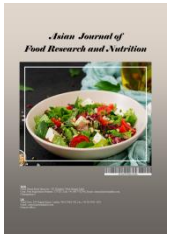

Asian Journal of Food Research and Nutrition

Volume 2, Issue 2, Page 43-50, 2023; Article no.AJFRN.97228

Effect of Substitution of Sorghum Grain by Teff (*Eragorestis tef*) Grain on the Performance of Broiler Chicks

Amasaib E. O. [a*] and Alamin A. A. [a]

[a] *Department of Animal Nutrition, Faculty of Animal Production, University of Khartoum, Sudan.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors contributed equally to research work execution, analysing, interpreting the data and manuscript preparation. Both authors read and approved the final manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97228

Original Research Article

Received: 06/01/2023
Accepted: 08/03/2023
Published: 21/03/2023

ABSTRACT

This study aimed to determine the effect of the substitution of sorghum grain with teff grain (*Eragorestis teff*) on the performance of broiler chicks. The teff plant has been grown in Ethiopia and is used to prepare a kind of food called injera. The seeds were brought from the Sudanese Ethiopian Border. A total of 160 one-day-old, unsexed broiler chicks (Ross 308) were used. The birds were distributed randomly into 16 pens (10/pen) as replicates, in a completely randomized design. The experimental diets were formulated by substitution of sorghum grain with teff grain at a level of 0, 10, 15 and 20%. The chemical constituents of teff grain were measured by two methods (AOAC) and (NIR) Near-Infrared spectroscopy. The parameters measured were feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR), carcass weight (CW), the weight of internal organs (liver, gizzard, pancreas, neck and heart), and serum contents (cholesterol, glucose and triglyceride). The CP percentage of teff grain was 7.96%, the starch content was (65.65%), and the fiber content was (8.61%). For chick's performance, the birds fed 20% teff consumed more feed (3403.0g), gained more weight (2040.5g), had the highest carcass weight (1733.8) and had the best FCR (1.66) than the control. For blood biochemical, the group of birds that fed 20 % teff grain

**Corresponding author: E-mail: samaniamasaib@gmail.com, samaniamasaib@uofk.edu;*

recorded the highest value of Glucose (113.0) and the lowest value of triglyceride (107.0) and Cholesterol (128.8). It could be concluded that the teff grain is superior to sorghum in terms of chemical constituents and broiler chicken's performance and could be a good substation for the sorghum if it is established in Sudan.

Keywords: Erogorestis tef grain; sorghum grain; broiler performance; chemical composition; blood biochemical.

1. INTRODUCTION

"The global dominance of the four crops, maize, wheat, rice, and sorghum in the current food system has raised an alarm. Heavy dependence on these crops can limit the capacity to deal with food shortages and dietary imbalances. The poultry industry has suffered more than any other livestock industry as a result of inadequate supply and high cost of feed" [1,2,3] and "feed cost is expected to continue in the upward swing" [4]. "Cereal grains constitute the major sources of energy in poultry diets in the tropics" [5]. "51% of the sorghum crop is used to feed livestock while 49% is for human food and other uses" [6]. This aggressive competition between livestock and humans requires a serious diversification of energy feedstuff for livestock. The introduction of a new grain crop to the environment of Sudan may assist in finding alternatives feed resources for poultry especially when the main crop sorghum is scarce. There has been increasing interest in grain teff due to its perceived greater nutritional quality compared to other grains [7,8]. "Teff (*Eragrostis tef*) is a tropical cereal that has its center of origin and diversity in the northern Ethiopian highlands from where it is believed to have been domesticated" [9,10]. Teff is a minor cereal crop worldwide, whereas, in Ethiopia, it is a major food grain, mainly used to make injera, a traditional fermented Ethiopian pancake. In other countries like Australia, South Africa, and the United States, it is principally used as a forage crop for animal feed. There are some data available regarding teff grain as a human food source, but there is little information available for teff as an animal feedstuff, particularly for monogastric animals such as broiler chickens. Therefore, the objectives of this study are to determine the effect of gradual substitution of sorghum grain by grain teff on the performance of broiler chick.

2. MATERIALS AND METHODS

2.1 Experimental Site

This experiment was carried out in the premises enclosure of the poultry unit of the Faculty of the Animal Production University of Khartoum, Shambat (Khartoum north). During the period between 13th November to 25 December 2022.

2.2 Housing

This experiment was conducted in a naturally ventilated, open-sided, deep-litter poultry house, with a concrete floor. The house was partitioned into 16 pens each of them one-meter square with enough working space allowance.

2.3 Experimental Birds and Diets

A total of 160 one-day-old unsexed commercial broiler chicks (Ross308) were weighted and randomly divided into (4) groups of 40 chicks, each group was further subdivided into four replicated with 10 chicks. The average initial weight of chicks was 37g. The experimental diets were formulated from local ingredients except the imported super concentrate to supplement the essential amino acids (lysine, methionine, vitamin and minerals).

All groups were fed the same commercial pre-starter feed for the first week. in the second week, the first group (control) was fed a basal diet with no teff containing, the other groups were fed the basal diet with (10%), (15%) and (20) % teff grain as percent from the whole diet. The formulation and calculation of the experimental diets are shown in Table (1).

2.4 Management and Medications

The flock was kept and reared under the same condition during the winter season. feed and water were provided *adlibitum*. Prebiotics with

Table 1. Ingredient composition of experimental diets as percent (%)

Ingredients	Control	10 %	15%	20%
Sorghum	62.5	52. 5	47.5	42.5
GNC	30	30	30	3o
Super Concentrate*	5	5	5	5
Teff	0	10	15	20
	2.5	2.5	2.5	2.5
Toxin Binder	0.1	0.1	0.1	0.1
Lime Stone	0.2	0.2	0.2	0.2
DCP	0.1	0.1	0.1	0.1
Total	100.4			100.4

vitamin A, E and Se (one item) was administrated in the water during the first week to avoid the expected stress and repeated after each vaccination for 3-5 days. All Chicks were vaccinated against infectious bronchitis (IB) and Newcastle (ND) at the first week of age as one dose, vaccinated against Gamboro diseases (Infectious Bursal disease) at the second week of age and also vaccinated against ND at the third week of age. the vaccines and prebiotics were given in drinking water.

2.5 Parameters Measurement

Feed intake and body weight gain were measured weekly. The mortality rate was recorded throughout the experimental period. At the end of the experiment, four birds from each replicate were manually slaughtered. Birds were then scalded, manually plucked and washed.

2.6 Internal Organs

The hot carcass weight was recorded. Internal organs were weighed mainly, liver, gizzard, proventriculus, pancreas, neck and heart.

2.7 Blood Parameters

On the slaughter day, blood samples were collected from four randomly selected birds from each cage to determine serum cholesterol, triglycerides and glucose contents using commercial kits.

2.8 Chemical Analysis

Proximate Analysis:

The proximate components of the sample were determined, Ash, EE, and CP according to AOAC methods [11].

2.9 Statistical Analysis

The data was subjected to analysis of variance by Statistical Packages for Social Science (SPSS) software program version 21. Using one-way ANOVA, the results are shown as mean and their errors, mean separation done by Duncan Multiple Range Test according to [12] and significance different set ($P<0.05$).

3. RESULTS AND DISCUSSION

Table (2) noted the chemical composition of teff grain. The CP percentage was found 7.96%. [13] stated that the average crude protein content of teff grain is in between 8 and 11 percent, in addition to that, [14] reported that the total protein content of teff grain was found to be 9.37%. For crude fat, the result was found to be 1.58%. This result is less than the results obtained by [15] who noted that the lipid contents of teff grain flour was 4.4%. The starch content of teff grain determined by the AOAC procedure was (65.65%). [16] reported that complex carbohydrates make up 80 percent of teff grain, it has a starch content of approximately 73 percent making teff a starchy cereal. Moreover, [17] reported that the total carbohydrate content of teff grain was reported to be 85.6% with starch content ranging from 74 to 75.5%. lower results were obtained by [18] who stated that the proximate analysis of teff grain revealed the seeds carbohydrates was found to be (57.27%). The crude fiber content was found to be (8.61%). Comparable results were obtained by [19] who reported that the crude fibre content in teff (8.0%) is far higher than when compared to some fruits, nuts, pulses and cereals such as corn and rice [16]. Stated that the crude fiber, total and soluble dietary fiber content of teff is several folds higher than that found in wheat, sorghum, rice, and maize, which could be attributed to the factor that

whole grains have higher fiber content than decorticated ones.

Table 2. Chemical composition of *Eragorestis teff* grain

Parameters %	Proximate analysis
DM	89.05
CP	7.96
CF	8.61
FAT	1.58
Ash	5.21
NFE	65.75
MJ/Kg	12.617

The effect of the substitution of graded levels of sorghum grain with grain teff on the feed intake of broiler chicks is shown in Table (3). The data showed that there was no significant difference between treatments except in week six which showed a significant difference ($P \leq 0.05$), in all weeks there is a gradual increase in feed intake with the increase in the level of substitution. This increase in feed intake may be due to the superiority of teff grain over sorghum grain, firstly, the teff grain is a starchy cereal with starch content accounting for 75% [16], with amylose content ranging from 20 to 30% [17], secondly, the protein content of the teff grain is superior to sorghum grain in term of quantity and quality, some researchers like [18] stated that the protein content of teff grain may reach 20% and in this study, the protein content is found to be 15% which is far higher from sorghum (10.48%) reported by [20], moreover, the quality of teff protein is better than sorghum, [13] stated that Teff's fractional protein composition revealed that the gluten (45%) and albumins (37%) are the major protein storages while prolamins are a minor constituent (less than 12%). Prolamine is a poor-quality protein with low digestibility [18], in addition to that, the amino acid composition in teff is well-balanced, a relatively high concentration of lysine amino acid is found in teff [21]. [22] reported that many amino acids that are higher in teff, such as lysine, methionine and tryptophan, are considered deficient in sorghum grain, third, comparative mineral content analysis of teff grain showed that P, Mg, Mn, and Cu are present in higher concentrations in the grain than in other common cereals like maize and wheat [23]. [9] reported that teff has the highest iron content of all cereals and contains more calcium, copper, zinc, aluminium, and barium than winter wheat and barley. This result is similar to the results obtained by [24] who found that the average daily feed intake/bird and cumulative feed intake/bird during the entire period was 79.4g and 3335.9g for birds fed local diet in Ethiopia.

Table (4) noted the effect of the substitution of different levels of *Eragorestis teff* grain on the weekly body weight. No significant effect was observed between different treatments. The birds fed 20% teff recorded the highest body weight, while the least body weight was obtained by the birds fed the control diet. The group of birds fed 20% *Eragorestis teff* consumed more feed and gained more weight which indicates the efficient utilization of the feed. These results are similar to the results obtained by [25] who found that chicks receiving 10% teff as an ingredient diet had significantly heavier body weights than all other treatments. Moreover, chicks receiving the 10% whole teff diet were also significantly heavier than the control with a corn-soy-based diet.

The weekly weight gains as affected by the different substitutions of *Eragorestis teff* grain at the expense sorghum grain is illustrated in Table (5). No significant difference was observed in all weeks except in week 6 which showed a significant difference ($P \leq 0.05$). The weight gains in week six was increased with the increase in the level of substitution which was found to be 315.5, 335.3, 356.6, and 333.0 for the control, 10%, 15%, and 20% g substitution respectively.

Table 3. Effect of substitution of graded levels of *Eragorestis teff* on weekly feed Intake (g) of broiler chicks

Weeks	Control	10%	15%	20%	p-value
WK2	249.0^{a}	270.1^{a}	245.5^{a}	270.2^{a}	0.330
WK3	602.9^{a}	594.7^{a}	585.8^{a}	589.8^{a}	0.855
WK4	272.6^{a}	313.6^{a}	301.7^{a}	318.2^{a}	0.357
WK5	978.1^{a}	992.1^{a}	987.7^{a}	993.8^{a}	0.543
WK6	1066.2^{b}	1212.2^{a}	1216.3^{a}	1230.7^{a}	0.003

Means bearing different superscripts in a row differ significantly at (P <0.05)

Table 4. Effect of substitution of graded levels of *Eragorestis teff* on weekly body weight (g) of broiler chicks

Weeks	Control	10%	15%	20%	P- value
WK1	127.5 [a]	130.0 [a]	130.0 [a]	130.0 [a]	0.426
WK2	313.6[a]	367.0 [a]	333.5 [a]	351.2 [a]	0.273
WK3	629.1[a]	703.3 [a]	690.1 [a]	684.2 [a]	0.653
WK4	934.0 [a]	1021.6 [a]	1002.6 [a]	1029.2 [a]	0.279
WK5	1481.0 [a]	1520.0 [a]	1551.0 [a]	1556.2 [a]	0.684
WK6	1834.7 [b]	1957.5 [ab]	2017.5 [a]	2077.5 [a]	0.007

Means bearing different superscripts in a row differ significantly at (P <0.05)

Table 5. Effect of substitution of graded Levels of *Eragorestis teff* on weekly body weight (g) of broiler Chicks

Weeks	Control	10%	15%	20%	p-value
WK1	90.0 [a]	93.0 [a]	93.0[a]	93.0[a]	0.426
WK2	186.1 [a]	237.0 [a]	203.5[a]	221.2[a]	0.277
WK3	315.5 [a]	335.3 [a]	356.6[a]	333.0[a]	0.855
WK4	304.8 [a]	318.2 [a]	312.5[a]	345.0[a]	0.939
WK5	547.7 [a]	498.3 [a]	548.3 [a]	527.0[a]	0.790
WK6	353.0 [b]	437.7 [ab]	466.5 [a]	521.0[a]	o.020

Means bearing different superscripts in a row differ significantly at (P <0.05)

Table 6. Average weekly feed conversion ratio as affected by different treatments

Weeks	Control	10%	15%	20%	p-value
WK2	1.38	1.14	1.25	1.22	0.391
WK3	1.95	1.81	1.71	1.81	0.826
WK4	0.94	1.00	1.40	0.93	0.626
WK5	1.80	2.01	1.85	1.90	0.689
WK6	3.09	2.79	2.61	2.41	0.171

The average weekly feed conversion ratio as affected by different levels of substitutions of sorghum grain by teff grain is shown in Table (6). No significant difference was found between treatments. In comparison to the feed consumption and weight gain, the birds which consumed more feed were heavier and had a less feed conversion ratio indicating that the heaviest birds are more efficient in utilizing the diet than lighter weight suggesting that the diet had high energy. These results were different to the results obtained by [25] who stated that the 10% whole teff and the teff as ingredient-fed chicks had significantly poorer conversions than control corn soy-fed chicks. It was observed that some chicks receiving the 10% ground teff treatment had incidences of fine, flour-like feed adhering to their beaks.

The results of cumulative feed intake as illustrated in Table (7) showed that there was a significant difference ($P \leq 0.05$) between different treatments. The highest feed intake (3403g) was obtained by 20% teff substitution while the lowest feed intake was recorded in the pure sorghum grain. The data also showed that the final body weight was affected significantly ($P \leq 0.05$) by the addition of teff grain, the trend is identical to what was found in the feed intake, and the highest final body weight (2040.5g) was obtained by 20 % teff substitution while the lowest body weight was recorded in the pure sorghum grain. Consistently, the effect of substitution of graded levels of sorghum grain by teff grain on cumulative feed conversion ratio was found to be in-significant, the group of birds fed a diet containing 20% teff consumed more feed, gained more weight and had the best feed conversion ratio, while the group of birds fed the diet with no teff consumed less feed, gained less weight and had poorer feed conversion ratio.

Table 7. Effect substitution sorghum grain with *Eragorestis tef* grain on overall performance of broiler Chicks

Treatment	FI	BW	FCR
Control	3168.9[b]	1797.7[b]	1.76[a]
10%	3382.8[a]	1920.5[ab]	1.76[a]
15%	3337.2[a]	1980.5[a]	1.68[a]
20%	3403.0[a]	2040.5[a]	1.66[a]
p-value	**0.021**	**0.007**	**0.057**

Means bearing different superscripts in a row differ significantly at (P <0.05).
FI = Feed Intake BW= Body weight FCR= Feed Conversation Ratio

Table 8. Effect of substitution of graded levels of *Eragorestis tef*f on the carcass parameter

Traits	Control	10%	15%	20%	p-value
Carcass Weight	1118.7[b]	1433.3[ab]	1548.8[ab]	1733.8[a]	0.005
Liver	40.0[a]	41.7[a]	50.0[a]	43.8[a]	0.841
Pancreas	17.5[a]	18.3[a]	17.5[a]	18.8[a]	0.984
Neck	81.3[c]	88.3[bc]	101.3[ab]	107.5[a]	0.016
Gizzard	33.8[a]	35.0[a]	38.8[a]	35.0[a]	0.624
Proventriculus	12.5[a]	8.3[a]	8.8[a]	10.0[a]	0.262
Heart	8.8[a]	8.3[a]	11.7[a]	10.0[a]	0.313

Means bearing different superscripts in a row differ significantly at (P <0.05)

Table 9. Effect of substitution of graded levels of *Eragorestis tef* on the blood biochemical

Concentration	Traits		
	Glucose	**TG**	**Cholesterol**
Control	110.0[a]	179.3[a]	130.3[b]
10%	117.5[a]	106.8[b]	131.5[b]
15%	109.3[a]	107.8[b]	150.5[a]
20%	113.0[a]	107.5[b]	128.8[b]
p-value	**0.790**	**0.001**	**0.042**

Means bearing different superscripts in a row differ significantly at (P <0.05)

Table (8) noted the effect of the substitution of graded levels of *Eragorestis tef* on the carcass parameter. For carcass weight, there was a significant difference between parameters ($P \leq 0.05$). The ranking of carcass weight from the smallest to the largest was found to be as follows: control < 10% < 15% < 20%. This result clearly indicated that the application of a 20% addition of teff grain yielded more meat than the other treatments. For the weight of the internal organs, the results showed that no significant difference was observed for all parameters studied except the weight of the neck ($P \leq 0.05$). Numerically, the weight of the all internal organs under study increased by increasing the percentage of teff except proventriculus wherein the control is higher than the treatment.

The effect of the inclusion of graded levels of teff grain on blood biochemicals on broiler chicks was demonstrated in Table (9). For blood glucose, no significant difference was found between the control and different levels of teff grain, although 10 % and 20 % inclusion recorded higher value of blood glucose than the control. For the content of blood triglyceride, the results showed a significant decrease ($P \leq 0.05$) as the percentage of teff increased, the same trend was observed for the blood cholesterol.

4. CONCLUSION

Based on the results of the current study it could be concluded that *Eragorestis teff* grain is superior to sorghum grain which could be indicated by higher feed intake, body weight gain, and feed conversion ratio. Moreover, the carcass meat yield and the internal organs weight were improved by the inclusion of teff grain. The blood serum constituents were also affected by the incorporation of the teff grain in the diet. Teff grain if establish in the environment of Sudan could be a good alternative of sorghum grain in livestock feeding.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hill FW. Poultry nutrition and nutrient requirements. In: Cutbertson D, editor. Nutrition of animals of agricultural importance Part 2: Assessment of and factors affecting requirements of farm livestock. 1989;1137-80.
2. Mtimuni JP. Ration formulation and feed guides. Lilongwe, Malawi: Likuni Press Publishing House. 1995;1.
3. Lepleaideur M, editor. Poultry farming – A disease called competition. In: SPORE magazine. 2004;114:4-5.
4. Conolly A. Poultry international magazine Clement M, editor. Available from: http://www.WATTAgNet.com. Seminar presentation on ”Pushing the boundaries – Performance and profitability”. 2012;18.
5. Oluyemi JA, Roberts RA. Poultry production in warm wet climates. 2nd ed. London: Macmillan Press. 2000;692.
6. Maunder B. SorghumThe global grain of the future; 2002. Sorghum growers.com/ maunder. htm. [retrieved Nov 30, 2004 from]http://www.
7. Bhargava A, Sudhir S, Deepak O. Chenopodium quinoa—an India perspective. Ind Crops Prod. 2006;23:73-87.
   DOI: 10.1016/j. indcrop.2005.04.002
8. Ando H, Chen Y, Tang H, Shimizu M, Watanabe K, Mitsunaga T. Food components in fractions of quinoa seed. Food Sci Technol Res. 2002;8(1):80-4.
   DOI: 10.3136/fstr.8.80
9. Ketema S. Tef, Eragrostis Tef (Zucc.) Trotter. Promoting the Conservation and Use of Underutilized and Neglected Crops series no. 12. Gatersleben: Institute of Plant Genetics and Crop Plant Research & Rome: International Plant Genetic Resources Institute; 1997.
10. Demissie A. ’Teff Genetic Resources in Ethiopia.’ narrowing the rift: tef Research and Development. In: Proceedings of the ”international workshop on tef genetics and improvement,” Debre Zeit, Ethiopia. 2000;2001:27-31.
11. AOAC. Officinal method of analysis association of officinal analytical chemists pp: 66-88 .15 th. Edition Washington, D.C., USA; 1990.
12. Steel RGD, Terrie JH. Principles and procedures of statistics. A biometric approach. 2nd ed. New York: McGraw-Hill; 1997.
13. Tatham AS, Fido RJ, Moore CM, Kasarda DD, Kuzmicky DD, Keen JN et al. Characterisation of the major Prolamins of teff (*Eragrostis tef*) and finger millet (*Eleusine coracana*). J Cereal Sci. 1996;24(1):65-71.
    DOI: 10.1006/jcrs.1996.0038
14. Gebru YA, Sbhatu DB, Kim K. Nutritional Composition and Health Benefits of Teff (*Eragrostis tef* (Zucc.) Trotter). J Food Qual. 2020;2020:ID9595086:6.
    DOI: 10.1155/2020/9595086
15. Hager A-S, Czerny M, Bez J, Zannini E, Arendt EK. Starch properties, *In vitro* digestibility and sensory evaluation of fresh egg pasta produced from oat, teff and wheat flour. J Cereal Sci. 2013;58(1):156-63.
    DOI: 10.1016/j.jcs.2013.03.004
16. Geremew B. Physicochemical Characteristics of Grain and Flour in 13 tef [*Eragrostis tef* (Zucc.) Trotter] grain Varieties. J Appl Sci Res. 2007;3(12): 2042-51.
17. Abebe W, Ronda F. Rheological and textural properties of tef [*Eragrostis tef* (Zucc.) Trotter] grain flour gels. J Cereal Sci. 2014;60(1):122-30.
    DOI: 10.1016/j.jcs.2014.02.001
18. Nascimento KDD, Paes SND, Oliveira IRD. IReis, I. J Food Nutr Res. Teff: Suitability for Different Food Applications and as a Raw Material of Gluten-free, a Literature Review. P. I, and Augusta, V. M. 2018;6(2):74-81.
19. Saturni L, Ferretti G, Bacchetti T. The gluten-free diet: Safety and nutritional quality. Nutrients. 2010;2(1):16-34.
    DOI: 10.3390/nu20100016, PMID 22253989.
20. Etuk EB, Ifeduba AV, Okata UE, Chiaka I, Okoli IC, Okeudo NJ, et al. Nutrient composition and feeding value of sorghum for livestock and poultry: a review. J Anim Sci Adv. 2012;2(6):510-24.
21. Akansha, Sharma, K, and Chauhan, E.S. (2018) Nutritional composition, physical characteristics and health benefits of teff grain for human consumption: a review. The Pharm Innov J. 2018;7(10):03-7.

22. Coleman JM. Assessing the potential use of Teff as an alternative grain crop in Virginia [M.Sc. thesis] university of Verginia; 2012.
23. Forsido SF, Rupasinghe HPV, Astatkie T. Antioxidant capacity, total phenolics and nutritional content in selected Ethiopian staple food ingredients. Int J Food Sci Nutr. 2013; 64(8):915-20. DOI: 10.3109/09637486.2013.806448, PMID: 23777527.
24. Moges F, Amare A, Dawud Ibrahim D. Demonstration and performance evaluation of broilers using locally processed feed in Bahir Dar Zuria District, Amhara region, Ethiopia. World Vet J. 2014;4(4):42-47.
25. Brockotter F. Teff grain of broiler feed. Poult World. 2017;33(2):29-30.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97228