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The Effect of Replacement of Maize for Sorghum on Broiler Performance and Some Carcass Characteristics

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Abstract

An experiment was conducted to evaluate the influence of replacing maize for sorghum grains in broiler diets on growth performance, carcass yield and some economic aspects. One hundred fifty one day-old Ross 308 broiler chicks were purchased from commercial hatchery. Chicks were sorted by initial live body weight (44.81 ±1.40 g). These chicks were randomly assigned to 15 pens (1x1m) with 10 birds per pen. The chicks were divided into five dietary treatments; three replicates each. Starter and finisher experimental diets were 0% maize replacement for sorghum (control), 25% maize replacement for sorghum, 50% maize replacement for sorghum, 75% maize replacement for sorghum and 100% maize replacement for sorghum were fed through the experimental period of 42 days. Data were analyzed in completely randomized design using the general linear model (GLM) procedure. Live performance parameters, were not significantly (P≥0.05) influenced by dietary treatments except for body weight gain and FCR during finisher and overall period. Birds fed on 50% replacement performed better versus others. During starter and finisher phase feed intake and body weight gain for birds on 50% replacement increased by (6.41 and 1.22%) and (7.13 and 3.56%), respectively versus control. Relative weight of breast, thigh and drumsticks and meat bone ratio of breast, thigh, drumsticks and internal organs were not significantly (P≥0.05) affected by dietary treatments. Economics analysis showed that feed cost per 1 Kg was the lowest in sorghum-based feed followed by 50, 25, 100 and 75% maize replacement. Cost index was lowest in sorghum-based feed followed by 50, 25, 100 and 75% maize replacement for sorghum. Sorghum-based feed accomplish highest economic efficiency index followed by 50, 25, 100 and 75% maize replacement. Based on these results, it concluded that 50% sorghum replacement for maize is sufficient to assure good performance.

Keywords: Maize, Sorghum, Broiler performance, Carcass, Economics.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth major staple cereal after wheat, rice, maize and barley (Baker *et al*., 2009). It is cultivated worldwide in warmer climates and is an

important food crop in semi-arid tropical areas of Africa, Asia and Central America. In Sudan, sorghum grain consumed as main food for the majority of the population as well as using it as main energy source for poultry. Due to competition between human and livestock for sorghum, the price of this ingredient is dramatically increased. This calls for the search for alternatives for sorghum in poultry feed. *Zea mays* L. could be one of these options, since it has virtually similar chemical composition (Subramanium and Metta, 2000). Worldwide, maize is the major energy source for poultry. Due to its relatively high starch (620 to 720 g/kg) and crude fat (34 to 52 g/kg) contents, AME_N value of maize for poultry is higher than other cereals (Lasek *et al*., 2012).

Studies on the replacement of maize by sorghum in broiler diets have resulted in controversial findings (Garcia *et al*., 2013). However, the dietary inclusion of new sorghum cultivars did not negatively affect broiler performance (Garcia *et al*., 2005 and Rocha *et al*., 2008).

The objective of this study, therefore, was to investigate the impact replacing sorghum by maize in diet on broiler performance, and to evaluate some carcass and non-carcass characteristics and some economics aspects.

Materials and Methods

The site and experimental birds and diets: This study was carried out at the experimental poultry farm (open-house system) 8x12 meter of Faculty of Agricultural Technology and Fish Sciences, University of Elneelain, Jebal-Awlia, Khartoum south. The prevailing temperature was ranging from 37°C to 40°C during 6 weeks experimental period. One hundred and fifty day-old unsexed Ross 308 broiler chicks (mean weight: 44.81 ±1.43 g) were purchased from commercial hatchery. The chicks were randomly assigned to five dietary treatments within which maize replaced sorghum at 0, 25, 50, 75 and 100%. Each treatment was replicated three times with 10 chicks per pen. Isocaloric and isonitrogenous starter and finisher diets were formulated according to the National Research Council (NRC.1994) as shown in Tables 1 and 2, respectively. For the first 3 weeks, the chicks were fed starter diets and then they were assigned to finisher diets.

Management: The chicks were raised in 1x1 m pens on wood shavings litter. The birds in each pen had continuous access to one metallic drinker and one metallic tubular feeder. Continuous lighting program was followed throughout the experimental period by a combination of natural and artificial light. The birds were vaccinated via mix vaccine (IB+ Newcastle clone) at fifth day of age, and were vaccinated against infections bursal disease (Gumboro) at 17^{th} day of age, and replicated the doze at 25^{th} day of age, finally the chicks were vaccinated via Newcastle (clone) at 32^{nd} day of age.

Data collection: Feed intake, live body weight and body weight gain (BWG) were determined weekly on a pen base. Mortality was recorded daily. Feed conversion ratio (FCR) was calculated as feed intake per weight gain. While protein efficiency ratio (PER) was calculated as weight gain per protein consumed. At the end of the experiment, birds were fasted from feed for an overnight and then weighed. The birds were manually slaughtered following Halal Islamic method. Then some carcass characteristics were determined. Dressing% was calculated as dressed weight per live body weight. Carcass

cuts and internal organs were expressed as percentage of dressed weight. Feed ingredients prices were used to calculate the cost of different diets. The cost of feed for producing 1 kg of BWG was calculated for each experimental diet. This was done by dividing the total price of consumed feed on each treatment by the overall BWG of the birds fed on that diet as described by Bellaver *et al.*, (1985). Moreover, the Economic Efficiency Index (EEI) and the Cost Index (IC) were calculated according to Fialho et al., (1992) as follows:

EEI = (MCe/CTei)×100

CI = (CTei/MCe)×100,

Where MCe is the lowest feed cost per kilogram of weight gain observed among treatments. CTei is the cost of the i treatment.

Table 1: Composition and calculated analysis of broiler starter diets containing graded replacement of maize for sorghum

Ingredients %	Replacement levels of maize for sorghum				
	0% (A)	25%(B)	50% (C)	75% (D)	100% (E)
Sorghum	64.00	48.00	32.00	16.00	0.00
groundnut cake	24.00	25.03	26.09	26.55	27.06
Wheat bran	1.19	0.50	0.01	0.10	0.01
Broiler Super concentrates*	5.00	5.00	5.00	5.00	5.00
Lime stone	1.25	1.31	1.30	1.30	1.28
Dicalcium phosphate	0.12	0.00	0.00	0.00	0.00
Vegetable oil	3.25	3.00	2.47	1.96	1.60
Maize	0.00	16.00	32.00	48.00	64.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.13	0.12	0.10	0.08	0.06
Methionine	0.16	0.14	0.13	0.11	0.09
Choline	0.20	0.20	0.20	0.20	0.20
Enzymes	0.20	0.20	0.20	0.20	0.20
Mycotoxin binder	0.20	0.20	0.20	0.20	0.20
Calculated analysis					
ME (kcal/kg)	3172	3181	3170	3154	3149
CP%	22.9	22.5	22.1	21.5	20.9
Crude fiber%	4.22	4.19	4.18	4.20	4.19
Ether extract%	6.93	6.95	6.70	6.44	6.33
Ca%	1.00	1.00	1.00	1.00	1.00
Available phosphorous%	0.45	0.45	0.48	0.50	0.52
Lysine%	1.10	1.11	1.10	1.10	1.10
Methionine%	0.58	0.57	0.57	0.56	0.55
Methionine + Cystine%	0.79	0.79	0.80	0.80	0.80

*Cp 35%, ME 1900 kcal/kg, C.fiber 3.0%, EE 3.0%, Ash 33%, Ca 6.5%, Av. P 6.5%, Lysine 11%, Methionine 4.2%, Methionine+Cystine 4.5%. Vitamin A 250000 IU/Kg, Vitamin D3 50000 IU/Kg, Vitamin E 500Mg/Kg, Vitamin K3 40 Mg/Kg, Vitamin B1/ Thiamin 20 Mg/Kg, Vitamin B2/ Riboflavin 100 Mg/Kg, Niacin Vitamin PP 600 Mg/Kg, Pantothenic acid/ Vitamin B3 160 Mg/Kg,Vitamin B6/ Pyridoxine 30 Mg/Kg, Vitamin B12 300 Mcg/Kg, Biotin/Vitamin H 1000 Mcg/Kg, Choline 7000 Mg/Kg, Folic Acid 15 Mg/Kg. Copper 300 mg/Kg, Zinc 1.100 mg/Kg, Iron 600 mg/Kg, Manganese 1.200 mg/Kg, Cobalt 4.0 mg/Kg, Iodine 20.0 mg/Kg, Selenium 4.0 mg/Kg, Anti-oxidant Added, Phytase Added, Mould inhibitor Added, Salinomycin 1200 mg/kg.

Table 2: Composition and calculated analysis of broiler finisher diets containing graded replacement of maize for sorghum

Ingredients, %	Replacement levels of maize for sorghum				
	0% (A)	25%(B)	50% (C)	75% (D)	100% (E)
Sorghum	70.00	52.50	35.00	17.50	0.00
groundnut cake	16.50	18.7	21.01	21.05	21.62
Wheat bran	3.00	1.70	0.01	0.01	0.01
Broiler Super concentrates*	5.00	5.00	5.00	5.00	5.00
Lime stone	1.17	1.14	1.11	1.11	1.11
Dicalcium phosphate	0.00	0.00	0.00	0.00	0.00
Vegetable oil	3.29	2.48	1.93	1.90	1.34
Maize	0.00	17.50	35.00	52.50	70.0
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.10	0.06	0.04	0.03	0.02
Methionine	0.04	0.02	0.00	0.00	0.00
Choline	0.20	0.20	0.20	0.20	0.20
Enzymes	0.20	0.20	0.20	0.20	0.20
Mycotoxin binder	0.20	0.20	0.20	0.20	0.20
Calculated analysis					
ME (kcal/kg)	3193	3176	3179	3194	3178
CP%	20.1	20.0	20.0	19.2	18.6
Crude fiber%	3.88	3.88	3.83	3.79	3.79
Ether extract%	6.58	6.14	5.95	6.15	5.86
Ca%	0.90	0.90	0.90	0.90	0.90
Available phosphorous%	0.42	0.45	0.48	0.50	0.53
Lysine%	1.00	1.00	1.00	1.00	1.00
Methionine%	0.44	0.43	0.43	0.44	0.45
Methionine + Cystine%	0.62	0.63	0.64	0.66	0.68

*As shown in Table 1.

Statistical analyses: Data were analyzed in completely randomized design using the general linear model (GLM) procedure of SAS version 9.0 for windows (SAS, 2003). Mean values ± standard deviation (SD) reported. When significant variation was obtained for any parameter, then Duncan's multiple range test will be used for separation of means (Steel and Torrie, 1980).

Results and Discussion

Table (3) shows the effect of graded replacement of maize for sorghum on live performance of broiler chicks during starter, finisher and overall period. Live performance parameters were not significantly ($P \geq 0.05$) influenced by dietary treatments except for body weight gain and FCR during finisher and overall period. Overall live body weight was significantly ($P \leq 0.05$) affected by dietary treatments. Generally birds fed on 50% replacement performed better than birds on other dietary treatments. In this regards, during starter and finisher phases feed intake and body weight gain among birds fed50% replacement increased by (6.41 and 1.22%) and (7.13 and 3.56%), respectively compared to control. Overall feed intake and body weight gain increased by 6.94 and 2.74%, respectively for birds fed 50% replacement when compared with control. Similar results reported by Torres *et al*. (2013) who concluded that 50% maize replacement with low-tannin sorghum is suitable for broiler. Conversely Torres *et al*., (2013) noticed negative effects on the overall performance of broilers in sorghum-based feed. However, Santos *et al*. (2006) did not report any differences in feed intake, weight gain, or feed conversion of broiler fed sorghum-based

diets. In controversy to our findings, Pour-Reza and Edriss (1997) found similar BW for broilers fed maize-based diet and 50% sorghum replacement. Moreover, birds fed on 100% replacement showed the poorest feed intake compared to other dietary treatments. Birds fed 75% replacement expressed, significantly (P≤ 0.05) the poorest FCR. This result is in disagreement with the findings of Robertson and Perez-Maldonado (2010) who due poor feed conversion efficiency in broilers to dietary inclusion of sorghum.

Table 3: The effect of graded replacement of maize for sorghum on live performance

Parameter	Replacement levels of maize for sorghum					
	0% (A)	25%(B)	50% (C)	75% (D)	100% (E)	± SEM
0-3 wk						
Feed intake (g/bird)	947.64+35.30	960.74+38.61	1008.36+117.25	933.39+53.17	923.42+59.68	39.05
Body weight gain (g/bird)	654.37+44.61	663.76+31.01	662.37+18.60	633.62+28.89	610.35+44.18	20.14
FCR (g feed /g Bwt gain)	1.45 +0.06	1.45 +0.10	1.52+0.20	1.47+0.02	1.51 +0.04	0.06
PER (Bwt gain/protein consumed)	3.01 +0.12	3.08 +0.22	3.00 ±0.36	3.16 ±0.04	3.16 +0.08	0.12
4-6 wk						
Feed intake	2730.90+89.62	2949.50+301.27	2925.60+438.27	2873.10+368.96	2422.20+154.50	173.37
Body weight gain	1212.62 ^{a}+132.38	1127.73 ^{ab}+142.95	1255.73 ^{a}+152.88	1083.13 ^{ab}+234.91	946.74 ^{b}+132.38	57.05
FCR	2.26 ^{b} +0.22	2.61 ^{a} +0.17	2.33 ^{ab}+0.23	2.65 ^{a} +0.23	2.57 ^{ab} +0.22	0.10
PER	2.21 +0.23	1.92 +0.22	2.15 ±0.21	1.97 ±0.21	2.11 +0.23	0.09
0-6 wk						
Live body W. (g/bird)	1912.16 ^{a}+62.19	1837.53 ^{a}+53.44	1962.30 ^{a}+152.56	1759.95 ^{ab}+152.07	1602.52 ^{b}+31.64	60.07
Feed intake (g/bird)	3678.60+98.32	3910.20+326.11	3933.90+353.06	3806.50+421.96	3345.70+213.88	207.47
Body weight gain (g/bird)	1866.99 ^{a}+62.06	1791.49 ^{a}+53.87	1918.10 ^{a}+153.07	1716.75 ^{ab}+152.03	1557.09 ^{b}+30.11	60.11
FCR (g feed /g Bwt gain)	1.97 ^{b} +0.09	2.18 ^{ab} +0.14	2.04 ^{ab} +0.12	2.21 ^{a} +0.07	2.15 ^{ab} +0.14	0.07
PER (Bwt gain/protein consumed)	2.44 +0.10	2.23 +0.15	2.39 ±0.14	2.29 ±0.07	2.43 +0.15	0.07

Values are means of 3 replicates per treatment (10 bird\replicate).
^{ab} Means ± SD with different superscripts in the same row are significantly different (P≤ 0.05).
SEM: Standard error of the means from ANOVA d.f 10.

Table (4) shows the effect of graded replacement of maize for sorghum on carcass characteristics. Relative weight of breast, thigh and drumsticks and meat bone ratio of breast, thigh and drumsticks were not significantly (P≥0.05) affected by dietary treatments. This agreed with Torres *et al*., (2013) who found no significant effect of maize replacement by sorghum on carcass part weights of broiler chickens at 42 d of age. On the other hand, dressing percentage was significantly (P≤ 0.05) affected by dietary treatments.

Table 4: The effect of graded replacement of maize for sorghum on carcass characteristics

Parameter	Replacement levels of maize for sorghum					
	0% (A)	25%(B)	50% (C)	75% (D)	100% (E)	± SEM
Live body weight	2067	1724	1755	1742	1525	
Dressing % on hot base	69.30 [a]+0.64	68.29 [ab]+1.72	66.46 [b]+1.55	67.69 [ab]+0.46	67.05 [b]+0.14	0.63
Absolute wt of Abdominal fat	38.33+3.79	39.00+16.00	43.67+5.77	42.33+15.04	38.67+18.45	7.62
Relative wt of Abdominal fat	2.68 +0.28	3.23 +0.93	3.81+0.90	3.54+1.02	3.89 +2.16	0.71
Absolute wt of breast	479.33 [a] +13.32	393.33 [ab] +97.58	410.00 [ab]±59.73	424.67 [ab] ±24.19	338.80 [b] +39.85	32.08
Relative wt of breast	33.49+1.84	33.46+6.36	35.04+1.30	36.20+4.23	32.99+1.75	2.11
Meat bone ratio of breast	4.32+2.47	5.67+2.81	5.68+4.99	4.02+1.29	5.28+2.32	1.75
Absolute wt of thigh	188.00+28.84	167.33+25.01	204.00+76.86	232.00 +74.00	209.33+75.29	35.13
Relative wt of thighs	13.16 +2.35	14.25 +1.17	17.13+4.30	19.46 +4.89	20.50 +7.16	2.59
Meat bone ratio of thigh	2.39 +0.26	4.40 +0.92	3.64 ±1.05	3.90 ±2.42	4.42 +3.14	1.09
Absolute wt of drumsticks	204.67 [a]+9.45	162.00 [ab]+13.11	172.67 [ab]+31.39	168.00 [ab]+29.87	148.67 [b]+33.49	14.74
Relative wt of drumsticks	14.30+0.94	13.89+1.49	14.72+1.04	14.20+1.78	14.43+2.36	0.93
Meat bone ratio of drumsticks	1.94 [c]+0.32	2.80 [a]+0.19	2.29 [abc]+0.22	2.59 [ab]+0.37	2.16 [bc]+0.24	0.16

Values are means of 3 replicates per treatment.
[abc] Means ± SD with different superscripts in the same row are significantly different (P≤ 0.05).
SEM: Standard error of the means from ANOVA d.f 10.

The effect of graded replacement of maize for sorghum on internal organs is shown in Table 5. No significant (P≥0.05) differences in internal organs among all dietary treatments. However relative weight of liver and gizzard was higher for birds fed 25, 50, 75 and 100 compared to control.

Table 5: The effect of graded replacement of maize for sorghum on internal organs

Parameter	Replacement levels of maize for sorghum					
	0% (A)	25%(B)	50% (C)	75% (D)	100% (E)	± SEM
Absolute wt of liver	38.33+5.69	31.33+1.53	37.67+5.69	36.00+4.58	31.33+6.03	2.88
Relative wt of liver	2.68+0.40	2.70+0.36	3.22+0.14	3.06+0.39	3.05+0.46	0.21
Absolute wt of gizzard	26.00+3.61	25.33+3.06	23.00+6.08	24.33+3.51	22.00+3.00	2.32
Relative wt of gizzard	1.81+0.20	2.16+0.11	1.95+0.26	2.06+0.28	2.16+0.28	0.14
Absolute wt of heart	9.33+1.53	8.33+1.53	7.67+2.52	9.00+2.00	6.33+0.58	1.01
Relative wt of heart	0.65+3.79	0.71+16.00	0.65+5.77	0.76+15.04	0.62+18.45	0.07
Length of Intestine	172.67+54.45	187.33+12.70	148.00+31.18	176.67+9.45	140.67+35.23	19.03

Values are means of 3 replicates per treatment.
SEM: Standard error of the means from ANOVA d.f 10.

Economics analysis (Table 6) showed that the lowest cost of 1 kg starter and finisher feed was in sorghum-based feed followed by 25, 50, 75 and 100% replacement. This was a consequence of high price of maize versus sorghum which was reflected in the cost that increased linearly as the replacement level of maize for sorghum increased. Feed cost per 1 Kg BWG was lowest in sorghum-based feed followed by 50, 25, 100 and 75% replacement. As a consequence, sorghum-based feed accomplish highest economic efficiency index followed by 50, 25, 100 and 75% replacement.

Table 6: The effect of graded replacement of maize for sorghum on economic efficiency

Parameter	**Replacement levels of maize for sorghum**				
	0% (A)	25 %(B)	50 %(C)	75 %(D)	100 %(E)
Cost (SDG) of 1 kg starter feed	3.29	3.34	3.38	3.41	3.46
Cost (%) of 1 kg starter feed	100	101.52	102.74	103.65	105.17
Cost (SDG) of 1 kg finisher feed	3.24	3.26	3.31	3.40	3.44
Cost (%) of 1 kg finisher feed	100	100.62	102.16	104.94	106.17
Feed cost (SDG)/1kg BWG	6.92	7.62	7.30	8.04	7.96
Economic efficiency index (EEI)	100.00	90.87	94.75	86.11	86.97
Cost index (CI)	100.00	110.05	105.55	116.13	114.99

Conclusion

The obtained results revealed that maize can replaced sorghum in starter and finisher diets without negative effect on broiler performance. During starter and finisher phases feed intake and body weight gain increased for birds fed 50% maize replacement. On the base of these results, 50% maize replacement for sorghum grains is sufficient for good broiler performance.

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تأثير استبدال الذرة الرفيعة بالذرة الشامية على آداء الدجاج اللاحم و خصائص الذبيحة

محمد الامين احمد و طلحة الصادق عباس
جامعة النيلين– كلية التقانة الزراعية وعلوم الاسماك– قسم الانتاج الحيواني

المستخلص:

تم اجراء تجربة لتقييم اثر الاستبدال التدريجي للذرة الرفيعة بالذرة الشامية على آداء الدجاج اللاحم وخصائص الذبيحة وبعض اقتصاديات الانتاج. تم استخدام 150 كتكوت لاحم من سلالة الروس 308 في عمر يوم وكان متوسط وزنها (44.81±1.40 جم). تم توزيع الكتاكيت عشوائياً على خمسة اغذية تجريبية تم تكرارها ثلاث مرات. اشتملت الاغذية التجريبية الابتدائية والنهائية على استبدال الذرة الرفيعة بالذرة الشامية بمعدلات متدرجة 0% (العلف الضابط)، 25%، 50%، 75% و100%. وقد استمرت التجربة لمدة 42 يوم. تم تحليل البيانات احصائياُ باستخدام التصميم العشوائي الكامل. لم تتأثر مقاييس الاداء الحي معنوياُ بالاغذية التجريبية عدا الوزن المكتسب ومعدل التحويل الغذائي خلال للفترة النهائية والاجمالية. وقد حققت الطيور التي تم تغذيتها على معدل استبدال 50% افضل آداء. حيث تحسن استهلاك العلف والوزن المكتسب لهذه الطيور بمعدل 6.41 و1.22%، على الترتيب مقارنة بالضابط وذلك خلال الفترة الابتدائية. وخلال الفترة النهائية تحسن استهلاك العلف والوزن المكتسب لهذه الطيور بمعدل 7.13 و3.56%، على الترتيب مقارنة بالضابط. اوضحت الدراسة أن الوزن النسبي ومعدل التشافي للصدر، الفخد والدقاقات لم تتأثر بصورة معنوية بالمعاملات الغذائية. اوضح التحليل الاقتصادي ان تكلفة انتاج 1كجم علف ومؤشر التكلفة كانتا الاقل في العلف الضابط يليه الاعلاف التي اشتملت على معدلات استبدال 50، 25، 100 و75%. وعلى ضوء هذه النتائج نخلص الي ان استبدال 50% من الذرة الرفيعة بالذرة الشامية يؤدي للحصول على افضل النتائج.