Effects of Dietary Pectin on Growth Performance, Body Measurement Traits, Slaughter Performance, and Organ Indices of Yangzhou Geese Aged 28–70 Days (Postprint)

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Abstract

This experiment aimed to investigate the effects of dietary pectin on growth performance, body measurement traits, slaughter performance, and organ indices of 28- to 70-day-old Yangzhou geese. A total of 180 healthy 28-day-old male Yangzhou geese with similar body weight were randomly divided into 3 groups with 6 replicates per group and 10 geese per replicate. Group I (control group) was fed a basal diet, while groups II and III were fed experimental diets supplemented with 1.5% and 3.0% pectin, respectively. The experimental period lasted 42 days. The results showed that: 1) Compared with the control group, dietary supplementation with 1.5% and 3.0% pectin significantly decreased the body weight of Yangzhou geese at 42, 56, and 70 days of age ($P<0.05$), significantly reduced the average daily gain of goslings from 28 to 70 days of age ($P<0.05$), and significantly increased the feed-to-gain ratio of goslings from 28 to 70 days of age ($P<0.05$). 2) Compared with the control group, dietary supplementation with 3.0% pectin significantly decreased the chest depth and chest width of 70-day-old goslings ($P<0.05$). 3) Compared with the control group, dietary supplementation with 1.5% pectin significantly decreased the breast muscle percentage of 70-day-old goslings ($P<0.05$), and dietary supplementation with 3.0% pectin significantly decreased the breast muscle percentage and abdominal fat percentage of 70-day-old goslings ($P<0.05$). 4) Compared with the control group, dietary supplementation with 3.0% pectin significantly increased the spleen index and proventriculus index of 70-day-old goslings ($P<0.05$), and significantly decreased the bursa of Fabricius index and thymus index of 70-day-old goslings ($P<0.05$). Therefore, it can be concluded that dietary pectin had adverse effects on the growth performance, body measurement traits, slaughter performance, and organ indices of 28- to 70-day-old Yangzhou geese, which suggests that in production practice, attention should be paid to the usage levels

of pectin-rich feed ingredients.

Full Text

Effects of Dietary Pectin on Growth Performance, Body Measurement Traits, Slaughter Performance and Viscera Indices of Yangzhou Geese at 28 to 70 Days of Age

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Abstract: This experiment was conducted to investigate the effects of dietary pectin on growth performance, body measurement traits, slaughter performance, and viscera indices of Yangzhou geese aged 28 to 70 days. One hundred eighty healthy 28-day-old male Yangzhou geese with similar body weight were randomly allocated into three groups, each consisting of six replicates with ten geese per replicate. Geese in group I (control group) received a basal diet, while those in groups II and III were fed experimental diets supplemented with 1.5% and 3.0% pectin, respectively. The trial lasted for 42 days. The results demonstrated that: 1) Compared with the control group, dietary supplementation with 1.5% and 3.0% pectin significantly reduced body weight at 42, 56, and 70 days of age ($P<0.05$), significantly decreased average daily gain from 28 to 70 days of age ($P<0.05$), and significantly increased the feed-to-gain ratio during the same period ($P<0.05$). 2) Supplementation with 3.0% pectin significantly decreased breast depth and breast width at 70 days of age compared to the control group ($P<0.05$). 3) The 1.5% pectin diet significantly reduced the percentage of breast muscle at 70 days of age ($P<0.05$), while the 3.0% pectin diet significantly decreased both breast muscle percentage and abdominal fat percentage at 70 days of age ($P<0.05$). 4) The 3.0% pectin diet significantly increased spleen index and proventriculus index while significantly decreasing bursa of Fabricius index and thymus index at 70 days of age ($P<0.05$). These findings indicate that dietary pectin exerts adverse effects on growth performance, body measurement traits, slaughter performance, and viscera indices of 28- to 70-day-old Yangzhou geese, suggesting that careful attention should be paid to the inclusion levels of pectin-rich feed ingredients in practical production.

Keywords: pectin; geese; growth performance; body measurement traits; slaughter performance; viscera indices

Pectin constitutes a component of dietary fiber, primarily located in the primary cell walls and intercellular layers of higher plants. Together with cellulose, hemicellulose, lignin, and certain extensin proteins, pectin maintains cell structure and rigidity. Production practices have demonstrated that geese can effectively utilize various forages, rice, and other high-fiber feeds to meet their dietary fiber requirements. However, geese lack the enzymes necessary for pectin degradation, and dietary pectin can only be broken down and absorbed by intestinal microorganisms, rendering it an anti-nutritional factor for geese. Numerous feed ingredients contain pectin, particularly unconventional feedstuffs such as alfalfa, silkworm excrement, and beet pulp, which have relatively high pectin contents. When pectin enters the gastrointestinal tract, it interacts with water molecules to significantly increase chyme viscosity, producing anti-nutritional effects that inhibit nutrient digestion, absorption, and metabolism, thereby impeding animal growth and development. Previous research investigating graded levels of silkworm excrement (0%, 3%, 6%, 9%, and 12%) in goose diets revealed that moderate inclusion had no adverse effects on growth performance, slaughter performance, viscera indices, or physical development, whereas inclusion levels of 9% to 12% significantly reduced body weight and breast muscle percentage, affecting body conformation development. To date, no studies have reported on the anti-nutritional effects of dietary pectin in geese. Therefore, this experiment utilized Yangzhou geese to examine the effects of dietary pectin on growth performance, body measurement traits, slaughter performance, and viscera indices of goslings from 28 to 70 days of age, aiming to provide a theoretical foundation and reference basis for the application of pectin-rich unconventional feedstuffs in goose production.

1.1 Experimental Materials

The experimental animals were 28-day-old male Yangzhou geese purchased from Yangzhou Tiange Goose Industry Development Co., Ltd. The pectin used in the trial was apple pectin obtained from Yantai Andre Pectin Co., Ltd., with a purity of 99%. The pectin appeared as a white or yellowish fine powder, odorless, and dissolved in 20 parts water to form a milky white viscous colloidal solution with weak acidity.

1.2 Experimental Design and Management

One hundred eighty healthy 28-day-old male Yangzhou geese with similar body weight were randomly divided into three groups, with six replicates per group and ten geese per replicate. Group I (control group) received a basal diet, while groups II and III were fed experimental diets supplemented with 1.5% and 3.0% pectin, respectively. The experimental period lasted 42 days. The trial was conducted at the Experimental Farm of Yangzhou University from September to November 2016. Prior to the formal experiment, the goose house underwent repair, cleaning, and disinfection. Geese were raised on net floors indoors with ad libitum access to feed and water under natural lighting conditions. Daily management included maintaining pen hygiene, ensuring adequate ventilation, monitoring flock health status, and recording mortality.

Dietary formulations were primarily based on NRC (1994) standards and research findings from our group, using corn and soybean meal as basal ingredients with rice hulls as the main fiber source. The composition and nutrient levels of experimental diets are presented in Table 1 .

Table 1 Composition and nutrient levels of experimental diets (air-dry basis) %

Items	Group I	Group II	Group III
Ingredients			
Corn	51.00	49.50	48.00
Soybean meal	19.00	19.00	19.00
Rice hull	22.00	22.00	22.00
Pectin	0.00	1.50	3.00
DL-methionine	0.15	0.15	0.15
NaCl	0.30	0.30	0.30
Limestone	1.20	1.20	1.20
CaHPO	1.85	1.85	1.85
Premix[1]	4.50	4.50	4.50
Total	**100.00**	**100.00**	**100.00**
Nutrient levels[2]			
ME (MJ/kg)	11.00	10.82	10.64
CP	15.50	15.50	15.50
CF	8.50	8.50	8.50
TP	0.60	0.60	0.60
Lys	0.75	0.75	0.75
Met	0.38	0.38	0.38

[1]The premix provided the following per kg of diet: VA 1,200 IU, VD 400 IU, VE 1,800 IU, VK 150 mg, VB 60 mg, VB 600 mg, VB 200 mg, VB 1 mg, nicotinic acid 3 g, pantothenic acid 900 mg, folic acid 50 mg, biotin 4 mg, choline 35 mg, Fe 6 g, Cu 1 g, Mn 9.5 g, Zn (as zinc sulfate) 9 g, I 50 mg, Se 30 mg.

[2]Nutrient levels were calculated values.

1.3.1 Growth Performance

At 42, 56, and 70 days of age, body weight (fasting weight) and feed consumption were recorded for each replicate to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G).

1.5.3 Slaughter Performance

At 70 days of age, two geese were randomly selected from each replicate for body measurement. Parameters included body length, half-diving depth, breast depth, breast width, keel length, shank length, and shank circumference, which were measured according to *Poultry Production Science*.

Following body measurements, experimental geese were slaughtered, bled, and plucked. Carcass weight, semi-eviscerated weight, fully eviscerated weight, breast muscle weight, leg muscle weight, and abdominal fat weight were recorded to calculate dressing percentage, semi-eviscerated yield percentage, eviscerated yield percentage, breast muscle percentage, leg muscle percentage, and abdominal fat percentage according to *Poultry Production Science*.

1.5.4 Viscera Indices

After slaughter and bleeding, the heart, liver (gallbladder removed), spleen, gizzard (epithelium and contents removed), proventriculus, and bursa of Fabricius were excised and weighed to calculate viscera indices using the following formula:

Viscera index (%) = 100 × organ weight (g) / live weight before slaughter (g).

1.6 Data Processing

Data were compiled using Microsoft Excel 2010 and subjected to one-way ANOVA using SPSS 17.0 software. Results are expressed as means ± standard deviation. Duncan' s multiple comparison test was employed for significance testing, with $P<0.05$ as the criterion for statistical significance.

2.1 Effects of Dietary Pectin on Growth Performance of Goslings at 28 to 70 Days of Age

The effects of dietary pectin on growth performance are presented in Table 2 . From 42 days of age onward, body weights in groups II and III were significantly lower than in group I ($P<0.05$), with no significant differences between groups II and III ($P>0.05$). Specifically, body weight at 42 days in group I was 11.31% and 15.04% higher than in groups II and III, respectively ($P<0.05$). At 56 days, group I body weight exceeded that of groups II and III by 6.20% and 8.81% ($P<0.05$), respectively. At 70 days, group I body weight was 7.49% and 9.01% higher than groups II and III ($P<0.05$), respectively. These results indicate that elevated dietary pectin levels significantly reduce gosling body weight.

Average daily gain in group I was significantly higher than in groups II and III ($P<0.05$), while the feed-to-gain ratio was significantly lower ($P<0.05$). No significant differences in average daily feed intake were observed among the three groups ($P>0.05$). Group I ADG was 11.34% and 13.94% higher than groups II and III ($P<0.05$), respectively, with no significant difference between groups II and III ($P>0.05$). The feed-to-gain ratio in group I was 10.80% and 12.22% lower than in groups II and III ($P<0.05$), respectively, with no significant difference between the latter two groups ($P>0.05$). These findings demonstrate that high dietary pectin content adversely affects average daily gain and feed efficiency in 28- to 70-day-old goslings, impeding their growth and development.

Table 2 Effects of dietary pectin on growth performance of geese at 28 to 70 days of age

Days of age	Items	Group I	Group II	Group III
28	Body weight (g)	1,073.50±14.67	1,071.33±15.12	1,068.83±14.44
42	Body weight (g)	1,885.80±123.63[a]	1,694.20±121.22	1,639.20±108.05
56	Body weight (g)	2,921.10±133.29[a]	2,750.60±81.20	2,684.60±100.02
70	Body weight (g)	3,267.84±138.37[a]	3,040.00±101.71	2,997.80±88.65
28-70	ADFI (g/d)	202.69±13.10	203.88±15.34	202.84±13.31
28-70	ADG (g/d)	52.22±3.17[a]	46.90±2.56	45.83±2.04
28-70	F/G	3.88±0.18	4.35±0.35[a]	4.42±0.16[a]

[a] Values within the same row with different superscripts differ significantly (P<0.05), while those with the same or no superscript do not differ significantly (P>0.05). The same notation applies to subsequent tables.

2.2 Effects of Dietary Pectin on Body Measurement Traits of Goslings at 70 Days of Age

The influence of dietary pectin on body measurement traits at 70 days is shown in Table 3 . Breast depth and breast width in group I were significantly greater than in group III (P<0.05). No significant differences were observed among the three groups for body length, half-diving depth, keel length, shank length, or shank circumference (P>0.05), although all parameters in group I were slightly higher than those in groups II and III. Breast depth and width in group I were 7.96% and 8.12% greater than in group III (P<0.05), respectively, with no significant differences between group II and the other groups (P>0.05). These results suggest that pectin negatively affects skeletal development, particularly breast bone development, in goslings.

Table 3 Effects of dietary pectin on body measurement traits of geese at 70 days of age

Items	Group I	Group II	Group III
Body length (cm)	32.50±1.38	33.08±1.80	32.67±0.82
Half-diving depth (cm)	66.17±4.49	65.00±1.26	65.83±1.17
Breast depth (cm)	10.17±0.41[a]	10.00±0.55[a]	9.42±0.74

Items	Group I	Group II	Group III
Breast width (cm)	8.92±0.38[a]	8.67±0.41[a]	8.25±0.61
Keel length (cm)	16.92±1.28	16.08±0.20	15.67±1.63
Shank length (cm)	10.73±0.21	10.68±0.29	10.53±0.38
Shank circumference (cm)	5.42±0.21	5.32±0.35	5.28±0.13

2.3 Effects of Dietary Pectin on Slaughter Performance of Goslings at 70 Days of Age

The effects of dietary pectin on slaughter performance are presented in Table 4 . The percentage of breast muscle in group I was significantly higher than in groups II and III ($P<0.05$), while abdominal fat percentage in groups I and II was significantly higher than in group III ($P<0.05$). No significant differences were detected among groups for dressing percentage, semi-eviscerated yield percentage, eviscerated yield percentage, or leg muscle percentage ($P>0.05$), although all parameters in group I were slightly higher than those in groups II and III. Breast muscle percentage in group I was 16.85% and 28.98% higher than in groups II and III ($P<0.05$), respectively, with no significant difference between the latter two groups ($P>0.05$). These findings indicate that pectin suppresses breast muscle development in goslings, and at a dietary level of 3.0%, significantly reduces abdominal fat deposition under the conditions of this experiment.

Table 4 Effects of dietary pectin on slaughter performance of geese at 70 days of age (%)

Items	Group I	Group II	Group III
Dressing percentage	85.80±2.37	85.11±1.87	83.98±1.83
Semi-eviscerated yield percentage	79.43±2.30	78.51±1.40	77.56±1.75
Eviscerated yield percentage	71.06±2.19	69.95±1.65	69.38±2.15
Breast muscle percentage	9.57±0.50[a]	8.19±0.20	7.42±0.35
Leg muscle percentage	15.72±0.53	15.61±0.65	16.01±0.37
Abdominal fat percentage	2.32±0.40[a]	2.50±0.30[a]	1.24±0.19

2.4 Effects of Dietary Pectin on Viscera Indices of Goslings at 70 Days of Age

The influence of dietary pectin on viscera indices is shown in Table 5 . No significant differences were observed among groups for heart index, liver index, or gizzard index (P>0.05). Spleen index and proventriculus index in groups I and II were 27.27% and 18.18% lower (P<0.05), and 22.86% and 25.71% lower (P<0.05) than in group III, respectively. Thymus index in groups I and II was 41.67% and 33.33% higher than in group III (P<0.05), with no significant difference between groups I and II (P>0.05). The bursa of Fabricius index in group I was 100.00% and 33.33% higher than in groups II and III (P<0.05), respectively, with no significant difference between the latter two groups (P>0.05). These results demonstrate that elevated dietary pectin levels affect the growth and development of internal organs in goslings.

Table 5 Effects of dietary pectin on viscera indices of geese at 70 days of age (%)

Items	Group I	Group II	Group III
Heart index	0.66±0.06	0.72±0.06	0.73±0.03
Liver index	1.72±0.14	1.80±0.12	1.81±0.10
Spleen index	0.08±0.00	0.09±0.00	0.11±0.01[a]
Bursa of Fabricius index	0.04±0.00[a]	0.02±0.00	0.03±0.00
Gizzard index	2.95±0.04	3.06±0.08	3.22±0.16
Proventriculus index	0.27±0.02	0.26±0.01	0.35±0.02[a]
Thymus index	0.17±0.01[a]	0.16±0.00[a]	0.12±0.02

3.1 Effects of Dietary Pectin on Growth Performance of Goslings at 29 to 70 Days of Age

Pectin exhibits properties of water-holding capacity, gel formation, and fermentability. Upon contact with water, it forms a viscous gel that impedes contact between nutrients and digestive enzymes in the gastrointestinal tract, hindering nutrient utilization and absorption, thus functioning as an anti-nutritional factor for poultry. Yu et al. reported that excessive dietary pectin reduces the utilization of carbohydrates, proteins, and other nutrients, thereby adversely affecting broiler growth and development. Currently, research on pectin' s effects on goose growth performance is limited, with most studies focusing on dietary pectinase supplementation. Huang et al. found that adding 10,000 IU of pectinase to goose diets improved average daily gain and reduced feed-to-gain ratio in 21- to 56-day-old Yangzhou geese without significantly affecting feed intake. Mao observed that dietary supplementation with 10,000 U/kg pectinase significantly increased average daily feed intake in 1- to 4-week-old Wulong geese and significantly reduced feed-to-gain ratio in 5- to 16-week-old geese. Furthermore, combined supplementation with 10,000 U/kg pectinase and 40,000 U/kg cellulase effectively improved average daily gain while reducing feed intake and feed-to-gain ratio in 1- to 16-week-old Wulong geese. These studies indicate that appropriate pectinase supplementation promotes pectin degradation in plants, enhancing utilization of high-fiber diets and benefiting goose growth and development, thereby indirectly confirming the anti-nutritional effects of pectin. The current results demonstrate that high dietary pectin levels significantly reduce body weight and average daily gain while increasing feed-to-gain ratio in 29- to 70-day-old goslings, without significantly affecting feed intake. This may be attributed to pectin' s gel-forming and water-holding properties, which increase chyme viscosity upon entering the gastrointestinal tract, thereby inhibiting nutrient digestion and absorption and compromising gosling growth and development.

3.2 Effects of Dietary Pectin on Body Measurement Traits of Goslings at 70 Days of Age

Body measurement traits represent important phenotypic characteristics in livestock breeding that directly reflect skeletal development. These traits can be measured in live animals with simple procedures and reliable results. Numerous studies have demonstrated correlations between body measurement traits and both growth and slaughter performance, enabling prediction of slaughter characteristics through live body measurements. Zhang et al. measured body weight and measurement traits in 91-day-old Siming Xiang roosters and 119-day-old hens, conducting principal component analysis that revealed significant correlations between body weight and various measurements in both sexes. Zhao et al. performed canonical correlation analysis between body measurement and slaughter traits in quality broiler lines, finding that correlations were primarily driven by breast width, body length, and breast muscle percentage in the male line, and by breast depth, shank circumference, and leg muscle percentage in the female line, suggesting that selection for specific body measurements could indirectly improve slaughter traits. The present results indicate that dietary pectin supplementation significantly reduced breast depth and width at 70 days of age without significantly affecting other body measurements, although pectin-supplemented groups exhibited slightly lower values across all parameters. When considered alongside growth and slaughter performance data, these findings demonstrate that high dietary pectin levels negatively affect skeletal development, particularly breast bone development, and confirm the existence of correlations among body weight, slaughter performance, and body measurement traits in goslings.

3.3 Effects of Dietary Pectin on Slaughter Performance of Goslings at 70 Days of Age

Slaughter performance constitutes a critical indicator for evaluating meat production capacity in livestock, reflecting not only the proportional contribution of different tissues but also differences in nutrient deposition among body parts.

In meat-type poultry, muscle is primarily distributed in the breast and legs, making breast and leg muscle yield key determinants of meat production performance. The abdomen represents the primary site for fat accumulation and energy storage in poultry, with abdominal fat comprising approximately 22% of total body fat in chickens. Abdominal fat deposition is primarily influenced by dietary protein, energy, amino acids, and fiber content. Dietary pectin typically coexists with cellulose, hemicellulose, and lignin, forming a physical barrier that encapsulates and adheres to these fibers, creating the first obstacle to nutrient utilization from higher plants. This barrier impedes interactions between digestive enzymes and substrates, thereby affecting protein and fat digestion, absorption, and utilization. Wu investigated the effects of pectin and xylan on growth performance and digestive physiology in Chinese mitten crabs, finding that pectin significantly reduced apparent digestibility of dry matter, protein, and fat. Tan examined the effects of 8% soluble pectin on digestion, metabolism, blood glucose, and ammonia in growing pigs, observing significant reductions in energy apparent digestibility and metabolic rate, along with decreased nitrogen apparent digestibility. The current results demonstrate that high dietary pectin levels significantly reduced breast muscle percentage and abdominal fat percentage in goslings, likely because pectin in the gastrointestinal tract prevented contact between digestive enzymes and protein or lipid substrates, thereby compromising protein and lipid digestion, absorption, and utilization, ultimately reducing their deposition in breast muscle and abdominal tissues.

3.4 Effects of Dietary Pectin on Viscera Indices of Goslings at 70 Days of Age

Viscera indices, calculated as the ratio of organ weight to live weight before slaughter, reflect the developmental status of internal organs to some extent. Normal development of internal organs is essential for effective nutrient deposition in muscle, bone, and other tissues, and can indicate current physiological function and growth status, being influenced by breed, sex, diet, and other factors. The spleen, bursa of Fabricius, and thymus are primary immune organs in poultry that serve as barriers against external pathogens, playing crucial roles in disease resistance. Many avian diseases affect these three immune organs, causing atrophy or enlargement and compromising immune function. The gizzard and proventriculus are digestive organs that temporarily store and initially process food, with the small proventriculus secreting gastric juice and the large gizzard storing and grinding feed. The present results indicate that high dietary pectin levels increased spleen, gizzard, and proventriculus indices while decreasing bursa of Fabricius and thymus indices, suggesting that pectin may promote gastric development to some extent but exerts adverse effects on immune organs. The specific mechanisms underlying these effects require further investigation.

4 Conclusion

Elevated dietary pectin levels reduce growth performance and slaughter performance while negatively affecting skeletal development and immune organ function in goslings. In practical production, careful attention should be paid to inclusion levels of pectin-rich feed ingredients.

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