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Effect of yeast peptide dietary supplementation on nutrient digestibility, growth performance, and blood metabolites in geese

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Abstract

A study was conducted to evaluate the effect of yeast peptide supplementation on growth performance, nutrient digestibility, and blood metabolites in geese. One-day-old Sichuan white geese (*n* = 300, 95.16 ± 1.98 g) were randomly assigned to five dietary treatment groups containing either 0 (control), 100, 200, 300, or 400 mg/kg commercial yeast peptide product. Compared with the control, dietary supplemental yeast peptide at 200 mg/kg substantially improved feed conversion ratio, body slope length, half-eviscerated percentage, and the apparent digestibility of phosphorus. With the increase in dietary yeast peptide, breast width, carcass percentage, serum triglyceride and high-density lipoprotein increased linearly. The average daily gain, pelvis width, half-diving depth, low density lipoprotein, and digestibility of gross energy exhibited quadratic responses with the increase in dietary yeast peptide, with the 200 mg/kg or 300 mg/kg feeding level being the most effective. It can be concluded that dietary supplementation of yeast peptides improves growth performance and affects nutrient digestibility and blood metabolites, which were optimized at 200 mg/kg or 300 mg/kg of yeast peptide in the present study.

Key words: geese, yeast peptide, performance, digestion, blood parameter

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Introduction

Antibiotics have been widely used in the animal breeding industry, and have made substantial contributions towards disease prevention, promotion of growth, and improvement in breeding efficiencies (Kim & Lillehoj, 2019). The modern breeding industry is developing into an intensive and large-scale industry; however this also increases the probability of infection, which in turn results in huge economic losses to the breeding industry. The imprudent use of antibiotics not only affects the healthy and sustainable development of animal husbandry, but also endangers human health and impacts the safety of the ecological environment (Dan *et al*., 2015). Therefore, an urgent need exists in relation to finding antibiotic substitutes which are safe, less toxic, and highly efficient, especially in the era of complete bans on antibiotic use in the industry.

Antimicrobial peptides (AMPs) are widely distributed in animals and plants and constitute part of the natural immune defence system in organisms. Antimicrobial peptides can kill or inhibit the growth and reproduction of potentially harmful microorganisms. Antimicrobial peptides have some advantages,

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including a multi-target, rapid bacteriostatic (Peschel & Sahl, 2006), wide antibacterial spectrum (Zasloff, 2019), the enhancement of the body's immune activity (Lai & Gallo, 2009), and resistant bacterial strains are not easily produced against AMPs (Christensen *et al*., 1988). Antimicrobial peptides have been studied in multiple animals, including largemouth bass (*Micropterus salmoides*) (Li *et al*., 2020), shrimp (Gyan *et al*., 2020), pigs (Xiong *et al*., 2014), and broiler chickens (Choi *et al*., 2013). Research has shown that dietary AMP supplementation at 337 and 359 mg/kg improved growth performance, digestibility, intestine morphology, and serum parameters of broilers (Sholikin *et al*., 2021). Similarly, Choi *et al*. (2013) also suggested that AMPs had a positive effect on the growth performance of broiler chickens, both in the starter and finisher phases.

Yeast peptide (YP), an antibacterial peptide induced by yeast, is known to have high activity levels, high nutrition (crude protein ≥ 3%; mannan ≥ 0.5%; crude ash ≤ 11%) and is a small molecule which is water-soluble and fully absorbed by the animal body. It is used to fight against a variety of gram-negative enterobacteria and has been shown to be highly effective in killing *Escherichia coli* and *Salmonella*. At present, the effects of dietary YP in geese have not been studied. Therefore, this study evaluated the effects of dietary supplementation of YP on nutrient digestibility, growth performance, and blood metabolites in geese.

Material and Methods

Ethical clearance for this research was granted by the Animal Care and Use Committee of Chongqing Three Gorges Vocational College and Southwest University (Ethical clearance number SWU-20143003). Three hundred healthy, Sichuan white geese (one-day-old, ♂ : ♀ = 1:1) with an average body weight of 95.16 ± 1.98 g were used in this study. The geese were randomly assigned to five dietary treatment groups containing either 0 (control), 100, 200, 300, or 400 mg/kg commercial yeast metabolites (YP ≥ 5000 mg/kg, Beijing Enhalor International Tech Co. Ltd, Beijing, China). Each treatment consisted of six replicates with 10 geese per replicate (♂ : ♀ = 1 : 1). The YP is composed of 19 amino acid residues (GGVGKIIEYFIGGGVGRYG) with a molecular weight of 1.9 kD; its structure is stable and it is shaped in a circular, folded structure with a lasso through the core. The corn–soybean meal basal diets were formulated to meet the recommendations of the National Research Council (1994) for both the starter (days 1–28) and grower (days 29–70) periods (Table 1). Geese were housed in pens (3.5 m × 3.0 m) and raised on a net-bed in a windowed poultry house. The geese were allowed free access to feed (in pellet form) and water *ad libitum* throughout the experimental period. Feed was provided four times daily at 07:30, 12:30, 17:00, and 21:00. The average house temperature during the experimental period was 18.26 ± 1.95 °C and the relative humidity was 80.32 ± 4.49%.

Table 1. Composition and nutrient content of starter (Day 1–28) and grower (Day 29–70) basal diets for geese (dry basis)

Ingredients (%)	Starter (1–28)	Grower (29–70)
Corn	63.80	53.60
Wheat bran	2.99	14.50
Soybean meal	20.00	11.50
Rapeseed meal	4.00	0.00
Rice bran	0.00	13.40
Silkworm chrysalis	4.30	1.79
$CaHPO_4$	1.59	0.90
Limestone	0.87	0.75
Salt	0.20	0.20
L-Lysine (98.5%)	0.15	0.18
DL-Methionine	0.05	0.06
Choline chloride	0.05	0.12
Premix[1]	2.00	2.00
Sand	0.00	1.00
Nutrient content		
ME (MJ/kg)[2]	11.97	11.21
CP (%)	20.43	14.81
Crude fibre (%)	4.12	8.04
Calcium (%)	0.87	0.80
P (%)	0.43	0.40
Lysine (%)	1.14	0.85
Methionine (%)	0.36	0.30

[1]The premix provided the following per kilogram of diet: VA, 40000 IU; VD_3, 2000 IU; VE, 60 mg; VK_3, 2 mg; VB_1, 4 mg; VB_2, 24 mg; VB_6, 4 mg; VB_{12}, 50 µg; nicotinic acid, 12 mg; pantothenic acid, 36 mg; folic acid, 4 mg; biotin, 0.4 mg; Fe, 120 mg; Cu, 4 mg; Mn, 300 mg; Zn, 160 mg; I, 0.2 mg; Se, 0.2 mg.
[2]Calculated values

Body weight and feed consumption (in grams) were determined weekly throughout the experiment on an individual basis. Average weight gain, average daily gain (ADG), average daily feed consumption, mortality, and feed conversion ratio (feed/gain) were calculated for the whole period. The measurement of body size traits was conducted with reference to NY/T823-2020 "*Terms and Statistics of Poultry Production Performance"*. Callipers were used to measure body oblique length, keel length, chest depth, chest width, tibial length, tibial circumference, hip bone width, and semi-diving length of the geese. Geese were sacrificed by cervical dislocation at day 70. Full evisceration weight, half evisceration weight, chest muscle weight, and leg muscle weight were recorded, and subcutaneous fat thickness was dissected and extracted.

Blood was collected on day 70 from the jugular veins of three randomly selected geese in each pen. Serum was extracted following centrifugation in preparation for the biochemical parameter assay. Serum samples were analysed for aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), total protein (TP), albumin (ALB), globulin (GLO), total cholesterol (CHOL), triglycerides (TG), high density lipoprotein (HDL), and low-density protein (LDL) using a CL-8000 clinical chemical analyser (Shimadzu, Kyoto, Japan) via standard enzymatic procedures.

Nutrient digestibility was determined by total faecal collection, therefore care was taken to collect fresh faeces which had not been in contact with the drinking water. Total excreta was collected from three geese in metabolic cages that were randomly selected from each pen. Excreta samples were analysed for Ca, P, crude protein (CP), and gross energy as per the published guidelines in '*Feed Analysis and Feed Quality Inspection Technology'.* Energy was determined using the oxygen bomb calorimetry method, whereby dry matter was dried using the published drying method. The CP was determined using the Kjeldahl method, and the crude fat was calculated using the Soxhlet extraction method.

Data were analysed using one-way ANOVA of SAS 8.02 for Windows (SAS Institute, 2001) and means were separated using Fisher's multiple range test. The effect of supplemental levels of YP was determined using orthogonal polynomials for linear and quadratic effects. Data were assumed to be statistically significant when P <0.05.

Results

The YP had no effect on ADFI and ADG (P >0.05), but FCR was affected by dietary YP (P <0.05) (Table 2). Compared to the control group, supplementation with YP at 100 and 200 mg/kg reduced FCR (P <0.05). With the increased concentrations of dietary YP, ADG exhibited quadratic responses; the 200 mg/kg supplementation was the most effective (P =0.04).

Table 2. Effect of supplemental yeast peptide in goose diets on growth performance

Item	Yeast peptide supplementation（mg/kg）					SEM	*P*-value[4]	
	0	100	200	300	400		L	Q
ADFI[1] (g)	154.43	149.17	155.81	158.41	153.33	3.37	0.59	0.87
ADG[2] (g)	46.90	48.63	50.38	49.20	46.78	1.48	0.96	0.04
FCR[3]	3.30[a]	3.07[b]	3.09[b]	3.22[ab]	3.28[a]	0.06	0.79	0.23

[ab]Means within a row lacking a common superscript are significantly different (P < 0.05); [1]ADFI = average daily feed intake; [2]ADG = average daily gain; [3]FCR = feed conversion ratio (feed/gain); [4]Orthogonal contrasts: L = linear, Q = quadratic

Compared to the control, supplementation with YP at 200 and 300 mg/kg improved body slope length and fossil bone length (P <0.05) (Table 3). As dietary YP supplementation increased, the breast width (linear, P =0.04), pelvis width (quadratic, P =0.02) and half-diving depth (quadratic, P =0.01) also increased.

Compared with the control geese, dietary YP supplementation at 300 and 400 mg/kg improved breast muscle percentage (P <0.05) (Table 4). In geese fed 200, 300, and 400 mg/kg YP, the abdominal fat percentage was also increased (P < 0.05). The half-eviscerated percentage at 200 and 400 mg/kg YP supplementation was higher than was observed at 100 mg/kg (P <0.05). As the levels of dietary YP increased, carcass percentage increased linearly (P =0.04).

Table 3. Effect of yeast peptide supplementation in goose diets on body size

Item	Yeast peptide supplementation (mg/kg)					SEM	*P*-value	
	0	100	200	300	400		L	Q
Body slope length (cm)	23.37[a]	24.87[ab]	28.07[c]	27.30[bc]	24.30[a]	0.95	0.58	0.14
Fossil bone length (cm)	12.33[a]	12.67[a]	14.23[b]	14.87[b]	13.03[a]	0.32	0.36	0.30
Breast depth (mm)	65.33	64.00	66.00	64.67	64.33	1.65	0.67	0.88
Breast width (mm)	53.33	54.67	55.67	55.33	56.00	1.11	0.04	0.08
Shank length (cm)	16.40	16.87	17.00	17.57	17.07	0.27	0.13	0.18
Shank circumference (cm)	5.73	5.60	5.67	5.67	5.83	0.16	0.41	0.12
Pelvis width (cm)	7.33	7.67	7.77	7.87	7.80	0.19	0.07	0.02
Half-diving depth (cm)	61.33	62.67	63.13	63.47	63.20	1.13	0.07	0.01

Table 4. Effect of yeast peptide supplementation in goose diets on carcass characteristics

Carcass characteristic (%)	Yeast peptide supplementation (mg/kg)					SEM	*P*-value	
	0	100	200	300	400		L	Q
Carcass	88.14	88.06	88.30	88.39	88.41	0.81	0.04	0.20
Half eviscerated	81.05[ab]	78.72[a]	84.18[b]	81.50[ab]	83.82[b]	1.13	0.29	0.65
Eviscerated	71.98	72.15	71.43	71.46	71.98	0.85	0.60	0.55
Breast muscle	4.46[a]	4.46[a]	4.27[a]	5.12[b]	5.17[b]	0.10	0.11	0.24
Leg muscle	11.49	11.97	11.59	11.31	11.12	0.24	0.20	0.25
Abdominal fat	1.91[a]	1.96[a]	2.25[b]	2.19[b]	2.13[b]	0.05	0.16	0.20

Compared to the control group, supplemental YP increased serum TC, TG, HDL, and LDL content ($P<0.05$) (Table 5). Furthermore, in both the 200 and 300 mg/kg YP groups, TP was increased ($P<0.05$), and the 300 mg/kg geese showed increases in GLO ($P<0.05$). With the increased levels of dietary YP, TG ($P = 0.01$), HDL ($P = 0.02$), and LDL ($P = 0.02$) increased in a linear fashion, and the 300 mg/kg feeding level was the most effective in terms of LDL (quadratic, $P = 0.03$). ALP (linear, $P = 0.06$), ALB (quadratic, $P = 0.08$), and TC (quadratic, $P = 0.07$) tended to be improved as dietary YP increased.

Table 5. Effect of yeast peptide supplementation in goose diets on blood metabolites

Blood metabolite	Yeast peptide supplementation（mg/kg）					SEM	*P*-value	
	0	100	200	300	400		L	Q
ALT (U/L)	26.00	26.00	27.00	27.33	26.33	0.84	0.37	0.38
AST (U/L)	30.33	31.00	32.67	32.00	31.33	0.86	0.36	0.17
ALP (U/L)	751.67	761.00	770.67	803.00	787.00	16.86	0.06	0.21
TP (g/L)	42.97[a]	46.07[ab]	49.07[bc]	51.87[c]	42.57[a]	1.40	0.75	0.26
ALB (g/L)	20.07	22.00	24.50	24.07	21.03	1.07	0.59	0.08
GLO (g/L)	22.90[ab]	24.07[b]	24.57[b]	27.80[c]	21.53[a]	0.78	0.91	0.52
TC (mmol/L)	3.96[a]	4.73[b]	5.71[c]	5.40[c]	5.40[c]	0.17	0.11	0.07
TG (mmol/L)	1.70[a]	2.31[b]	2.44[b]	3.48[c]	3.68[c]	0.09	0.01	0.06
HDL (mmol/L)	2.56[a]	2.77[ab]	3.10b[c]	3.58[d]	3.44[cd]	0.14	0.02	0.09
LDL (mmol/L)	1.19[a]	2.19[b]	2.45[c]	3.02[d]	2.93[d]	0.08	0.02	0.03

ALT: alanine aminotransferase; AST: aspartate aminotransferase; ALP: alkaline phosphatase; TP: total protein; ALB: albumin; GLO: globulin; TC: total cholesterol; TG: triglyceride; HDL: high density lipoprotein; LDL; low density lipoprotein

Dietary YP affected the apparent digestibility of phosphorus (P) and gross energy (P <0.05; Table 6). Digestibility of Ca and retention of CP were unaffected by supplementation with YP at the levels administered (P >0.05). Compared with the control group, dietary supplementation with YP at 100, 200, and 400 mg/kg improved digestibility of P (P <0.05), and at 200, 300, and 400 mg/kg YP supplementation increased gross energy (P <0.05). As the levels of dietary YP supplementation increased, digestibility of gross energy increased linearly (P = 0.02), exhibiting quadratic responses (P = 0.02); the 300 mg/kg supplementation was the most effective. Retention of CP tended to be improved (quadratic, P = 0.07) as dietary YP increased.

Table 6. Effect of yeast peptide supplementation in goose diets on nutrient digestibility

Nutrient digestion factors (%)	Yeast peptide supplementation (mg/kg)					SEM	*P*-value	
	0	100	200	300	400		L	Q
Ca	23.75	24.30	24.30	23.63	23.44	0.30	0.37	0.21
P	53.66^{a}	57.01^{b}	58.49^{b}	56.83^{ab}	58.90^{b}	1.05	0.11	0.24
CP	66.07	67.54	68.26	68.94	67.45	1.15	0.27	0.07
Gross energy	74.73^{a}	76.97^{ab}	78.49^{bc}	80.26^{c}	79.68^{c}	0.72	0.02	0.02

Ca: calcium; P: phosphorus; CP: crude protein

Discussion

At appropriate levels, dietary supplementation with YP substantially decreased the FCR in the geese in the present study. This may be due to improved nutrient retention because of modulation of the gut environment, improvement of beneficial intestinal microbial balance, improved small intestinal morphology, or via stimulation of the mucosal immune system (Ohh *et al.*, 2009; Choi *et al*., 2013). Furthermore, it may also be because YP not only absorbs faster and consumes less energy, but it may be eliminating the competition between free amino acids (Mo *et al.*, 2013). The research shows that diets with 200 mg/kg of antibacterial peptides improve growth performance and reduce the FCR in broiler chickens (Bao *et al.*, 2009). Xie *et al*. showed that the two kinds of ABP combinations could reduce ADFI in broilers, whilst also increasing the feed conversion efficiency and survival rate (Xie *et al.*, 2020).

Body size parameters can reflect the growth and genetic characteristics of livestock and poultry (Xu *et al.*, 2019). At appropriate levels, dietary supplemental YP substantially improved the lengths of both the body slope and fossil bone of the geese in this study. This may be because dietary YP supplementation improves both the palatability of feed and digestive performance; it may also promote nutrient absorption, all of which can affect growth and development. A similar study has shown that yeast cultures substantially increased body slope length and fossil bone length in geese (Zhang *et al.*, 2022).

Slaughter performance can reflect the meat yield of broilers effectively, which is the main reference basis used to measure the meat performance of poultry. At appropriate levels, dietary supplementation with YP substantially improved half eviscerated, breast muscle, and abdominal fat weight of the geese in this study. Therefore, YP may promote the digestion and absorption of nutrients, such as CP. Abou-Kassem *et al*. indicated that higher CP levels in diets increased meat yield of young fattening geese (Abou-Kassem *et al*., 2019). Other studies have shown that small peptides can improve the slaughter rate, breast muscle percentage, and leg muscle percentage of broilers (Janocha *et al*., 2011; Rao *et al*., 2021).

Blood metabolite parameters reflect the physiological changes in an organism to a great extent. The ALT and AST are parameters for liver damage evaluation. No significant differences were shown in ALT or AST levels between the control group and any of the treatment groups in this study, which indicates that YP supplementation had no negative effects on liver health. TP levels reflect the absorption of protein and its relationship with humoral immunity (Tran-Mi *et al*., 2004). Sahar *et al*. (2018) showed that a high TP content was conducive to improving the body performance and immune capacity of broiler chickens, and could promote their health and rapid growth. In the current study, both 200 and 300 mg/kg YP substantially increased TP, and 300 mg/kg of YP supplementation substantially increased GLO, which was consistent with the ADG results. Similar results in calves have shown that the use of AMP increased the serum TP (Li & Han, 2014; Song *et al*., 2018; Xie *et al*., 2020). Concentrations of TG and HDL are important indicators for metabolic balance of blood lipids, which can directly reflect the condition of lipid metabolism within the body (Stanley *et al*., 2002; Ansell *et al*., 2005). In the current study, TG and HDL increased linearly as dietary YP increased, which suggests that increased YP affects lipid metabolism in geese.

In the present study, the YP had no substantial effect on the digestibility of protein, but tended to increase the digestibility of protein, which suggests that YP promotes protein absorption to a certain extent. This may be because yeast can stimulate the secretion and activity of digestive enzymes (Castro *et al*., 2013). Furthermore, the YP increased the digestibility of P and gross energy in this study. Studies have found that AMP can effectively regulate the digestive and absorption capacities of the intestinal tract in broilers, thus enhancing and improving the digestibility of nutrients (Wen & He, 2012). A similar study has shown that dietary-supplemented AMP-A3 improved the retention of DM, CP, and GE, and reduced pathogens in broilers (Choi *et al*., 2013).

Conclusions

In summary, the results of the current study indicate that supplementing diets with YP improves growth performance and affects digestibility of P and gross energy, and the blood metabolite profile in geese. Growth performance varied with the levels of YP supplementation, and was optimal in this study when 200 mg/kg or 300 mg/kg of YP was administered.

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Authors' contributions

Zhang Jie and He Hang led the experiment and gave some advice on the experimental idea. He Hang and Yuan Yancong, who conducted the experiment, were major contributors to writing the manuscript. Liu Anfang, Xiang Bangquan, and Zhang Chuanshi gave some advice on experimental ideas. All authors read and approved the final manuscript.

Conflict of interest declaration

The authors have no conflict of interest to declare.

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