Asian Journal of

Poultry Science

ISSN 1819-3609

Academic
Journals Inc.

www.academicjournals.com

Asian Journal of Poultry Science 8 (4): 123-130, 2014
ISSN 1819-3609 / DOI: 10.3923/ajpsaj.2014.123.130

Performance, Carcass Criteria and Profitability of Broiler Chicks as Affected by Yellow Corn Replacement with Sorghum Grains and Enzymes Supplementation

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ABSTRACT

This study was conducted to evaluate the effect of replacing yellow corn with sorghum with or without enzymes supplementation on performance, carcass criteria and profitability of broiler chickens. Total 90, seven-day-old Ross 308 broiler chickens were randomly assigned to factorial 2×3 dietary treatments as completely randomized design with 6 treatments and 3 replicates contain 15 birds in each treatment. Experimental treatment were as: Diet contains yellow corn and without sorghum grain (control group); replacing 50% sorghum grain in place of yellow corn; replacing 100% sorghum grain in place of corn grain. The experimental diets were fed to the broiler without or with enzyme supplementation. Growth performances were determined at 21 and 42 days of age and carcass criteria and profitability were determined at 42 days of age. Body weight, body weight gain and profitability significantly ($p<0.05$) increased with the sorghum grain replacements. However, feed intake and feed conversion ratio did not show any significant differences among replacement diets. Addition of enzymes had significant ($p<0.001$) effect on body weight, body weight gain, feed conversion ratio and profitability. The best profitability was observed in 50% sorghum with enzyme. No differences were observed for carcass criteria in terms of dressing, abdominal fat, heart, gizzard and liver percentages amongst treatment groups. It could be stated that sorghum can replace yellow corn with enzymes without adverse effect on performance, carcass criteria and economic cost in broiler diets.

Key words: Broilers, sorghum, enzymes, performance, carcasses, profitability

INTRODUCTION

Broiler production is the quickest means of achieving high-quality animal protein in the shortest possible time. In raising poultry, feed expenditure accounts for about 70-75% of the total cost (Esonu *et al*., 2006; Sharif *et al*., 2012). High feed cost is the major constraint for further progress of the poultry industry.

Cereal grains account for about 50-60% of a typical broiler diet where this feed serve as a principal carbohydrate energy source for poultry. Yellow corn has remained the chief energy source in compounded diets and constitutes about 50% of poultry diet (Ajaja *et al*., 2002). However, the dependence on yellow corn grain becomes a problem in feed formulations when it is unavailable, expensive or of poor quality and competition between human beings and poultry over the consumption of cereal grains has compelled the nutritionists and led them to explore new and non-conventional feedstuffs.

In regard to the nutritive value, cost and availability, sorghum grain is probably the next alternative to maize in poultry feed (Hancock, 2000). However, sorghum contains a high level of tannins, variable amounts of phytate, kafirin and possibly polyphenols in the sorghum grain may act as anti-nutritional factors (Serna-Saldivar and Rooney, 1995; Doka *et al.*, 2004; Selle *et al.*, 2010a). These factors can negatively influence the nutritive properties of sorghum and therefore cause negative effects on feed intake, palatability, digestibility of nutrients and growth performance (Hassan *et al.*, 2003; Makkar, 2003; Kim and Miller, 2005).

Some researchers used sorghum in chicken diets (Pour-Reza and Edriss, 1997; Mateo and Carandang, 2006; Robertson and Perez-Maldonado, 2006; Campos *et al.*, 2007; Medugu *et al.*, 2010) but revealed contradictory results. One of these solutions is using of enzymes as a feed additives to improve the growth, prevent disease, nutrient digestibility, improvement of feed efficiency and as result to increase economic indicators (Wu *et al.*, 2004; Cadogan *et al.*, 2005; Selle *et al.*, 2010a; Ibrahim *et al.*, 2012).

To our knowledge, only limited data exist on broiler chicks effected by different levels of sorghum replacement with enzyme supplementation. Therefore, the aim of this study was to evaluate the effect of replacing yellow corn with sorghum and enzymes supplementation on performance, carcass criteria and profitability of broiler chickens.

MATERIALS AND METHODS

Animal housing and management: This study was carried out at the Research Poultry Farm, Department of Animal and poultry Production, Faculty of Agriculture, South Valley University. Chicks were reared in three-tier wire floor battery in a closed house. The chicks of each replicate were allocated in a cage with slatted floor of iron. The diameters of the cage were 97×50×45 cm for length, width and height, respectively. Chicks had full access to feed and water during the experimental period. The environmental temperature was kept about 32°C during the first week and then gradually reduced by 2°C weekly to reach about 24°C during fourth week and at termination of the experiment at 42 days.

Experimental design and dietary treatments: A 3×2 factorial arrangement of treatments was employed in a completely randomized design to test the effect of enzymes mixture supplementation (Allzyme®) and sorghum at level 0, 50 and 100% partly replacing yellow corn and their interactions. Total 90, seven-day-old Ross 308 broiler chickens were weighed and randomly distributed into six experimental treatments providing 3 replicate pens per treatment and each replicate pen consisted of 5 birds.

The experimental period was divided into two feeding phases, starter period (from7-21 days of age) and grower period (from 22-42 days of age). All diets were formulated to meet requirements of broiler chickens according to NRC (1994) (Table 1). Enzyme used in this study was (Allzyme® SSF, Alltech, Inc) at 0.02% level, it is a natural preparation which contains enzyme complex (protease, amylase, β-glucanase, xylanase, pectinase, cellulase and phytase).

Experimental procedures and measurements: The experiment lasted for 42 days and consisted of 2 phases (0 to 21 days, starter; 21 to 42 days, grower-finisher).

Feed consumption and body weight were measured on a pen basis on day 7, 21 and 42 whereas, mortality was recorded daily. Average total feed intake, average total body weight gain and the Feed Conversion Ratio (FCR) were calculated for each period (7 to 21days of age, 21 to 42 days of age and 7 to 42 days of age).

Table 1: Diet ingredients and chemical composition

	Starter (7-21 days)			Grower (22-42 days)		
Ingredients (%)	Control	Sorg. 50	Sorg. 100	Control	Sorg. 50	Sorg. 100
Yellow corn, ground	51.33	25.66	-	58.66	29.33	-
Sorghum, ground	0.00	25.66	51.33	0.00	29.33	58.66
Soybean meal (44% CP)	40.28	39.60	38.94	32.21	31.45	30.69
Vitamin and Mineral Premix*	0.71	0.71	0.71	0.71	0.71	0.71
Sunflower oil	3.84	4.50	5.12	5.04	5.76	6.45
Dicalcium phosphate	1.87	1.86	1.85	1.61	1.59	1.58
Limestone	0.91	0.92	0.93	0.83	0.84	0.85
NaCl	0.51	0.51	0.51	0.47	0.47	0.47
DL-methionine	0.30	0.31	0.32	0.23	0.25	0.28
L- lysine HCl	0.18	0.20	0.22	0.17	0.20	0.24
Choline chloride	0.07	0.07	0.07	0.07	0.07	0.07
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
ME, kcal kg^{-1}	3090.00	3113.00	3132.00	3252.00	3275.00	3297.00
Crude protein	22.02	22.33	22.65	19.10	19.36	19.75
Calcium	0.87	0.87	0.87	0.77	0.77	0.77
Phosphorus	0.50	0.49	0.47	0.44	0.42	0.40

*Each diet was supplied with 3 kg t^{-1} vit. and Min. Mix (commercial source B. p. Max) each 3 kg contains, vit. A 10,000,000 MIU, vit. D 2,000,000 MIU, vit. E 10000 mg, vit. K3 1000 mg, vit. B1 1000 mg, vit. B2 5000 mg, vit. B6 1500 mg, biotin 50 mg, BHT 10000 mg, pantothenic 10000 mg, folic acid 1000 mg, nicotinic acid 30000 mg, Mn 60 g, Zn 50 g, Fe 30 g, Cu 4 g, I 3 g, Se 0.1 g and Co 0.1 g

At 42 days of age, birds were starved overnight with access to water. Nine birds per treatment (3 birds per replicate) were randomly selected, weighted and slaughtered by the Islamic method and plucked. After removal of the head, neck, viscera, shanks, spleen, digestive tract, liver, heart, gizzard and abdominal fat, the rest of the body was weighed to determine the dressed weight. Dressing percentage (dressed weight/live weight×100) was calculated. The liver, heart, empty gizzard and abdominal fat from each bird were weighed and calculated as a percentage of live body weight.

Experiment profitability: Economic parameters of production including feed cost (starter and grower), income and returns per birds were calculated. The other productive costs were disregarded since they were constant. Economical Efficiency (EE) is defined as the difference of net revenue (total revenue per chick (L.E) and total feed cost (starter and grower) per chick (L.E)). Relative Economical Efficiency (REE) was calculated assuming control treatment equal to 100%.

Statistical analysis: The statistical analysis was performed using a completely randomized design and the General Linear Model (GLM) procedure of SAS 9.2 (SAS, 2005). Pens were the experimental units for all analysis. Significance was declared at $p<0.05$; p-values less than 0.001 are expressed as "<0.001" rather than the actual value. Differences among treatment means were calculated using Duncan multiple range test.

RESULTS AND DISCUSSION

Productive performance: The performance data of broiler chickens was summarized (Table 2 and 3). The dietary enzyme significantly increase body weight, body weight gain and

Table 2: Effect of sorghum replacement and enzymes supplementation on body weight and body weight gain

Items	Body weight (days)			Body weight gain (days)		
	7	21	42	7-21	22-42	7-42
Enzymes supplementation						
Without 0.0%	113.8	726.1[b]	2212[b]	612.2[b]	1485.9[b]	2098[b]
With 0.02%	113.8	910.6[a]	2619[a]	796.7[a]	1709.2[a]	2506[a]
SEM	0.235	14.23	113.0	37.50	120.02	138.2
p-value	0.999	<0.001	<0.001	<0.001	0.007	<0.001
Replacements with sorghum						
Control	114.2	787.5[b]	2423	673.3[b]	1635	2309
Sorghum 50%	114.2	825.5[ab]	2396	710.8[ab]	1572	2283
Sorghum 100%	113.3	842.5[a]	2428	729.2[a]	1586	2315
SEM	21.66	105.0	46.19	102.2	53.75	45.21
p-value	0.926	0.050	0.936	0.049	0.733	0.935
Interactions						
Control without enzymes	115	878.3	2610.6	763.3	1732	2496
Control with enzymes	113.3	696.6	2235.4	583.3	1534	2122
50% sorghum without enzyme	115.5	916.6	2599.9	803.3	1683	2487
50% sorghum with enzyme	113.3	733.3	2193.3	618.3	1460	2078
100% sorghum without enzyme	113.3	936.6	2648.7	823.3	1712	2535
100% sorghum with enzyme	113.3	748.3	2207.4	635.0	1459	2094
SEM	2.880	5.770	67.20	12.58	30.34	65.30
p-value	0.797	0.985	0.939	0.979	0.933	0.936

[a, b]Means within column at each item bearing different superscripts are significantly different ($p\leq 0.05$)

Table 3: Effect of sorghum replacement and enzymes supplementation on feed intake and body feed conversion ratio

Items	Feed intake (days)			Feed conversion ratio (days)		
	7	21	42	7-21	22-42	7-42
Enzymes supplementation						
Without 0.0%	1458	2693	4208	2.380[a]	1.820[a]	1.980[a]
With 0.02%	1486	2722	4208	1.860[b]	1.590[b]	1.680[b]
SEM	42.63	73.60	67.90	0.170	0.110	0.100
p-value	0.364	0.619	0.275	<0.001	0.013	<0.001
Replacements with sorghum						
Control	1459	2738	4197	2.190	1.690	1.831
Sorghum 50%	1433	2715	4148	2.050	1.751	1.840
Sorghum 100%	1525	2670	4195	2.130	1.690	1.830
SEM	60.15	55.13	59.22	0.260	0.123	0.210
p-value	0.060	0.610	0.667	0.174	0.791	0.992
Interactions						
Control without enzymes	1508	2735	4243	1.971	1.591	1.701
Control with enzymes	1410	2741	4151	2.410	1.790	1.960
50% sorghum without enzyme	1476	2753	4230	1.832	1.631	1.701
50% sorghum with enzyme	1390	2653	4067	2.260	1.860	1.981
100% sorghum without enzyme	1473	2677	4151	1.781	1.561	1.641
100% sorghum with enzyme	1576	2661	4238	2.482	1.821	2.021
SEM	25.65	49.32	20.69	0.142	0.041	0.051
p-value	0.024	0.830	0.142	0.156	0.961	0.683

[a, b]Means within column at each item bearing different superscripts are significantly different ($p\leq 0.05$)

improved feed conversion ratio ($p<0.001$) while, it had no significant effect on feed consumption. Enzyme supplementation caused higher body weight gain in periods of 7-21 days of age and 22-42 days of age. These results agree with those of Carvajal *et al.* (2010) reported that protease supplementations at 0 or 500 g t^{-1} for 600,000 U g^{-1} to sorghum levels of 0, 10, 20 and 30% in broiler diets improved ($p<0.05$) body weight, body weight gain and feed conversion ratio during starter and grower periods. Ibrahim *et al.* (2012) indicated that inclusion of the β-glucanase enzyme in sorghum based diet significantly ($p<0.05$) decreased total feed intake and significantly ($p<0.05$) improved weight gain and feed conversion ratio of broiler. Moreover, Selle *et al.* (2010b) found that sorghum-based diets supplemented with enzymes (protease, xylanase and β-glucanase) enhanced feed efficiency and weight gain. Likewise Shakouri *et al.* (2009) found that the addition of enzymes (xylanase and β-glucanase) increased 28-day weight gain by 19.3% in broilers offered wheat-based diets but did not alter growth rates of birds offered sorghum-based diets.

Furthermore, it could explain the improvements with enzymes supplementations as reviewed by Cowieson *et al.* (2006) it is accepted that xylanases have two prime modes of action. One is that increased gut viscosity triggered by soluble NSP which facilitates digestive and absorptive processes in the gut. The second is that by degrading insoluble NSP, xylanase disrupts the integrity of cell walls thereby permitting the release of 'caged' nutrients. While sorghum is a 'non-viscous' grain as it contains 48 g kg^{-1} NSP including arabinoxylan but only 4% of sorghum NSP is soluble (Choct, 2006). Moreover, the disruption of insoluble NSP in sorghum endosperm cell walls by NSP-degrading enzymes is considered to be limited. Both Taylor (2005) and Black *et al.* (2005) have suggested that the inclusion of proteases with the capacity to degrade kafirin in sorghum-based poultry diets may be beneficial as Selle *et al.* (2010a) reported that approximately 50% of sorghum protein consists of kafirin which is located in protein bodies in sorghum endosperm where it is intimately associated with starch granules.

In the present study, the main effects of sorghum level replacement and interaction with enzymes, it can be noticed that there is no significant effect ($p>0.05$) amongst treatments on body weight, body weight gain and feed intake of chicks in grower period (7-42 days of age).Similar to Torres *et al.* (2013) found no significant differences in performance parameters ($p>0.05$) of birds fed on sorghum during the period of 1-42 days. Selle *et al.* (2010a) reported no significant differences among grain type (sorghum and wheat) on feed intake and weight gain at period 1-14 and 14-28 days. Also, Medugu *et al.* (2010) found no significant effect on bird performance when comparing yellow corn replacement with low or high taninn sorghum. Moreover, Nyannor *et al.* (2007) found that weight gain, feed intake and feed efficiency were not different in chicks fed the corn-soybean meal or sorghum-soybean meal diets and decided that sorghum could serve as a substitute for corn in cereal grain-SBM diets for pigs and broiler chicks. On the other hand, Ahmed *et al.* (2011) showed significant increase ($p<0.01$) in feed intake and body weight gain for birds fed diets containing 75 or 100% sorghum.

Carcass criteria: In related to carcass criteria, there were no significant effect of enzymes supplementation, sorghum replacement or their interaction on carcass criteria and internal organs except abdominal fat (Table 4). These results are in agreement with those of Torres *et al.* (2013) reported that there were no significant differences among the treatments on ($p>0.05$) in whole carcass or carcass part weights of broiler chickens fed on sorghum based diets at 42 days of age. Also, Ahmed *et al.* (2011) observed that replacement of corn by 100, 75, 50, 25 and 0% sorghum in broiler diets did not show any significant effects on carcass traits, liver and abdominal fat weights.

Table 4: Effect of sorghum replacement and enzymes supplementation on carcass criteria

Items	LBW	Dressing (%)	Fat	Liver	Heart	Gizzard
Enzymes supplementation						
Without 0.0%	1995	71.01	2.61	2.26	0.51	2.59
With 0.02%	2039	72.04	2.81	2.34	0.50	2.84
SEM	89	0.35	0.21	0.05	0.03	0.12
p-value	0.757	0.084	0.573	0.565	0.866	0.154
Replacements with sorghum						
Control	1973	71.37	2.26	2.28	0.52	2.66
Sorghum 50%	2063	72.11	2.99	2.52	0.48	2.51
Sorghum 100%	2014	71.11	2.88	2.09	0.51	2.98
SEM	69	0.80	0.41	0.10	0.04	0.11
p-value	0.875	0.334	0.933	0.082	0.821	0.094
Interactions						
Control without enzymes	1836	70.48	1.96	2.21	0.50	2.43
Control with enzymes	2048	72.79	3.56	2.59	0.55	2.55
50% sorghum without enzyme	2099	69.77	2.32	1.98	0.47	2.79
50% sorghum with enzyme	2110	72.26	2.55	2.36	0.53	2.89
100% sorghum without enzyme	2078	71.42	2.42	2.46	0.42	2.46
100% sorghum with enzyme	1929	72.44	3.44	2.21	0.55	3.18
SEM	92	0.82	0.45	0.13	0.01	0.06
p-value	0.463	0.025	0.039	0.556	0.196	0.374

[a, b]Means within column at each item bearing different superscripts are significantly different ($p\leq 0.05$)

Table 5: Effect of sorghum replacement and enzymes supplementation on profitability

	Sorghum (S) without			Sorghum (S)+enzyme		
Items	Control	S100 (%)	S50 (%)	Control	S100 (%)	S50 (%)
Starter diet cost (LE)	5.27	4.87	4.80	4.79	5.38	5.38
Grower diet cost (LE)	9.15	9.17	8.82	8.86	8.66	8.70
Total feed costs (LE)	14.42	14.04	13.62	13.56	14.04	14.08
Bird weight at 6 wk (g)	2122.00	2496.00	2078.00	2487.00	2094.00	2535.00
Bird price (LE)[1]	38.19	44.92	37.40	44.74	37.69	45.63
Net revenue per bird	23.77	30.78	23.78	31.88	23.65	31.55
Economical efficiency	1.64	2.19	1.74	2.35	1.68	2.24
REE	100.00	133.50	106.10	143.30	102.40	136.60

Price of kg live body weight, 2014 = 16 L.E. [1]LE: Egyptian pound: 7.2 \$, Net revenue per bird: Total revenue/bird (LE)- Total feed cost/bird (LE), (REE) Relative Economical Efficiency (assuming control treatment 100%)

Profitability: Results of Economical Efficiency (EE) from chickens fed the different levels of sorghum replacement (0, 50 and 100%) with or without enzymes supplementation (Table 5). The results indicated that all feed treatments gave better Relative Economical Efficiency (REE) than the control. These improvements in relative economical efficiency are due to reduced total feed costs for starter and grower diets and the high body weight gain of such treatments. These results agree with Mateo and Carandang (2006) who found that the feed cost per kg gain was significantly low in corn-sorghum and sorghum based diets being 4.22 and 3.78% relative to corn based-diet. The use of low tannin US sorghum has an advantage over wheat as cheap alternative to corn in broiler diets. Moreover, Medugu *et al.* (2010) reported that replacements of maize by sorghum in broiler diets reduced the feed cost.

CONCLUSION

It could be concluded that enzymes supplementation improves bird performance in corn or sorghum levels in broiler diets. Moreover, the economic cost was the optimum at 50% level of substitution with enzymes supplementation. It could be stated that based on the weight gain of the birds and the feed cost per weight gain, sorghum can completely replace corn in broiler chicken diets without adverse effects on performance and carcass traits.

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