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The Effect of Replacing Maize with Sorghum on Carcass Characteristics and Economics Feasibility on Commercial Broiler Chicken

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Abstract

Background: Maize occupy the largest part in poultry ration, but its availability in the future is under question, because the higher demand to different industrial product, so it is important to find locally available feed which can replace maize either totally or in part. The experiment was conducted with aimed to evaluate replacement of maize by sorghum on carcass characteristics and economic feasibility of feeding different level of sorghum on Hubbard classic broiler chicken.

Methodology: Two-hundred forty chicks day-old with initial body weight of 42.5 ± 0.24 g were used for the experiment in complete randomized design. The experiment consisted of 28 days starter phase and 21 days finisher phase. The treatment were T_1 (maize based, control), T_2 (15% sorghum), T_3 (30% sorghum), and T_4 (45% sorghum). The experiment lasted for 7 weeks. At the end of the experimental period, 12 broilers from each treatment were randomly selected and slaughtered to evaluate carcass parameters.

Results: Significant difference was observed in slaughter weight ($P<0.05$). Dressed, eviscerated, drumstick, thigh, breast meat weight was lower ($P<0.01$) for control groups and abdominal fat was not significantly ($P>0.05$) different between the treatment and the control group. Crop, pro-ventricular, gizzard, small intestine and liver weight was significantly higher ($P<0.01$). Mortality was not significant ($P>0.05$) among treatments and the control. The highest net return from cost benefit analysis was seen in T_4.

Conclusion: From the present study, it can be concluded that replacement of sorghum with maize up to 45% appeared to be biologically better, not having adverse effect on broiler performance and Economic feasible.

Keywords: Sorghum; Maize; Carcass; Mortality; Economic

Abbreviations: CP: Crude Protein; CF: Crude Fiber; DM: Dry Matter; ME: Metabolizable Energy; NSC: Noug Seed Cake; OM: Organic Matter; GIT: Gastro Intestinal Tract; LSD: Least Significant Difference; CBD: Completely Randomized Design.

Introduction

In Ethiopia the availability and cost of feed is one of the major limitations to poultry production because of the fact that there is shortage of cereal grains, protein sources, vitamins and mineral supplements required to formulate balanced poultry rations. The major cost of production of egg and meat in commercial poultry production is feed. Feed cost can be 55-75% of the total production expenses depending on the geographical location, season and country. The ever-rising prices of feed ingredient remained to be the greatest single item determining the profit margins in poultry farming, especially in developing countries. The most appropriate strategy for these countries is to develop diets which allow locally available new ingredients to be used. Such an approach would reduce feed costs as well as the dependency on imported and conventional feed materials [1].

Maize is a major source of dietary energy in poultry nutrition. Although it is produced throughout the world, there is stiff competition for maize among human's, livestock and the industry. This is because maize is high in energy as compared to other cereal grains [2]. As a result of its multiple uses and relatively higher moisture requirement for growth, use of maize in drier areas, such as most part of Ethiopia may be limited in the future. In comparison to maize, sorghum can be grown successfully on relatively poor soils and with lower moisture condition. According to [3] the ME and percent crude protein content of sorghum are 3270 kcal/kg and 9.5%, respectively, which is comparable with 3319 kcal/kg ME and 10.1% CP, respectively of maize. The percent ash (1.2) and fiber (7.8) are higher than that of maize (1% ash and 5.5% CF) and sorghum is relatively similar in cost with maize compared to other cereal such as wheat [4]. A common complaint about sorghum is that it has high tannin levels [5].

As a result, sorghum is frequently substituted for corn in poultry rations in other regions of the world, including USA, depending on relative prices [5]. Therefore, it is imperative to assess the feeding and replacement value of sorghum for maize as alternative cheap and easily available feedstuffs in the broiler ration. This study aimed with to evaluate carcass characteristics and economics of feeding different levels of sorghum as a substitute for maize in broilers production.

Materials and Methods

Description of the study area

The experiment was conducted at Haramaya University which is located 515 km East of Addis Ababa. The site is located at an altitude of 1950 meter above sea level at 9°26´N latitude and 42°3´E longitude.

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The mean annual rainfall and temperature of the study area is 790 mm and 16°C, respectively [6].

Experimental design and dietary treatment

The broilers were assigned to four dietary treatment groups following a completely randomized design (CRD). Each treatment group had three replicates of 20 birds per treatment. The broilers were randomly distributed to replicate groups to give near uniform initial weights for all the groups. In the control diet (T_1), maize served as the main energy source and therefore has no sorghum grain inclusion. The three test diets designated as T_2, T_3 and T_4, are formulated to contain 15, 30 and 45 percent sorghum grain in replacement for maize, respectively.

Ingredients and experimental rations

The feed ingredients used in the formulation of the different experimental rations of the present study were sorghum grain, corn grain, wheat short, soybean meal, noug seed cake, vitamin premix, and salt. Sorghum and corn grains were purchased from the local market; Wheat short was obtained from Dire Dewa flour mill factory, and soybean meal, noug seed cake and vitamin premix were purchased from Addis Ababa. All the ingredients, except wheat short, vitamin premix and limestone was hammer milled to 5 mm sieve size and stored until required for formulation of the experimental rations. Chemical analysis was done from representative samples of the individual ingredients. Based on the ingredient analysis results; four treatment rations were formulated. The proportion of each ingredient used to formulate the starter and finisher ration are given in Tables 1 and 2.

Management of experimental birds

240 Hubbard classic chickens were raised in a floor system pen which is partitioned into 12 pens, each with a dimension of 1.5 × 1.5 m and stocking density of 10 chickens per m^2 from day old to seven weeks of age. The pens and the equipment were properly cleaned and disinfected and infra-red lamps, drinker and feeder were placed in each pen before the arrival of the chicks. The day old baby chicks were purchased from debrezeit (DZARC). Feed were given to chicks on one feeder and drinker in group for each replication until three weeks and then after one feeder and drinker were added. Body weight change was taken using sensitive balance every week starting from day old. The chicks were vaccinated with live vaccine against mar`ek's disease at the first day and against Newcastle Disease ($HB_{1)}$ on third and 21st day through ocular and against Gumburo at seventh day through drinking water. Water was available all time and weighed quantities of diets were given on ad libitum base to the birds.

Ingredients	Treatments			
	T1	T2	T3	T4
Maize	40	34	28	22
Sorghum*	0	6	12	18
Wheat short	13	13	13	13
Soyabean	22	22	22	22
Noug sees cake	25	25	25	25
Premix	1	1	1	1
Limestone	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5

*When calculated from total ration representing 15, 30 and 45% maize replacement by sorghum.

Table 1: Proportion of ingredients used in formulating the starter rations (%).

Ingredients	Treatments			
	T1	T2	T3	T4
Maize	40	34	28	22
Sorghum*	0	6	12	18
Wheat short	25	25	25	25
Soyabean	15	15	15	15
Noug sees cake	17	17	17	17
Premix	1	1	1	1
Limestone	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5

*When calculated from total ration representing 15, 30 and 45% maize replacement by sorghum.

Table 2: Proportion of ingredients used in formulating the finisher rations (%).

Data collection

Chemical analysis: Representative samples were taken from each of the feed ingredients used in the experiment and analyzed before formulating the actual dietary treatments. In the same way, samples were taken from each of the treatment diets at each mixing and from leftovers every day during the experiment and kept in paper bags until analyzed. The left over from each pen was collected each morning before fresh feed is given, cleaned from external contaminants by use of 5 mm mesh size sieve and by hand picking, weighed and pooled by treatment, thoroughly mixed and sample was taken and the rest discarded.

All samples were analyzed for dry matter, nitrogen, ether extracts, crude fiber and ash by employing the proximate analysis method of the [7] CP was calculated. Metabolizable energy (ME) of the experimental diets was determined by indirect methods, by using the formula given by [8] as follows: ME (Kcal/kg DM)=3951+54.4 EE-88.7 CF-40.8 ash.

Carcass traits

At the end of the experiment, four broilers (two males and two females) were randomly selected from each replication (12 birds per treatments) and starved for 12 hours, weighed and slaughtered for carcass evaluation. After slaughtering, the birds were de-feathered, eviscerated and carcass cuts, edible and non-edibles offal were weighed and recorded following to the procedure described by [9] and [10]. Dressing percentage was calculated as percent of live weight after bleeding and de-feathering. Eviscerated carcass weight were determined after removing blood, feather, shank, head, heart, liver, gizzard, kidney, lung, pancreas, crop, pro-ventricles, small and large intestine, caecum and urogenital tracts. The eviscerated percentages were determined as the proportion of eviscerated weight and slaughter weight multiplied by 100. Abdominal fat was determined by weighing the fat trimmed from pro-ventricles up to cloaca.

Partial budget analysis

To estimate the net gain or lose as a result of replacing sorghum for maize, the partial budget was analyzed taking into consideration the feed expense as a variable cost and sale of broiler meat as a return following the principles developed by [11]. The calculation was done by using the formulae; Marginal Rate of Return=Δ Variable cost/Δ Net Return; Net Return=Total return-Total variable cost. Feed cost per live weight gain was also calculated as follows as an indicator of cost and biological efficiency.

$$\text{Feed cost per live weight gain} = \frac{\text{Cost of feed consumed}}{\text{Live weight gain (kg)}} \times 100$$

Statistical analysis

The data collected were analyzed as completely randomized design following the procedures suggested by [12] employing SAS. Where the analysis of variance indicated the existence of significant difference among treatment means, least significant difference (LSD) was employed to test and locate the treatment means that are significantly different from each other. The model for data analysis was; Yijk=μ + τi + εijk; Where Yij=response variable; μ=over all means; $t_{i=}$treatment effect; $b_{j=}$block effect; eij_random error

Results and Discussion

Result of chemical analysis

The chemical compositions of different feed ingredients and the four formulated experimental rations are shown in Tables 3 and 4, respectively. The energy and protein content of sorghum used in the present study is 3986.4 kcal/kg DM and 11.4%, respectively which were in line with reported by [4] 11.6% CP and 3800.1 kcal/kg DM ME [13]. Reported ME of 3838 and 3200 kcal/kg for low and high-tannin sorghum, respectively. The CP content of maize used in the current study is comparable with that of [14] who reported CP of 8.2% and ME of 3602.11 kcal/kg DM ME and [15] who reported 10.02% CP and 3578.78 kcal/kg DM ME. Both energy and protein content of sorghum is slightly higher than maize, which indicate that sorghum to be good feed ingredient to replace maize in poultry ration. The CF of sorghum used in the present study was 2.3% which is comparable with the result of [16] and [17]; who reported 2.1, 1.97, respectively [18]. Also reported crude fiber contents of serana sorghum (2.7%) and white sorghum (3.4). The CF content of maize used in the current study was 6.5%, which is similar with the result reported by [19] 6.49% related. The inclusion of adequate amounts and types of fiber might benefit the development of the GIT and improve growth performance.

Ingredients	Chemical composition (%)					
	DM	CP	CF	EE	Ash	ME (Kcal/kg DM ME)
Sorghum	89	11.4	2.3	7.1	3.6	3986.35
Maize	88	9.6	6.5	6.8	1.5	3683.17
Wheat short	89	15.3	6.3	8.6	3.6	3717.58
Soybean meal	92	39.2	4.1	12.4	6.1	4013.01
Noug seed cake	92	34.4	18.4	17.7	9.8	2881.96

DM: Dry Matter; CP: Crude Protein; CF: Crude Fiber; EE: Ether Extract; ME: Metabolizable Energy.

Table 3: Chemical composition of ingredient (dry matter base).

Treatment		Nutrient% DM					
		DM	CP	CF	EE	Ash	ME(Kcal/kg DM ME)
Offered	T1	90	22.3	6.3	7.5	7.4	3498.27
	T2	91	22.1	6.5	7.9	7.6	3494.13
	T3	90	21.9	6.8	8.6	8.5	3468.88
	T4	91	22.6	7.2	6.1	7.3	3346.36
Ort	T1	88	20. 1	5.8	6.1	7.0	3482.78
	T2	89	21.0	5.4	6.8	7.1	3552.26
	T3	88	20.3	5.1	5.5	6.4	3536.71
	T4	90	20.8	6.4	5.9	6.8	3426.84

T_1: full based; T_2: 15% sorghum; T_3: 30% sorghum; T_4: 45% sorghum; DM: Dry Matter; CP: Crude Protein; CF: Crude Fiber; EE: Ether Extract; ME: Metabolizable Energy.

Table 4: The Chemical compositions of feed offered and leftovers (dry matter basis).

Parameter	T1	T2	T3	T4	Sig.	SEM
Dressing percentage	92.0^{b}	92.2^{ab}	92.2^{ab}	92.5^{a}	**	0.07
Eviscerated percentage	70.8	71.3	70.9	71.4	Ns	0.12
Drumstick percentage	10.2^{b}	10.3^{ab}	10.3^{a}	10.3^{ab}	**	0.03
Breast meat percentage	22.2^{b}	22.2^{b}	22.7^{a}	22.6^{a}	**	0.07
Abdominal fat percentage	1.0	0.9	0.9	0.9	Ns	0.02
Heart percentage	0.5	0.5	0.5	0.5	Ns	0.003
Gizzard percentage	3.0	3.0	2.9	2.9	Ns	0.07
Liver percentage	2.5^{b}	2.6^{a}	2.6^{a}	2.6^{a}	**	0.07

**P<0.01; *P<0.05; NS: Non Significant; SEM: Standard Error of Mean; T1: full maize; T2: 15% sorghum; T3: 30% sorghum; T4: 45% sorghum.

Table 5: Percent of some carcass cut to live weight.

Carcass traits

The mean carcass traits of the experimental chicken fed the four treatment ration are presented in Table 5. Mean slaughter weight of T_4 was significantly higher (P<0.01) than the other treatments and was no difference between T_1, T_2 and T_3. Except for shank; abdominal fat, head, skin and cloaca, there were significant (P<0.05) differences among treatments for carcass and organ measurements. The dressed weight and percentage of T_4 broiler chicks were significantly higher (P<0.01) than other treatments and was no difference between T_1, T_2 and T_3 treatments [19]. Reported significant difference for Hubbard classic chicks. In contrast to the current study [4] reported dressing percentage no significant difference among the treatments. The eviscerated weight broilers in the current experiment showed significant (P<0.05) difference among the treatments. This result is supported by [19] who reported higher eviscerated weight for Hubbard Classic broilers. The breast meat of fed four treatment diet showed significantly higher (P<0.01) value. This result agrees with [4] who reported significant difference. Breast meat treatments T_4 and T_3 significantly higher (P< 0.01) than treatment T_2 and T_1 and the later treatments showed no significance difference between each other. Broilers with better developed breast meat are considered superior finishing. Statistical analysis revealed that drumstick and thigh was different among the treatment where T_4 was higher as compared to T_2 and T_1, but similar with T_3 which is in agreement with the result [20] who reported that significance difference (P<0.01) in drumstick and thigh on chick fed high-Tannin sorghum diet.

Abdominal fat components of finished broilers are very important in assessing quality and heavy deposit of abdominal fat in finished broilers indicates poor finishing. According to the present study the abdominal fat weight and percentage were not significantly (p>0.05) different among the four treatments. The result found in the current study is comparable with [4] who reported no significance difference in abdominal fat among chick fed millet, sorghum and maize based diet and concluded that millet and sorghum can be well-utilized to produce broiler chickens with superior carcass quality compared to maize.

Giblet (gizzard, heart and liver) weight and percentage of chicks found in the current study were presented in Tables 5 and 6, respectively. Both liver and heart weight were significantly higher (P<0.01) among the treatment diet which were similar report with [21] and [20]. Dietary tannins do not seem to influence liver weight in chicks [22] and results of the present study support this conclusion. Gizzard weight and percentage were showed no significant (P<0.01) difference between dietary treatments. Heart percentage was similar between the treatments. This result is in agreement with [4] who reported no significant difference among the treatment diet.

Parameter(g)	T1	T2	T3	T4	SEM	Sig.
Slaughter weight	1612.4^{b}	1623.1^{b}	1623.8^{b}	1648.4^{a}	4.66	**
Dressed	1483.9^{b}	1497.0^{b}	1497.3^{b}	1524.7^{a}	5.26	**
Eviscerated weight	1149.8^{b}	1151.6^{b}	1150.2^{b}	1178^{a}	4.65	*
Breast meat	356.7^{b}	361.2^{b}	367.7^{a}	372.4^{a}	1.99	**
Drumstick	163.7^{b}	166.5^{ab}	167.9^{a}	169.4^{a}	0.74	**
Thigh	170.5^{c}	173.2^{bc}	174.5^{ab}	177.2^{a}	0.79	**
Drumstick and thigh	336.6^{c}	340.5^{bc}	343.0^{ab}	346.9^{a}	1.29	**
Abdominal fat	16.7	14.8	15.3	15.3	1.21	Ns
Gizzard	36.1	35.8	35.6	35.5	0.14	Ns
Liver	39.6^{b}	41.7^{a}	42.4^{a}	42.6^{a}	0.39	**
Heart	8.6^{a}	8.5^{ab}	8.4^{ab}	8.4^{b}	0.01	*
Skin	88.9	89.4	87.7	87.4	0.72	Ns
Shank	79.4	81.8	80.9	80.8	0.55	Ns
Head	58.1	58.2	58.4	57.9	0.09	Ns
Crop	10.4^{b}	11.6^{a}	11.6^{a}	11.9^{a}	0.22	*
Proventriculus	7.9^{c}	8.5^{b}	8.7^{a}	8.7^{a}	0.09	*
SI	44.2^{b}	47.9^{a}	48.6^{a}	48.8^{a}	0.59	***
Ceaca	7.2^{b}	7.3^{b}	7.4^{ab}	7.6^{a}	0.06	*
Cloaca	3.1	3.3	3.0	3.0	0.07	Ns

***P<0.001; **P<0.01; *P<0.05; NS: Non Significant; SEM: Standard Error of Mean; T1: full maize; T2: 15% sorghum; T3: 30% sorghum; T4: 45% sorghum; sig: Significant.

Table 6: Mean carcass characteristics of commercial broiler fed ration containing increasing level of sorghum replacing maize.

Parameter	T1	T2	T3	T4
Total cost of feed /chick	25.3	26.3	27.3	28.1
Cost of day old chick	6	6	6	6
Feed cost per kg	3.3	3.4	3.5	3.6
Feed cost per daily gain	0.51	0.53	0.55	0.57
Total variable cost	31.3	32.3	33.3	34.1
Chick sale (gross return)	40	40	40	50
Net return/chick	8.8	7.7	6.7	15.9
Change in total variable cost	-	1	2	2.8
Change in gross return	-	0	0	10
Change in net return	-	-1.1	-2.1	7.1
Marginal rate of return	-	-1.1	-1.05	2.5

T1: full maize; T2: 15% sorghum; T3: 30% sorghum; T4: 45% sorghum.

Table 7: Economics of replacing maize with sorghum in raising broiler chicken.

Skin, shank and head weight of chicks showed no significant (P>0.05) difference. Crop was not significant (P>0.05) among T_2, T_3 and T_4, but T_1 recorded lighter crop weight as compared to the other treatments. Pro-ventricles of chick assigned under four treatment ration for seven consecutive weeks was analyzed and it showed significance difference (P<0.05) among the treatments, but T_3 and T_4 were recorded similar weight and they were significantly vary from T_1 and T_2. Gizzard was showed no significance difference (P>0.05) between each treatments. In the current study the weight of small intestine and caeca were analyzed and both parameter were showed significant difference (P<0.01) between treatments. When we see small intestine T_4 was different statistically higher (P<0.05) T3, T2 and T1 respectively and caeca in T_4 was significantly different from T_3, T_2 and T_1, but T_2 and T_1 was not significantly different from each other. This result is with the conformity of previous work of [20]. The cloaca in experimental chicks fed different sorghum level (15, 30 and 45%) were analyzed and resulted in no significant difference (P>0.05) among the treatments. This result is support with the result of [20] who found the same result with the current study in liver weight when chicks fed high tannin sorghum diet.

Partial budget analysis

The economic return (benefit) in terms of partial budget from Hubbard Classic broiler chicks fed ration containing increasing level of sorghum replacing maize are presented in Table 7. Cost of production and net profit per broiler determine the fate of broiler productivity [23]. According to the result of partial budget analysis, broiler chick fed on treatment four (ration containing 45% sorghum) returned a higher profit than those fed on ration containing 15 and 30% and control group. Accordingly the net return of broiler on T_4 was 10 Ethiopian birr and zero net return for the rest treatment with marginal rate return of 2.5 for T_4 and -1.05 and -1.1 for T_3 and T_2, respectively. The present study reveals that the replacement of maize by sorghum up to 45% (T_4) in to the broiler ration is potentially more profitable than the rest treatments [19]. Reported the highest net return for Hubbard Classic chick fed imported or local protein balancer. The net returns were highest in the group fed diet 50% replacement of corn with finger millet and sorghum reported by [24]. Accordingly, the least cost ration per chick reared was found to be diet T_1 as evidenced by the minimum cost. However, the daily gains of chicks in T_1 were relatively lower. For this reason, treatment rations relatively with better daily gain and economic return could be recommended as the biological and also economical optimum for raising chicks from day old to 7 weeks of age. Though chicken under T_4 were biologically better weight gain and in turn economically highest return. Medegu et al. [4] stated that the highest cost per kg feed was in the maize-based diet compared to sorghum - based diets. The sorghum based diet was the cheapest. Based on the current finding dietary treatment four (ration containing 45% sorghum inclusions) can be concluded as profitable ration in broiler production.

Mortality

The incidence of chick death was slightly higher in the starter phase of experimental period. Though accurate cause of death was not known sudden syndrome was suspected. During finisher phase of experimental period chick death were not recorded. Percent mortality of chick in T_1, T_2, T_3 and T_4 were 0.33, 1.33, 1.66 and 1.66, respectively. There were no significant difference (P>0.05) between these value. This result agrees with [19] reported 2.59% mortality during starter phase.

Conclusion

The CP content and ME values of the formulated feed were 22% CP and 3200 kcal/kg DM; and 21 CP and 2883 kcal/kg DM, for starter and finisher ration, respectively. The replacement of maize with sorghum in different level resulted in a significant difference (P<0.05) in slaughter weight, dressed carcass, drumstick, thigh and breast meat weight whereas abdominal fat and skin weight were not shown significant (P>0.05) difference. The profitability of replacing maize with sorghum also revealed T_4 was the profitable treatment diet compared to the rest. The mortality recorded from the starting of the experiment were not significant (P>0.05) between treatments. Therefore, the current study revealed that replacements of maize with sorghum up to 45% were not having adverse effect on the performance of broiler chicken.

Authors' Contributions

KG conceived the study, designed and conducted all laboratory experiments; analyzed and interpreted experimental results. AM and MU participated in the proposal, study design and manuscript preparations. All authors read and approved the final manuscript.

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