Original Research Article

Growth performance and blood indices of growing turkeys fed diets containing shrimp waste meal

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Abstract

Fish meal (FM) is a major source of animal protein in the diet of turkeys but its high cost has been a major challenge to poultry practitioners in developing countries. Growth performance and blood indices of growing turkeys fed diets containing shrimp waste meal (SWM) as substitute for FM were investigated in a 56-day feeding trial using eighty (80) 4-weeks-old male British United Turkeys (BUT). The turkeys were allotted on weight equalisation into four treatments with four replicates of five turkeys each. Four diets were formulated such that FM in the control diet (diet 1) was substituted by SWM at 150, 300 and 450 g/kg (protein for protein) in diets 2, 3, and 4, respectively. The experiment was arranged in a completely randomised design and data collected were analysed using ANOVA. Cost of feed consumed was highest ($p < 0.05$) for turkeys fed the control diet and lowest for group fed diet 4. Weight gain decreased ($p < 0.05$) with increasing SWM level in the diet at the grower phase (day 57–84). Turkeys fed the 450 g/kg SWM diets had the lowest ($p < 0.05$) feed intake. At the grower phase, best feed:gain, cost of feed consumed, feed cost per weight gain and protein efficiency ratio were recorded in turkeys fed control and 150 g/kg SWM diets. Uric acid, creatinine, cholesterol, alanine aminotransferase (ALT), haematocrit, and white blood count differed significantly ($p < 0.05$) among the treatments at the starter phase. In conclusion, the present study showed that SWM can serve as a potential replacement for FM when substituted at 150 g/kg in the diets of turkeys without any deleterious effect on their performance and haematocrit.

Keywords: *Meleagris gallopavo;* performance; body weight; feed intake; shrimp; waste; fish meal; nutrition; blood; cholesterol; blood enzymes; creatinine; haematocrit

INTRODUCTION

Feed cost for any poultry enterprise in developing countries is on the increase. This scenario has led to high cost of production and reduced return on investment. The cost of feed is up to 80% of the running cost in commercial poultry enterprise (Kirkpinar and Acikgoz, 2018) with protein ingredients covering about 15% of the total cost of compounded ration. Fish meal (FM) is a major source of animal protein in the diet of turkeys. High cost of FM has been a major challenge to poultry practitioners in developing countries. Therefore, there is a need to explore available and cheaper alternatives. Shrimp waste meal (SWM) has the potential of replacing FM.

Coastal demographic analysis suggests that Nigeria has an abundant supply of shrimps with annual production of 12,000 MT which is basically from captured fisheries (Zabbey et al., 2010). About two-thirds of raw shrimp is a waste because the head,

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exoskeleton and tail are removed during processing. Apart from its potential as a feedstuff in poultry diets, its utilisation will reduce the environmental impact created by shrimp farming (Yugandharkumar et al., 2017).

Previous research on the utilisation of SWM has focused on broilers (Rahman and Koh 2016; Rahman, 2016), growing pullets (Islam et al., 2020), and pigs (Yugandharkumar et al., 2017). However, to the best of our knowledge, there is paucity of information on utilisation of SWM in rations for turkeys. We therefore hypothesised that SWM can comfortably replace FM in practical diets for growing turkeys without impairment to their health or growth. This study seeks to investigate the performance characteristics and blood indices of growing turkeys fed diets containing SWM.

MATERIALS AND METHODS

Study area

The experiment was carried out at the Poultry Unit of the Directorate of University Farms (DUFARMS), Abeokuta, Ogun-State, Nigeria. The farm is located in the Tropical rainforest zone South-Western Nigeria on latitude 7°10N and longitude 3°2E.

Collection and processing of shrimp waste

Fresh shrimp waste was collected from a commercial shrimp processing industry in Lagos, south-west Nigeria. It was immediately sun-dried by spreading thinly on a clean concrete slab for three consecutive days (till constant moisture of 10–11%). The dried shrimp waste was milled using a hammer mill and was passed through a 2 mm sieve and stored in air tight container. Chitin content was determined on the acid detergent fibre (ADF) as organic residue according to the method described by Trung and Stevens (2010). The mineral content was assayed using the Buck Scientific Atomic Absorption/Emission Spectrophotometer (Perkin Elmer Optima 4300DV ICP Spectrophotometer, Beaconsfield, UK) while phosphorus was determined using the corning colorimeter according to the method of Fiske and Subbarow (1925). The amino acid content was determined using an amino acid analyser (Model S433 (SYKAM) Eresing, Germany).

Management of experimental birds

A total of one hundred (100) one-day-old, male British United Turkeys (BUT) poults were obtained from a reputable hatchery in Ibadan, south-west Nigeria. The turkeys were brooded for a period

Table 1. Gross composition of experimental diets

Phases of growth	Starter (days 29–56)				Grower (days 57–84)			
Shrimp waste substitution levels (g/kg)	**0**	**150**	**300**	**450**	**0**	**150**	**300**	**450**
Maize	465.00	465.00	465.00	465.00	564.00	564.00	564.00	564.00
Soybean meal	345.00	345.00	345.00	345.00	258.00	258.00	258.00	258.00
Shrimp waste meal	0.00	25.00	50.00	75.00	0.00	15.00	30.00	45.00
Fish meal (72%)	80.00	68.00	56.00	43.00	50.00	43.00	35.00	28.00
Wheat offal	60.00	47.00	34.00	22.00	62.00	54.00	47.00	39.00
Bone meal	33.00	33.00	33.00	33.00	32.00	32.00	32.00	32.00
Oyster shell	9.00	9.00	9.00	9.00	25.00	25.00	25.00	25.00
Vitamin/Mineral Premix[a]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Salt	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Lysine	-	-	-	-	0.50	0.50	0.50	0.50
Methionine	-	-	-	-	0.50	0.50	0.50	0.50
TOTAL	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Determined values (g/kg)								
ME (MJ/kg)	11.78	11.80	11.80	11.82	11.87	11.88	11.90	11.95
Crude protein	262.70	260.70	258.70	256.20	206.40	205.30	205.00	204.10
Crude fat	34.10	35.00	36.00	36.90	34.30	34.90	35.40	36.00
Crude fibre	36.30	36.60	36.80	37.10	37.30	37.90	38.10	38.80
Mineral profile (g/kg)								
Phosphorus	7.00	6.80	6.60	6.40	6.20	6.10	6.00	5.90
Calcium	14.10	13.90	13.60	13.30	18.70	18.60	18.40	18.20

Vit/min premix contained per kg of diet: Vit A 11500 IU, Vit D_3 1600 IU, Riboflavin 9.9 mg, Biotin 0.25 mg, Pantothenic acid 11.0 mg, Vitamin K 3.0 mg, Vit B_2 2.5 mg, Vit B_6 0.3 mg, VitB_{12} 8.0 mg, Nicotinic acid 8.0 mg, Iron 5.0 mg, Manganese 10 mg, Zinc 4.5 mg, Cobalt 0.02 mg, Selenium 0.01 mg.

of pre-experimental 28 days during which time a pre-starter diet (11.93 MJ/kg, 28% crude protein, CP) was fed to them. At day 29, eighty (80) birds were selected based on weight equalisation and assigned to four dietary treatments of 20 birds per treatment. Each treatment was replicated four times with five turkeys each. Four experimental diets were formulated such that the FM in the control diet (diet 1) was substituted with SWM at 150, 300 and 450 g/kg (protein for protein) in diets 2, 3, and 4, respectively. Hence, the experiment was arranged in a completely randomised design. The crude protein (g/kg) and metabolisable energy (MJ/kg) contents of the diets were balanced according to NRC (1994). The gross composition of experimental diets is presented in Table 1. The study had the starter (days 29–56) and grower (days 57–84) phases.

Data collection

Initial body weights (g/bird) were obtained before the administration of experimental treatments. Weekly live body weight was measured. Average daily weight gain per turkey was calculated as total final body weight – total initial body weight divided by the number of birds in a replicate. Daily feed intake (g) was obtained as the difference between the quantity of feed given the previous day and the left over, and divided by the number of turkeys in a replicate. Feed:gain ratio (FGR) was calculated as the ratio of daily feed intake and daily weight gain. Daily protein intake was calculated by multiplying daily feed intake with percent protein of the diet.

Mortality was recorded as it occurred and mortality percentage was calculated as the number of dead turkeys divided by the total number of turkeys stocked multiplied by 100.

Blood indices

At the end of the starter and grower phases, 3 ml blood samples were collected from two turkeys per replicate through brachial vein puncture into tubes containing ethylene-diamine-tetra-acetate (EDTA) for haematological indices. Another 3 mL were collected into plain bottles without anti-coagulant which were centrifuged for 15 minutes at 503.1 × *g* to collect the serum for biochemistry indices. Haemoglobin concentration (Hb) was determined using the cyanmethaemoglobin method (Cannan, 1958). Haematocrit, red blood cell (RBC) and white blood cell (WBC) counts were determined using Wintrobe haematocrit tube according to the method of Schalm et al. (1975). Total serum protein, serum albumin, serum globulin (Varley et al., 1980) and serum uric acid concentration (Wootton, 1964) and serum creatinine (Bonsnes and Taussky, 1945) were measured according to standard procedures. Serum enzymes, alanine aminotransferase (ALT), aspartate aminotransferase (AST) were measured using commercial Kits (Randox test Kits, Randox Laboratories, Antrim, UK).

Research policy

Animal Ethics Committee guidelines of the Federal University of Agriculture, Abeokuta (FUNAAB, 2014) were strictly adhered to throughout the duration of the experiment.

Statistical analysis

Data obtained were fitted into one-way Analysis of Variance (ANOVA) in a Completely Randomised Design using the general linear model procedure of the Minitab version 17. Means of significant results were compared by Duncan multiple range test of the same package. A probability of $p < 0.05$ was considered to be statistically significant.

Table 2. Chemical analysis of SWM

Variables	Values
Proximate (g/kg)	
Crude protein	367.40
Crude fat	13.10
Crude fibre	116.00
Ash	162.60
NFE	340.90
ME (MJ/kg)	11.24
Mineral profile	
Phosphorus (g/kg)	2.00
Calcium (g/kg)	90.60
Zinc (mg/kg)	45.10
Iron (mg/kg)	110.00
Manganese (mg/kg)	242.90
Fibre fraction (g/kg)	
NDF	427.00
ADF	402.70
ADL	Not determined
Amino acid profile (g/kg)	
Methionine	8.00
Lysine	16.60
Arginine	16.00
Tryptophan	4.00
Threonine	14.20
Chitin	156.00

Values are average of two (2) determinations (n = 2)
NFE = Nitrogen Free Extract, ME = Metabolizable energy, NDF = Neutral Detergent Fibre, ADF = Acid Detergent Fibre, ADL = Acid Detergent Lignin. Metabolisable energy of the test ingredient (SWM) was calculated using the Pauzenga formula (37 × % CP + 81.8 × % EE + 35.5 × % NFE).

Table 3. Performance characteristics of turkey starter and grower fed SWM in partial replacement for FM

Variables	SWM level of inclusion (g/kg)					
	0	150	300	450	SEM	*P*-VALUE
Starter phase (days 29–56)						
Initial weight (g/b)	560.00	560.00	560.00	560.00	0.00	-
Final weight (g/b)	3243.00	2855.00	2801.00	2913.00	115.00	0.074
Weight gain (g/b)	2683.00	2295.00	2241.00	2353.00	115.00	0.074
Feed Intake (g/b)	6063.00^{a}	5443.00^{b}	5430.00^{b}	5177.00^{c}	153.00	0.038
Feed conversion ratio	2.27	2.38	2.44	2.46	0.06	0.141
Feed Cost/kilogram	130.70	128.00	125.40	122.10	0.00	0.125
Cost of feed consumed (₦/bird)	792.40^{a}	696.90^{b}	680.90^{b}	632.11^{c}	19.50	0.007
Feed cost/Weight gain (₦/gram)	296.82	304.29	305.18	299.84	7.10	0.822
Protein efficiency ratio	1.68	1.62	1.59	1.59	0.04	0.357
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.168
Grower phase (days 57–84)						
Initial weight (g/b)	3243.00	2855.00	2801.00	2913.00	115.00	0.074
Final weight (g/b)	5796.00	5446.00	4775.00	4417.00	485.00	0.250
Weight gain (g/b)	2553.00^{a}	2591.00^{a}	1974.00^{b}	1504.00^{c}	419.00	0.033
Feed Intake (g/b)	9823.00^{b}	10069.00^{a}	9720.00^{b}	7551.00^{c}	1919.00	0.041
Feed conversion ratio	3.85^{b}	3.89^{b}	4.92^{a}	5.02^{a}	0.35	0.035
Feed Cost/kilogram	111.90	110.50	108.40	106.90	0.00	0.067
Cost of feed consumed (₦/bird)	1099.19^{a}	1112.62^{a}	1053.65^{b}	807.20^{c}	208.00	0.036
Feed cost/Weight gain (₦/gram)	430.82^{b}	429.85^{b}	533.33^{a}	536.64^{a}	38.30	0.055
Protein efficiency ratio	1.22^{a}	1.25^{a}	0.90^{b}	0.98^{b}	0.08	0.031
Mortality (%)	6.67	20.00	33.33	40.00	9.43	0.137

SEM, pooled standard of means,. ^{abc} Means on the same row having different superscripts are significantly different when $p < 0.05$. g/b = gram per bird, ₦ = naira sign

RESULTS

Chemical composition of shrimp waste meal

The result of the proximate composition, mineral profile, fibre fractions and amino acid profile of SWM is as presented in Table 2. The test ingredient contained 360 g/kg crude protein, 8 g/kg and 16.6 g/kg methionine and lysine, respectively. The chitin content was 156 g/kg.

At the starter phase, feed intake (FI) was significantly ($p < 0.05$) reduced as the replacement of FM with SWM increased in the diets (Table 3). Turkeys fed (control diet) 0 g/kg SWM recorded the highest whereas turkeys fed 450 g/kg SWM recorded the lowest ($p < 0.05$) value. Final weight (FW), Weight gain (WG), Feed conversion ratio (FCR) ad protein efficiency ratio (PER) were not significantly affected ($p > 0.05$) by dietary replacement of FM with SWM. Cost of the feed consumed (CFC) was significantly ($p < 0.05$) reduced as the level of SWM inclusion increased in the diets. The highest value was recorded for control and the lowest for turkeys fed 450 g/kg SWM.

At the grower phase, weight gain (WG) and feed intake (FI) changed ($p < 0.05$) as SWM replaced FM in the diets. Weight gain (WG) of turkeys fed 0 and 150 g/kg SWM was similar but significantly different ($p < 0.05$) from other treatments. The highest FI was recorded for turkey fed 150 g/kg SWM whereas the lowest ($p < 0.05$) FI and weight gain was recorded for turkeys fed 450 g/kg SWM. The FCR became worsened ($p < 0.05$) as SWM level increased with the lowest value of 5.02 recorded for turkeys fed 450 g/kg SWM. Cost of feed consumed (CFC) was similar for turkeys fed 0 and 150 g/kg SWM but significantly ($p < 0.05$) different from the other treatments. The lowest CFC was recorded for turkeys fed with 450 g/kg. Feed cost/weight gain (FC/WG) was highest ($p < 0.05$) for turkeys fed 450 g/kg SWM and similar to turkeys fed 300 g/kg. The lowest FC/WG was recorded for turkeys fed 150 g/kg which was similar to turkeys fed control diet. Protein efficiency ratio (PER) values significantly ($p < 0.05$) reduced as the replacement of FM with SWM increased in the diets.

Table 4. Blood indices of turkey starter and grower fed SWM in partial replacement for FM

Indices	SWM level of inclusion (g/kg)					
	0	150	300	450	SEM	*P*-VALUE
Starter phase (days 29–56)						
n values	8	8	8	8		
Glucose (mmol/l)	12.47	12.20	11.98	11.42	0.27	0.100
Total protein (g/l)	42.35	43.60	41.27	36.97	2.25	0.234
Albumin (g/l)	26.23	26.10	25.20	23.43	0.98	0.210
Globulin (g/l)	16.13	17.50	16.07	13.55	1.83	0.511
Uric acid (µmol/l)	444.91^{a}	365.80^{b}	306.32^{c}	327.14^{bc}	11.30	0.000
Creatinine (µmol/l)	99.89^{a}	83.98^{ab}	83.98^{ab}	77.79^{b}	4.42	0.035
Cholesterol (mmol/l)	3.91^{a}	3.57^{b}	2.94^{c}	2.86^{c}	0.41	0.264
AST (µkat /l)	5.28	4.72	5.34	4.54	0.17	0.114
ALT (µkat /l)	0.65^{a}	0.54^{ab}	0.46^{ab}	0.26^{b}	0.08	0.034
Haematocrit (l/l)	0.37	0.35	0.35	0.34	0.01	0.359
Haemoglobin (g/l)	124.30	117.50	117.00	113.00	4.30	0.366
White blood cells (10^{9}l)	27.70^{a}	20.58^{ab}	18.34^{b}	15.04^{b}	2.23	0.011
Red blood cells (10^{12}l)	2.94	2.85	2.84	2.81	0.05	0.351
Grower phase (days 57–84)						
n values	8	8	8	8		
Glucose (mmol/l)	14.84	14.51	16.14	17.06	2.45	0.871
Total protein (g/l)	46.33	47.07	49.33	48.23	1.25	0.401
Albumin (g/l)	31.17	32.80	34.13	32.56	0.90	0.222
Globulin (g/l)	15.17	14.27	15.20	15.67	0.99	0.790
Uric acid (µmol /l)	493.68	334.87	420.52	438.37	42.83	0.144
Creatinine (µmol /l)	97.24	97.24	103.43	123.76	8.84	0.172
Cholesterol (mmol/l)	4.15	4.85	5.32	5.02	0.40	0.275
AST (µkat /l)	6.10^{a}	5.04^{ab}	4.56^{b}	4.24^{b}	0.24	0.003
ALT (µkat/l)	0.35^{b}	0.35^{b}	0.38^{b}	0.51^{a}	0.02	0.002
Haematocrit (l/l)	0.38	0.32	0.35	0.33	0.03	0.468
Haemoglobin (g/l)	129.00	108.30	118.30	111.70	9.20	0.445
White blood cells (10^{9}l)	31.23	33.06	23.07	30.05	3.92	0.347
Red blood cells (10^{12}l)	3.17	2.61	2.85	2.81	0.21	0.366

AST = Aspartate aminotransferase; ALT = Alanine aminotransferase, n = number of observations. SEM, pooled standard of means, ^{abc} Means on the same row having different superscripts are significantly different when $p < 0.05$

Blood indices

At the starter phase, the results of blood indices in Table 4 shows that there was a significant ($p < 0.05$) decline in uric acid, creatinine and cholesterol concentrations as the levels of SWM increased in the diets. Turkeys fed 0 g/kg had the highest values for these indices whereas the lowest values for creatinine and cholesterol were recorded in turkeys fed 450 g/kg SWM. The values for ALT and WBC significantly ($p < 0.05$) differed among treatments with highest and lowest values recorded for turkeys fed the control (0 g/kg) and 450 g/kg SWM, respectively. At the grower phase, only ALT and AST showed a significant ($p < 0.05$) effect following dietary replacement of FM with SWM. There was a significant increase in AST in turkeys fed 0 g/kg SWM diet compared to turkeys on other diets. The ALT values recorded for turkeys fed 0, 150 and 300 g/kg SWM were similar but different ($p < 0.05$) from the value recorded for 450 g/kg SWM fed turkeys which were the highest.

DISCUSSION

The chemical composition of SWM used in this study showed its prospect as a rich protein, calcium and lysine animal feed ingredient. The crude protein of SWM recorded in this study was lower than 39.5% and 49.0% reported by Yugandharkumar et al. (2017) and Sánchez-Camargo et al. (2011), respectively, but higher than 30.4% and 24.9% reported by Brito et al. (2020) and Bellaaj et al. (2012). The crude fibre (CF) was lower than the values reported by Khempaka et al. (2011) but higher than the values reported by Okonkwo et al. (2012).

However, the ether extract (EE) of 1.31% recorded for the SWM was lower than the values reported by the aforementioned authors. The ash content (16.26%) was lower than values reported by Bellaaj et al. (2012) and Brito et al. (2020) but higher than the value (10.5%) reported by Ehigiator and Nwangwu (2011). The values recorded for phosphorus and calcium (0.2 and 0.9%) in this study were lower than the values (0.42 and 0.98%) reported by Yugandharkumar et al. (2017) and Khempaka et al. (2011). The differences in values obtained in our study compared with those reported by other authors could be attributed to the sources of shrimp waste used, composition of shrimp waste, processing techniques employed and storage methods used. According to Yugandharkumar et al. (2017), the chemical composition of shrimp shell waste will vary significantly depending upon the nature of the processing operation. The most common methods of processing are hand de-heading and mechanical peeling.

The reduction in the weight gain and worse FCR obtained for growing turkeys as the level of SWM increased in the diets could be attributed to the poor nutritional profile of SWM as compared to FM. The result of this study is in tandem with the reports of Rahman (2016) and Brito et al. (2020) stating that the final weight, weight gain and feed conversion ratio was reduced with increasing levels of SWM in diets of broilers. Improved growth and feed conversion ratio similar to the response reported for the control group was obtained in the present study with growing turkeys fed diet containing 150 g/kg SWM. Beyond 150 g/kg SWM inclusion, feed conversion worsened and weight gain decreased drastically. This could be attributed to the increasing chitin content of the diet as SWM replacement increased. Chitin is an N-acetylated glucosamine polysaccharide that forms part of the protein complex and is considered to cause reduced nutrient digestibility. The decline in FI at the starter phase and PER at the grower phase as the level of SWM increased in the diets could be attributed to the reduced nutritional profile of SWM compared to FM (Oduguwa et al., 2004). Fish meal is a conventional animal protein source rich in crude protein and essential amino acids. The slight mortality recorded was a result of mild Salmonella infection which occurred at the rearing pen. However, the effect evened out since it was not connected to a specific treatment. It also occurred in the control birds. The significant decrease in serum cholesterol as the SWM level increased in the diets of starter turkeys could be attributed to high content of crude fibre (CF) in the diets. The CF increased as the level of SWM increased in the diets. According to Regar et al. (2019), the fibre is correlated with low cholesterol concentration in the blood plasma. High fibre diet reduces cholesterol by absorbing bile acids. Cholesterol is a precursor of bile acid biosynthesis and steroid hormones. The values recorded for haemoglobin (Hb), haematocrit (Hct) and white blood cell (WBC) fell within the physiological range of 9–12 g/dl, 32–35% and 9–31 g/l for Hb, haematocrit and WBC, respectively (Nanbol et al., 2016). This suggested that the birds were healthy and not susceptible to diseases. According to Akinmutimi et al. (2004), a low WBC count suggests susceptibility to infection. The Hb and Hct recorded in this study shows that the turkeys had sufficient blood pigment for proper transmission of oxygen, thus, the birds were healthy. Reduced Hb concentration suggests the presence of a toxic factor which may have an adverse effect on blood formation (Oguntoye et al., 2018). The non-significance of most of the indices at the grower phase suggested that the birds showed a healthy status and there was no indication of SWM showing deleterious effects on their health. However, a significant reduction in AST as SWM increased in the diets could also be attributed to low quality of SWM as compared to FM. Fish meal is rich in vitamins including vitamin B6 (pyridoxine) which is essential for the activities of AST.

CONCLUSION AND RECOMMENDATION

The findings of this study revealed that SWM (a non-conventional protein ingredient) showed prospects as a substitute for the expensive FM in the diets of growing turkeys. Based on the findings of this study, the 150 g/kg replacement level (protein for protein) of the expensive FM with the cheaper SWM is recommended in the diets of growing turkeys with no deleterious effect on their health status. However, the replacement value of FM with SWM should not exceed 150 g/kg in composite diets since a higher amount of SWM resulted in poor performance of the growing turkeys. The use of SWM as animal protein ingredient in turkey nutrition is a new and novel approach that has not been fully explored. Our study shows that dietary inclusion of SWM in composite turkey feed could substantially reduce the cost of production in commercial turkey enterprise and indirectly enhance the affordability of turkey meat for human consumption.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to research, authorship and publication of this article.

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