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# Evaluation of Proximate, Mineral Contents, and Anti-nutritional Characteristics of Teff Varieties Grown in Somali Region, Ethiopia

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ABSTRACT

This study evaluated the proximate composition, mineral contents, and anti-nutritional characteristics of teff varieties grown in the Somali Regional State, Ethiopia. Seven improved teff varieties adapted by the Somali Region Livestock and Agricultural Research Institute, one local market teff sample, and one mixed flour sample (teff blended with white rice) were analyzed. Association of Official Analytical Chemists(AOAC) procedures were used to determine moisture, ash, crude protein, crude fat, crude fiber, carbohydrate, and energy, while mineral contents were analyzed using atomic absorption spectrophotometry and flame photometry. Phytate and tannin contents were determined using colorimetric methods. Data were analyzed using one-way ANOVA and Duncan's Multiple Range Test at $P \leq 0.05$. The results showed significant differences among varieties in all proximate parameters, mineral contents, and tannin levels, while phytate content did not differ significantly. Crude protein ranged from 6.65 to 13.56%, with Simada showing the highest value. Bora had the highest crude fat (5.77%) and energy value (364.7 kcal/100 g), while V.flagale had the highest crude fiber (2.45%). Dagem recorded the highest ash content (2.77%). In mineral analysis, Simada had the highest calcium content (297.2 mg/100 g), Dagem and Boni showed the highest iron contents (22.02 and 21.55 mg/100 g, respectively), Boni and Bishoftu had the highest zinc contents (4.415 mg/100 g), and Negus had the highest potassium (799.0 mg/100 g). Tannin content ranged from 0.3140 to 1.1025 mg/g, with the mixed flour showing the lowest value and Bora the highest. Overall, the study confirmed that teff varieties grown in the Somali Region possess considerable nutritional potential with meaningful varietal differences, indicating strong prospects for their use in nutrition-sensitive agriculture, food product development, and dietary diversification.

**Key Words:** Antinutritional factors, Macronutrients, Mineral profile, Teff (Eragrostis tef)

## 1. Introduction

Teff, an ancient cereal that was domesticated in the Ethiopian highlands, is now extensively cultivated in Ethiopia and Eritrea (Barretto et al., 2020; Ereful et al., 2022). It is adaptable and tolerant of drought, poor soils and diverse ecologies which makes it paramount to food security in marginal areas (Awulachew, 2020). Teff offers high nutritional benefits. It is rich in carbohydrates, protein, dietary fiber, and minerals like iron, calcium, zinc, and magnesium. Notably, teff has higher levels of these minerals than wheat and maize (Gebru et al., 2020). Due to its gluten free quality and low glycemic index, it has attracted worldwide attention, especially from celiac disease and diabetes patients (Gebru et al., 2020; Habte et al., 2022). According to proximate analyses, teff contains around 10-11% moisture, 11% crude protein, 2.5-3% fat, 2.8-3% ash, 3% crude fiber and 70-75% carbohydrates (Daba, 2024; Kuyu et al., 2024; Suraj et al., 2024). Because of beneficial minerals, it is considered a good source of macro minerals (Ca, Mg, K) and micro minerals (Fe, Zn) which is usually greater than other cereals (Abera et al., 2025; Daba, 2024; Nyachoti et al., 2020).

The content of iron is quite high in teff, especially red teff, which is one reason for the lower rates of anemia in the Ethiopian highlands, and teff is promoted to combat iron deficiency anaemia and other micronutrient deficiencies (Adepoju et al., 2024; Kiewlicz & Rybicka, 2020; Tura et al., 2023). Teff has antinutritional factors like phytic acid (phytate) and polyphenols including tannin-like factors which can chelate minerals and reduce their bioavailability (Adepoju et al., 2024). The phytate and related components have been shown to affect the absorption of iron and zinc (respectively). Further, high phytate/mineral molar ratios can limit the utilization of zinc and iron. Thus, their measurement is essential (Kiewlicz & Rybicka, 2020; Tura et al., 2023). Nevertheless, the traditional fermentation (injera

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making) can greatly reduce phytate, enhancing iron availability, and the prevalence of anemia is rather low where Teff is a staple (Gebru et al., 2020; Tura et al., 2023). Thus we should evaluate nutrients and antinutrients levels to understand true nutritional contribution (Kiewlicz & Rybicka, 2020; Tura et al., 2023). Teff is available in different colors, i.e., white, red/brown and mixed types. These kinds differ in colour and iron content. The red types are markedly rich in iron and used against iron deficiency anemia (Gebru et al., 2020; Habte et al., 2022).

Researches conducted using 15–24 Ethiopian varieties demonstrated a significant variation in the proximate composition of the varieties along with mineral contents (Fe, Zn, Ca, K, Na, Mn) and phytate across the genotypes (Daba, 2024; Ereful et al., 2022). Most of the compositional works have been on highland or Main Ethiopian Rift Valley teff. Data from arid and semi-arid regions are limited (Nyachoti et al., 2020; Tadele & Hibistu, 2021). The levels of antinutrients and mineral profiles are known to vary as a function of soil type, climate and management (Adepoju et al., 2024; Awulachew, 2020; Daba, 2024).

Teff that is grown in the Somali Regional State, which is arid and semi arid, may have different proximate, mineral and antinutrient composition, but this has not been characterized systematically. National and regional dataset are calling for a region specific analysis to inform better local nutrition planning (Daba, 2024; Tadele & Hibistu, 2021). Teff is known for its nutritious value, but there is limited information on the proximate composition of different varieties of teff under particular regions (Kuyu et al., 2024; Suraj et al., 2024), the detailed macro and micro mineral content and their possible contribution to recommended intakes at local consumption levels (Daba, 2024; Kiewlicz & Rybicka, 2020; Nyachoti et al., 2020), and levels of phytates, tannin type polyphenols and other related antinutritional factors, and their effect on mineral bioavailability in different varieties and environments (Kiewlicz & Rybicka, 2020; Tura et al., 2023). Most of the available work either pool variations from across regions or concentrate on other areas like the Oromia, Main Rift, etc., or do not analyze separately the varieties grown in arid/semi arid ecologies (Daba, 2024; Ereful et al., 2022; Tadele & Hibistu, 2021). Due to this absence of local evidence, the design of nutrition sensitive agriculture, fortification and dietary recommendations for Somali Region.

The objective of this study is generating proximate composition, mineral content and anti-nutritional factors of teff varieties grown in Somali Regional State. Information from this study will help to generate scientific evidence that supports the nutritious quality of locally produced teff which helps in combating food and nutrition insecurity strategies (Awulachew, 2020; Daba, 2024; Tadele & Hibistu, 2021). Besides, it helps in development of nutrition-sensitive agricultural practices and breeding characterizing varieties with high nutrient densities and good phytate/mineral ratios in an arid and semi-arid environment (Adepoju et al., 2024; Ereful et al., 2022). Finally, it supports the development of regionally appropriate products (e.g. composite flours, complementary foods, fortified foods) that capture the high iron, calcium, and fiber and manage its anti-nutritional factors.

## 2. Materials and Methods

### *2.1. Materials and equipment*

The seven different varieties of teff were obtained from all research centres of Somali Region Livestock and Agricultural research institute. After exhaustive search and collections from above centres, one popular widely marketed variety and mixed flour teff with other cereals as a control was purchased from local market. The teff selected for analysis were free from insect infestation and pure. All equipment including tools used in sample preparation work were taken from Somali region livestock and agricultural research institute (SoRLARI) laboratories and equipment's used was taken from local institutes. Also, upon arrival at the laboratory, the teff flour samples were separately ground into fine powder (30 mesh size), packed in airtight polyethylene plastic bags, and then stored at 4oC for further analysis.

### *2.2. Proximate composition*

#### *2.2.1. Moisture content*

The moisture levels in the raw teff flour samples were determined by the Association of Official Analytical Chemists according to the official method 925.05 (AOAC, 2000; Yohannes et al., 2020). The moisture determination dishes were dried for one hour at 103°C (Leicester, LE675FT, England) and then placed in desiccators for approximately 30 minutes. The mass of each of the dishes was measured (M1), and 5 g of the sample (M2) was carefully measured and added to each dish. The sample was dried for 6 hours at a temperature of 103°C. The combined mass of the sample and its container was measured (M3) after the drying process. The amount of moisture was calculated by applying Equation (1).

$$\text{Moisture content (\%)} = \frac{M2 - M3}{M2 - M1} \times 100 \quad (1)$$

Where:
M1 = mass of empty dish
M2 = mass of the empty dish plus mass of the sample before drying
M3 = mass of the empty dish plus mass of the sample after drying

#### *2.2.2. Crude protein*

Kjeldahl method determination was performed with semi-automatic (VELP SCIENTIFA nitrogen analyzer) according to (AOAC, 2000) and (Yohannes et al., 2020) for crude protein. Place in Kjeldahl flask, about 1.00 g of sample flour and 1.00 g of a mixture of catalase 10% copper (II) sulphate and 90% potassium sulphate. After that, 12 mL of concentrated sulfuric acid was added and placed on the digesting track for one hour at a temperature of 420°C until a clear solution was observed. Once the digestion came to a halt and cooled down, the sample was distilled automatically by the addition of 50 mL deionized water and 50 ml of 40% sodium hydroxide solution. They respectively titrated the distilled solution with hydrochloric acids of about 0.2 N to reddish coloration. Then onwards the result was derived as Eq. and Eq. (3).

$$\text{Total nitrogen } (\%) = \frac{(V - Vb) \times N \times 14}{W \times 100} \tag{2}$$

$$\text{Crude protein } (\%) = \text{Total nitrogen } (\%) \times 6.25 \tag{3}$$

Where:
V = volume of acid consumed to neutralize the sample
Vb = volume of acid consumed to neutralize the blank
N = normality of the acid
14 = equivalent weight of nitrogen; 6.25 and 5.51 (for peanut control) are conversion factors from total nitrogen to crude protein
W = weight of the sample

### 2.2.3. Crude fat

The analysis of crude fat was conducted by Soxhlet extraction methods as done by Association of Official Analytical Chemists (AOAC, 2000; Yohannes et al., 2020). A thimble was loaded with 1.5 g of the milled sample for weighing. A 50 ml beaker containing the thimble with the sample was dried for 2 hours in a oven at 103 ± 2°C. The cup intended for extraction weighing between 150 and 250 ml was taken and rinsed thoroughly with petroleum ether. The sample in the thimble was extracted with petroleum ether for 6–8 hours in a Soxhlet apparatus. In a pre-weighed beaker, the solvent containing the crude fat is collected after extraction process. The beaker containing the extracted fat was kept in a fume hood to let the solvent evaporate on a steam bath until the odour disappeared. After that, the beaker and the contents were dried at 103°C in an oven for 30 minutes. Once dried, the beaker was taken out and cooled in a desiccator until its final weight (mf) was taken. The formula listed below was used to calculate the crude fat content of teff flour.

$$\text{Fat } (\%) = \frac{mf - mi}{m} \times 100 \tag{4}$$

Where:
mf = dried mass of fat with cup
mi = mass of the cup
m = weight of the sample

### 2.2.4. Crude fiber

The teff flour was subjected to crude fiber evaluation according to AOAC (AOAC, 2000; Yohannes et al., 2020) using an official method of calculation 920.169. Each 600 mL beaker contained around 1.6 g of the sample. Sulfuric acid solution was added to each beaker in equal quantity of 200 mL of 1.25%. The solution was boiled for 30 minutes by rotating and stirring after every few seconds. Hot distilled water was added to keep the level constant during boiling. After 30 minutes, 20 mL of potassium hydroxide solution was added to each beaker and allowed to boil for another 30 min. The addition of hot distilled water then kept the level constant.

After 30 minutes, each of the solutions in both beakers was filtered through a crucible that contained sand, which was placed on a Buchner funnel that had been fitted with a No. 9 rubber stopper. While filtering, washed sample was rinsed with hot distilled water. Final residue was washed with 1% sulphuric acid solution, hot distilled water, 1% sodium hydroxide solution and acetone. The mass (M1) will be determined after drying the content in each crucible for 1 hour at 130°C, cooling in desiccators. Then, ashed for 30 min at 550°C in a furnace and cooled in desiccators. Finally, the mass of each crucible was considered (M2). Calculated the crude fiber from Eq. (5).

$$\text{Crude fiber } (\%) = \frac{M1 - M2}{W} \times 100 \tag{5}$$

Where:
M1 = the mass of the crucible, the sand, and the wet residue
M2 = the mass of the crucible, the sand, and the ash
W = sample weight, dry matter basis

### 2.2.5. Total ash content

The total ash content was estimated gravimetrically by Association of Official Analytical Chemists (AOAC, 2000) and Yohannes et al. (Yohannes et al., 2020) according to official method 941.12, where 3 g of the sample were placed in tared silica crucibles. The samples were dried, slowly heated over a hot plate, until most of organic matter was charred. The crucibles were then ignited in a muffle furnace (SX-5-12, China) at 550C for 8 hr to leave a white residue, free of organic matter. The ash content of the sample was calculated as presented below: Equation (6).

$$\text{Ash } (\%) = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100 \tag{6}$$

Where:
Weight of ash (g) = mass of the residue remaining after incineration
Weight of sample (g) = initial mass of the sample used for analysis

### 2.2.6. Total Carbohydrate content

Determination of the carbohydrate content of teff flour samples by using the difference (Ciabotti et al., 2016). The carbohydrate content estimated will be subtracted from the moisture, fat, protein, fiber, and ash contents.

$$\text{CHO\%} = 100 - (\text{\%Moisture} + \text{\%Crude fat} + \text{\%Crude protein} + \text{\%Ash} + \text{\%Crude fiber}) \tag{7}$$

Where:
CHO % = percentage of carbohydrate (by difference)

### 2.2.7. Energy content

To determine energy content, mean values of crude protein, utilizable carbohydrate and crude fat will be multiplied with 4, 4 and 9, respectively. Therefore, the sum of the products and the result will be stated in kilocalories per 100g (Kcal/100g) as per Atwater general factors system. Formula shown below will be used for calculating energy.

$$\text{Energy (kcal/100 g)} = 4 \times \%\text{Protein} + 4 \times \%\text{Carbohydrate} + 9 \times \%\text{Fat} \quad (8)$$

### *2.3. Mineral analysis*

According to AOAC standards the calcium, iron, zinc, magnesium, copper and potassium mineral contents were analyzed using atomic absorption spectrophotometry (AAS) and flame photometry. A 2-g milled sample of the plant material was mixed with a 2:5 ratio of a concentrated nitric acid (69%) and hydrochloric acid (37%) and diluted to 50 mL using distilled water. Stock solutions at a concentration of 10 ppm of the minerals (iron, zinc, calcium, magnesium, manganese and potassium) were prepared respectively. The samples and standards were nebulized using an air-acetylene flame and the absorbance was read at 248.33 nm for iron, 213.8 nm for zinc, 422.67 nm for calcium, 285.21 nm for magnesium, 327.40 nm for copper and 766.49 nm for potassium. The aforementioned solution was then applied for the determination of Fe, Zn, Ca, Mg, Mn, and K elements in the flour and formulated injera samples.

$$\text{Mineral content (mg/100g)} = \frac{A - B}{W} \times V \times D \quad (9)$$

Where:
W = weight (g) of the sample
V = volume of extract (mL)
A = concentration (mg/L) of the sample solution
B = concentration (mg/L) of the blank solution
D = dilution factor

### *2.4. Determination of anti-nutritional factors*

*2.4.1. Phytate*

Phytate content was analyzed according to method of Vaintraub and Lapteva (1988), with modification (Vaintraub & Lapteva, 1988). 0.1 g dried Injera flour was extracted using 10 ml 0.2% HCl at room temperature for 1 hour. The solution was centrifuged at 3000 rpm for 30 min, then supernatant was collected. In the assay, 3 ml sample was mixed with 2 ml Wade reagent (0.06% FeCl36H2O and 0.6% sulfosalicylic acid), the absorbancy of the mixture was determined using a UV-VIS spectrophotometer at 500nm, and concentration of phytate was computed using a standard curve (4-32ppm), the results were expressed as phytic acid (mg /100g dry wt.).

$$\text{Phytic acid (mg/100 g)} = \frac{(AB - AS - \text{intercept}) \times 10}{\text{slope} \times W \times 3} \quad (10)$$

Where:
AB = absorbance of the blank sample
AS = absorbance of the sample
3 = volume extracted from the sample (supernatant)

*2.4.2. Tannin*

Condsed tannins were determined by the method of Dykes (Dykes, 2019). In short 0.30g of sample was measured in to screw cap test tubes, 8mL of 1% HCl in methanol was added to test tubes and vortexed for 10sec. Test tubes were put in a water bath at 20min (spun for 10sec at half time) and vortexed for a 10 sec. They were then centrifuged for 15min at 1000rpm. The supernatent was carefuly poured out ensuring no solid were left behind. 1mL of supernatent was removed into another test tube, this test tube was the sample (the other was the blank),test tubes were placed in water bath at 30C for 20min, 5ml of vanillin reagent were added to the sample test tube, and 5ml of 4% HCl in methanol was added to the blank test tube in 15 sec intervals. After 20min sample and blank were read at 500nm at the spectrophotometer (zero set with a methanol blank). 40mg D- Catechin was weighed and made up to 100ml of 1% HCl in methanol (stock), then different concentrations were read as follows, different ppm stock solution in test tube were measured at, 0, 2.69, 5.38, 26.88, 53.76, and 107.52. Test tubes were topped up to 1ml with 1% HCl in methanol.

$$\text{Tannin (mg/100 g)} = \frac{V \times A}{m \times W} \quad (11)$$

Where:
V = volume of extract (mL)
A = absorbance at 500 nm (Absorbance of sample − Absorbance of blank)
m = slope of the standard curve
W = weight of the sample

### *2.5. Statistical analysis*

The analyses were run in duplicate unless specified otherwise, and results are presented as mean ± standard deviation to express the variation in the measurements. The use of one-way analysis of variance (ANOVA) to evaluate the presence of a significant difference between the means different teff varieties applies as statistical analysis of data. If there are significant variations, the post hoc technique undertaken is Duncan's Multiple Range Test (DMRT) to separate group means. We conducted all statistical analyses in GenStat software (version 18.0). A statistical significance was determined using the probability level of $P \leq 0.05$.

## 3. Results and Discussion

### *3.1. Proximate composition and energy content of Teff varieties*

The data in Table 1 on proximate composition show that all the teff varieties differed significantly at ($P < 0.05$) in all the parameters. The teff varieties have significant varietal effects on the proximate composition of the teff varieties. The mixed flour had the least moisture content at 9.85 %. Further, V.flagale had the next most moisture content at 12.47 % and was significantly similar to Boni (12.45 %) which formed a group with it. Rest of the samples were significantly different to it. The mixed flour was significant lower than all other samples. The highest value of the ash content, which reflects the total mineral residue, was obtained from Dagem, which was 2.77%. Closest to Dagem was Boni, which was 2.67%.

The mixed flour had the least ash value of 1.42%. This was due to the dilution of the mineral-rich teff components after it was blended with white rice. The values of ash for the pure teff samples are very much same as those reported for teff (about 2-3%). Therefore, it could be inferred that the present varieties fall in the mineral range of teff grain and flour (Bultosa, 2007; Gebremariam et al., 2014). The assessment of crude protein was one of the most essential traits. The protein content of Simada (13.56%) was significantly higher than all other samples, and this was followed by Dagem (13.09%). Alternatively, the protein content of mixed flour was the lowest among the flours at 6.65%, while the JLM control also had a low protein content at 9.54%. This indicates that Simada and Dagem are better protein sources than the other materials.

The mean protein value of the samples (12.16%) is at the upper end of the range of protein values reported for teff, which is normally 9–15%, depending on genotype and growing conditions (Hager et al., 2012; Shumoy & Raes, 2017). Crude fiber fluctuated greatly between varieties, with V.flagale recording the highest value (2.45%) and the mixed flour the lowest (0.44%). Earlier studies show that teff generally contains more fiber than refined cereal flours. Although values of crude fiber are much lower than total dietary fiber values, the resulting values are dependent on the analytical method used, as this method measures only part of the fiber fraction (Gebremariam et al., 2014).

One of the notable results studied is the crude fat content. Of all the varieties, Bora had the maximum fat value (5.77%) which was significantly higher than all the varieties. While mixed flour had the minimum value (1.99%). Bora, which has high fat content, likely had high energy value (364.7 kcal/100 g) which was statistically similar to that of mixed flour (363.1 kcal/100 g). Most of the published studies report teff fat contents closer to about 2-4% so that the Bora variety seems unusually lipid-rich compared to the typical teff materials reported in the literature (Bultosa, 2007; Shumoy & Raes, 2017). The carbohydrate content displayed quite the opposite trend. The mixed flour had a maximum carbohydrate value (79.64%), which was significantly greater than all the teff varieties. Bora had a minimum carbohydrate value (65.53%). This inverse correlation is anticipated because carbohydrate is assessed by difference hence samples with low protein other ash fat and fiber would generally show high carbohydrate values. The pure teff varieties' carbohydrate values are more or less comparable with published teff values which have generally reported teff to be about 65–75% carbohydrate and about 330–370 kcal/100 g energy (Gebremariam et al., 2014; Hager et al., 2012).

Table 1: Proximate composition and energy content of Teff varieties

| **Varieties** | **Result in (%) (100g)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Moisture** | **Ash** | **C.Fiber** | **C.Protein** | **C.Fat** | **CHO** | **Energy (Kcal/100g)** |
| Simada | $11.64 \pm 1.02^{b}$ | $2.52 \pm 0.68^{de}$ | $1.13 \pm 0.09^{b}$ | $13.56 \pm 1.88^{f}$ | $3.68 \pm 0.91^{de}$ | $67.48 \pm 2.15^{b}$ | $357.2 \pm 5.19^{d}$ |
| Bora | $11.79 \pm 1.24^{bc}$ | $2.32 \pm 0.56^{bc}$ | $1.92 \pm 0.14^{de}$ | $12.66 \pm 1.42^{d}$ | $5.77 \pm 1.02^{f}$ | $65.53 \pm 2.01^{a}$ | $364.7 \pm 5.45^{e}$ |
| Boni | $12.45 \pm 1.43^{d}$ | $2.67 \pm 0.82^{ef}$ | $1.86 \pm 0.13^{de}$ | $12.30 \pm 1.32^{d}$ | $3.77 \pm 0.98^{e}$ | $66.69 \pm 2.11^{b}$ | $350.9 \pm 5.09^{b}$ |
| Dagem | $11.61 \pm 1.09^{b}$ | $2.77 \pm 0.91^{f}$ | $1.42 \pm 0.12^{c}$ | $13.09 \pm 1.78^{e}$ | $2.89 \pm 0.87^{b}$ | $68.22 \pm 2.35^{c}$ | $351.2 \pm 5.10^{bc}$ |
| Negus | $11.69 \pm 1.04^{b}$ | $2.47 \pm 0.57^{cd}$ | $1.26 \pm 0.08^{bc}$ | $11.42 \pm 1.08^{c}$ | $3.32 \pm 0.93^{c}$ | $69.84 \pm 2.41^{d}$ | $354.9 \pm 5.14^{d}$ |
| Bishoftu | $11.84 \pm 1.08^{bc}$ | $2.54 \pm 0.62^{de}$ | $1.95 \pm 0.18^{e}$ | $12.30 \pm 1.48^{d}$ | $3.14 \pm 0.81^{c}$ | $68.22 \pm 2.43^{c}$ | $350.3 \pm 5.10^{b}$ |
| Mixed flour | $9.85 \pm 1.01^{a}$ | $1.42 \pm 0.21^{a}$ | $0.44 \pm 0.05^{a}$ | $6.65 \pm 1.01^{a}$ | $1.99 \pm 0.47^{a}$ | $79.64 \pm 2.65^{f}$ | $363.1 \pm 5.65^{e}$ |
| V.flagale | $12.47 \pm 1.58^{d}$ | $2.25 \pm 0.42^{b}$ | $2.45 \pm 0.21^{f}$ | $12.42 \pm 1.62^{d}$ | $3.18 \pm 0.82^{c}$ | $67.23 \pm 2.25^{b}$ | $347.2 \pm 4.96^{a}$ |
| JLM Control | $12.26 \pm 1.38^{cd}$ | $2.19 \pm 0.39^{b}$ | $1.96 \pm 0.16^{e}$ | $9.54 \pm 1.08^{b}$ | $3.15 \pm 0.90^{c}$ | $70.90 \pm 2.98^{e}$ | $350.1 \pm 5.03^{b}$ |
| **Grand Mean** | 11.97 | 2.47 | 1.74 | 12.16 | 3.61 | 68.05 | 354.4 |

**Key:** Mixed flour = mixture of teff and white rice; JLM Control = Jigjiga local market control teff.
All values are means expressed on a dry matter basis ± standard error. Means with the same superscripts do not differ significantly ($P < 0.05$).

### *3.2. Minerals content of Teff varieties*

As shown in Table 2 the mineral composition of the various studied teff varieties reveals a significant variation in calcium (Ca), iron (Fe), zinc (Zn), magnesium (Mg), copper (Cu) and potassium (K). The Dagem and Boni varieties possessed the highest iron contents, at 22.02 ± 1.38 mg/100 g and 21.55 ± 1.34 mg/100 g respectively. These values are much higher than the usual 6.7–15.8 mg/100 g range (Baye, 2014; Gebremariam et al., 2014) reported for teff. Similarly high levels of zinc were observed in the varieties, Boni and Bishoftu (4.415 ± 0.941 and 4.415 ± 0.981 mg/100 g), which is in the range of 2.7–3.8 mg/100 g found in Ethiopian staples (Abebe et al., 2007).

The calcium content of Simada (297.2 ± 3.54 mg/100 g) was found to be the highest among all varieties tested. This is consistent with the upper values reported in literature on teff that has calcium content of around 150–300 mg/100 g (Gebremariam et al., 2014). The magnesium content of Boni (102.43 ± 2.65 mg/100 g) falls within the commonly reported range of 80–130 mg/100 g for teff grains (Baye, 2014; Bultosa, 2007). The potassium content of Negus (799.0 ± 6.9 mg/100 g) was the highest, again indicating teff is a rich source of potassium (Gebremariam et al., 2014). Clearly, the mixed flour of teff and white rice had a significantly lower mineral content for all parameters, thus stronger overall benefits for pure teff varieties. The results underscore the nutritiousness of teff and highlight some varieties that have greater concentrations than previously reported.

Table 2: Mineral content of Teff varieties

| Varieties | Results in (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Ca | Fe | Zn | Mg | Cu | K |
| Simada | 297.2±3.54$^{f}$ | 10.66±1.02$^{c}$ | 3.765±0.891$^{c}$ | 76.76±2.01$^{b}$ | 0.7335±0.008$^{c}$ | 749.5±6.8$^{c}$ |
| Bora | 290.5±3.24$^{c}$ | 12.02±1.06$^{cd}$ | 4.300±0.923$^{ef}$ | 96.66±2.34$^{de}$ | 0.4405±0.004$^{abc}$ | 754.0±6.5$^{c}$ |
| Boni | 293.0±3.65$^{d}$ | 21.55±1.34$^{f}$ | 4.415±0.941$^{f}$ | 102.43±2.65$^{e}$ | 0.2935±0.002$^{a}$ | 764.0±6.6$^{c}$ |
| Dagem | 295.8±3.76$^{ef}$ | 22.02±1.38$^{f}$ | 4.225±0.973$^{def}$ | 93.17±2.31$^{cde}$ | 0.5875±0.005$^{abc}$ | 770.0±6.7$^{c}$ |
| Negus | 294.8±3.26$^{def}$ | 10.66±1.04$^{c}$ | 3.875±0.882$^{cd}$ | 86.60±2.16$^{bcd}$ | 0.5870±0.005$^{ac}$ | 799.0±6.9$^{c}$ |
| Bishoftu | 293.7±3.36$^{de}$ | 13.61±1.12$^{e}$ | 4.415±0.981$^{f}$ | 100.26±2.64$^{e}$ | 0.4400±0.004$^{abc}$ | 779.0±6.7$^{c}$ |
| MF | 272.5±3.34$^{a}$ | 7.94±0.98$^{b}$ | 1.535±0.021$^{a}$ | 21.36±1.03$^{a}$ | 0.2940±0.002$^{ab}$ | 525.0±5.5$^{a}$ |
| V.flagale | 295.4±3.83$^{def}$ | 7.26±0.95$^{b}$ | 3.955±0.894$^{cde}$ | 80.64±2.07$^{bc}$ | 0.5875±0.005$^{abc}$ | 580.0±5.5$^{b}$ |
| JLMC | 280.1±3.56$^{b}$ | 3.62±0.67$^{a}$ | 2.490±0.672$^{b}$ | 89.39±2.09$^{bcde}$ | 0.5865±0.005$^{c}$ | 763.5±6.6$^{c}$ |
| **Grand Mean** | 290.33 | 12.55 | 3.66 | 65.95 | 0.51 | 720.44 |

**Key:** MF = Mixed flour; JLMC = Jigjiga local market control teff.
Values are mean ± SE (dry matter basis). Means with the same superscripts are not significantly different at $P \leq 0.05$.

### *3.3. Anti-nutritional content of different Teff varieties*

There was a significant difference (P < 0.05) of tannin content in all the samples as shown in Table 3. Phytate content did not differ significantly as all the means of phytate carried the same superscript (a). The mixed flour had the lower level (0.3140 ± 0.0011 mg/g) of the tannins. Also, it was significantly lower than the other samples. It shows that mixing teff with white rice reduces tannins. The intermediate tannin level of Boni is 0.5755 ± 0.0141 mg/g, which is significantly different from the mixed flour and higher tannin group. According to Table 3, the highest group of statistics contained Simada, Bora, Dagem, Negus, Bishoftu, V.flagale and JLM control (0.8630–1.1025 mg/g). Bora was the sample which possessed the highest numerical value (1.1025 ± 0.0221 mg/g) in the same superscript group. However this does not show a significantly different result from the other samples that fall under the same group.

The varietal differences impact tannin content more than phytate content, according to this finding. Reported low tannin values further support published observations that teff is a low-tannin cereal compared with many small grains, especially high-tannin sorghum types. Hence, the nutritional superiority of teff due to a low anti-nutritional polyphenolic burden (Gebremariam et al., 2014; Shumoy & Raes, 2017) is supported. The phytate ranging values were numerically from JLM control 1.156 ± 0.0015 mg/g and mixed flour 1.157 ± 0.0013 mg/g to Bora 2.072 ± 0.0072 mg/g but did not statistically significant as they all have the same superscript (a). Thus, the results also indicate that phytate is statistically similar for all teff varieties and flour types regardless of the numbers. Phytate is among the key anti-nutritional compound capable of reducing mineral bioavailability through its chelation of iron, zinc and calcium.

Table 3: Anti-nutritional content of different teff varieties

| Varieties | Results (mg/g) | |
|---|---|---|
| | Tannins | Phytate |
| Simada | 1.0485±0.0401$^{c}$ | 1.735±0.0032$^{a}$ |
| Bora | 1.1025±0.0221$^{c}$ | 2.072±0.0072$^{a}$ |
| Boni | 0.5755±0.0141$^{b}$ | 1.845±0.0034$^{a}$ |
| Dagem | 1.0495±0.0411$^{c}$ | 1.730±0.0007$^{a}$ |
| Negus | 0.9215±0.0011$^{c}$ | 1.621±0.0005$^{a}$ |
| Bishoftu | 0.9460±0.0092$^{c}$ | 1.735±0.0051$^{a}$ |
| Mixed | 0.3140±0.0011$^{a}$ | 1.157±0.0013$^{a}$ |
| V.flagale | 0.8630±0.0082$^{c}$ | 1.612±0.0061$^{a}$ |
| JLM Control | 0.9445±0.0091$^{c}$ | 1.156±0.0015$^{a}$ |

**Key:** Mixed = mixture of teff and white rice flour; JLM Control = Jigjiga local market control teff. All values are means expressed on a dry matter basis ± standard error. Means with the same superscripts do not differ significantly ($P < 0.05$).

## 4. Conclusion and Recommendation

### *4.1. Conclusion*

The present study demonstrated that teff varieties grown in the Somali Regional State differ significantly in their proximate composition, mineral profile, and tannin content. Among the varieties tested, Simada was superior in crude protein, and calcium. Dagem and Boni were found outstanding in iron content. Boni and Bishoftu were relatively high in zinc. Negus was richest in potassium. V.flagale was found with maximum crude fiber. Bora had the highest fat value and energy value, despite it having the highest tannin value and phytate value numerically. On the other hand, the mixed flour sample had generally lower nutrient and mineral contents, implying that blending teff with white rice may undermine the nutritional quality.

The results indicate that teff from the dry and semi-dry situation of the Somali Region is a nutritious grain that can play a significant role in food and nutrition security. The observed varietal differences also suggest that some teff varieties can serve specific nutritional purposes, such as higher protein, more iron, extra fiber, and more mineral-rich food. As a result, the biomass of locally grown teff has tremendous potential for the household diet, value-added foods and nutrition-sensitive agriculture interventions in the region.

### *4.2. Recommendation*

The study recommends the promotion of nutritionally superior varieties of Teff such as Simada, Dagem, Boni, and Negus because of their higher protein and mineral contents.

Specialized types may be drawn on for preparing targeted foodstuff, such as protein, calcium, iron and fibre-rich food formulations. Breeding programs must include nutritional quality with yield and adaptability. There is need for traditional processing methods such as fermentation, soaking, and germination to be encouraged to reduce anti-nutritional factors and enhance mineral bio-availability. According to the researchers, more work across varied places and seasons is necessary to substantiate this claim while the outcome should help regional nutrition interventions for better diet quality as well as lower micro-nutrient deficiencies.

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## Conflict of interest

The authors declare that there is no conflict of interest publishing this article.

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