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Growth, nutrient digestibility, ileal digesta viscosity and energy metabolisability of growing turkeys fed diets containing malted sorghum sprouts supplemented with enzyme or yeast

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Running head: Turkeys fed with malted sorghum sprouts

Summary

Growth, apparent nutrient digestibility, ileal digesta viscosity and energy metabolisability of growing turkeys fed diets containing malted sorghum sprouts (MSP) supplemented with enzyme or yeast was investigated using 120, 28-days old, male turkeys. There were six treatments laid out in a 3 × 2 factorial arrangement of treatments having three dietary inclusion levels of MSP (0, 50 and 100 g/kg) supplemented with or without 200 mg/kg of a commercial enzyme. The experiment lasted for the starter (day 28-56) and grower phases (day 57-84) of the birds. Each treatment group consisted of 20 turkeys replicated 4 times with 5 birds each. Data were analysed using analysis of variance while polynomial contrast was used to determine the trends (linear and quadratic) of MSP inclusion levels. Irrespective of dietary supplementation with enzyme or yeast, final live weight, total weight gain and feed intake for turkey poults from day 29-56 reduced ($P < 0.05$) with increasing inclusion level of MSP. Dietary supplementation with yeast resulted in increased ($P < 0.05$) feed intake while enzyme supplementation improved ($P < 0.05$) feed conversion ratio of the poults. Starter and grower turkeys fed enzyme-supplemented MSP diets had higher ($P < 0.05$) weight gain than their counterparts fed yeast-supplemented MSP diets. Apparent ash digestibility reduced linearly ($P < 0.05$) with increasing inclusion levels of MSP. Apparent metabolisable energy (AME) did not vary significantly ($P > 0.05$) with MSP inclusion levels**.** Dietary inclusion of 100 g/kg MSP recorded the highest ($P < 0.05$) ileal digesta viscosity. Enzyme supplementation reduced ($P < 0.05$) ileal viscosity but had no effect ($P > 0.05$) on AME. Inclusion of MSP resulted in poor growth performance. This confirms reports of earlier studies that utilization of MSP by poultry is rather poor. Supplementation with enzyme or yeast did not lead to any appreciable improvement in performance of turkeys in this study.

Keywords: Turkey poults, ileal digesta viscosity, malted sorghum sprouts, yeast, energy metabolisability.

Introduction

Feed cost required in commercial poultry production has risen astronomically due to the competition between man, livestock and agro-industries for the limited cereal grains available (Oso *et al.*, 2010). This food-feed pressure especially in the developing countries necessitated the search for alternative feed stuffs which are cheap and readily available.

Malted sorghum sprouts (MSP) produced as a result of incomplete germination of sorghum (referred to as malting) is a cheap alternative feedstuff. This malting process is commonly used in breweries and food processing companies for the manufacture of drinks, beverages, etc. (Briggs *et al.*, 1991). The residue remaining after the extraction of malt from the germinated cereal seed is referred to as 'malted sorghum sprouts' (MSP) (Oduguwa *et al.*, 2001).

Commercial malting of sorghum with an output estimated to the tune of 200 000 metric tons of malted and unmalted extracts per annum was reported by Ikediobi (1989). This has led to the production of large quantities of MSP.

Nutritional evaluation of MSP showed that it contained 226, 224, 33 and 522 g/kg (DM basis) of crude protein, neutral detergent fibre, ether extract and nitrogen free extract, respectively (Aning *et al.*, 1998). Oke (2010) reported a crude protein, ether extract, ash, NDF, ADF and ADL values of 163.7, 38.2, 62.70, 217, 147, 10.3 g/kg, respectively for MSP. Successful utilization of MSP up to 10% inclusion in growing pullets has been reported in previous studies (Fafiolu *et al.*, 2006). However, the nutritional potentials of MSP as feedstuff for poultry are limited due to the constituent fibre fractions (NDF and ADF), hydrocyanide and tannin contents (Oduguwa *et al.*, 2001). Residues of tannin and arabinoxylan have been reported to reduce nutrient digestibility and growth of poultry (Balogun *et al.*, 2005). Recent studies have shown that dietary supplementation with fibre degrading enzymes improved ileal nitrogen retention, apparent metabolisable energy (AME) (Cowieson *et al.*, 2003), digestion of dietary starch, fibre, protein and lipid in poultry (Choct *et al.*, 1999). Similarly, yeast and its extracts have been reported to improve growth, nutrient digestibility and stimulate birds' immune systems (Abel and Czop, 1992). In this present study, diets containing 0, 50, or 100 g/kg MSP in which supplements of either enzyme or yeast have been incorporated were fed to growing turkeys. The performance characteristics, nutrient digestibility, viscosity of ileal digesta and energy metabolisability were used as criteria of response.

Materials and methods

Source and chemical composition of malted sorghum sprouts

Malted sorghum sprouts (MSP) was obtained commercially from a local brewery industry in Ogun State, Nigeria. This was dried (10-11% moisture content) prior to collection and included on DM basis in the experimental diets. Proximate composition (AOAC, 1990), fibre fractions (Van Soest *et al.*, 1991), gross energy (Adiabatic bomb calorimeter, Parr Instrument Company, Moline, IL, USA) and tannin content (Hoff and Singleton, 1977) of MSP was determined according to standard procedures (Table 1). For Ca and P determination of MSP, samples were further dried in a hot air oven (105 ^{o}C for 8 h), milled to pass through 0.5 mm sieve and ignited at 400 ^{o}C for 4 h in a muffle furnace. The ash was treated with HNO_3 under mild heat (80 ^{o}C) and digested (15ml HNO_3). Analysis was done using the atomic absorption spectrophotometer (Perkin Elmer Optima 4300DV ICP spectrophotometer, Beaconsfield, UK).

Enzyme and yeast

The commercial enzyme used in this study is a blend of enzymes consisting of endo – 1, 4 – β – xylanase (EC 3.2.1.8), endo – 1, 3 (4) – β – glucanase (EC 3.2.1.6) and endo – 1, 4 – β – glucanase (EC 3.2.1.4) produced by *Trichoderma reesei*. Baker's yeast was purchased commercially.

Experimental birds and management

One hundred and fifty, 1 day-old, male British United turkeys (BUT) were purchased from a commercial hatchery. Brooding (day 0 to 28) was done intensively in a deep litter housing system during which all the birds were fed with a pre-starter turkey ration (Table 2). During this time, temperature was controlled at 34.5°C for the first 2 days and then gradually reduced by 2°C per week to a final ambient temperature of 27°C in the last week of brooding. Feed and clean water were supplied *ad libitum*. Normal vaccination program and medication schedule were strictly adhered to.

Dietary treatments

At day 28, 120 male turkeys of similar weight were selected from the flock above and assigned on weight equalization basis to six dietary treatments laid out in a 3 × 2 factorial arrangement of treatments having three dietary inclusion levels of MSP (i.e. 0, 50 and 100 g/kg) supplemented with either 200 mg/kg commercial enzyme or 200 mg/kg yeast for day 29 to 56 (starter phase) and day 57 to 84 (grower phase), respectively (Table 2). Each treatment group consisted of 20 turkeys replicated four times with 5 birds each.

Growth performance

Feed intake was computed as the difference between the feed offered and leftovers. Gain in weights and feed intake were measured at weekly intervals. Feed to gain ratio was computed as the ratio of feed consumed to weight gain. No mortality occurred during the study

Metabolic trial

Metabolic trial was conducted from day 77 to 84 of the study to determine the apparent nutrient digestibility and metabolisable energy values. Briefly, 2 birds per replicate (n = 8 per treatment) were randomly selected and housed separately in appropriate metabolic cages fitted with individual feed troughs and facility for separate excreta collection. The birds were acclimatized for 2 days prior to the commencement of 4 days metabolic trial. Excreta collected per bird per day (for 4 days) were oven dried (60^{o}C) and used for analysis. Proximate compositions of feed and dried excreta samples were determined according to standard procedures (AOAC, 1990). The birds on metabolic trial were still used as part of the performance because their feed intake and weight during the metabolic trial were noted and computed along with performance data

Gross energy determination of excreta samples was carried out (Adiabatic bomb calorimeter, Parr Instrument Company, Moline, IL, USA). The equation below was used to calculate apparent metabolizable energy (AME), as described by Sibbald (1989):

$$\textbf{AME}\ (\text{MJ/Kg DM}) = \frac{[(\text{Fi} \times \text{GEf}) - (E \times \text{GEe})]}{\text{Fi}}$$

Where Fi is the feed intake (g), *E* is excreta output (g), GEf is the gross energy (MJ/ kg) of feed, GEe the gross energy (MJ/ kg) of excreta.

Viscosity of ileal digesta

A bird was randomly selected from each replicate (n = 4 birds per treatment) and slaughtered at day 84 for the determination of viscosity of ileal digesta. The gastro-intestinal tract was dissected aseptically immediately after slaughter and the intestinal content was exposed. The ileal digesta content was collected from the Merckel's diverticulum to the ileocaecal junction. Uniform weights of the samples (5 g) were taken from each bird using a sensitive scale and diluted to a volume of 400 ml. The ileal contents collected were centrifuged at 6000 rpm for 20 minutes. The supernatant was withdrawn and the viscosity (expressed as milli-Pascal seconds mPas) was measured using a viscometer (Brookfield digital DV-II+, Brookfield Engineering Labs, Stoughton, U.K.) while values were recorded at a shear rate of 45 s^{-1}.

Statistical analysis

Data obtained were analyzed by the general linear model of the SAS (SAS Institute, 2003). Polynomial contrast (linear and quadratic) was also applied using SPSS (1999) to determine the trends (linear and quadratic) of inclusion levels (0, 50 and 100 g/kg) of MSP. A probability of $P < 0.05$ was considered to be statistically significant.

Results

The chemical composition of MSP as shown in Table 1 reveals a high NDF and ADF (217 and147 g/kg respectively), fairly low ADL (10.3 g/kg), low Ca (9.2 g/kg) and extractible tannin content (0.09 mg/kg). The HCN value is 3.02 mg/kg. It has low gross energy (14.9 MJ/kg) and moderately fibrous (107.50 g/kg crude fibre).

Main effects of MSP inclusion and supplementation with enzyme or yeast on growth performance of turkeys

The final live weight, weight gain and feed intake of the starter turkey poults (day 29 to 56) reduced (Linear, $P < 0.01$, Quadratic, $P < 0.0001$) with increasing dietary inclusion levels of MSP (Table 3). However, dietary supplementation with enzyme reduced ($P<0.05$) feed intake and improved ($P < 0.05$) feed conversion ratio of turkey poults.

Final live weight and total feed intake of grower turkeys (day 57 to 84) decreased ($P < 0.01$) with increasing inclusion levels of MSP. All grower turkeys fed diet containing MSP (irrespective of inclusion levels) had reduced ($P < 0.01$) weight gain compared to those fed diet containing no MSP. Enzyme supplementation improved ($P < 0.05$) the final live weight and total weight gain while supplementation with yeast increased ($P < 0.05$) total feed intake.

Interaction effects of MSP inclusion and supplementation with enzyme or yeast on growth performance of turkeys

Irrespective of dietary supplementation with enzyme or yeast, final live weight, total weight gain and feed intake of the turkey poults reduced ($P < 0.05$) with increasing MSP inclusion (Table 4). Turkey poults fed enzyme-supplemented diets containing 100 g/kg MSP had better ($P < 0.05$) weight gain than their counterparts fed with 100 g/kg MSP supplemented with yeast. Supplementation of MSP based diets with yeast resulted in increased ($P < 0.05$) feed intake while enzyme supplementation of MSP based diets showed improved ($P < 0.05$) feed conversion ratios.

At the grower phase, final live weight and feed intake reduced ($P < 0.05$) with increasing inclusion levels of MSP with enzyme or yeast supplementation (Table 3). Grower turkeys fed diets containing no MSP had the highest (P < 0.05) final live weight, total weight gain and feed intake. Grower turkeys fed diets containing 50 g/kg MSP supplemented with yeast had the least (P < 0.05) total weight gain. Supplementation of MSP diets with enzyme resulted in higher (P < 0.05) final live weight and weight gain than their counterparts fed yeast-supplemented MSP diets.

Main effects of MSP inclusion and dietary supplementation with enzyme or yeast on apparent nutrient digestibility, metabolizable energy value and intestinal viscosity

Turkeys fed diets containing 100 g/kg MSP recorded the highest (P < 0.05) apparent dry matter digestibility while those fed diets containing 0 and 50 g/kg MSP had the least (P < 0.05) dry matter digestibility values. (Table 5) Ash retention reduced linearly (P < 0.05) with increasing inclusion levels of MSP.

Turkeys fed diets containing varying inclusion levels of MSP had no significant effect (P > 0.05) on AME values neither was the enzyme supplementation also. Highest viscosity of ileal digesta was obtained with turkeys fed diets containing 100 g/kg MSP. Dietary supplementation with enzyme reduced (P < 0.05) viscosity of ileal digesta.

Interaction effect of MSP inclusion and dietary supplementation with enzyme or yeast on apparent nutrient digestibility, metabolisable energy values and intestinal viscosity

Turkeys fed diet containing 100 g/kg MSP supplemented with enzyme had the highest (P < 0.05) apparent dry matter digestibility while those fed diets containing 0 and 50 g/kg MSP supplemented with enzyme or yeast recorded the least (P < 0.05) values (Table 6). Turkeys fed diets containing no MSP supplemented with enzyme recorded the least (P < 0.05) viscosity of ileal digesta. High ($P < 0.05$) viscosity of ileal digesta values were obtained for turkeys fed diets containing MSP supplemented with either enzyme or yeast.

Discussion

Reduced feed intake of turkeys obtained with increasing dietary inclusion of MSP could be attributed to the gritty nature of MSP. Previous studies attested to the fact that MSP is quite gritty with a variable crude fibre content ranging between 80 to 170 g/kg of dry matter and NDF of 224 g/kg (DM basis) depending on the processing methods employed (Akinola, 2002). Poultry has been reported to be poor digester of fibre (Longe and Ogedengbe, 1989).

The reduced growth of turkeys obtained in the current study following increasing inclusion levels of MSP agreed with previous studies (Oduguwa *et al*., 2007). The observed poor growth could also be attributed to the presence of some deleterious factors contained in MSP which limits its utilization. MSP used in the current study contain 3.02 g/kg HCN content. Dietary HCN when fed to birds forms a complex with Fe in the heamoglobin to form cynahaemoglobin (Hb-CN) resulting in reduced mean oxygen carrying capacity of the blood (Cardoso *et al*., 2005). Although, the extractible tannin content of MSP in the current study is low, MSP was reported to contain high content of tannins bound with fibre which were not extractible but had potential to inhibit digestive enzymes and reduced nutrient digestibility (Mariscal- Landın *et al*., 2004). Oduguwa *et al*. (2007) reported that MSP contained indigestible fibre which increased ileal viscosity and depressed nutrient digestibility.

Enzyme supplementation of MSP diets in the current study showed a slight improvement in feed conversion ratio of young turkey poults, final liveweight and weight gain of growing turkeys.

Previous studies with broilers also reported improved performance when similar enzyme was supplemented in MSP diets (Oke, 2010). Supplementation with fibre-degrading enzymes had been reported to increase weight gain, improve feed conversion and protein digestibility of poultry birds (Café *et al.*, 2002).

Higher feed intake obtained for turkey poults and growing turkeys in this study following dietary supplementation with yeast compared to enzyme supplementation corroborated previous findings that feed intake and feed efficiency improved following dietary inclusion of yeast (Parks *et al.*, 2001). These beneficial effects following inclusion of yeast have been linked with increased digestive enzyme activity (Zhang *et al.*, 2005) stimulated by the ß -1,3, ß -1,6 glycosidic linkages present in yeast which stimulated immune modulator substances in animals (Parks *et al.*, 2001).

The high apparent dry matter digestibility obtained with turkeys fed an enzyme-supplemented diet containing 100 g/kg MSP showed possible improvement in the utilization of MSP when supplemented with fibre degrading enzymes. Improvement in the nutrient digestibility of erstwhile denigrated feedstuffs when supplemented with enzyme has been reported (Zyla *et al.*, 2000). The trend of this study also supported earlier findings which reported improved digestibility coefficient following dietary supplementation with an enzyme (Cowieson *et al.*, 2003).

High viscosity of ileal digesta obtained with growing turkeys fed MSP diets supplemented with yeast and those fed diets containing 100 g/kg MSP supplemented with enzyme implied an adverse effect of MSP inclusion. Previous studies have shown that the higher the viscosity of the ileal digesta the lesser the AME values (Petersen *et al.*, 1999). Increasing intestinal viscosity of poultry birds have been reported to result in poor feed conversion ratio (Bedford, 2000).

Reduced intestinal viscosity obtained with turkeys fed diets containing 50 g/kg MSP supplemented with enzyme corroborated their apparent improved growth response. The reduction in viscosity within the gastro-intestinal tract caused by enzyme supplementation has been linked with bile salt production and de-conjugation influencing nutrient uptake and dietary metabolizable energy values, a mechanism which could lead to improved nutrient uptake and animal performance (Choct *et al.,* 1989). Yeast supplementation, however, did not reduce intestinal viscosity of turkeys in this study.

In conclusion, dietary inclusion level of malted sorghum sprouts with or without yeast or enzyme supplementation resulted in poor growth performance and increased viscosity of ileal digesta of turkeys. Higher dosage of enzyme supplementation or use of more specific enzyme mixture is suggested in further studies since the improvement in performance following enzyme supplementation was not appreciable.

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Table 1. Chemical composition of malted sorghum sprouts (MSP)

Chemical compositions	**Concentration**
Gross energy (MJ/kg)	14.9
*Metabolisable energy (MJ/kg)	11.69
Anti-nutritional factors	
Dry matter (g/kg)	912
Crude protein (g/kg)	163.7
Ether extract (g/kg)	38.2
Crude fibre (g/kg)	107.5
Mineral content	
Calcium (g/kg)	9.2
Phosphorus (g/kg)	11.1
Fibre fraction	
Neutral detergent fibre (g/kg)	217
Acid detergent fibre (g/kg)	147
Acid detergent lignin (g/kg)	10.3
Gross energy (MJ/kg)	14.9
Anti-nutritional factors	
Hydrocyanide content (mg/kg)	3.02
Extractible tannin (mg/kg)	0.09

*Metabolisable energy (ME) value of MSP was estimated using NRC (1994), ME = 37 9 % CP + 81.1 9 % EE + 35.5 9 % NFE

Table 2. Gross composition (g/kg) of pre-starter (1-28d), starter (28-56d) and grower (28-56d) diets

Phases of growth	Pre - starter	Starter diets			Grower diets		
MSP inclusion (g/kg)	Diets	0	50	100	0	50	100
Feed ingredients							
Maize	430	425	425	425	505	505	505
Soybean meal	412	240	240	240	180	180	180
Full fat soybean	-	100	100	100	80	80	80
Fish meal	80	80	80	80	60	60	60
Vegetable oil	-	-	-	-	20	20	20
Wheat offal	-	100	50	-	100	50	-
MSP	-	-	50	100	-	50	100
Bone meal	45	30	30	30	30	30	30
Oyster shell	20	14	14	14	14	14	14
Lysine	1	1.5	1.5	1.5	1.5	1.5	1.5
Methionine	4	2	2	2	2	2	2
Premix †	5	5	5	5	5	5	5
Common salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Total	1000	1000	1000	1000	1000	1000	1000
Chemical composition (g/kg)							
Dry matter	900.5	910.6	908.7	911.1	902	904	901
ME (MJ/kg) ‡	11.93	12.15	12.21	12.27	12.74	12.80	12.75
Crude protein	281.9	260.7	262.2	263.6	220.3	221.8	223.2
Ether extract	37.6	53.7	53.4	53.0	49.5	49.2	48.8
Crude fibre	30	35.3	35.2	35.1	32.6	32.5	32.4
Calcium	21.6	15.4	15.5	15.6	11.5	11.5	15.0
Phosphorus	8.6	6.7	6.6	6.7	6.1	6.9	6.0
Lysine	19.1	17.7	18.1	18.6	14.3	14.7	15
Methionine	8.8	6.7	6.7	6.8	6.7	6.7	6.8

†Vitamin/mineral premix provided the following per kg diet (pre-starter and starter diet): 210 g Ca; 85.7 g P; 828 mg F; 75 mg retinol; 1.25 mg cholecalciferol; 375 mg dl-tocopheryl acetate; 42.5 mg menadione; 45 mg thiamin; 150 mg riboflavin; 62.5 mg pyridoxine; 300 µg cyanocobalamin; 100 mg niacin; 27 mg folic acid; 400 mg pantothenic acid; 12.5 g choline; 2 mg biotin; 45 g methionine; 2500 mg Mn; 1500 mg Zn; 1250 mg Fe; 250 mg Cu; 15 mg I; 8.2 mg Se.

†Vitamin/mineral premix provided the following per kg diet (grower diet): 200 g Ca; 77 g P; 710 mg F; 42 mg retinol; 1 mg cholecalciferol; 325 mg dl-tocopheryl acetate; 35 mg menadione; 45 mg thiamin; 125 mg riboflavin; 75 mg pyridoxine; 300 µg cyanocobalamin; 875 mg niacin; 19 mg folic acid; 300 mg pantothenic acid; 7.5 g choline; 31 g methionine; 2500 mg Mn; 1500 mg Zn; 1250 mg Fe; 250 mg Cu; 15 mg I; 8.2 mg Se.

‡Calculated value using standard tables of NRC (1994).

Table 3. Main effect of MSP inclusion levels and supplementation with enzyme or yeast on growth performance of turkeys

	MSP inclusion levels				P-value of MSP inclusion		Additives			P-value of additive
	0	**50**	**100**	SEM	Linear	Quadratic	Enzyme	Yeast	SEM	
n	8	8	8				12	12		
Day 29-56										
Initial weight (g /bird)	705	675	665	9.23	0.321	0.322	683	687	7.20	0.090
Final live weight (g/bird)	3006[a]	2718[b]	2549[c]	119.93	0.002	<0.0001	2773	2743	17.91	0.120
Total weight gain (g/bird)	2334[a]	2045[b]	1879[c]	99.12	0.005	<0.0001	2101	2071	18.06	0.180
Total Feed intake (g/bird)	5535[a]	4844[b]	4588[c]	220.15	0.002	<0.0001	4778[b]	5200[a]	229.25	0.040
Feed conversion ratio	2.37	2.37	2.44	0.02	0.079	0.912	2.27[b]	2.51[a]	0.09	0.022
Day 57-84										
Final live weight (g/bird)	6138[a]	5485[b]	5303[c]	246.33	0.004	<0.0001	5778[a]	5506[b]	237.83	0.024
Total weight gain (g/bird)	3131[a]	2768[b]	2804[b]	104.22	0.006	<0.0001	3005[a]	2797[b]	95.29	0.013
Total Feed intake (g/bird)	8576[a]	8081[b]	7815[c]	267.10	0.009	<0.0001	8048[b]	8268[a]	258.46	0.025
Feed conversion ratio	2.73	2.92	2.79	0.02	0.062	0.075	2.68	2.97	0.04	0.079

[a,b,c]Means in the same row within the same effect (MSP inclusion level or additive) with different superscripts are significantly different (P < 0.05)

Table 4: Interaction effect of MSP inclusion levels and supplementation with enzyme or yeast on growth performance of turkeys

Measurement	200 mg/kg enzyme			200 mg/kg yeast			SEM	**P-Value**
	0	50	100	0	50	100		
N	4	4	4	4	4	4		
Day 29-56								
Initial weight (g/bird)	675	670	670	670	675	670	7.55	0.150
Final live weight (g/bird)	3008[a]	2725[b]	2585[c]	3005[a]	2710[b]	2513[c]	135.01	0.020
Total weight gain (g/bird)	2333[a]	2055[b]	1915[c]	2335[a]	2035[b]	1842[d]	101.29	0.040
Total feed intake (g/bird)	5535[a]	4572[d]	4230[e]	5540[a]	5115[b]	4940[c]	245.47	0.010
Feed conversion ratio	2.37[b]	2.22[b]	2.21[b]	2.41[b]	2.51[a]	2.68[a]	0.09	0.025
Day 57-84								
Final live weight (g/bird)	6175[a]	5675[b]	5483[c]	6100[a]	5295[d]	5123[e]	235.51	0.022
Total weight gain (g/bird)	3168[a]	2950[b]	2894[b]	3095[ab]	2585[d]	2710[c]	130.12	0.020
Total feed intake (g/bird)	8543[a]	7965[c]	7635[d]	8610[a]	8198[b]	7995[c]	266.61	0.012
Feed conversion ratio	2.70	2.70	2.64	2.79	3.17	2.95	0.04	0.073

[a,b,c]Means in the same row within the same effect (MSP inclusion level or additive) with different superscripts are significantly different ($P < 0.05$)

Table 5. Main effect of malted sorghum sprout (MSP) inclusion and supplementation with enzyme or yeast on apparent nutrient digestibility, metabolisable energy values and intestinal viscosity of growing turkeys

	MSP inclusion levels				P-value		Additives			
	0	50	100	SEM	Linear	Quadratic	Enzyme	Yeast	SEM	P-value
Apparent nutrient digestibility (%)										
N	16	16	16				24	24		
Dry matter	69.79[b]	69.86[b]	77.32[a]	5.99	0.029	0.042	73.41	71.23	1.48	0.095
Crude protein	69.89[b]	69.75[b]	73.99[a]	5.61	0.040	0.022	71.48	70.94	1.97	0.100
Crude ash	84.57[a]	82.23[b]	80.80[c]	4.79	0.037	0.060	82.87	82.07	1.21	0.077
NDF	64.46	64.49	64.52	1.63	0.642	0.589	64.35	64.96	1.22	0.070
ADF	43.13	44.90	47.35	1.02	0.084	0.229	44.70	45.56	1.08	0.075
ADL	34.65	37.86	40.10	1.18	0.065	0.166	36.78	38.29	1.02	0.090
Metabolisable energy value										
N	16	16	16				24	24		
AME (MJ/kg)	15.73	16.15	16.48	0.69	0.064	0.060	16.16	16.07	0.21	0.105
Intestinal viscosity (mPas)	216.2[b]	222.6[b]	230.5[a]	9.52	0.021	0.019	218.3[b]	227.8[a]	9.83	0.035
N	8	8	8				12	12		

[a,b,c]Means in the same row within the same effect (MSP inclusion level or additive) with different superscripts are significantly different ($P < 0.05$)

NDF = Neutral detergent fibre

ADF = Acid detergent fibre

ADL = Acid detergent lignin

AME= Apparent metabolisable energy

Table 6. Interaction effect of malted sorghum sprout (MSP) inclusion and supplementation with enzyme or yeast on apparent nutrient digestibility, metabolisable energy values and intestinal viscosity of growing turkeys

	200 mg/kg enzyme			200 mg/kg yeast				
Measurements	0	50	100	0	50	100	SEM	P-Value
Apparent nutrient digestibility (%)								
n (samples per treatment)	8	8	8	8	8	8		
Dry matter	70.80[bc]	69.40[c]	80.03[a]	68.78[c]	70.32[bc]	74.61[b]	7.40	0.042
Crude protein	70.03	69.66	74.78	69.77	69.84	73.21	6.10	0.060
Crude ash	85.55	81.31	81.31	83.59	82.71	79.94	0.95	0.099
NDF	64.50	64.49	64.05	64.39	64.50	65.00	1.01	0.097
ADF	43.52	44.18	46.39	42.75	45.62	48.31	1.10	0.077
ADL	32.82	37.08	40.43	36.48	38.64	39.76	0.81	0.090
Metabolisable energy values								
n (samples per treatment)	8	8	8	8	8	8		
AME (MJ/kg)	15.91	16.13	16.46	15.55	16.17	16.50	0.79	0.064
Intestinal viscosity (mPas)	205.0[c]	219.8[b]	230.3[a]	227.3[ab]	225.5[ab]	230.7[a]	8.18	0.027
n (samples per treatment)	4	4	4	4	4	4		

[a,b,c,d,e] Means on the same row having different superscripts are significantly different ($P < 0.05$)

NDF = Neutral detergent fibre
ADF = Acid detergent fibre
ADL = Acid detergent lignin
AME= Apparent metabolisable energy