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Effects of Replacing Maize with Sorghum on Growth and Feed Efficiency of Commercial Broiler Chicken

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Abstract

Background: 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. This experiment was conducted to evaluate replacement of maize by sorghum on growth rate and feed conversion ratio, on Hubbard classic broiler chicken.

Methods: Two-hundred forty chicks day-old with mean 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, during which dry matter intake (DMI), body weight gain were measured and Feed conversion ratio.

Results: The laboratory chemical analysis of feeds showed that 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. No significant (P>0.05) difference was seen in daily, total DM intake, Final body weight, average daily body weight gain and DM conversion ratio between treatments and the control group for starter, finisher and entire period

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

Keywords: Sorghum; Maize; Replacing; Broiler; Ration

Abbreviations: CP: Crud Protein; CF: Crude Fiber; DM: Dry Matter; FCE: Feed Conversion Efficiency; FCR: Feed Conversion Ratio; ME: Metabolizable Energy; NSC: Noug Seed Cake; OM: Organic Matter; GIT: Gastro Intestinal Tract; LSD: Least Significant Difference; DMI: Dry Matter Intake; CBD: Completely Randomized Design; TDN: Total Digestible Nutrient

Background

Poultry production is an important economic activity in Ethiopia. Beside its social and cultural benefits, it plays a significant role in family nutrition [1]. The total poultry population at country level is estimated to be about 38.13 million [2] and more than ninety five percent of these population consists of local breed types that are owned by rural farm households and kept under scavenging management system [3]. The remaining proportion comes from the commercial sector.

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. In response to this, researches conducted in Ethiopia also focused, among other things, on determining the feeding value of locally available feed resources, comparative economic and biological evaluation of different feed resources and assessment of the values of various feed ingredients and supplements in improving product quality [4]. However, further effort in this line is becoming evident as a result of changing conditions and a need for widening the range of the possible feed ingredients. This is particularly important in Ethiopia since 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, which are further aggravated by the competition between poultry and human for food and the upcoming alternative uses of major feed ingredients of poultry, such as maize.

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 [5]. 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 Olomu [6] the ME and percent crude protein content of sorghum are 3270 kcal kg^{-1} and 9.5%, respectively, which is comparable with 3319 kcal kg^{-1} 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 [7]. A common complaint about sorghum is that it has high tannin levels [8].

As a result, sorghum is frequently substituted for corn in poultry

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rations in other regions of the world, including USA, depending on relative prices [8]. In Africa, such as Ethiopia and West Africa, however, feed and poultry producers rely on maize as the principal cereal in the ration. This might be partly because of the unavailability of local information on the inclusion level and effect of sorghum on performance of birds such as broiler. The objectives of this study were; to evaluating the effect of replacing sorghum for maize on the growth rate and feed efficiency.

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. The mean annual rainfall and temperature of the study area is 790 mm and 16°C, respectively [9].

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 marek'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.

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 [10] CP was calculated. Metabolizable energy (ME) of the experimental diets was determined by indirect methods, by using the formula given by Wiseman [11] as follows:

ME (Kcal/kg DM)=3951+54.4 EE - 88.7 CF - 40.8 Ash

Dry matter intake

Mean daily dry matter intake was determined every day by subtracting the amount of ort collected from the amount of feed offered. Dry matter intake was computed by multiplying the feed intake by their respective laboratory dry matter.

Body weight gain

Birds were weighed in group with sensitive balance until three weeks on weekly base and individually thereafter until the end of the

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 (%).

experiment and the average body weight of the chicks were computed for each replication. Mean pen weights were used for data analysis. Weekly body weight gains of chicks were determined.

Dry matter conversion ratio

Dry matter conversion ratio relates dry matter consumed per unit of weight gained. Dry matter conversion ratio was calculated by dividing the mean daily dry matter intake by the mean daily body weight gains [12].

Statistical analysis

The data collected were analyzed as completely randomized design following the procedures suggested by Gomez and Gomez [13] 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; $Yijk=\mu+\tau i+\varepsilon ijk$; 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 energy and protein content of sorghum used in the present study is 3986.4 Kcal/kg DM and 11.4%, respectively which is comparable with that reported by [7] 11.6% CP and 3800.1 Kcal/kg DM ME. Douglas et al. [14] reported ME of 3838 and 3200 kcal/kg for low and high-tannin sorghum, respectively. 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 and maize used in the present study was 2.3% and 6.5% which is in line with Eekeren et al. [15] and Zena [16], respectively. Jacob et al. [17] also reported crude fiber contents of serana sorghum (2.7%) and white sorghum (3.4). The CF content of the inclusion of adequate amounts and types of fiber might benefit the development of the GIT and improve growth performance (Tables 3 and 4).

Dry matter intake

The dry matter intakes (DMI) and body weight of the four groups of chicks fed the four treatment rations during the starter phase are shown in Table 5. There was no significant difference (P>0.05) in daily and total DMI among the treatment groups. Numerically both total and daily DMI showed higher with increasing level of sorghum in ration. The numerical increments of dry matter intake as an increasing level of sorghum is might be due to the low amount of crude fiber and slightly higher amount of energy and protein contents. Similarly, Nyannor et al. [18] reported no difference in feed consumption of chicks fed high digestible sorghum from 1 to 21 days of growing period. The result of the current study generally support that research conducted in Kenya replacement of sorghum for maize up to 40 percent did not significantly vary [19].

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	SEM	Sign.
Total DM intake (g/kg)	1847.9	1860.9	1863.3	1872.5	5.24	Ns
Daily DM intake (g/day)	65.9	66.4	66.5	66.8	0.18	Ns
Initial weight (g)	42.5	43.2	43.0	42.7	0.25	Ns
Final weight (g)	791.3	792.7	826.0	883.3	16.80	Ns
Daily weight gain (g/day)	28.3	28.3	29.5	31.5	0.59	Ns
Weight change (g)	748.8	749.5	783	840.6	16.73	Ns
Mortality (%)	0.3	1.3	1.6	1.6	0.30	Ns
FCR	1.32	1.34	1.20	1.29	0.02	Ns

NS: Non Significant; SEM: Standard Error of Mean; T1: Full Maize; T2: 15% Sorghum; T3: 30% Sorghum; T4: 45% Sorghum.

Table 5: Dry matter intake, body weight gain, feed conversion ratio and mortality of commercial broiler fed ration containing increasing level of sorghum replacing maize during starter phase (1 to 28 days).

The mean daily and total DMI of broiler chicken fed the four treatment diets during the finisher phase are presented in Table 6. Similar to the starter phase the total and daily DMI during finisher were not significantly (P>0.05). The present results agrees with results of Medegu et al. [7] who reported no significant difference in DMI intake in chick fed sorghum or millet as replacement for maize in semi-arid zone of Nigeria. Cramer et al. [20] also reported similar DMI were recorded in chicks fed Sorghum-based diets subjected to various manufacturing procedures from 3-6 weeks.

The dry matter intakes during the entire period (1 to 49 days) of the experiment were presented in Table 7. Similar to starter and finisher phase total and dry matter intake were not significantly different (P>0.05). This is may be due to the slight difference in chemical composition between sorghum and maize. This result is agree with the result reported by Kyarisiima et al. [21] no significant difference in feed intake between the maize based diet and the two diets that contained wood ash extract treated sorghum. Okeye et al. [22] Discussed average feed intake was statistically similar between the treatments in checks fed graded level of sorghum replacing for maize. Dry matter intake during the entire period showed increasing trend as the level of sorghum inclusion increased, but not significantly different, this might be due to the lower crude fiber content as compared to the control group or maize. Talha et al. [23] also reported no significant difference in feed intake of broiler reared on germinated low tannin sorghum during the entire production period.

Parameter	T1	T2	T3	T4	SEM	Sign.
Total DM intake (g/kag)	5061.9	5108.7	5127.8	5261.1	45.29	Ns
Daily DM intake (g/day)	241.0	243.2	244.1	250.5	2.16	Ns
Initial weight (g)	791.33	792.67	826.0	883.3	16.80	Ns
Final weight (g)	1618.0	1688.6	1730.7	1768.5	38.48	Ns
Weight change (g)	825.3	896	904.7	885.2	36.16	Ns
Daily weight (g/day)	77.0	80.4	82.4	84.2	1.83	Ns
FCR	3.1	3.0	3.0	3.0	0.08	Ns

NS: Non Significant; SEM: Standard Error of Mean; T1: Full Maize; T2: 15% Sorghum; T3: 30% Sorghum; T4: 45% Sorghum.

Table 6: Dry matter intake, body weight gain and feed conversion ratio of commercial broiler fed ration containing increasing level of sorghum replacing maize during finisher phase (29 to 49 days).

Parameter	T1	T2	T3	T4	SEM	Sign.
Total DM intake	6909.8	6981.1	6991.1	7122.0	44.59	Ns
Daily DM intake	141.0	142.5	142.5	145.3	0.91	Ns
Initial weight	42.5	43.2	43.0	42.7	0.25	Ns
Final weight	1618.0	1688.6	1730.7	1768.5	38.48	Ns
Weight change	1574.8	1646.1	1688	1725.5	38.48	Ns
Daily weight	33.0	34.5	35.3	36.1	0.78	Ns
Mortality	0.3	1.3	1.7	1.7	0.30	Ns
FCR	4.3	4.1	4.0	4.0	0.08	Ns

NS: Non Significant; SEM: Standard Error of Mean; T1: Full Maize; T2: 15% Sorghum; T3: 30% Sorghum; T4: 45% Sorghum.

Table 7: Dry matter intake, body weight gain, feed conversion ratio and mortality of commercial broilers fed ration containing increasing level of sorghum replacing maize during the entire period (1 to 49 days).

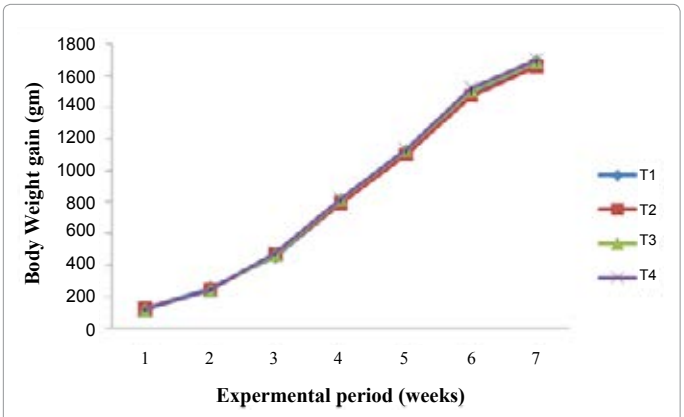

Figure 1: Weekly body weight change of experimental birds.

Body weight gain

There is no significant difference (P>0.05) was observed in daily as well as final weight gain during among treatments. Melaku [24] reported no significant difference average daily weight gain of Hubbard classic broiler strain during the starter phase. During the starter phase (1 to 3 weeks) chicks attend statistically similar body weight gain when corn replaced by sorghum from 25% up to 50% [25]. The average daily and final body weight gain during the finisher phase is presented in Table 6 and no significant difference (P>0.05) was observed among the treatments. Although there is no significant difference among treatments, body weight tends to increase as sorghum level increase. Similarly, Nyamambi et al. [26] reported during grower and finisher period, days 22 to 42 and day 56, there were no significant differences in average daily gain.

In the current study initial weight, average daily and final weight of chicks in different dietary treatment group were not significantly (P>0.05) different. Mean daily and final weight gain showed increasing trend as the level of sorghum inclusion increase. This might be due to similar nutrient composition of ingredient diet and decreasing trend of crude fiber content of treatment diet as the level of sorghum in the diet increases. The current finding is comparable with the result of Medegu et al. [7] who stated that final body weight, overall weight gain, daily feed intake, daily weight gain and feed conversion ratio showed no significant differences among all the treatment groups (Table 6 and Figure 1).

Dry matter conversion ratio

Feed conversion ratio of the experimental chicks expressed as grams of feed consumed per unit body weight gain are presented in Table 6. There is no significant (P>0.05) difference between the treatment groups in mean feed to gain ratio during the first four week of growth. T_1 and T_2 relatively have better dry matter conversion ratio as compared to T_3 and T_4. This result is in agreement with Kumar et al. [25] no significant difference in dry matter conversion ratio during the starter phase. Dry matter conversion ratio during finishing phase of experimental period was not also significantly different (P>0.05) among the treatments. This result is in conformity with Medegu et al. [7] who found as no significance difference in dry matter conversion ratio in broiler consumed Sorghum or millet as replacement for maize.

Dry matter conversion ratio during the entire period is presented in Table 7 and similar to starter and finisher phase was not significantly (P>0.05) different among the treatments. The current finding agrees with who reported feed conversion ratio was statistically similar between dietary treatments during the entire experimental period. Dief et al. [27] observed the absence of significant difference in feed conversion ratio for Hubbard classic broiler chicks at the end of six weeks of feeding. Jacob et al. [17] reported no significant difference in feed conversion ratio between treatments. Okeye et al. [22] also reported no significant difference in feed conversion ratio when maize replaced by sorghum up to 20% (Table 7).

Conclusion

The results of laboratory chemical analysis showed that 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. Therefore, the results obtained from present study revealed that replacement of maize with sorghum up to 45% were not have adverse effect on the performance of broiler chicken. More over T_4, 45% sorghum inclusion resulted in better body weight gain.

Competing Interest

The authors declare that they have no competing interest.

Authors' Contributions

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

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References

1. Tadelle D (1996) Studies on village poultry production system in central high lands of Ethiopia. MSc Thesis, Swidish University of Agricultural Science. pp. 70.
2. CSA (Central Statistical Authority) (2009) Agricultural sample survey report on livestock and livestock characteristics (private peasant holding). Vol. 2. Statistical Bulletin 468. CSA, Addis Ababa, Ethiopia.
3. Alamargot J (1987) Avian pathology of industrial poultry farms in Ethiopia. Proceedings of the first National Livestock Improvement Conference, 11-13 Feb., 1987. Addis Ababa, Ethiopia, pp. 114-117.
4. Tadelle D, Nigusie D, Alemu Y, Peters KJ (2001) The feed resource base and its potentials for increased chicken production in Ethiopia. Humboldt University of Berlin, Animal Breeding for Tropics and sub-tropics, Philippstr. 13, Haus 9, 10115 Berlin, Germany Debre Zeit Agriculture Research Centre, P.O. Box 32, Debre Zeit, Ethiopia.
5. Attah JO (2002) Principles and practice of livestock feed manufacturing. Adlek Printers.Ilorin. Kwara state. Nigeria, pp. 13-17.
6. Olomu J M (1995) Monogastric animal nutrition, Principle and practice. A Jachem Puplication, pp. 108-121.
7. Medegu CI, Kwari ID, Igwebuike J, Nkama I, Mohammed ID et al. (2010) Performance and economics of production of broiler chickens fed sorghum or millet as replacement for maize in the semi-arid zone of Nigeria. Agriculture and Biology Journal of North America 11: 445-450.
8. Tahirou A, John S (2006) Sorghum or Maize in West African poultry ration. Marketing-Processing Project-INTSORMIL January 2006.
9. Mishra BB, Kidan HG, Kibret K, Assen M, Eshetu B (2004) Soil and land resource inventory at Alemaya University Research Farm with reference to land evaluation for sustainable agricultural management and production. Synthesis of working papers, Soil Science Bulletin No. 1. Alemaya University, Alemaya, Ethiopia.
10. AOAC (1990) (Association of Official Analytical Chemists): Official methods of Analysis. Washington DC. Pp. 1298.
11. Wiseman J (1987) Feeding of non-ruminant animals. In: Meeting nutritional requirement from available resources. Butter worth and C. Ltd. pp. 9-15.
12. Lawrence TLJ, Fowler VR (1998) Growth of Farm Animals. CAB International press, UK.
13. Gomez KA, Gomez AA (1984) Statistical Procedures for Agricultural Research. 2nd ed. John Willey and Sons, New York.
14. Douglas JH, Sulivan TW, Bond PL, Baier FJ, Robeson LG (1990) Nutrient composition and metabolizable energy of selected grain sorghum varieties and yellow corn. Poult Sci 69: 1147-1155.
15. Eekeren NV, Maas A, Saatkamp HW, Verschuur M (2006) Small scale chicken production. Agridok 4. Fourth ed. Agromisa Foundation and CTA, Wageningen, p. 80.
16. Zena (2011) Comparative performance evaluation of Hubbard classic and Cobb-500 broilers fed ration containing imported or local protein balancer. MSc Thesis presented to school of graduate studies of Haramaya University Ethiopia. pp. 31-62.
17. Jacob JP, Mitaru N, Mbugu PN, Blair R (1996) The Feeding Value Of Kenya Sorghum, Sunflower Seed Cake And Sesame Seed Cake For Broilers And Layers. Anim Feed Sci. And Tech. 61: 41-56.
18. Nyannor EK, Adedokun SA, Hamaker BR, Ejeta G, Adeola O (2007) Nutritional evaluation of high-digestible sorghum for pigs and broiler chicks. See comment in PubMed Commons below J Anim Sci 85: 196-203.
19. Ambula MK, Oduho GW, Tuitoek JK (2001) Effect of sorghum tannin, a tannin binder (Polyvinylpyrrolidone) and sorghum inclusion level on the performance of broiler chicks. Asian-Aust. J. Anim. Sci. 14: 1276-1281.
20. Cramer KR, Wilson KJ, Moritz JS, Beyer RS (2003) Effect of Sorghum-Based Diets Subjected to Various Manufacturing Procedures on Broiler Performance. Poultry Science Association, Inc. 12: 404-410.
21. Kyarisiima CC, Okot MW, Svihus B (2004) Use of wood ash in the treatment of high tannin sorghum for poultry feeding. South African Journal of Animal Science. 34: 110-115.
22. Okeye FC, Ugwuene MC, Ubaeduonu LC (2006) Effects of the replacement of maize with graded levels of sorghum malt (Sorghum bicolor) on the performance of broiler chicks. Agricultural Journal. 1: 77-80.
23. Talha EE, Abbas, Nuredin A, Musharaf (2008) The Effect of Germination of Low-Tannin Sorghum Grains on its Nutrient Contents and Broiler Chicks Performance. Pakistan Journal of Nutrition. 7: 470-474.
24. Melaku W (2011) Effect of Egg Storage Temperature and Fumigation on Hatchability and Post-Hatching Performance of Two Strain of Broiler Chicks Reared in Hay-Box during Starter Phase. MSc thesis presented to the school of graduate studies of Haramaya University, Ethiopia. p. 34.
25. Kumar V, Elangovan AV, Mandal AB (2005) Utilization of reconstituted High-tannin sorghum in the Diets of Broiler Chickens. Asian-Aust. J Anim Sci 18: 538-544.
26. Nyamambi B, Ndlovu LR, Naik YS, Kock ND (2007) Intestinal growth and function of broiler chicks fed sorghum based diets differing in condensed tannin levels. South African Journal of Animal Science. 37: 202-214.
27. Dief EA, Galal A, Fathi MM, Zein El-Dein A (2007) Immuno competence of two broiler strains fed marginal and high protein diets. International Journal of Poultry Science 6: 901-911.