

# Original Research Article

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

**Abstract:** This study aimed to determine the effect of the substitution of sorghum grain with teff grain (*Eragrostis tef*) 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 was 7.96 % and 15.5 % for AOAC and NIR procedures respectively, the starch content was higher when determined by the NIR procedure (77.05%) than AOAC procedure (65.65%), while the fiber content was found to be higher in the AOAC procedure (8.61%) than the NIR procedure (2.61%). 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 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 substitution for the sorghum if it is established in Sudan. (Write structured abstract by using sub headings as aim, place and duration of study, methodology, results and conclusion)

**Keywords:** *Eragrostis tef* grain. Sorghum Grain, Broiler Performance (Keywords should be 4 to 8)

### **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.

## Material and Methods

### 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 13<sup>th</sup> November to 25 December 2022.

### 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.

### Experimental birds and Diets:

A total of 160 one-day-old unsexed commercial broiler chicks (Ross 308) were weighted and randomly divided into (4) groups of 40 chicks, each group was further subdivided into four replicated with 10 chicks. The average of the 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 of (10%), (15%) and (20) %. (Please clear that the teff gain was included at , 10, 15 and 20 % of whole diet or the percent of sorghum grains in the diet?) The formulation and calculation of the experimental diet are shown in Table (1).

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

Ingredients	Control	10 %	15%	20%
Sorghum(not clear)	62.5	56.25	53.125	42.5
GNC	30	30	30	30

<b>Super Concentrate*</b>	5	5	5	5
<b>TEFF</b>	0	10	15	20
<b>OIL</b>	2.5	2.5	2.5	2.5
<b>TOXIN BINDER</b>	0.1	0.1	0.1	0.1
<b>LIME STON</b>	0.2	0.2	0.2	0.2
<b>DCP</b>	0.1	0.1	0.1	0.1
<b>TOTAL</b>	100.4			100.4

#### **Management and Medications:**

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

#### **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.

#### **Internal Organs:**

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

#### **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.

#### **Chemical Analysis:**

#### **Proximate Analysis:**

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

#### **3.8.2 Near-infrared microscopy (NIR) analysis**

The sample of teff grain was measured by the means of Near-infrared microscopy (NIR) analysis. The FT-NIR spectra were scanned using the Thermo Antaris II FT-NIR spectrometer (Thermo Scientific Inc., Madison, WI, USA) prepared with an absorbance accessory.

#### **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 ( $P < 0.05$ ).

**Results and Discussion (It should be bold case, uppercase and 11 font size)**

Table (2) noted the chemical composition of teff grain using two methods of analysis. The two methods were the AOAC procedure and the NIR procedure. The results showed significant differences between the two procedures for all parameters. The CP percentage was found 7.96 % and 15.5 % for the AOAC and the NIR procedures respectively. [13] stated that the average crude protein content of teff grain is in the range of 8 to 11 percent. [14] reported that the total protein content of teff grain was found to be 9.37%. For crude fat, the result was found 1.58 and 3.3 for the two methods respectively. This result was in line with the results obtained by [15] who noted that the lipid contents of teff grain flour were 4.4%. The starch content of teff grain determined by NIR (77.05%) is higher than the AOAC procedure (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 high nutritive value of the seeds carbohydrates (57.27%). The crude fiber content was found to be higher in the AOAC procedure (8.61%) than in the NIR procedure (2.61%). 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. (Give reason for the changes in the chemical composition of grains by the two different methods of a same grains)

**Table (2) Chemical Composition of *Eragrostis teff* Using Two Methods of Analysis**

Parameters %	NIR Analysis	Proximate Analysis	P- value
DM	92.83 <sup>a</sup>	89.05 <sup>b</sup>	0.024
CP	15.50 <sup>a</sup>	7.96 <sup>b</sup>	0.001
CF	2.61 <sup>b</sup>	8.61 <sup>a</sup>	0.000
FAT	3.30 <sup>a</sup>	1.58 <sup>b</sup>	0.006
Ash	1.52 <sup>b</sup>	5.21 <sup>a</sup>	0.000
NFE	77.05 <sup>a</sup>	65.75 <sup>b</sup>	0.001
Me/Kg	1.38 <sup>b</sup>	2.617 <sup>a</sup>	0.000

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

The effect of the substitution of graded levels of sorghum grain with teff grain 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, **and** 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 (3) Effect of Substitution of Graded Levels of *Eragrostis teff* on Weekly Feed Intake (g) of Broiler Chicks**

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

Means with dissimilar superscripts in a row varied significantly at ( $P < 0.05$ ), while the same letters are not significant. (change it as suggested for above table)

**Table (4)** noted ~~that~~ the effect of the substitution of different levels of *Eragrostis 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. (Why the body weights during the 6th week has a significant difference and during 1<sup>st</sup> to 5<sup>th</sup> week it was non-significant?) The group of birds fed 20% *Eragrostis 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.

**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 <sup>a</sup>	130.0 <sup>a</sup>	130.0 <sup>a</sup>	130.0 <sup>a</sup>	<b>0.426</b>
WK2	313.6 <sup>a</sup>	367.0 <sup>a</sup>	333.5 <sup>a</sup>	351.2 <sup>a</sup>	<b>0.273</b>
WK3	629.1 <sup>a</sup>	703.3 <sup>a</sup>	690.1 <sup>a</sup>	684.2 <sup>a</sup>	<b>0.653</b>
WK4	934.0 <sup>a</sup>	1021.6 <sup>a</sup>	1002.6 <sup>a</sup>	1029.2 <sup>a</sup>	<b>0.279</b>
WK5	1481.0 <sup>a</sup>	1520.0 <sup>a</sup>	1551.0 <sup>a</sup>	1556.2 <sup>a</sup>	<b>0.684</b>
WK6	1834.7 <sup>b</sup>	1957.5 <sup>ab</sup>	2017.5 <sup>a</sup>	2077.5 <sup>a</sup>	<b>0.007</b>

Means with dissimilar superscripts in a row varied significantly at (P <0.05), while the same letters are not significant.

The weekly weight gains as affected by the different substitutions of *Eragorestis teff* grain at the expense of 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<0.05). The value of 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 (5) Effect of substitution of Graded Levels of *Eragorestis teff* on Weekly Body Weight (g) of Broiler Chicks (use sentence case)**

Weeks	CONTROL	10%	15%	20%	p-value
WK1	90.0 <sup>a</sup>	93.0 <sup>a</sup>	93.0 <sup>a</sup>	93.0 <sup>a</sup>	<b>0.426</b>
WK2	186.1 <sup>a</sup>	237.0 <sup>a</sup>	203.5 <sup>a</sup>	221.2 <sup>a</sup>	<b>0.277</b>
WK3	315.5 <sup>a</sup>	335.3 <sup>a</sup>	356.6 <sup>a</sup>	333.0 <sup>a</sup>	<b>0.855</b>
WK4	304.8 <sup>a</sup>	318.2 <sup>a</sup>	312.5 <sup>a</sup>	345.0 <sup>a</sup>	<b>0.939</b>
WK5	547.7 <sup>a</sup>	498.3 <sup>a</sup>	548.3 <sup>a</sup>	527.0 <sup>a</sup>	<b>0.790</b>
WK6	353.0 <sup>b</sup>	437.7 <sup>ab</sup>	466.5 <sup>a</sup>	521.0 <sup>a</sup>	<b>0.020</b>

Means with dissimilar superscripts in a row varied significantly at (P <0.05), while the same letters are not significant

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.

**Table (6) Average weekly feed conversion ratio as affected by different treatments**

Weeks	CONTROL	10%	15%	20%	p-value
WK2	1.38 <sup>a</sup>	1.14 <sup>a</sup>	1.25 <sup>a</sup>	1.22 <sup>a</sup>	<b>0.391</b>
WK3	1.95 <sup>a</sup>	1.81 <sup>a</sup>	1.71 <sup>a</sup>	1.81 <sup>a</sup>	<b>0.826</b>
WK4	0.94 <sup>a</sup>	1.00 <sup>a</sup>	1.40 <sup>a</sup> Please check stat again	0.93 <sup>a</sup>	<b>0.626</b>
WK5	1.80 <sup>a</sup>	2.01 <sup>a</sup>	1.85 <sup>a</sup>	1.90 <sup>a</sup>	<b>0.689</b>
WK6	3.09 <sup>a</sup>	2.79 <sup>a</sup>	2.61 <sup>a</sup>	2.41 <sup>a</sup>	<b>0.171</b>

(If results are non-significant there is no need to give superscripts)

Means with dissimilar superscripts in a row varied significantly at ( $P < 0.05$ ), while the same letters are not significant.

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 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) The Effect of substitution Sorghum Grain with *Eragoestis tef* Grain on Overall performance of broiler Chicks. (use sentence case)**

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

Means with dissimilar superscripts in a columns varied significantly at ( $P < 0.05$ ), while the same letters are not significant

FI = Feed Intake    BW= Body weight    FCR= Feed Conversion Ratio

Table (8) noted the effect of the substitution of graded levels of *Eragrostis 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.

**Table (8): Effect of Substitution of Graded Levels of *Eragrostis tef* on the Carcass Parameter (Sentence case)**

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

Means with dissimilar superscripts in a column varied significantly at ( $P < 0.05$ ), while the same letters are not significant

The effect of the inclusion of graded levels of teff grain on blood biochemicals in 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 values 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.

**Table (9): Effect of Substitution of Graded Levels of *Eragrostis tef* on the Blood biochemical. (Sentence case)**

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

Means with dissimilar superscripts in a column varied significantly at ( $P < 0.05$ ), while the same letters are not significant

**Conclusion:**

Based on the results of the current study it could be concluded that *Eragrostis tef* 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.

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