{12}, 0.28 mg; niacin, 900 mg; pantothenic acid, 90 mg; folic acid, 24 mg; biotin, 3 mg; choline chloride, 4,500 mg; iron, 700 mg; copper, 8 mg; manganese, 1,440 mg; zinc, 1,100 mg; iodine, 2 mg; selenium, 2 mg. Premix for 15 to 70 days of age provided per kg of diet: vitamin A, 130 KIU; vitamin D_3, 19 KIU; vitamin E, 100 mg; vitamin K_3, 10 mg; vitamin B_1, 26 mg; vitamin B_2, 40 mg; vitamin B_6, 60 mg; vitamin B_{12}, 0.1 mg; niacin, 700 mg; pantothenic acid, 400 mg; folic acid, 12 mg; biotin, 4 mg; choline chloride, 10,000 mg; iron, 1,000 mg; copper, 90 mg; manganese, 600 mg; zinc, 600 mg; iodine, 8 mg; and selenium, 2 mg.

[2)]Metabolizable energy, crude protein, calcium, and available phosphorus values were calculated.

Sample collection

At 70 days of age, twenty-four birds (equal numbers of males and females) were randomly selected from each treatment group. After 12 h of fasting, they were anesthetized with sodium pentobarbital, and then the carotid arteries were manually transected for exsanguination. The pectoralis majors and thigh muscles from the left side were excised and split into two pieces. One piece was chilled for 24 h at 4℃, and the pH, meat color, water loss rate, shear force and moisture content were measured. The other piece was stored in liquid nitrogen for further measurements of conventional characteristics and flavor substances.

Meat quality measurement

After the muscle fascia were removed, the muscles were evenly spread and the sensor surface of a handheld colorimeter (OPTO-STAR, Matthaus, Berlin, Germany) was placed in full contact with the muscle surface until the displayed value stabilized, and then this value was recorded. The meat color of each sample was assessed at three random positions and averaged to determine the value of the meat color.

Fresh muscle (1.0 g, accurate to 0.0001 g) was weighed by an analytical balance (XB120A, Precisa, Dietikon, Switzerland) after removing the fascia and fat; it was wrapped in two layers of medical gauze with 15 layers of absorbent filter paper on the top and bottom and a rigid plastic pad on each side of the filter paper. Then, the sample was placed on the platform of a compactor (Tenovo M-1, Tenovo International, Beijing, China), and the parameters were set to pressurize at a constant speed of 35.0 kg and then held for 5.0 min. The sample was weighed immediately after

compression, and the water loss rate (%) was calculated according to the following formula:

$$\text{Water loss rate (\%)} = \frac{(\text{Weight before compression} - \text{Weight after compression})}{\text{Weight before compression}} \times 100$$

The fresh muscle was trimmed into strips (length: 3 cm, width: 1 cm, thickness: 0.5 cm) parallel to the longitudinal muscle fibers, and the fascia, fat and sarcolemma were removed. Then, the shear force was measured with a digital tenderness meter (Bosin-BS, BosinTech, Shanghai, China). The average value was calculated after each sample was sheared three times.

An incision (0.5 cm) on the muscle surface was made with a scalpel, and the electrode end of an acidometer (PH-STAR, Matthaus) was inserted into the incision, ensuring that the electrode segment was completely embedded in the meat. The pH value was recorded after the displayed value stabilized. For each sample, three points were randomly chosen for measurements, and the average of these three values was recorded as the pH value. The pH value was measured at 0 h, 12 h, and 24 h after sampling.

The sampling and the measurement environments were kept as consistent as possible.

Measurement of conventional meat characteristics

The measurements of the moisture, crude ash (CA), crude protein (CP), and crude fat (CF) contents was performed according to the corresponding methods specified in the National Standard for Food Safety (GB/T 5009.3-2016).

A weighing bottle with a cap placed on the edge of the bottle was placed in an oven (FD260, Binder GmbH, Tuttlingen, Germany) at 101-105℃ for 1.0 h; then, the cap was placed on the top and the weighing bottle was moved to a desiccator (DZG-6050SAD, Senxin Experimental Instrument, Shanghai, China) to cool for 0.5 h before being weighed. The heating and cooling processes were repeated, and the difference in mass between the first and second weighing did not exceed 2 mg, which was the constant mass of the weighing bottle (m_3). Uniformly ground muscle (2 g; accurate to 0.1 mg) with a thickness of no more than 5 mm was weighed. After being placed in the weighing bottle, the heating and cooling processes were carried out as described previously; however, the durations of the heating and cooling were 2 h and 1 h, respectively. The mass of muscle + weighing bottle before drying and the mass of muscle + weighing bottle after drying were recorded as m_1 and m_2, respectively. The moisture content of the meat was calculated according to the following formula:

$$\text{Moisture (\%)} = \frac{m_1 - m_2}{m_1 - m_3} \times 100$$

To measure the CA content, a crucible was heated in a muffle furnace (M110, Thermo Fisher Scientific, Waltham, MA, USA) at 550 ± 25℃ for 30 min; the difference in weight before and after heating did not exceed 0.5 mg. Then, muscle was added to the crucible and heated at 550 ± 25℃ for 4 h; the difference in weight before and after heating did not exceed 0.5 mg.

The CP content (%, nitrogen content × 6.25) was measured following the Kjeldahl method with an automatic Kjeldahl meter (Kjeltec 8400, FOSS NIRSystems, Hillerød, Denmark).

The CF content was measured by a Soxhlet apparatus (SOX606, Hanon Technology, Jinan, China) using petroleum ether reflux extraction for 6 h.

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Inosinic acid, amino acid and fatty acid measurements

The pH of the combined supernatant after repeated extraction with 5% perchloric acid was adjusted to 6.5 by 0.5 mol/L sodium hydroxide solution. Then, the inosinic acid content was measured by a high-performance liquid chromatography system (Alliance e2695, Waters, Milford, MA, USA) in a Waters C18 column (4.6 mm × 250 mm, 5 μm) with 0.05 mol/L sodium dihydrogen phosphate buffer solution (pH 6.5) and analytical-grade methanol as the mobile phase.

Amino acid (AA) levels were measured according to the corresponding method specified in the National Standard for Food Safety (GB5009.124-2016). Muscle and hydrochloric acid were added to the hydrolysis tube, and then it was vacuum-packed and placed in a 110 ± 1℃ temperature-controlled chamber (FD260, Binder GmbH) for 22 h. After cooling to room temperature, the hydrolysis solution was transferred to a 50-mL volumetric flask, and sodium citrate was added to adjust the pH to 2.2; the solution was then filtered through a 0.22-μm membrane and transferred to a sample bottle for AA level measurement by an automatic amino acid analyzer (L-8900, Hitachi, Tokyo, Japan).

Fatty acid (FA) content was measured according to the corresponding method specified in the National Standard for Food Safety (GB5009.168-2016). Muscle, toluene, and 10% acetylchloromethanol solution were placed in a glass tube; the tube was filled with nitrogen, sealed, placed in a water bath at 80 ± 1℃ for 2 h, removed and shaken once every 20 min. The sample solution was cooled to room temperature and then transferred to a centrifuge tube, and the wall of the glass tube was washed three times with sodium bicarbonate solution. The combined solution was centrifuged at 5,000 r/min for 5 min, and then the supernatant was measured by a gas chromatography system (7890A, Agilent, Santa Clara, CA, USA). The relevant parameters are described in detail in the study by Yu et al. [14].

Statistical analyses

All data analyses were performed using a one-way analysis of variance (ANOVA) performed in SPSS 25.0 statistical software (IBM-SPSS, Armonk, NY, USA). Each replicate pen served as an experimental unit for all statistical analyses. The statistical significance of the differences between treatment groups was measured using Duncan's multiple range test, polynomial contrasts were used to test the linear and quadratic effects of ATC supplementation, and p values less than or equal to 0.05 were considered statistically significant. All data are presented as arithmetic mean values ± standard deviations.

RESULTS

Meat quality

The meat color, water loss rate and shear force of Hortobágy geese from the 4 treatment groups did not differ significantly among males, females, or both sexes ($p > 0.05$). The relevant data are shown in Table 2, presented separately for the pectoralis major and thigh muscle. As shown in Table 3, the pH of the pectoralis major did not significantly differ at 0 h postmortem and 24 h postmortem among the 4 treatment groups ($p > 0.05$). In females and both sexes, the pH of the pectoralis major at 12 h postmortem in the moderate-dose group was significantly higher than that of the control group. In females, the pH of the pectoralis major at 12 h postmortem increased in a linear ($p = 0.002$) and quadratic ($p = 0.008$) manner as levels of dietary ATC supplementation increased. In both sexes, the pH of the pectoralis major at 12 h postmortem exhibited a quadratic increase ($p = 0.009$). In contrast, the pH of the thigh muscle at 12 h postmortem in the control group was significantly higher than that of the moderate-dose group when comparing among males, females,

Table 2. Effects of dietary *Acremonium terricola* culture supplementation on the meat color, water loss rate and shear force of Hortobágy goose meat

Item	Muscle	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
								ANOVA	Linear	Quadratic
Meat color	Pectoralis major	♂ (n = 12)	81.66 ± 4.47	80.25 ± 5.75	82.96 ± 3.21	84.22 ± 3.23	0.944	0.517	0.532	0.188
		♀ (n = 12)	83.58 ± 5.89	82.67 ± 5.12	84.17 ± 1.74	84.94 ± 4.23	0.947	0.877	0.704	0.488
		♂ + ♀ (n = 24)	82.62 ± 5.03	81.46 ± 5.29	83.57 ± 2.51	84.58 ± 3.57	0.672	0.412	0.460	0.139
	Thigh	♂	85.39 ± 3.83	85.44 ± 1.44	87.01 ± 3.23	87.63 ± 4.19	0.722	0.644	0.947	1.221
		♀	85.27 ± 3.55	87.02 ± 4.88	87.50 ± 2.61	88.99 ± 1.22	0.751	0.396	0.582	0.179
		♂ + ♀	85.33 ± 3.48	86.23 ± 3.49	87.25 ± 2.78	88.31 ± 3.00	0.518	0.202	0.718	0.056
Water loss rate (%)	Pectoralis major	♂	32.88 ± 5.34	30.95 ± 4.02	33.18 ± 4.15	30.65 ± 4.68	0.974	0.753	0.727	0.998
		♀	27.34 ± 2.92	28.46 ± 6.40	31.45 ± 3.44	30.23 ± 5.34	1.038	0.541	0.636	0.184
		♂ + ♀	30.11 ± 5.00	29.70 ± 5.20	32.32 ± 3.71	30.44 ± 4.74	0.731	0.615	0.922	0.328
	Thigh	♂	28.75 ± 4.27	26.21 ± 4.69	28.91 ± 2.37	27.84 ± 4.02	0.845	0.690	0.417	0.617
		♀	26.33 ± 1.21	25.82 ± 3.46	28.26 ± 1.96	26.21 ± 3.10	0.574	0.470	0.924	0.334
		♂ + ♀	27.54 ± 3.22	26.01 ± 3.89	28.59 ± 2.08	27.03 ± 3.49	0.514	0.365	0.513	0.323
Shear force (N)	Pectoralis major	♂	27.00 ± 1.53	28.31 ± 3.25	27.89 ± 2.58	25.09 ± 1.43	0.556	0.172	0.167	0.280
		♀	25.26 ± 2.68	25.37 ± 2.04	26.20 ± 1.85	26.29 ± 1.97	0.456	0.819	0.956	0.353
		♂ + ♀	26.13 ± 2.25	26.84 ± 2.99	27.04 ± 2.30	25.69 ± 1.74	0.370	0.554	0.303	0.873
	Thigh	♂	19.45 ± 1.08	21.14 ± 2.28	20.28 ± 1.91	20.74 ± 2.60	0.444	0.607	0.277	0.815
		♀	19.52 ± 1.32	19.55 ± 1.91	20.37 ± 1.86	19.45 ± 0.91	0.330	0.762	0.750	0.599
		♂ + ♀	19.49 ± 1.14	20.34 ± 2.15	20.33 ± 1.78	20.10 ± 1.96	0.279	0.686	0.277	0.607

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

and both sexes ($p < 0.05$); in both sexes, the pH of the thigh muscle at 0 h postmortem in the control group was significantly higher than that in the moderate-dose and high-dose groups ($p < 0.05$). In males, increasing doses of dietary ATC decreased the pH of the thigh muscle at 12 h postmortem in a quadratic manner ($p < 0.001$). In females, the pH of the thigh muscle at 12 h postmortem decreased in a linear manner ($p = 0.002$) as the dose of dietary ATC increased. In both sexes, the pH of the pectoralis major at 12 h postmortem decreased in a linear ($p < 0.001$) and quadratic ($p = 0.002$) manner as the dose of dietary ATC increased. In females, the pH of the thigh muscle at 24 h postmortem was significantly higher in the control group than in the low-dose and moderate-dose groups ($p < 0.05$). Additionally, in females, increases in dietary ATC dose decreased the pH of the thigh muscle at 24 h postmortem in a linear ($p = 0.001$) manner.

Meat conventional characteristics

There was no significant difference in the moisture content among the 4 treatment groups ($p > 0.05$) (Table 4). The CA, CP, and CF contents were comparable among the treatment groups. In male geese, the CA content of the pectoralis major in the control group was significantly lower than that in the moderate-dose group ($p < 0.05$). The CA content of the thigh muscle in males increased linearly ($p = 0.005$) and quadratically ($p = 0.036$) as the dietary ATC dose increased. In female geese, the CP content of the pectoralis major in the high-dose group was 22.4%, which was significantly higher than that in the control group ($p < 0.05$). In contrast, in females, the CP content of the thigh muscle was significantly lower in the high-dose group than in the control group ($p < 0.05$). Similarly, in females and in both sexes, the CP content of the thigh muscle was significantly

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Table 3. Effects of dietary *Acremonium terricola* culture supplementation on the pH value of Hortobágy goose meat

Muscle	Time point	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
								ANOVA	Linear	Quadratic
Pectoralis major	pH at 0 h postmortem	♂	5.95 ± 0.07	5.85 ± 0.11	5.82 ± 0.16	5.75 ± 0.15	0.031	0.118	0.370	0.049
		♀	5.83 ± 0.10	5.84 ± 0.16	5.85 ± 0.19	5.91 ± 0.18	0.033	0.876	0.906	0.554
		♂ + ♀	5.89 ± 0.10	5.85 ± 0.14	5.83 ± 0.16	5.83 ± 0.17	0.022	0.746	0.515	0.407
	pH at 12 h postmortem	♂	5.73 ± 0.06	5.77 ± 0.26	5.82 ± 0.27	5.97 ± 0.22	0.049	0.350	0.924	0.151
		♀	5.59 ± 0.10^{Bc}	5.85 ± 0.20^{ABb}	6.08 ± 0.10^{Aa}	5.77 ± 0.17^{Bbc}	0.050	0.001	0.002	0.008
		♂ + ♀	5.66 ± 0.11^{Bb}	5.81 ± 0.22^{ABab}	5.95 ± 0.23^{Aa}	5.87 ± 0.21^{ABa}	0.035	0.021	0.073	0.009
	pH at 24 h postmortem	♂	5.98 ± 0.05	6.03 ± 0.19	6.01 ± 0.15	6.04 ± 0.13	0.028	0.896	0.697	0.747
		♀	6.00 ± 0.11	5.99 ± 0.12	5.96 ± 0.09	6.05 ± 0.13	0.024	0.649	0.616	0.859
		♂ + ♀	5.99 ± 0.08	6.01 ± 0.15	5.98 ± 0.12	6.05 ± 0.12	0.018	0.640	0.986	0.701
Thigh	pH at 0 h postmortem	♂	6.21 ± 0.09	6.15 ± 0.09	6.08 ± 0.22	6.04 ± 0.06	0.031	0.181	0.568	0.046
		♀	6.26 ± 0.12	6.07 ± 0.10	6.04 ± 0.18	6.09 ± 0.15	0.035	0.104	0.043	0.139
		♂ + ♀	6.24 ± 0.11^{Aa}	6.11 ± 0.10^{ABb}	6.06 ± 0.19^{Bb}	6.06 ± 0.11^{Bb}	0.023	0.016	0.045	0.011
	pH at 12 h postmortem	♂	6.12 ± 0.11^{Aa}	6.01 ± 0.09^{Aa}	5.80 ± 0.13^{Bc}	5.95 ± 0.09^{ABb}	0.034	0.003	0.040	0.001
		♀	6.13 ± 0.14^{A}	5.79 ± 0.22^{B}	5.73 ± 0.13^{B}	5.92 ± 0.17^{AB}	0.049	0.009	0.002	0.103
		♂ + ♀	6.12 ± 0.12^{Aa}	5.90 ± 0.20^{Bbc}	5.77 ± 0.13^{Bc}	5.94 ± 0.13^{Bb}	0.030	< 0.001	< 0.001	0.002
	pH at 24 h postmortem	♂	6.21 ± 0.16	6.16 ± 0.13	6.11 ± 0.23	6.14 ± 0.07	0.034	0.808	0.598	0.427
		♀	6.36 ± 0.10^{Aa}	6.17 ± 0.05^{Bb}	6.16 ± 0.09^{Bb}	6.24 ± 0.05^{ABb}	0.024	0.004	0.001	0.089
		♂ + ♀	6.28 ± 0.15	6.16 ± 0.09	6.14 ± 0.17	6.19 ± 0.08	0.022	0.084	0.032	0.146

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

$^{a–c}$Means within a row with different superscripts differ significantly ($p < 0.05$).

$^{A–C}$Means within a row with different superscripts differ extremely significantly ($p < 0.01$).

lower in the high-dose group than in the control group ($p < 0.05$). As displayed in Table 4, in females and both sexes, the CF content of the pectoralis major was significantly higher in the high-dose group than in the control group ($p < 0.05$). In males, the high-dose group had the lowest CF content of the thigh muscle, and this difference was significant. There was a quadratic increase in the CF content of the pectoralis major in females ($p = 0.01$) and in both sexes ($p = 0.031$).

Inosinic acid, amino acid levels and fatty acid composition

Table 5 lists the inosinic acid content of the pectoralis major and the thigh muscle of the Hortobágy geese. In both sexes, the inosinic acid content of the pectoralis major and thigh muscle were significantly higher in the moderate-dose group than in the control group ($p < 0.05$). There was a quadratic increase in the inosinic acid content of the pectoralis major in both sexes ($p = 0.013$). In males, the inosinic acid content of the thigh muscle was significantly higher in the high-dose group than in the control group ($p < 0.05$). Additionally, in males, increases in the dose of dietary ATC increased the inosinic acid content of the thigh muscle in a linear ($p = 0.011$) manner. In females, the inosinic acid content of the thigh muscle was significantly higher in the moderate-dose group than in the control group ($p < 0.05$). The inosinic acid content of the thigh muscle in both sexes increased in a linear ($p = 0.009$) and quadratic ($p = 0.005$) manner with increasing doses of dietary ATC. However, there were no significant differences in the inosinic acid content of the pectoralis major in males or females.

The group differences in AA levels (g/100 g of meat) of the pectoralis major and thigh muscle of Hortobágy geese are presented in Tables 6 and 7. Our study did not detect any significant

Table 4. Effects of dietary *Acremonium terricola* culture supplementation on conventional meat characteristics of Hortobágy geese (%)

Characteristic	Muscle	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
								ANOVA	Linear	Quadratic
Moisture content	Pectoralis major	♂	76.03 ± 1.98	74.34 ± 1.90	74.28 ± 0.76	75.03 ± 0.63	0.340	0.237	0.063	0.425
		♀	74.35 ± 0.94	74.91 ± 0.75	75.16 ± 1.79	74.55 ± 2.05	0.314	0.823	0.448	0.736
		♂ + ♀	75.19 ± 1.71	74.63 ± 1.39	74.72 ± 1.38	74.79 ± 1.45	0.229	0.843	0.411	0.748
	Thigh	♂	75.91 ± 2.16	74.73 ± 2.11	75.63 ± 2.27	76.00 ± 1.97	0.484	0.325	0.076	0.837
		♀	75.00 ± 1.54	74.96 ± 1.87	75.20 ± 1.61	76.12 ± 1.74	0.364	0.678	0.759	0.385
		♂ + ♀	76.15 ± 2.13	74.85 ± 1.89	75.41 ± 1.87	76.06 ± 1.75	0.303	0.398	0.101	0.695
Crude ash	Pectoralis major	♂	1.63 ± 0.24^{b}	1.64 ± 0.18	1.91 ± 0.19^{a}	1.86 ± 0.21	0.051	0.092	0.817	0.014
		♀	1.79 ± 0.21	1.80 ± 0.19	1.72 ± 0.21	1.53 ± 0.38	0.059	0.347	0.660	0.158
		♂ + ♀	1.71 ± 0.23	1.72 ± 0.19	1.81 ± 0.21	1.70 ± 0.34	0.039	0.719	0.644	0.629
	Thigh	♂	1.25 ± 0.10^{B}	1.54 ± 0.23^{A}	1.26 ± 0.04^{B}	1.27 ± 0.06^{B}	0.038	0.007	0.005	0.036
		♀	1.35 ± 0.09	1.26 ± 0.08	1.29 ± 0.11	1.28 ± 0.13	0.023	0.600	0.232	0.705
		♂ + ♀	1.30 ± 0.10	1.40 ± 0.22^{a}	1.27 ± 0.08^{b}	1.28 ± 0.10	0.022	0.149	0.143	0.089
Crude protein	Pectoralis major	♂	20.40 ± 0.90	21.14 ± 0.29	20.76 ± 0.86	20.39 ± 0.88	0.175	0.399	0.116	0.585
		♀	21.10 ± 0.61^{b}	21.30 ± 0.75^{ab}	21.03 ± 0.43^{b}	22.40 ± 1.30^{a}	0.214	0.066	0.649	0.189
		♂ + ♀	20.75 ± 0.81	21.22 ± 0.54	20.89 ± 0.66	21.39 ± 1.49	0.150	0.421	0.504	0.599
	Thigh	♂	21.49 ± 0.69	21.99 ± 0.21	21.75 ± 0.89	20.99 ± 1.20	0.191	0.298	0.192	0.336
		♀	22.41 ± 1.04^{a}	21.76 ± 1.17^{ab}	21.90 ± 0.74^{ab}	20.96 ± 1.03^{b}	0.239	0.193	0.622	0.165
		♂ + ♀	21.95 ± 0.97^{a}	21.88 ± 0.80^{a}	21.83 ± 0.78^{a}	20.98 ± 1.06^{b}	0.152	0.072	0.629	0.082
Crude fat	Pectoralis major	♂	1.58 ± 0.29	1.82 ± 0.39	1.73 ± 0.42	1.84 ± 0.13	0.071	0.586	0.361	0.565
		♀	1.78 ± 0.33^{Bb}	1.74 ± 0.32^{Bb}	1.92 ± 0.31^{ABb}	2.42 ± 0.29^{Aa}	0.089	0.013	0.351	0.010
		♂ + ♀	1.68 ± 0.31^{Bb}	1.78 ± 0.34^{ABb}	1.83 ± 0.36^{ABab}	2.13 ± 0.37^{Aa}	0.059	0.039	0.989	0.031
	Thigh	♂	2.37 ± 0.39^{a}	2.40 ± 0.29^{a}	2.65 ± 0.43^{a}	2.10 ± 0.10^{b}	0.081	0.115	0.352	0.952
		♀	2.39 ± 0.34	2.78 ± 0.29	2.42 ± 0.32	2.74 ± 0.29	0.076	0.120	0.185	0.960
		♂ + ♀	2.38 ± 0.35	2.59 ± 0.34	2.53 ± 0.38	2.42 ± 0.40	0.057	0.550	0.158	0.945

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

^{a,b}Means within a row with different superscripts differ significantly ($p < 0.05$).

^{A,B}Means within a row with different superscripts differ extremely significantly ($p < 0.01$).

differences in AAs, nonessential AAs (NEAAs), essential AAs (EAAs), flavoring AAs (FAAs), or total AAs (TAAs) of the pectoralis major and thigh muscle in males, females, or both sexes ($p > 0.05$). The EAA/TAA, FAA/TAA, and EAA/NEAA ratios did not significantly differ ($p > 0.05$). Table 8 displays the FA levels in the pectoralis major. The percentage of palmitoleic acid (C16:1 n-7) in the pectoralis major in males and in both sexes was higher in the low-dose group and the moderate-dose group than in the control group ($p < 0.05$). In females, however, the percentage of palmitoleic acid in the pectoralis major did not differ among the groups ($p > 0.05$). In males, females, and both sexes, increased doses of dietary ATC increased the percentage of palmitoleic acid in the pectoralis major in a linear manner ($p < 0.05$). In females and both sexes, the high-dose group had a higher percentage of α-linolenic acid (C18:3 n-3) in the pectoralis major than the control group and the low-dose group ($p < 0.05$). In both sexes, increased doses of dietary ATC increased the percentage of α-linolenic acid in the pectoralis major in a linear ($p = 0.023$) and quadratic ($p = 0.001$) manner; the maximum increase in the percentage of α-linolenic acid in the pectoralis major occurred in the high-dose group. In both sexes, the pectoralis major had a lower percentage of arachidonic acid (C20:3 n-3) in the low-dose group than the control group ($p < 0.05$). Additionally,

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Table 5. Effects of dietary *Acremonium terricola* culture supplementation on the inosinic acid content of Hortobágy geese (mg/g)

Muscle	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
Pectoralis major	♂	1.26 ± 0.08	1.28 ± 0.05	1.36 ± 0.12	1.30 ± 0.08	0.020	0.349	0.494	0.143
	♀	1.21 ± 0.04	1.30 ± 0.04	1.34 ± 0.18	1.35 ± 0.05	0.023	0.162	0.243	0.062
	♂ + ♀	1.24 ± 0.07^{Bb}	1.29 ± 0.04^{ABab}	1.35 ± 0.14^{Aa}	1.32 ± 0.07^{ABa}	0.015	0.045	0.164	0.013
Thigh	♂	1.74 ± 0.05^{B}	1.80 ± 0.15^{AB}	1.87 ± 0.07^{AB}	1.93 ± 0.11^{A}	0.026	0.046	0.570	0.011
	♀	1.71 ± 0.09^{Bb}	1.94 ± 0.07^{ABa}	2.00 ± 0.20^{Aa}	1.85 ± 0.13^{ABab}	0.037	0.016	0.005	0.101
	♂ + ♀	1.72 ± 0.07^{Bb}	1.87 ± 0.13^{ABa}	1.93 ± 0.15^{Aa}	1.89 ± 0.12^{Aa}	0.023	0.003	0.009	0.005

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

[a,b]Means within a row with different superscripts differ significantly ($p < 0.05$).

[A,B]Means within a row with different superscripts differ extremely significantly ($p < 0.01$).

Table 6. Effects of dietary *Acremonium terricola* culture supplementation on the amino acid levels of the pectoralis major of Hortobágy geese (g/100 g of meat)

Amino acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
Aspartic acid	♂	6.29 ± 0.03	6.14 ± 0.17	6.23 ± 0.10	6.16 ± 0.33	0.051	0.793	0.476	0.868
	♀	6.29 ± 0.27	5.98 ± 0.40	6.18 ± 0.09	6.16 ± 0.16	0.072	0.536	0.196	0.813
	♂ + ♀	6.29 ± 0.17	6.06 ± 0.29	6.20 ± 0.09	6.16 ± 0.23	0.043	0.312	0.101	0.921
Glutamic acid	♂	13.29 ± 0.13	13.02 ± 0.36	13.16 ± 0.18	12.87 ± 0.56	0.099	0.529	0.584	0.522
	♀	13.21 ± 0.51	12.48 ± 0.72	12.95 ± 0.23	13.02 ± 0.36	0.145	0.378	0.115	0.643
	♂ + ♀	13.25 ± 0.34	12.75 ± 0.59	13.05 ± 0.22	12.94 ± 0.43	0.087	0.244	0.084	0.283
Glycine	♂	3.71 ± 0.18	3.86 ± 0.27	3.61 ± 0.35	3.81 ± 0.10	0.067	0.596	0679	0.606
	♀	3.74 ± 0.21	3.50 ± 0.11	3.81 ± 0.31	3.64 ± 0.33	0.073	0.499	0.425	0.469
	♂ + ♀	3.72 ± 0.18	3.68 ± 0.27	3.71 ± 0.32	3.73 ± 0.24	0.049	0.988	0.763	0.862
Alanine	♂	4.94 ± 0.15	4.88 ± 0.13	4.78 ± 0.16	4.90 ± 0.25	0.048	0.738	0.541	0.500
	♀	4.92 ± 0.20	4.67 ± 0.30	4.84 ± 0.17	4.78 ± 0.20	0.062	0.575	0.255	0.917
	♂ + ♀	4.93 ± 0.16	4.78 ± 0.24	4.81 ± 0.15	4.84 ± 0.22	0.039	0.546	0.173	0.711
Serine	♂	3.24 ± 0.04	3.20 ± 0.07	3.18 ± 0.05	3.22 ± 0.15	0.023	0.870	0.510	0.717
	♀	3.26 ± 0.11	3.11 ± 0.20	3.20 ± 0.07	3.17 ± 0.06	0.034	0.538	0.216	0.939
	♂ + ♀	3.25 ± 0.07	3.15 ± 0.14	3.19 ± 0.06	3.20 ± 0.11	0.020	0.447	0.126	0.866
Arginine	♂	4.94 ± 0.20	4.81 ± 0.20	4.77 ± 0.12	4.78 ± 0.23	0.052	0.710	0.461	0.403
	♀	4.85 ± 0.18	4.61 ± 0.30	4.79 ± 0.13	4.72 ± 0.18	0.058	0.560	0.264	0.841
	♂ + ♀	4.90 ± 0.18	4.71 ± 0.25	4.78 ± 0.11	4.75 ± 0.19	0.039	0.405	0.153	0.641
Proline	♂	10.41 ± 0.20	10.46 ± 0.21	10.11 ± 0.35	10.07 ± 0.42	0.093	0.352	0.828	0.090
	♀	10.27 ± 0.41	10.00 ± 0.50	10.14 ± 0.23	10.15 ± 0.20	0.092	0.838	0.408	0.970
	♂ + ♀	10.34 ± 0.30	10.23 ± 0.42	10.13 ± 0.27	10.11 ± 0.30	0.065	0.592	0.607	0.221
NEAAs	♂	52.18 ± 0.53	51.65 ± 1.48	51.25 ± 1.02	51.25 ± 2.34	0.387	0.854	0.692	0.466
	♀	52.06 ± 1.93	49.50 ± 2.87	51.22 ± 1.24	50.89 ± 1.51	0.563	0.499	0.190	0.814
	♂ + ♀	52.12 ± 1.27	50.58 ± 2.36	51.24 ± 1.01	51.07 ± 1.77	0.341	0.470	0.162	0.783
Tyrosine	♂	2.66 ± 0.12	2.56 ± 0.09	2.57 ± 0.03	2.56 ± 0.15	0.030	0.597	0.281	0.996
	♀	2.63 ± 0.09	2.52 ± 0.16	2.56 ± 0.05	2.53 ± 0.07	0.029	0.600	0.330	0.572
	♂ + ♀	2.65 ± 0.10	2.54 ± 0.12	2.57 ± 0.04	2.54 ± 0.11	0.020	0.223	0.110	0.334
Phenylalanine	♂	3.07 ± 0.04	2.97 ± 0.11	3.01 ± 0.04	3.03 ± 0.15	0.026	0.688	0.253	0.984
	♀	3.07 ± 0.10	2.94 ± 0.15	3.01 ± 0.08	2.98 ± 0.09	0.030	0.570	0.258	0.868
	♂ + ♀	3.07 ± 0.07	2.96 ± 0.12	3.01 ± 0.06	3.01 ± 0.11	0.020	0.278	0.072	0.900

Table 6. Continued

Amino acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
Threonine	♂	4.17 ± 0.07	4.05 ± 0.09	4.10 ± 0.11	4.12 ± 0.19	0.034	0.718	0.281	0.996
	♀	4.17 ± 0.14	3.96 ± 0.24	4.05 ± 0.09	4.08 ± 0.09	0.043	0.459	0.136	0.993
	♂ + ♀	4.17 ± 0.10	4.00 ± 0.17	4.08 ± 0.09	4.10 ± 0.14	0.027	0.208	0.040	0.992
Cysteine	♂	0.62 ± 0.04	0.62 ± 0.02	0.64 ± 0.02	0.63 ± 0.04	0.008	0.752	0.815	0.316
	♀	0.66 ± 0.01	0.60 ± 0.04	0.67 ± 0.04	0.60 ± 0.04	0.013	0.061	0.232	0.874
	♂ + ♀	0.64 ± 0.03	0.61 ± 0.03	0.65 ± 0.03	0.62 ± 0.04	0.007	0.131	0.449	0.448
Valine	♂	3.85 ± 004	3.77 ± 0.13	3.75 ± 0.13	3.83 ± 0.22	0.037	0.790	0.410	0.800
	♀	3.85 ± 0.18	3.65 ± 0.19	3.72 ± 0.07	3.75 ± 0.14	0.043	0.483	0.149	0.878
	♂ + ♀	3.85 ± 0.12	3.71 ± 0.16	3.74 ± 0.09	3.79 ± 0.17	0.029	0.335	0.076	0.758
Methionine	♂	2.21 ± 0.04	2.23 ± 0.06	2.15 ± 0.08	1.72 ± 0.76	0.113	0.379	0.638	0.240
	♀	2.15 ± 0.11	2.10 ± 0.13	2.11 ± 0.02	2.18 ± 0.08	0.025	0.686	0.370	0.719
	♂ + ♀	2.18 ± 0.08	2.16 ± 0.11	2.13 ± 0.06	1.95 ± 0.54	0.057	0.490	0.805	0.270
Isoleucine	♂	3.88 ± 0.07	3.75 ± 0.13	3.77 ± 0.11	3.75 ± 0.24	0.040	0.697	0.381	0.545
	♀	3.83 ± 0.17	3.59 ± 0.19	3.67 ± 0.06	3.71 ± 0.14	0.096	0.289	0.071	0.840
	♂ + ♀	3.86 ± 0.12	3.67 ± 0.17	3.72 ± 0.10	3.73 ± 0.17	0.031	0.175	0.041	0.542
Leucine	♂	7.61 ± 0.29	7.23 ± 0.23	7.29 ± 0.18	7.33 ± 0.41	0.084	0.446	0.159	0.522
	♀	7.45 ± 0.29	7.11 ± 0.48	7.25 ± 0.10	7.18 ± 0.21	0.084	0.562	0.245	0.718
	♂ + ♀	7.53 ± 0.27	7.17 ± 0.34	7.27 ± 0.13	7.26 ± 0.30	0.059	0.154	0.044	0.436
Lysine	♂	5.74 ± 0.06	5.67 ± 0.12	5.80 ± 0.19	5.65 ± 0.33	0.053	0.764	0.904	0.874
	♀	5.80 ± 0.24	5.47 ± 0.40	5.59 ± 0.06	5.71 ± 0.22	0.074	0.476	0.137	0.930
	♂ + ♀	5.77 ± 0.16	5.57 ± 0.29	5.70 ± 0.17	5.68 ± 0.25	0.045	0.493	0.167	0.861
Histidine	♂	2.08 ± 0.22	2.09 ± 0.07	2.19 ± 0.13	2.24 ± 0.16	0.127	0.548	0.977	0.188
	♀	2.23 ± 0.12	2.03 ± 0.18	2.09 ± 0.08	2.13 ± 0.06	0.037	0.293	0.074	0.719
	♂ + ♀	2.16 ± 0.18	2.06 ± 0.13	2.14 ± 0.11	2.19 ± 0.13	0.028	0.487	0.213	0.375
EAAs	♂	30.53 ± 0.39	29.68 ± 0.78	29.87 ± 0.75	29.43 ± 1.56	0.268	0.574	0.421	0.443
	♀	30.32 ± 1.22	28.81 ± 1.75	29.40 ± 0.33	29.58 ± 0.88	0.330	0.502	0.156	0.916
	♂ + ♀	30.42 ± 0.82	29.24 ± 1.30	29.64 ± 0.58	29.51 ± 1.13	0.211	0.232	0.076	0.528
FAAs	♂	33.16 ± 0.51	32.72 ± 1.13	32.55 ± 0.74	32.53 ± 1.45	0.264	0.860	0.635	0.515
	♀	33.01 ± 1.30	31.24 ± 1.81	32.58 ± 0.92	32.32 ± 1.18	0.385	0.461	0.181	0.687
	♂ + ♀	33.09 ± 0.88	31.98 ± 1.58	32.56 ± 0.75	32.42 ± 1.19	0.233	0.432	0.142	0.933
TAAs	♂	82.70 ± 0.91	81.32 ± 2.26	81.12 ± 1.76	80.68 ± 3.82	0.640	0.766	0.571	0.451
	♀	82.38 ± 3.15	78.31 ± 4.63	80.63 ± 1.56	80.48 ± 2.39	0.887	0.507	0.175	0.913
	♂ + ♀	82.54 ± 2.08	79.82 ± 3.65	80.87 ± 1.51	80.58 ± 2.85	0.545	0.361	0.119	0.679
EAA/TAA%	♂	36.91 ± 0.08	36.49 ± 0.07	36.82 ± 0.15	36.48 ± 0.47	0.086	0.150	0.204	0.726
	♀	36.80 ± 0.08	36.79 ± 0.11	36.47 ± 0.30	36.76 ± 0.08	0.059	0.125	0.460	0.104
	♂ + ♀	36.86 ± 0.09	36.64 ± 0.18	36.65 ± 0.29	36.62 ± 0.34	0.051	0.318	0.179	0.257
FAA/TAA%	♂	40.10 ± 0.39	40.23 ± 0.35	40.13 ± 0.54	40.32 ± 0.35	0.105	0.913	0.854	0.810
	♀	40.07 ± 0.29	39.89 ± 0.10	40.40 ± 0.38	40.16 ± 0.35	0.092	0.287	0.692	0.164
	♂ + ♀	40.09 ± 0.31	40.06 ± 0.30	40.26 ± 0.44	40.24 ± 0.32	0.069	0.662	0.930	0.223
EAA/NEAA%	♂	58.51 ± 0.20	57.47 ± 0.16	58.29 ± 0.38	57.43 ± 1.17	0.213	0.148	0.200	0.729
	♀	58.24 ± 0.20	58.19 ± 0.28	57.40 ± 0.75	58.13 ± 0.21	0.147	0.125	0.459	0.104
	♂ + ♀	58.37 ± 0.23	57.83 ± 0.45	57.85 ± 0.72	57.78 ± 0.85	0.126	0.316	0.176	0.258

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

FAAs include aspartic acid, glutamic acid, glycine, alanine and arginine.

NEAA, nonessential amino acid; EAA, essential amino acid; FAA, flavoring amino acid; TAA, total amino acid.

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Table 7. Effects of dietary *Acremonium terricola* culture supplementation on the amino acid levels of the thigh muscle of Hortobágy geese (g/100 g of meat)

Amino acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
Aspartic acid	♂	6.73 ± 0.70	6.46 ± 0.09	6.62 ± 0.13	6.73 ± 0.35	0.104	0.829	0.410	0.737
	♀	6.52 ± 0.36	6.48 ± 0.08	6.27 ± 0.46	6.19 ± 0.21	0.087	0.535	0.959	0.173
	♂ + ♀	6.62 ± 0.51	6.47 ± 0.07	6.44 ± 0.36	6.46 ± 0.39	0.072	0.827	0.495	0.541
Glutamic acid	♂	13.92 ± 0.98	13.64 ± 0.24	13.91 ± 0.24	14.34 ± 0.78	0.177	0.639	0.476	0.381
	♀	13.88 ± 0.90	13.79 ± 0.10	13.34 ± 1.07	13.07 ± 0.37	0.205	0.510	0.994	0.170
	♂ + ♀	13.90 ± 0.84	13.71 ± 0.18	13.63 ± 0.76	13.70 ± 0.88	1.397	0.927	0.638	0.637
Glycine	♂	3.82 ± 0.31	3.61 ± 0.13	3.69 ± 0.19	3.64 ± 0.18	0.058	0.645	0.326	0.681
	♀	3.62 ± 0.25	3.53 ± 0.11	3.44 ± 0.30	3.35 ± 0.02	0.146	0.461	0.742	0.171
	♂ + ♀	3.72 ± 0.28	3.57 ± 0.12	3.57 ± 0.26	3.50 ± 0.19	0.046	0.376	0.364	0.221
Alanine	♂	5.02 ± 0.28	4.95 ± 0.06	5.03 ± 0.05	5.09 ± 0.25	0.049	0.852	0.613	0.516
	♀	4.95 ± 0.22	4.91 ± 0.10	4.76 ± 0.29	4.70 ± 0.17	0.059	0.426	0.943	0.127
	♂ + ♀	4.98 ± 0.23	4.93 ± 0.08	4.90 ± 0.28	4.89 ± 0.28	0.043	0.880	0.715	0.489
Serine	♂	3.30 ± 0.07	3.33 ± 0.05	3.35 ± 0.04	3.42 ± 0.17	0.027	0.525	0.940	0.238
	♀	3.34 ± 0.20	3.33 ± 0.05	3.21 ± 0.21	3.19 ± 0.09	0.043	0.533	0.982	0.166
	♂ + ♀	3.32 ± 0.14	3.33 ± 0.04	3.28 ± 0.16	3.30 ± 0.18	0.026	0.937	0.955	0.572
Arginine	♂	5.04 ± 0.37	4.96 ± 0.05	5.03 ± 0.05	5.15 ± 0.24	0.058	0.787	0.547	0.530
	♀	4.99 ± 0.34	4.97 ± 0.08	4.76 ± 0.35	4.72 ± 0.11	0.072	0.471	0.958	0.138
	♂ + ♀	5.02 ± 0.32	4.97 ± 0.06	4.89 ± 0.27	4.93 ± 0.29	0.049	0.857	0.675	0.460
Proline	♂	10.46 ± 0.30	10.66 ± 0.12	10.64 ± 0.33	11.04 ± 0.65	0.117	0.401	0.854	0.258
	♀	10.84 ± 0.66	10.81 ± 0.17	10.41 ± 0.72	10.31 ± 0.44	0.151	0.555	0.986	0.178
	♂ + ♀	10.65 ± 0.50	10.74 ± 0.16	10.53 ± 0.52	10.68 ± 0.63	0.094	0.897	0.902	0.651
NEAAs	♂	53.76 ± 3.17	53.49 ± 0.72	51.66 ± 3.67	50.79 ± 1.61	0.737	0.472	0.993	0.146
	♀	54.19 ± 3.17	53.91 ± 0.75	55.17 ± 2.75	53.98 ± 3.16	0.671	0.930	0.962	0.741
	♂ + ♀	53.98 ± 2.84	53.70 ± 0.70	53.42 ± 3.48	52.39 ± 2.84	0.526	0.753	0.968	0.402
Tyrosine	♂	2.69 ± 0.25	2.67 ± 0.01	2.69 ± 0.04	2.78 ± 0.14	0.038	0.775	0.674	0.543
	♀	2.71 ± 0.12	2.70 ± 0.04	2.60 ± 0.22	2.52 ± 0.11	0.041	0.363	0.895	0.112
	♂ + ♀	2.70 ± 0.18	2.69 ± 0.03	2.64 ± 0.15	2.65 ± 0.18	0.029	0.895	0.834	0.466
Phenylalanine	♂	3.15 ± 0.22	3.10 ± 0.03	3.12 ± 0.05	3.20 ± 0.13	0.035	0.798	0.518	0.653
	♀	3.15 ± 0.12	3.11 ± 0.04	3.02 ± 0.20	2.96 ± 0.13	0.040	0.382	0.903	0.118
	♂ + ♀	3.15 ± 0.16	3.11 ± 0.03	3.07 ± 0.14	3.08 ± 0.18	0.027	0.781	0.596	0.384
Threonine	♂	4.30 ± 0.22	4.27 ± 0.04	4.31 ± 0.11	4.45 ± 0.26	0.049	0.653	0.635	0.412
	♀	4.27 ± 0.25	4.27 ± 0.02	4.13 ± 0.32	4.10 ± 0.14	0.058	0.661	0.973	0.239
	♂ + ♀	4.29 ± 0.22	4.27 ± 0.03	4.22 ± 0.23	4.27 ± 0.27	0.040	0.945	0.495	0.541
Cysteine	♂	0.67 ± 0.05	0.64 ± 0.01	0.68 ± 0.02	0.67 ± 0.04	0.010	0.652	0.391	0.448
	♀	0.66 ± 0.04	0.64 ± 0.01	0.64 ± 0.04	0.64 ± 0.05	0.009	0.895	0.529	0.706
	♂ + ♀	0.67 ± 0.04	0.64 ± 0.01	0.66 ± 0.04	0.66 ± 0.04	0.007	0.703	0.275	0.779
Valine	♂	3.95 ± 0.31	3.90 ± 0.01	3.97 ± 0.06	4.06 ± 0.21	0.050	0.772	0.632	0.447
	♀	3.91 ± 0.13	3.92 ± 0.05	3.78 ± 0.26	3.72 ± 0.15	0.048	0.436	0.876	0.129
	♂ + ♀	3.93 ± 0.21	3.91 ± 0.03	3.87 ± 0.20	3.89 ± 0.25	0.037	0.956	0.808	0.629
Methionine	♂	2.30 ± 0.13	2.31 ± 0.02	2.30 ± 0.05	2.36 ± 0.11	0.023	0.816	0.906	0.705
	♀	2.28 ± 0.10	2.27 ± 0.07	2.19 ± 0.13	2.21 ± 0.15	0.031	0.737	0.900	0.298
	♂ + ♀	2.29 ± 0.11	2.29 ± 0.05	2.24 ± 0.11	2.29 ± 0.14	0.021	0.829	0.863	0.529
Isoleucine	♂	3.97 ± 0.34	3.97 ± 0.07	3.98 ± 0.07	4.12 ± 0.23	0.056	0.784	0.785	0.541
	♀	3.98 ± 0.19	3.96 ± 0.06	3.83 ± 0.28	3.76 ± 0.14	0.054	0.463	0.967	0.143
	♂ + ♀	3.98 ± 0.25	3.96 ± 0.06	3.90 ± 0.20	3.94 ± 0.26	0.040	0.927	0.820	0.574

Table 7. Continued

Amino acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
Leucine	♂	7.66 ± 0.56	7.62 ± 0.06	7.65 ± 0.15	7.87 ± 0.39	0.092	0.807	0.715	0.577
	♀	7.69 ± 0.41	7.62 ± 0.07	7.32 ± 0.50	7.26 ± 0.27	0.103	0.410	0.878	0.114
	♂ + ♀	7.67 ± 0.44	7.62 ± 0.06	7.48 ± 0.37	7.57 ± 0.45	0.072	0.830	0.720	0.428
Lysine	♂	6.18 ± 0.52	6.10 ± 0.06	6.19 ± 0.16	6.33 ± 0.26	0.078	0.819	0.622	0.511
	♀	6.11 ± 0.37	6.15 ± 0.03	5.91 ± 0.37	5.79 ± 0.21	0.213	0.415	0.757	0.127
	♂ + ♀	6.15 ± 0.40	6.12 ± 0.05	6.05 ± 0.30	6.06 ± 0.36	0.060	0.936	0.887	0.537
Histidine	♂	2.32 ± 0.29	2.24 ± 0.04	2.27 ± 0.11	2.31 ± 0.02	0.040	0.885	0.459	0.918
	♀	2.26 ± 0.09	2.33 ± 0.06	2.23 ± 0.04	2.10 ± 0.16	0.035	0.118	0.216	0.056
	♂ + ♀	2.29 ± 0.19	2.28 ± 0.07	2.25 ± 0.07	2.21 ± 0.16	0.027	0.702	0.939	0.288
EAAs	♂	31.52 ± 2.30	31.28 ± 0.22	31.50 ± 0.57	34.40 ± 1.58	0.374	0.785	0.670	0.524
	♀	31.39 ± 1.58	31.29 ± 0.33	30.18 ± 2.05	29.80 ± 1.17	0.409	0.471	0.984	0.141
	♂ + ♀	31.46 ± 1.77	31.28 ± 0.25	30.84 ± 1.53	31.10 ± 1.89	0.291	0.906	0.781	0.522
FAAs	♂	34.53 ± 2.42	33.63 ± 0.43	34.28 ± 0.25	34.95 ± 1.77	0.400	0.762	0.418	0.559
	♀	33.96 ± 2.07	33.67 ± 0.42	32.57 ± 2.46	32.02 ± 0.83	0.475	0.484	0.945	0.154
	♂ + ♀	34.24 ± 2.04	33.65 ± 0.38	33.43 ± 1.82	33.48 ± 2.02	0.332	0.835	0.565	0.489
TAAs	♂	85.50 ± 5.46	84.45 ± 0.78	85.41 ± 1.32	87.57 ± 4.33	0.943	0.752	0.579	0.483
	♀	85.15 ± 4.75	84.78 ± 1.05	81.84 ± 5.73	80.59 ± 2.77	1.145	0.470	0.990	0.144
	♂ + ♀	85.33 ± 4.58	84.62 ± 0.85	83.63 ± 4.20	84.08 ± 5.01	0.776	0.896	0.727	0.503
EAA/TAA%	♂	36.85 ± 0.34	37.04 ± 0.08	36.88 ± 0.11	37.00 ± 0.10	0.052	0.600	0.396	0.951
	♀	36.87 ± 0.20	36.91 ± 0.07	36.88 ± 0.08	36.97 ± 0.23	0.042	0.865	0.983	0.713
	♂ + ♀	36.86 ± 0.25	36.97 ± 0.10	36.88 ± 0.09	36.99 ± 0.16	0.033	0.462	0.457	0.830
FAA/TAA%	♂	40.37 ± 0.59	39.82 ± 0.18	40.14 ± 0.34	39.90 ± 0.16	0.110	0.308	0.169	0.726
	♀	39.87 ± 0.21	39.71 ± 0.03	39.79 ± 0.25	39.74 ± 0.44	0.069	0.893	0.566	0.853
	♂ + ♀	40.12 ± 0.48	39.77 ± 0.13	39.97 ± 0.33	39.82 ± 0.31	0.070	0.288	0.152	0.704
EAA/NEAA%	♂	58.36 ± 0.85	58.83 ± 0.21	58.43 ± 0.28	58.72 ± 0.25	0.131	0.602	0.399	0.947
	♀	58.41 ± 0.51	58.50 ± 0.18	58.43 ± 0.21	58.67 ± 0.57	0.105	0.864	0.986	0.713
	♂ + ♀	58.39 ± 0.63	58.66 ± 0.25	58.43 ± 0.22	58.69 ± 0.40	0.082	0.464	0.462	0.833

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

FAAs include aspartic acid, glutamic acid, glycine, alanine and arginine.

NEAA, nonessential amino acid; EAA, essential amino acid; FAA, flavoring amino acid; TAA, total amino acid.

the percentage of arachidonic acid in the pectoralis major decreased linearly ($p = 0.001$) in both sexes. In males, the percentage of MUFAs consisting of pentadecenoic acid (C15:1 n-5), C16:1 n-7, oleic acid (C18:1 n-9c), eicosanoic acid (C20:1 n-9), and neuronic acid (C24:1 n-9) in the pectoralis major was significantly higher in the low-dose group than in the control group and the moderate-dose group ($p < 0.05$). In contrast, the percentage of MUFAs did not significantly differ among groups in females and in both sexes ($p > 0.05$). As shown in Table 9, among the SFAs detected in the thigh muscle, only the percentage of heptadecanoic acid (C17:0) significantly differed among the groups. Additionally, in males, the percentage of heptadecanoic acid in the thigh muscle decreased in a linear ($p = 0.027$) manner as the dose of dietary ATC increased. In both sexes, the percentage of eicosatrienoic acid (C20:3 n-3) in the thigh muscle was significantly higher in the control group than in the 3 treatment groups ($p < 0.05$). In both sexes, increased doses of dietary ATC decreased the percentage of eicosatrienoic acid in the thigh muscle in a linear manner ($p = 0.005$).

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Table 8. Effects of dietary *Acremonium terricola* culture supplementation on the fatty acid composition of the pectoralis major of Hortobágy geese (% total fatty acids)

Fatty acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
C14:0	♂	0.57 ± 0.12	0.42 ± 0.04	0.48 ± 0.06	0.48 ± 0.19	0.033	0.554	0.194	0.850
	♀	0.63 ± 0.17	0.62 ± 0.21	0.53 ± 0.07	0.50 ± 0.04	0.038	0.607	0.957	0.209
	♂ + ♀	0.60 ± 0.13	0.52 ± 0.17	0.51 ± 0.06	0.49 ± 0.12	0.026	0.518	0.394	0.258
C15:1 n-5	♂	0.81 ± 0.16	0.69 ± 0.11	0.62 ± 0.01	0.78 ± 0.01	0.033	0.137	0.070	0.365
	♀	0.72 ± 0.24	0.73 ± 0.34	0.77 ± 0.15	0.95 ± 0.23	0.068	0.657	0.804	0.385
	♂ + ♀	0.77 ± 0.19	0.71 ± 0.23	0.69 ± 0.13	0.87 ± 0.17	0.038	0.377	0.317	0.598
C16:0	♂	22.22 ± 1.11	22.69 ± 0.16	22.78 ± 0.56	22.61 ± 1.15	0.219	0.858	0.491	0.640
	♀	23.50 ± 0.94	23.59 ± 1.46	22.80 ± 1.91	21.61 ± 0.65	0.405	0.308	0.685	0.119
	♂ + ♀	22.86 ± 1.15	23.14 ± 1.05	22.79 ± 1.26	22.11 ± 1.00	0.227	0.455	0.468	0.243
C16:1 n-7	♂	1.06 ± 0.25^{Bc}	1.89 ± 0.15^{Aa}	1.70 ± 0.19^{Aab}	1.45 ± 0.22^{ABbc}	0.106	0.006	0.001	0.417
	♀	1.28 ± 0.18	1.91 ± 0.25	1.78 ± 0.28	1.09 ± 0.04	0.114	0.004	0.001	0.215
	♂ + ♀	1.17 ± 0.23^{B}	1.90 ± 0.19^{A}	1.74 ± 0.22^{A}	1.27 ± 0.24^{B}	0.076	< 0.001	< 0.001	0.740
C17:0	♂	0.69 ± 0.18	0.56 ± 0.12	0.76 ± 0.20	0.92 ± 0.31	0.065	0.288	0.356	0.118
	♀	0.51 ± 0.33	0.49 ± 0.04	0.70 ± 0.06	0.85 ± 0.46	0.083	0.414	0.783	0.133
	♂ + ♀	0.60 ± 0.26	0.53 ± 0.09	0.73 ± 0.13	0.89 ± 0.35	0.052	0.068	0.390	0.018
C18:0	♂	14.18 ± 0.20	13.04 ± 0.89	14.29 ± 0.33	13.78 ± 0.61	0.204	0.101	0.086	0.234
	♀	13.18 ± 0.78	13.22 ± 0.62	13.54 ± 1.33	14.34 ± 0.61	0.259	0.404	0.774	0.188
	♂ + ♀	13.68 ± 0.75	13.13 ± 0.69	13.92 ± 0.96	14.06 ± 0.62	0.164	0.200	0.216	0.078
C18:1 n-9c	♂	36.05 ± 0.70^{AB}	37.41 ± 0.57^{A}	34.83 ± 0.98^{B}	36.15 ± 0.84^{AB}	0.337	0.025	0.208	0.026
	♀	35.92 ± 0.15	35.30 ± 0.58	36.15 ± 0.38	36.08 ± 1.49	0.227	0.596	0.421	0.319
	♂ + ♀	35.99 ± 0.46	36.36 ± 1.27	35.49 ± 0.98	36.12 ± 1.08	0.200	0.504	0.789	0.375
C18:2 n-6c	♂	14.35 ± 0.67	13.69 ± 0.20	14.17 ± 0.94	13.94 ± 0.89	0.196	0.724	0.386	0.927
	♀	14.42 ± 0.66	14.56 ± 0.20	13.55 ± 0.78	13.80 ± 0.16	0.181	0.130	0.889	0.028
	♂ + ♀	14.38 ± 0.60	14.13 ± 0.51	13.86 ± 0.85	13.87 ± 0.57	0.131	0.468	0.519	0.156
C18:3 n-3	♂	0.98 ± 0.22	0.49 ± 0.13	0.92 ± 0.05	1.04 ± 0.36	0.085	0.057	0.024	0.090
	♀	0.69 ± 0.15^{b}	0.59 ± 0.15^{b}	0.99 ± 0.36^{ab}	1.25 ± 0.30^{a}	0.101	0.049	0.431	0.012
	♂ + ♀	0.83 ± 0.23^{ABb}	0.54 ± 0.14^{Bc}	0.96 ± 0.23^{Aab}	1.15 ± 0.32^{Aa}	0.065	0.002	0.023	0.001
C20:1 n-9	♂	0.61 ± 0.12	0.82 ± 0.15	0.80 ± 0.13	0.80 ± 0.12	0.041	0.234	0.096	0.295
	♀	0.67 ± 0.29	0.69 ± 0.13	0.78 ± 0.13	0.92 ± 0.18	0.056	0.423	0.882	0.171
	♂ + ♀	0.64 ± 0.20	0.76 ± 0.15	0.79 ± 0.12	0.86 ± 0.15	0.034	0.133	0.345	0.062
C20:3 n-6	♂	5.86 ± 0.72	6.21 ± 0.54	6.41 ± 0.59	5.56 ± 0.74	0.189	0.437	0.289	0.901
	♀	5.57 ± 0.40	6.49 ± 0.30	6.06 ± 0.84	5.63 ± 0.31	0.168	0.179	0.042	0.553
	♂ + ♀	5.71 ± 0.55	6.35 ± 0.42	6.24 ± 0.68	5.60 ± 0.51	0.124	0.065	0.019	0.609
C20:3 n-3	♂	0.80 ± 0.15	0.56 ± 0.06	0.75 ± 0.08	0.89 ± 0.22	0.051	0.102	0.048	0.124
	♀	1.22 ± 0.51	0.59 ± 0.03	0.71 ± 0.12	0.96 ± 0.08	0.098	0.074	0.013	0.659
	♂ + ♀	1.01 ± 0.41^{Aa}	0.57 ± 0.04^{Bbc}	0.73 ± 0.09^{ABb}	0.93 ± 0.15^{ABab}	0.056	0.013	0.001	0.694
C20:5 n-3	♂	0.85 ± 0.06	1.00 ± 0.23	0.88 ± 0.35	0.80 ± 0.05	0.057	0.728	0.387	0.509
	♀	0.77 ± 0.23	0.65 ± 0.27	0.95 ± 0.07	1.07 ± 0.04	0.066	0.076	0.306	0.019
	♂ + ♀	0.81 ± 0.15	0.82 ± 0.29	0.91 ± 0.23	0.94 ± 0.15	0.043	0.673	0.472	0.233
C24:1 n-9	♂	0.98 ± 0.13	0.52 ± 0.23	0.61 ± 0.19	0.78 ± 0.17	0.070	0.058	0.010	0.626
	♀	0.92 ± 0.20	0.57 ± 0.09	0.70 ± 0.05	0.93 ± 0.24	0.061	0.071	0.016	0.449
	♂ + ♀	0.81 ± 0.15^{Aa}	0.82 ± 0.29^{Cb}	0.91 ± 0.23^{BCb}	0.94 ± 0.15^{ABa}	0.046	0.001	< 0.001	0.873

Table 8. Continued

Fatty acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
SFAs	♂	37.65 ± 1.21	36.72 ± 1.16	38.31 ± 0.30	37.80 ± 0.81	0.289	0.293	0.376	0.151
	♀	37.82 ± 0.64	37.92 ± 1.52	37.56 ± 0.47	37.30 ± 0.92	0.250	0.863	0.825	0.459
	♂ + ♀	37.74 ± 0.87	37.32 ± 1.37	37.94 ± 0.54	37.55 ± 0.82	0.187	0.717	0.627	0.587
MUFAs	♂	39.51 ± 1.02^{ABb}	41.33 ± 0.47^{Aa}	38.56 ± 1.02^{Bb}	39.96 ± 0.51^{ABab}	0.360	0.017	0.085	0.036
	♀	39.52 ± 0.50	39.20 ± 0.73	40.18 ± 0.16	39.98 ± 1.45	0.239	0.523	0.743	0.181
	♂ + ♀	39.52 ± 0.72	40.27 ± 1.29	39.37 ± 1.10	39.97 ± 0.97	0.212	0.435	0.393	0.609
PUFAs	♂	22.83 ± 0.22	21.94 ± 0.81	23.13 ± 0.85	22.24 ± 1.30	0.259	0.394	0.458	0.577
	♀	22.67 ± 0.38	22.88 ± 0.79	22.26 ± 0.49	22.72 ± 0.61	0.160	0.633	0.912	0.427
	♂ + ♀	22.75 ± 0.29	22.41 ± 0.88	22.70 ± 0.78	22.48 ± 0.94	0.149	0.843	0.573	0.983

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

SFAs include C14:0, C16:0, C17:0, and C18:0; MUFAs include C15:1 n-5, C16:1 n-7, C18:1 n-9c, C20:1 n-9, and C24:1 n-9; PUFAs include C18:2 n-6c, C18:3 n-3, C20:3 n-6, C20:3 n-3, and C20:5 n-3.

$^{a-c}$Means within a row with different superscripts differ significantly ($p < 0.05$).

$^{A-C}$Means within a row with different superscripts differ extremely significantly ($p < 0.01$).

SFAs, saturated fatty acids; MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids.

DISCUSSION

According to the WHO report [14] and a previous study [15], goose meat is a valuable source of AAs. Goose meat is gaining popularity, particularly in the Chinese market, due to its high protein and low fat content and its superior quality [16]. To our knowledge, our study is the first to evaluate and compare the effects of different levels of dietary ATC supplementation on the quality, conventional characteristics, and flavor substances of gosling meat.

Genetics, nutrition, rearing conditions, slaughter, processing, and many other factors affect meat quality, which is very important for taste and consumer preferences [17]. Many nutrients are involved in and control the biochemical metabolic processes that determine meat quality, and an appropriate dietary formulation is essential to improve meat quality and reduce feeding costs. Fresh meat color is the most direct visual sensory characteristics and therefore one of the decisive factors in consumer purchasing behavior, and has an important influence on shelf life. According to the reference standard of Opto-Wert, which classified scores ≥ 63 as excellent, the meat color of Hortobágy goose is superb. In addition, the lower the water loss rate is, the stronger the water holding capacity and the more tender the meat. Tenderness (defined as how easily the meat can be chewed or cut [18]) is expressed in terms of shear force, which is an important sensory feature for assessing meat quality; the greater the shear force is, the lower the tenderness [19]. We supplemented the basal diet of geese with different levels of ATC (0, 3, 5, and 7 g/kg) and demonstrated that there were no significant differences in meat color, water loss rate, or shear force of the pectoralis major and thigh muscle in males, females, and in both sexes. Moreover, the pH value is an important indicator that reflects muscle glycogenolysis after slaughter, which is directly affected by the lactic acid produced by anaerobic glycolysis and the phosphoric acid produced by the breakdown of ATP. A good pH range maintains the activity of muscle proteolytic enzymes, reduces water loss due to exudation, and enhances the freshness and flavor of meat; in contrast, a rapid decrease in pH after slaughter can reduce the tenderness of meat and cause it to turn pale [18]. In females and in both sexes, the pectoralis major of goslings supplemented with 5 g/kg ATC had a

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Table 9. Effects of dietary *Acremonium terricola* culture supplementation on the fatty acid composition of the thigh muscle of Hortobágy geese (% total fatty acids)

Fatty acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
C14:0	♂	0.63 ± 0.18	0.81 ± 0.43	0.51 ± 0.08	0.63 ± 0.15	0.069	0.567	0.523	0.335
	♀	0.80 ± 0.32	0.76 ± 0.08	0.48 ± 0.03	0.62 ± 0.08	0.056	0.180	0.570	0.052
	♂ + ♀	0.71 ± 0.25	0.78 ± 0.28	0.50 ± 0.05	0.63 ± 0.11	0.043	0.106	0.818	0.032
C15:1 n-5	♂	0.88 ± 0.34	0.87 ± 0.31	0.94 ± 0.62	0.90 ± 0.33	0.103	0.996	0.986	0.841
	♀	0.78 ± 0.15	0.56 ± 0.19	0.74 ± 0.16	0.77 ± 0.49	0.075	0.766	0.380	0.619
	♂ + ♀	0.83 ± 0.24	0.72 ± 0.29	0.84 ± 0.42	0.84 ± 0.38	0.065	0.903	0.598	0.631
C16:0	♂	22.90 ± 0.45	22.17 ± 1.00	23.65 ± 1.91	23.16 ± 1.41	0.360	0.593	0.627	0.283
	♀	23.22 ± 0.86	23.72 ± 1.06	23.85 ± 0.82	22.90 ± 0.46	0.235	0.505	0.288	0.840
	♂ + ♀	23.06 ± 0.64	22.95 ± 1.25	23.75 ± 1.32	23.03 ± 0.95	0.215	0.551	0.853	0.391
C16:1 n-7	♂	1.85 ± 0.46	2.11 ± 0.22	1.96 ± 0.28	1.77 ± 0.39	0.094	0.673	0.319	0.577
	♀	1.71 ± 0.41	1.88 ± 0.37	2.25 ± 0.44	2.00 ± 0.15	0.106	0.370	0.446	0.149
	♂ + ♀	1.78 ± 0.39	1.99 ± 0.30	2.11 ± 0.36	1.88 ± 0.29	0.069	0.414	0.187	0.451
C17:0	♂	1.01 ± 0.24^{a}	0.59 ± 0.12^{b}	0.80 ± 0.11^{ab}	0.64 ± 0.11^{b}	0.062	0.043	0.027	0.409
	♀	0.94 ± 0.20	0.77 ± 0.16	0.59 ± 0.10	0.82 ± 0.12	0.052	0.109	0.093	0.129
	♂ + ♀	0.97 ± 0.20^{Aa}	0.68 ± 0.16^{Bb}	0.70 ± 0.15^{Bb}	0.73 ± 0.14^{ABb}	0.040	0.020	0.007	0.112
C18:0	♂	12.78 ± 0.33	12.75 ± 0.17	12.66 ± 0.15	13.14 ± 1.11	0.155	0.773	0.716	0.705
	♀	11.77 ± 1.20	12.95 ± 1.18	12.45 ± 0.35	13.15 ± 0.18	0.267	0.279	0.238	0.402
	♂ + ♀	12.28 ± 0.96	12.85 ± 0.76	12.56 ± 0.27	13.15 ± 0.71	0.153	0.217	0.399	0.341
C18:1 n-9c	♂	37.13 ± 0.86	38.05 ± 0.82	37.70 ± 0.75	37.36 ± 1.14	0.246	0.639	0.222	0.914
	♀	37.39 ± 0.88	37.19 ± 0.38	37.42 ± 1.11	37.27 ± 1.51	0.261	0.992	0.874	0.928
	♂ + ♀	37.26 ± 0.79	37.62 ± 0.74	37.56 ± 0.86	37.32 ± 1.20	0.177	0.877	0.438	0.998
C18:2 n-6c	♂	13.72 ± 1.09	13.73 ± 0.51	13.73 ± 1.82	13.27 ± 0.89	0.297	0.951	0.877	0.752
	♀	14.19 ± 0.45	13.72 ± 0.45	13.29 ± 0.69	13.82 ± 0.75	0.177	0.386	0.244	0.282
	♂ + ♀	13.95 ± 0.79	13.72 ± 0.43	13.51 ± 1.26	13.55 ± 0.80	0.170	0.804	0.651	0.390
C18:3 n-3	♂	0.80 ± 0.21	0.65 ± 0.18	0.64 ± 0.20	0.75 ± 0.05	0.047	0.649	0.258	0.759
	♀	0.59 ± 0.19	0.83 ± 0.45	0.76 ± 0.30	0.65 ± 0.17	0.079	0.759	0.309	0.978
	♂ + ♀	0.69 ± 0.21	0.74 ± 0.32	0.70 ± 0.24	0.70 ± 0.12	0.045	0.983	0.735	0.850
C20:1 n-9	♂	0.89 ± 0.36	0.97 ± 0.44	0.67 ± 0.06	0.86 ± 0.31	0.087	0.711	0.954	0.395
	♀	0.90 ± 0.29	0.75 ± 0.36	0.66 ± 0.19	0.62 ± 0.14	0.071	0.583	0.547	0.254
	♂ + ♀	0.90 ± 0.29	0.86 ± 0.38	0.67 ± 0.12	0.74 ± 0.25	0.056	0.461	0.719	0.136
C20:3 n-6	♂	5.05 ± 0.54	5.18 ± 0.36	4.69 ± 0.30	5.49 ± 0.75	0.154	0.364	0.752	0.940
	♀	5.33 ± 0.67	4.87 ± 0.36	5.34 ± 0.45	5.39 ± 0.17	0.127	0.485	0.251	0.329
	♂ + ♀	5.19 ± 0.56	5.02 ± 0.36	5.02 ± 0.50	5.44 ± 0.49	0.099	0.404	0.307	0.542
C20:3 n-3	♂	0.87 ± 0.13	0.66 ± 0.14	0.67 ± 0.24	0.61 ± 0.12	0.050	0.291	0.216	0.230
	♀	0.95 ± 0.14	0.63 ± 0.07	0.62 ± 0.17	0.78 ± 0.14	0.052	0.054	0.013	0.272
	♂ + ♀	0.91 ± 0.13^{Aa}	0.65 ± 0.10^{Bb}	0.65 ± 0.19^{Bb}	0.69 ± 0.15^{ABb}	0.036	0.014	0.005	0.085
C20:5 n-3	♂	0.76 ± 0.16	0.85 ± 0.37	0.72 ± 0.14	0.83 ± 0.22	0.061	0.899	0.814	0.806
	♀	0.72 ± 0.18	0.73 ± 0.18	0.66 ± 0.18	0.59 ± 0.21	0.049	0.803	0.837	0.392
	♂ + ♀	0.74 ± 0.15	0.79 ± 0.27	0.69 ± 0.15	0.71 ± 0.23	0.040	0.840	0.741	0.439
C24:1 n-9	♂	0.72 ± 0.14	0.62 ± 0.09	0.64 ± 0.13	0.60 ± 0.16	0.036	0.701	0.435	0.548
	♀	0.72 ± 0.10	0.64 ± 0.15	0.89 ± 0.34	0.60 ± 0.16	0.061	0.381	0.909	0.602
	♂ + ♀	0.72 ± 0.11	0.63 ± 0.11	0.77 ± 0.27	0.60 ± 0.14	0.035	0.327	0.728	0.906

Table 9. Continued

Fatty acid	Sex	Control	Low dose	Moderate dose	High dose	SEM	*p*-value		
							ANOVA	Linear	Quadratic
SFAs	♂	37.32 ± 0.29	36.32 ± 0.84	37.63 ± 1.96	37.56 ± 1.54	0.362	0.613	0.414	0.338
	♀	36.72 ± 0.66	38.20 ± 1.95	37.37 ± 0.58	37.50 ± 0.65	0.317	0.494	0.175	0.968
	♂ + ♀	37.02 ± 0.56	37.26 ± 1.69	37.50 ± 1.30	37.53 ± 1.06	0.237	0.878	0.765	0.461
MUFAs	♂	41.48 ± 0.72	42.62 ± 0.17	41.92 ± 0.53	41.50 ± 0.83	0.205	0.158	0.042	0.363
	♀	41.50 ± 1.49	41.02 ± 1.43	41.97 ± 0.36	41.26 ± 1.02	0.306	0.784	0.810	0.614
	♂ + ♀	41.49 ± 1.05	41.82 ± 1.26	41.94 ± 0.40	41.38 ± 0.84	0.186	0.704	0.382	0.988
PUFAs	♂	21.20 ± 0.97	21.06 ± 0.99	20.45 ± 2.43	20.94 ± 1.03	0.377	0.931	0.823	0.627
	♀	21.77 ± 0.84	20.78 ± 0.74	20.66 ± 0.69	21.24 ± 0.53	0.219	0.282	0.089	0.448
	♂ + ♀	21.49 ± 0.87	20.92 ± 0.80	20.56 ± 1.60	21.09 ± 0.75	0.214	0.515	0.267	0.391

Control, low dose, moderate dose and high dose represent Hortobágy geese supplemented with 0 g, 3 g, 5 g, and 7 g *Acremonium terricola* culture per kg of the basal diet, respectively.

The average n values for ♂ (males), ♀ (females), and ♂ + ♀ (both sexes) were 12, 12, and 24, respectively.

SFAs include C14:0, C16:0, C17:0, and C18:0; MUFAs include C15:1 n-5, C16:1 n-7, C18:1 n-9c, C20:1 n-9, and C24:1 n-9; PUFAs include C18:2 n-6c, C18:3 n-3, C20:3 n-6, C20:3 n-3, and C20:5 n-3.

[a,b]Means within a row with different superscripts differ significantly ($p < 0.05$).

[A,B]Means within a row with different superscripts differ extremely significantly ($p < 0.01$).

SFAs, saturated fatty acids; MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids.

significantly higher pH at 12 h postmortem. Meat with a high pH is commonly darker in color. A comparative analysis showed that the pH of the thigh muscle was higher than that of the pectoralis major after slaughter, and the color of the thigh muscle was correspondingly slightly darker than that of the pectoralis major.

In general, meat with lower moisture content has higher dry matter and protein content; hence, its nutritional value is higher. Nevertheless, a certain amount of moisture contributes to the juiciness, palatability and tenderness of meat. Additionally, the fat content and distribution in meat also affect juiciness and tenderness, thus influencing the meat quality and flavor [14]. The present study indicated that the moisture content was not affected by dietary ATC supplementation. However, the CF content of the pectoralis major was increased by supplementation with 7 g/kg ATC compared to the control in females and in both sexes. This difference cannot simply be interpreted as an adverse effect, since Damaziak et al. concluded that fat is a carrier of meat flavor [20]. When dairy cows were supplemented with 30 g/d ATC, the fat content of their milk was significantly enhanced [4]. Currently, the human diet contains many highly processed foods; thus, minerals and trace elements are vital. The CA content of meat consists mainly of mineral oxides, mineral salts, and silica. In males, ATC supplementation increased the CA content compared to that of the control, with ATC supplementations of 3 and 5 g/kg significantly increasing the CA content in the thigh muscle and pectoralis major, respectively. CP is a general term for nitrogenous compounds, and the CP content largely reflects the nutritional value of meat. Uhlířová et al. [21] and Liu et al. [18] suggested that meat from male geese has a higher CP content, but the data from this study are inconsistent with their findings. In females, supplementation with 7 g/kg ATC significantly increased the CP content of the pectoralis major. A similar outcome was reported by Li et al., who showed that ATC supplementation linearly increased the apparent digestibility of feed CP in dairy cows [4].

The mechanism underlying the formation meat flavor is complex and unclear and is the result of the interaction of various substances. Inosinic acid is mainly produced by the degradation of ATP and is the main flavor substance; it has a fresh flavor and a strong synergism with the fresh

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flavor of sodium glutamate [22]. As inosinic acid levels drop continuously after slaughter, the inosinic acid content can reflect the freshness of meat to a certain extent [23]. In males and females, supplementation with 5 and 7 g/kg ATC increased the inosinic acid content of the pectoralis major compared with that of the control. In addition, the inosinic acid content of the thigh muscle was higher than that of the pectoralis major, which is consistent with general recognition that the flavor of thigh muscles is better than that of the pectoralis major.

AAs are the basic building blocks of animal proteins and are an important element that affects the quality and flavor of meat [24]. NEAAs refer to a class of AAs that the body can synthesize by itself or requires less of, whereas EAAs refer to a class of AAs that the body cannot synthesize or are synthesized too slowly to meet the demand. FAAs contribute to meat flavor and buffer acidity, bitterness and saltiness. Among the FAAs, glutamic acid is the primary meat flavor substance [22], followed by aspartic acid, glycine, alanine, and arginine [25]. Valine is also considered to be an important precursor to flavor substances in meat [26]. There were no differences in AA levels among treatments, possibly due to age, metabolism, diet, dosage, or duration of feeding [22,25]. In the present study, the EAA/TAA percentage was 35.89%-36.53% and the EAA/NEAA percentage was 55.98%–57.55%, both of which were close to the 40% and 60% specified in the FAO/WHO ideal protein standards [27], respectively, indicating that the meat of Hortobágy geese had a superior protein composition.

In the study, it was found that palmitic acid (C16:0) and C18:1 n-9c were the most abundant SFAs and MUFAs, respectively. Growing evidence has indicated that SFA levels are closely associated with the risk of cardiovascular and cerebrovascular diseases [28]. Analysis of the SFAs revealed that ATC supplementation significantly decreased the percentage of C17:0 in the thigh muscle in males and in both sexes, which contributes to the nutritional value of goose meat. PUFAs are valued for their lipid-lowering, blood pressure-lowering, antioxidant and flavor improving properties. It has been suggested that the levels of C18:1 n-9c [29] and C18:3 n-3 [29, 30] are susceptible to dietary changes, and the present study yielded results consistent with this proposal. Supplementation with 7 g/kg ATC resulted in a significant increase in C18:3 n-3 levels of the pectoralis major in females and in both sexes, which was in line with the suggestion that higher n-3 FA levels are beneficial for human health [25,30]. In males and both sexes, supplementation with 3 and 5 g/kg ATC significantly increased the C16:1 n-7 level of the pectoralis major; in males, supplementation with 3 g/kg ATC significantly increased the percentage of MUFAs in the pectoralis major. However, FAs other than C17:0 and C18:3 n-3 in goose thigh muscle were hardly affected by dietary ATC supplementation.

CONCLUSION

In summary, the results of the present study revealed that the meat color, water loss rate, shear force, moisture content, and AA levels of goose meat were not affected by dietary ATC. Dietary supplementation with ATC improved meat quality by altering the pH, CA, CP, CF, and inosinic acid contents as well as the FA composition of young Hortobágy geese. Moreover, it may be concluded that this study provides a practical reference for providing green additives under intensive feeding conditions to high-quality geese.

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