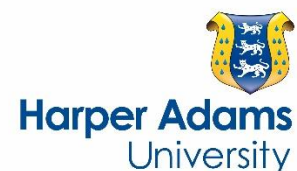


# Growth, nutrient digestibility, ileal digesta viscosity and energy metabolizability of growing turkeys fed diets containing malted sorghum sprouts supplemented with enzyme or yeast

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

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12

13 **Running head:** Turkeys fed with malted sorghum sprouts

14

15 **Summary**

16 Growth, apparent nutrient digestibility, ileal digesta viscosity and energy metabolisability of  
17 growing turkeys **fed diets containing malted** sorghum sprouts (MSP) supplemented with enzyme  
18 or yeast was investigated using **120**, 28-days old, male turkeys. There were six treatments laid  
19 out in a 3 × 2 factorial arrangement of treatments having three dietary inclusion levels of MSP  
20 (0, 50 and 100 g/kg) supplemented with or without 200 mg/kg of a commercial enzyme. The

21 experiment lasted for the starter (day 28-56) and grower phases (day 57-84) of the birds. Each  
22 treatment group consisted of 20 turkeys replicated 4 times with 5 birds each. Data were analysed  
23 using analysis of variance while polynomial contrast was used to determine the trends (linear and  
24 quadratic) of MSP inclusion levels. Irrespective of dietary supplementation with enzyme or  
25 yeast, final live weight, total weight gain and feed intake for turkey poults from day 29-56  
26 reduced ( $P < 0.05$ ) with increasing inclusion level of MSP. Dietary supplementation with yeast  
27 resulted in increased ( $P < 0.05$ ) feed intake while enzyme supplementation improved ( $P < 0.05$ )  
28 feed conversion ratio of the poults. Starter and grower turkeys fed enzyme-supplemented MSP  
29 diets had higher ( $P < 0.05$ ) weight gain than their counterparts fed yeast-supplemented MSP  
30 diets. Apparent ash digestibility reduced linearly ( $P < 0.05$ ) with increasing inclusion levels of  
31 MSP. Apparent metabolisable energy (AME) did not vary significantly ( $P > 0.05$ ) with MSP  
32 inclusion levels. Dietary inclusion of 100 g/kg MSP recorded the highest ( $P < 0.05$ ) ileal digesta  
33 viscosity. Enzyme supplementation reduced ( $P < 0.05$ ) ileal viscosity but had no effect ( $P > 0.05$ )  
34 on AME. Inclusion of MSP resulted in poor growth performance. This confirms reports of earlier  
35 studies that utilization of MSP by poultry is rather poor. Supplementation with enzyme or yeast  
36 did not lead to any appreciable improvement in performance of turkeys in this study.

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

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## 43 **Introduction**

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

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

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

56 Nutritional evaluation of MSP showed that it contained 226, 224, 33 and 522 g/kg (DM basis) of  
57 crude protein, neutral detergent fibre, ether extract and nitrogen free extract, respectively (Aning  
58 *et al.*, 1998). Oke (2010) reported a crude protein, ether extract, ash, NDF, ADF and ADL values  
59 of 163.7, 38.2, 62.70, 217, 147, 10.3 g/kg, respectively for MSP. Successful utilization of MSP  
60 up to 10% inclusion in growing pullets has been reported in previous studies (Fafiolu *et al.*,  
61 2006). However, the nutritional potentials of MSP as feedstuff for poultry are limited due to the  
62 constituent fibre fractions (NDF and ADF), hydrocyanide and tannin contents (Oduguwa *et al.*,  
63 2001). Residues of tannin and arabinoxylan have been reported to reduce nutrient digestibility  
64 and growth of poultry (Balogun *et al.*, 2005). Recent studies have shown that dietary  
65 supplementation with fibre degrading enzymes improved ileal nitrogen retention, apparent

66 metabolisable energy (AME) (Cowie *et al.*, 2003), digestion of dietary starch, fibre, protein  
67 and lipid in poultry (Choct *et al.*, 1999). Similarly, yeast and its extracts have been reported to  
68 improve growth, nutrient digestibility and stimulate birds' immune systems (Abel and Czop,  
69 1992). In this present study, diets containing 0, 50, or 100 g/kg MSP in which supplements of  
70 either enzyme or yeast have been incorporated were fed to growing turkeys. The performance  
71 characteristics, nutrient digestibility, viscosity of ileal digesta and energy metabolisability were  
72 used as criteria of response.

73

## 74 **Materials and methods**

### 75 **Source and chemical composition of malted sorghum sprouts**

76 Malted sorghum sprouts (MSP) was obtained commercially from a local brewery industry in  
77 Ogun State, Nigeria. This was dried (10-11% moisture content) prior to collection and included  
78 on DM basis in the experimental diets. Proximate composition (AOAC, 1990), fibre fractions  
79 (Van Soest *et al.*, 1991), gross energy (Adiabatic bomb calorimeter, Parr Instrument Company,  
80 Moline, IL, USA) and tannin content (Hoff and Singleton, 1977) of MSP was determined  
81 according to standard procedures (Table 1). For Ca and P determination of MSP, samples were  
82 further dried in a hot air oven (105 °C for 8 h), milled to pass through 0.5 mm sieve and ignited  
83 at 400 °C for 4 h in a muffle furnace. The ash was treated with HNO<sub>3</sub> under mild heat (80 °C)  
84 and digested (15ml HNO<sub>3</sub>). Analysis was done using the atomic absorption spectrophotometer  
85 (Perkin Elmer Optima 4300DV ICP spectrophotometer, Beaconsfield, UK).

86

87

## 88 **Enzyme and yeast**

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

## 93 **Experimental birds and management**

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

## 101 **Dietary treatments**

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

108

109

110 **Growth performance**

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

114

115 **Metabolic trial**

116 Metabolic trial was conducted from **day 77 to 84** of the study to determine the apparent nutrient  
117 digestibility and metabolisable energy values. Briefly, 2 birds per replicate (n = 8 per treatment)  
118 were randomly selected and housed separately in appropriate metabolic cages fitted with  
119 individual feed troughs and facility for separate excreta collection. The birds were acclimatized  
120 for 2 days prior to the commencement of 4 days metabolic trial. Excreta collected per bird per  
121 day (**for 4 days**) were oven dried (60°C) and used for analysis. Proximate compositions of feed  
122 and **dried excreta samples were determined** according to standard procedures (AOAC, 1990).

123 **The birds on metabolic trial were still used as part of the performance because their feed intake**  
124 **and weight during the metabolic trial were noted and computed along with performance data**

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

128 
$$\text{AME (MJ/Kg DM)} = \frac{[(F_i \times \text{GE}_f) - (E \times \text{GE}_e)]}{F_i}$$

129  
130  
131 Where  $F_i$  is the feed intake (g),  $E$  is excreta output (g),  $\text{GE}_f$  is the gross energy (MJ/ kg) of feed,

132  $\text{GE}_e$  the gross energy (MJ/ kg) of excreta.

### 133 **Viscosity of ileal digesta**

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

### 143 **Statistical analysis**

144 Data obtained were analyzed by the general linear model of the SAS (SAS Institute, 2003).  
145 Polynomial contrast (linear and quadratic) was also applied using SPSS (1999) to determine the  
146 trends (linear and quadratic) of inclusion levels (0, 50 and 100 g/kg) of MSP. A probability of *P*  
147 < 0.05 was considered to be statistically significant.

148

### 149 **Results**

150 The chemical composition of MSP as shown in Table 1 reveals a high NDF and ADF (217  
151 and 147 g/kg respectively), fairly low ADL (10.3 g/kg), low Ca (9.2 g/kg) and extractible tannin  
152 content (0.09 mg/kg). The HCN value is 3.02 mg/kg. It has low gross energy (14.9 MJ/kg) and  
153 moderately fibrous (107.50 g/kg crude fibre).

154



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

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

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

166

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

169 Irrespective of dietary supplementation with enzyme or yeast, final live weight, total weight gain  
170 and feed intake of the turkey poults reduced ( $P < 0.05$ ) with increasing MSP inclusion (Table 4).

171 Turkey poults fed enzyme-supplemented diets containing 100 g/kg MSP had better ( $P < 0.05$ )  
172 weight gain than their counterparts fed with 100 g/kg MSP supplemented with yeast.

173 Supplementation of MSP based diets with yeast resulted in increased ( $P < 0.05$ ) feed intake while  
174 enzyme supplementation of MSP based diets showed improved ( $P < 0.05$ ) feed conversion **ratios**.

175

176 At the grower phase, final live weight and feed intake reduced ( $P < 0.05$ ) with increasing  
177 inclusion levels of MSP with enzyme or yeast supplementation (Table 3). Grower turkeys fed

178 diets containing no MSP had the highest ( $P < 0.05$ ) final live weight, total weight gain and feed  
179 intake. Grower turkeys fed diets containing 50 g/kg MSP supplemented with yeast had the least  
180 ( $P < 0.05$ ) total weight gain. Supplementation of MSP diets with enzyme resulted in higher ( $P <$   
181  $0.05$ ) final live weight and weight gain than their counterparts fed yeast-supplemented MSP  
182 diets.

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

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

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

193

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

196 Turkeys **fed diet containing** 100 g/kg MSP supplemented with enzyme had the highest ( $P < 0.05$ )  
197 apparent dry matter digestibility while those **fed diets containing** 0 and 50 g/kg MSP  
198 supplemented with enzyme or yeast recorded the least ( $P < 0.05$ ) values (Table 6). Turkeys **fed**  
199 **diets containing** no MSP supplemented with enzyme recorded the least ( $P < 0.05$ ) viscosity of

200 ileal digesta. High ( $P < 0.05$ ) viscosity of ileal digesta values were obtained for turkeys fed diets  
201 containing MSP supplemented with either enzyme or yeast.

202

203

## 204 Discussion

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

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

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

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

227 Higher feed intake obtained for turkey poults and growing turkeys in this study following dietary  
228 supplementation with yeast compared to enzyme supplementation corroborated previous findings  
229 that feed intake and feed efficiency improved following dietary inclusion of yeast (Parks *et al.*,  
230 2001). These beneficial effects following inclusion of yeast have been linked with increased  
231 digestive enzyme activity (Zhang *et al.*, 2005) stimulated by the  $\beta$ -1,3,  $\beta$ -1,6 glycosidic  
232 linkages present in yeast which stimulated immune modulator substances in animals (Parks *et*  
233 *al.*, 2001).

234 The high apparent dry matter digestibility obtained with turkeys fed an enzyme-supplemented  
235 diet containing 100 g/kg MSP showed possible improvement in the utilization of MSP when  
236 supplemented with fibre degrading enzymes. Improvement in the nutrient digestibility of  
237 erstwhile denigrated feedstuffs when supplemented with enzyme has been reported (Zyla *et al.*,  
238 2000). The trend of this study also supported earlier findings which reported improved  
239 digestibility coefficient following dietary supplementation with an enzyme (Cowieson *et al.*,  
240 2003).

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

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

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

258

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

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

355 \*Metabolisable energy (ME) value of MSP was estimated using NRC (1994), ME = 37.9 % CP  
 356 + 81.19 % EE + 35.59 % NFE

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

Phases of growth	Pre - starter Diets	Starter diets			Grower diets		
		0	50	100	0	50	100
<b>Feed ingredients</b>							
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
<b>Chemical composition (g/kg)</b>							
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

361 †Vitamin/mineral premix provided the following per kg diet (pre-starter and starter diet): 210 g  
 362 Ca; 85.7 g P; 828 mg F; 75 mg retinol; 1.25 mg cholecalciferol; 375 mg dl-tocopheryl acetate;  
 363 42.5 mg menadione; 45 mg thiamin; 150 mg riboflavin; 62.5 mg pyridoxine; 300 µg  
 364 cyanocobalamin; 100 mg niacin; 27 mg folic acid; 400 mg pantothenic acid; 12.5 g choline; 2  
 365 mg biotin; 45 g methionine; 2500 mg Mn; 1500 mg Zn; 1250 mg Fe; 250 mg Cu; 15 mg I; 8.2  
 366 mg Se.

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

372

373 ‡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		SEM	P-value of additive
	0	50	100	SEM	Linear	Quadratic	Enzyme	Yeast		
<i>n</i>	8	8	8				12	12		
<b>Day 29-56</b>										
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 <sup>a</sup>	2718 <sup>b</sup>	2549 <sup>c</sup>	119.93	0.002	<0.0001	2773	2743	17.91	0.120
Total weight gain (g/bird)	2334 <sup>a</sup>	2045 <sup>b</sup>	1879 <sup>c</sup>	99.12	0.005	<0.0001	2101	2071	18.06	0.180
Total Feed intake (g/bird)	5535 <sup>a</sup>	4844 <sup>b</sup>	4588 <sup>c</sup>	220.15	0.002	<0.0001	4778 <sup>b</sup>	5200 <sup>a</sup>	229.25	0.040
Feed conversion ratio	2.37	2.37	2.44	0.02	0.079	0.912	2.27 <sup>b</sup>	2.51 <sup>a</sup>	0.09	0.022
<b>Day 57-84</b>										
Final live weight (g/bird)	6138 <sup>a</sup>	5485 <sup>b</sup>	5303 <sup>c</sup>	246.33	0.004	<0.0001	5778 <sup>a</sup>	5506 <sup>b</sup>	237.83	0.024
Total weight gain (g/bird)	3131 <sup>a</sup>	2768 <sup>b</sup>	2804 <sup>b</sup>	104.22	0.006	<0.0001	3005 <sup>a</sup>	2797 <sup>b</sup>	95.29	0.013
Total Feed intake (g/bird)	8576 <sup>a</sup>	8081 <sup>b</sup>	7815 <sup>c</sup>	267.10	0.009	<0.0001	8048 <sup>b</sup>	8268 <sup>a</sup>	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

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

<sup>a,b,c</sup>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			SEM	P-value		Additives		SEM	P-value
	0	50	100		Linear	Quadratic	Enzyme	Yeast		
<b><i>Apparent nutrient digestibility (%)</i></b>										
<b>N</b>	<b>16</b>	<b>16</b>	<b>16</b>				<b>24</b>	<b>24</b>		
Dry matter	69.79 <sup>b</sup>	69.86 <sup>b</sup>	77.32 <sup>a</sup>	5.99	0.029	0.042	73.41	71.23	1.48	0.095
Crude protein	69.89 <sup>b</sup>	69.75 <sup>b</sup>	73.99 <sup>a</sup>	5.61	0.040	0.022	71.48	70.94	1.97	0.100
Crude ash	84.57 <sup>a</sup>	82.23 <sup>b</sup>	80.80 <sup>c</sup>	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
<b><i>Metabolisable energy value</i></b>										
<b>N</b>	<b>16</b>	<b>16</b>	<b>16</b>				<b>24</b>	<b>24</b>		
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 <sup>b</sup>	222.6 <sup>b</sup>	230.5 <sup>a</sup>	9.52	0.021	0.019	218.3 <sup>b</sup>	227.8 <sup>a</sup>	9.83	0.035
<b>N</b>	<b>8</b>	<b>8</b>	<b>8</b>				<b>12</b>	<b>12</b>		

<sup>a,b,c</sup>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

Measurements	200 mg/kg enzyme			200 mg/kg yeast			SEM	P-Value
	0	50	100	0	50	100		
<b><i>Apparent nutrient digestibility (%)</i></b>								
<b>n (samples per treatment)</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>		
Dry matter	70.80 <sup>bc</sup>	69.40 <sup>c</sup>	80.03 <sup>a</sup>	68.78 <sup>c</sup>	70.32 <sup>bc</sup>	74.61 <sup>b</sup>	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
<b><i>Metabolisable energy values</i></b>								
<b>n (samples per treatment)</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>		
AME (MJ/kg)	15.91	16.13	16.46	15.55	16.17	16.50	0.79	0.064
Intestinal viscosity (mPas)	205.0 <sup>c</sup>	219.8 <sup>b</sup>	230.3 <sup>a</sup>	227.3 <sup>ab</sup>	225.5 <sup>ab</sup>	230.7 <sup>a</sup>	8.18	0.027
<b>n (samples per treatment)</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>		

<sup>a,b,c,d,e</sup> 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