**Original Research Article**

**Proximate Composition and Anti-nutritional Factor of Different Sorghum (*Sorghum bicolor* L. Moench) Varieties**

ABSTRACT

|  |
| --- |
| The objective of this research was to determine the proximate composition (moisture, crude protein, crude fat, crude fiber, crude ash, carbohydrate contents) and anti-nutritional factor (phytic acid content) of different sorghum varieties. This research was conducted at the Department of Postharvest Technology, Advanced Center for Agricultural Research and Education (ACARE), Yezin Agricultural University (YAU). The sorghum varieties, Yezin-7, Yezin-8, Yezin-9, and Yezin-15 were collected from Other Cereal Crop Research Section, Department of Agricultural Research (DAR), Ministry of Agriculture, Livestock, and Irrigation. The proximate composition of sorghum varieties was determined according to the method of AOAC (Association of Official Analytical Chemists). The phytic acid content was determined according to Wheeler and Ferrel's (1971) with slight modification. This experiment was laid out by Completely Randomized Design (CRD) with five replications. Within the sorghum varieties, Yezin-7 had the highest crude protein and crude fat content, whereas Yezin-9 had the highest fiber content. The highest amount of crude ash was found in Yezin-15. The anti-nutritional factor (phytic acid content) was the lowest in Yezin-8 and but not significant amount in Yezin-7. Among the different sorghum varieties, Yezin-7 is the suitable sorghum variety to be used for the production of protein rich sorghum-based products due to its high protein and low anti-nutritional factor (phytic acid). |

Keywords: **Sorghum, Four varieties, Proximate composition, Phytic acid**

1. INTRODUCTION

Sorghum (*Sorghum* *bicolor L. Moench*) is the fifth most important cereal crop grown in the world after wheat, maize, rice, and barley (Kazungu *et al*., 2023). Sorghum is one of the six future smart foods of Myanmar that were selected based on their potential to address nutritional needs and adapt to climate change while increasing farmers income and improving social conditions (Chadalavada *et al.,* 2021). Sorghum can be grown in harsh environments where other crops would not survive.

From a nutritional point of view, sorghum is superior to other mainstream cereals like maize and wheat, with substantial amounts of iron, calcium, and zinc (Pontieri *et al*., 2024). The nutrients in sorghum grain have a positive role in human health and nutrition, especially in people suffering from disorders such as celiac disease, diabetes, and obesity (Khalid *et al.,* 2022). Although sorghum possesses high nutritional value and health benefits for consumers, sorghum-based food products are not available on the market (Adebo, 2020).

Over 50% of the sorghum grain produced in the country is for human consumption, and it is a staple food in the rice-deficient central dry zone and mountainous area (Mar *et al.,* 2019). The underdeveloped value chains and the image of the food as old-fashioned are the major constraints for the production and utilization of sorghum crops to their full potential. Innovative value chain development of sorghum provides benefits including increased farmer income, employment opportunities, improved food security, and nutritional benefits Rao, B. D. (2019). However, the nutritional and functional value of sorghum can differ with different sorghum varieties. Therefore, it is necessary to select the suitable sorghum variety to be accepted in terms of nutritional and functional quality. The released sorghum varieties had no comprehensive nutritional profile data. Therefore, the present study was conducted with the following objective. The objective of this study was to determine the proximate compositions and anti-nutritional factors of four different sorghum varieties.

**2. MATERIALS AND METHODS**

Four different sorghum varieties (Yezin-7, Yezin-8, Yezin-9, Yezin-15) cultivated during the summer season, 2023-2024 were collected from Other Cereal Crop Research Section, Department of Agricultural Research (DAR), Ministry of Agriculture, Livestock and Irrigation.

**2.1 Sample Preparation**

Sorghum grains were cleaned to remove foreign materials. They were washed thoroughly and then dried under sunlight. The dried samples were ground using a micro-pulverizer through a 1 mm mesh sieve. The sorghum flour was packed in polyethylene bags and kept at the refrigerator until analysis.

**2.2 Determination of Proximate Composition**

Proximate composition (moisture, crude protein, crude fat, crude ash, crude fiber and carbohydrate contents) of the sorghum varieties was analyzed by using standard Association of Official ̀s Analytical Chemists (AOAC) methods.

**2.2.1 Moisture content**

To determine the moisture content, (10 g) of sorghum flour were put in a pre-weighed aluminum dish and was placed at 105 ± 1°C in a hot air oven (AOAC, 2005). The samples were taken out of the oven, allowed to cool in a desiccator for half an hour, and then weighed again using a 4-digit analytical balance until constant weight. The initial weight and final weight were collected. Moisture content on percentage (%) was calculated using the following equation:

Moisture content (%) = $\frac{W\_{2}- W\_{3}}{W\_{2}- W\_{1}}$ $×$ 100

Where; W1 = Weight of sample container (g)

W2 = Weight of sample container and sample before drying (g)

W3 = Weight of sample container and sample after drying (g)

**2.2.2 Crude protein content**

The crude protein content of sorghum flour was analyzed by using DKL heating digester and UDK automatic distillation and titration system (Velp Scientifica, F30100210, Italy). The kjeldahl method can be determined through three steps; Digestion, Distillation, Titration (AOAC, 2005).

Nitrogen content (%) (w/w) = $\frac{\left(T-B\right) × N × 1.4007}{Weight of Sample}$ $×$ 100

Crude protein (%w/w) = Nitrogen % × F

Where, N = Normality of hydrochloric acid

 T = Titration volume of sample (ml)

 B = Titration volume of blank (ml)

 F = Conversion factor for nitrogen to protein

**2.2.3 Crude fat content**

The crude fat content of sorghum flour was measured by solvent extraction method (AOAC, 2003) using Randall apparatus (Velp Scientifica Ser 158 solvent auto extractor).

Crude fat content (%) = $\frac{Weight of fat}{Weight of sample}$ $×$ 100

**2.2.4 Crude fiber content**

 Determination of crude fiber was conducted by digesting the sample in 12.5% H2SO4 solution follow by 12.5% NaOH solution through. Fiber Analyzer as described in mention in method (AOAC, 2005). The crude fiber content was calculated using the following formula;

Crude fiber (%) = $\frac{W\_{3}-(W\_{1} × C\_{1})}{W\_{2}}$ ×100

Where, W1 = Bag tare weight

 W2 = Weight of sample

 W3 = Weight of organic matters (Loss of weight on ignition of bag and fiber)

 C1 = Ash corrected blank bag factor (Loss of weight on ignition of blank/
 original blank bag)

**2.2.5 Crude ash content**

Crude ash content was obtained by heating 5 g of samples in crucible. The samples were allowed to ignite at 600℃ for 4 h until the ash was free from black particles. After ignition was completely finished, the crucibles were cooled in muffle furnace (made by An Cryo Instruments Pvt. Ltd., India) for 2 h to cool down to 300℃. And then, the crucibles were placed in a desiccator for 30 min. Ash contents were calculated by using this formula (AOAC, 2003).

Crude ash (%) (w/w) = $\frac{Difference in weight of ash}{Weight of Sample}$ $×$ 100

Where, Difference in weight, of ash = W3 – W1

 Weight of sample = W2

**2.2.6 Carbohydrate**

The total carbohydrate content was calculated by the sum of the Moisture, Crude Protein, Fat, Fiber and Ash contents were subtracted from 100 as follow;

Carbohydrate (%) = 100 – (% of Moisture + Protein + Fat + Ash + Fiber)

(Anwar *et al*., 2022)

**2.2.7 Phytic acid content**

The phytic acid content was determined according to the method of (Wheeler and Ferrel, 1971) with slightly modification. Three grams of sample were weighed and put in 100 ml conical flask. The sample was extracted with 50 ml of 3% Hydrochloric acid (HCl) for 3 hours shaking at 60 ºC. The suspension was centrifuged for 15 minutes at 3000 rpm. Ten milliliters aliquot of the supernatant were transferred to 50 ml test tube and then 4 ml FeCl3 (solution containing 2 mg Fe+3 ion/ml 3% HCl) were added to the aliquot. The tube was heated in a boiling water bath for 45 minutes. After 30 minutes, three drops of 3% Na2SO4 in 3% HCl were added to develop a precipitate. The tube was cooled and centrifuged again for 15 minutes at 3000 rpm. The clear supernatant was decanted and the precipitate was washed twice by dispersing well in 25 ml of 3% HCl, heated for 15 minutes in boiling water bath, then cooled and centrifuged. The precipitate was washed one or two times with water, and was dispersed in a few ml of water. Three milliliters of 1.5 N NaOH was then added and the volume was made up to 30 ml with distilled water. The tube was heated in a boiling water bath for 30 minutes, and hot filtered using Whatman No. 40 filter paper. The precipitate was washed with 60 ml of hot water and washings were decanted. The precipitate was left on the filter paper dissolved with 40 ml hot 3.2 N HNO3 into 100 ml volumetric flask and the paper was washed again with water in the same flask and completed to volume with water. A volume of 2.5 ml of the above suspension was transferred into 50 ml volumetric flask and 37.5 ml distilled water added. Finally, 10 milliliters of 0.5, potassium thiocyanate (KSCN) were added, and then the absorbance was read using spectrometer (UV-2600) at 480 nm exactly within one minute reaction. A standard curve of different Fe (NO3)2 concentrations was plotted to calculate the ferric ion concentration. The phytate phosphorus was calculated from the ferric ion concentration assuming 4:6 iron phosphorus molar ratio and multiplying by factor 3.53. Calculation;

 Phytic acid (mg/100g) = $\frac{6}{4}$ × $\frac{C × Final Value × Factor}{A}$ ×100

 $(Wheeler \& Ferrel, 1971)$

Where,

 C = Concentration corresponding to the optical density (mg/ml)

 A = Amount of sample in aliquot taken (ml/g)

**2.3 Experimental Design and Statistical Analysis**

The recorded data for all samples flour of different sorghum varieties were subjected five replications with Completely Randomized Design (CRD). All of the data were analyzed by ANOVA using statistics (8th version) and treatment means were compared using Least Significant Difference (LSD) test at 5% level.

**3. RESULTS AND DISCUSSION**

**3.1. Moisture content**

 The range of moisture contents found in the results was 9.97 to 10.60% (Figure 1). This moisture content was nearly similar to the finding of Tasie and Gebreyes, (2020) who reported that the moisture content of sorghum ranged from 9.66 to 12.94%. The World Food Program (WFP) reported the maximum standard moisture content for sorghum grain was 13%. Low moisture content usually means that they may be kept in storage for a long time because high moisture content is prone to microbial and storage pest infestations. The grain size, the harvesting period and environmental conditions are responsible for the slight variation shown between the varieties.

**3.2. Crude protein content**

Protein plays an important role in growth and development as it provides the body with essential amino acids (Rezaei *et al.,* 2016). Identified sorghum varieties should be considered for food product development to combat protein malnutrition and for the breeders to improve sorghum nutritional quality. The quality of sorghum flour was determined by the quantity of protein in flour. It was observed that the highest protein content of 8.34% was found in the Yezin-7 variety and the lowest protein content 6.20% in Yezin-8 variety. The protein content 8.34%, 7.57%, 6.70% and 6.20% were found in sorghum flour from Yezin-7, Yezin-15, Yezin-9 and Yezin-8, respectively (Figure 2). The crude protein content of different sorghum varieties was significantly different (p < 0.05). The protein content difference that was observed in sorghum varieties may be due to the environment and genotype difference (Njuguna *et al.,* 2018).

Badigannavar *et al*., (2016) reported that the crude protein content of sorghum range from 3.25 to 14.53%, 7 to15%, and 10.30 to 14.90%, respectively. Furthermore, Chung *et al.,* (2011) indicated that the protein content of sorghum varied from 11.23 to 13.42%, 8.32 to 11.82%, and 9.06 to 18.58%, respectively.

**3.3. Crude fat content**

###  Fats are important nutritional components as they provide the body with energy. They also mediate the absorption of some important vitamins and add flavor to food (Sanders, 2024). The crude fat content ranged from 3.05% to 3.65%. The crude fat content 3.65%, 3.50%, 3.10% and 3.05% was found in sorghum flour of Yezin-7, Yezin-15, Yezin-8, Yezin-9, respectively (Figure 3). There was a significant difference (p < 0.05) in the crude fat content obtained for the different sorghum varieties. The range of crude fat content from 2.76 to 3.7% of sorghum was observed by Khosravi *et al.,* (2018). Tasie and Gebreyes, (2020) found that crude fat content varied from 2.5 to 4.6%, and others reported that fat content ranged from 3.44 to 4.90% and 1.38 to 4.50%.

### **3.4. Crude fiber content**

Dietary fiber plays an important role in human health. High-fiber-content food prevents the development of coronary heart disease, hypertension, obesity, stroke, and gastrointestinal disease (Arranz, *et al.,* 2012). Sorghum flour is a good source of dietary fiber, with a typical range of 6-8% (Tanwar, *et al.,*  2025). The fiber content of different sorghum varieties was ranged between 4.20% and 10.43%. The crude fiber content of 10.43%, 8.82% and 5.37%, 4.20% were found in sorghum flour from Yezin-9, Yezin-7, Yezin-15, Yezin-8, respectively (Figure 4). There was a significant difference (p < 0.05) in the crude fat content obtained for the different sorghum varieties. The fiber content obtained was in a range of 2.17-8.59% (Tasie & Gebreyes, 2020). Various researches have proven that sorghum contains about 10.4% fibers (both soluble and insoluble) (Wahjuningsih *et al.,* 2020). Variability may be attributed to environmental factors, soil type, and genotype variations of sorghum.

The varieties with a higher amount of crude fiber might not be good for food consumption because it binds minerals, making them unavailable for absorption (de Oliveira *et al.,* 2022), and this binding could produce essential mineral imbalance and deficiencies. In contrast, it can be useful in products that require hydration to improve yield and modify texture and viscosity due to its properties of water and oil holding capacity (Elleuch *et al.,* 2012).

**3.5. Crude ash** **content**

The crude ash content of sorghum measures the presence of mineral content in it and different varieties recorded different ash content. The higher the ash content of the varieties, the higher the total mineral content. There was a significant difference (p < 0.05) in the crude ash content obtained for the different sorghum varieties. Yezin-15 had the highest amount of ash (1.25%) of all tested varieties, followed by Yezin-8 (0.51%), Yezin-9 (0.50%) and Yezin-7 (0.43%) respectively (Figure 5). The ash content of sorghum obtained was in the range of (0.15- 2.76%) (Tasie & Gebreyes, 2020). Ali, *et al.,* (2024) reported that the crude ash content of different sorghum varieties may vary due to variability in agroecology (soil, water, altitude, and climate) at which the sorghum is cultivated.

**3.6. Carbohydrate**

Carbohydrates provide the majority of energy in the diets of most people. It is a desirable source of energy because it provides easily available energy for the oxidative metabolism of our body. The carbohydrate content of different sorghum varieties was ranged from 68.45% to 75.40%. There was a significant difference (p < 0.05) in the carbohydrate content obtained for the different sorghum varieties. The carbohydrate content 75.40%, 72.17%, 69.35% and 68.45% were found in sorghum flour prepared from Yezin-8, Yezin-15, Yezin-9, Yezin-7, respectively as shown in (Figure 6). Tasie and Gebreyes (2020) reported that the carbohydrate content of sorghum ranged from 67.56% to 76.41%.

**3.7. Phytic acid content**

Phytic acid are commonly found in seeds and grains cereals, legumes and other plants where they constitute the main storage form of total phosphorus (Osman & Mustafa 2013). Phytic acid is one of the anti-nutrients that is found in most cereals. Phytic acid is considered an anti-nutrient because it makes minerals unavailable for absorption by the body. There was a significant difference (p < 0.05) in the phytic content obtained for the different sorghum varieties. Yezin-15 variety showed the highest content of phytic acid (1597.50 mg/100 g). Yezin-8 (1367.50 mg/100 g) contained the lowest phytic acid followed by Yezin-7 (1415.00 mg/100 g) and Yezin-9 (1422.50 mg/100 g) respectively (Figure 7). Phytic acid ranged from 875.1 to 2,211.9 mg/100 g in sorghum (Makokha *et al.,* 2002). The content of phytic acid in different cereals varies according to species and the environment where they have been grown and stored. There are many factors that affect the content of phytic acid in cereals. Germination, temperature and phytase activity are some of those factors that affect the content of phytic acid in cereal (Kumar & Anand, 2021).

**Figure 1. Moisture content of different sorghum varieties**

**Figure 2. Crude protein content of different sorghum varieties**

**Figure 3. Crude fat content of different sorghum varieties**

**Figure 4. Crude fiber content of different sorghum varieties**

**Figure 5. Crude ash content of different sorghum varieties**

**Figure 6. Carbohydrate content of different sorghum varieties**

LSD0.05 54.67

Pr>F 0.001

CV% 3.13

Pr>F 0.001

CV% 3.13

Pr>F 0.001

CV% 3.13

**Figure 7. Phytic acid content of different sorghum varieties**

**4. CONCLUSION**

The research has conducted to determine the proximate composition and anti-nutritional factor (phytic acid content) of different sorghum varieties. The proximate analysis revealed that sorghum samples contain appreciable nutrient contents. Varieties of sorghum have their nutritional quality. However, according to this research, Yezin-7 variety emerged as the superior choice, the highest of crude protein and crude fat content, the lowest crude ash content, and second least content of anti-nutritional factor (phytic acid). The results of this research indicate that the sorghum flours are rich in carbohydrate, protein, fat and fiber and are therefore inexpensive source of macronutrients which can be used in intervention programme aimed at reducing protein-energy malnutrition. Among those of different sorghum varieties, Yezin-7 can be considered as raw material for the food industries, consumers, and breeders.

**Disclaimer (Artificial intelligence)**

 Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

**COMPETING INTERESTS**

 Authors have declared that no competing interests exist.

References

Adebo, O. A. (2020). African sorghum-based fermented foods: past, current and future prospects. *Nutrients*, *12*(4), 1111.

Ali, A. M., Ali, M. S., Ateye, M. D., Mohamed, H., & Mohamud, N. D. (2024). Characterization of Nutritional, Anti-nutritional, and Mineral Contents of Twenty-seven Sorghum Varieties Grown in Different Parts of Somali Region, Eastern Ethiopia. *J Food Chem Nanotechnol*, *10*(4), 212-219.

Anwar, S., Mohammad, Z., Hussain, W., Ali, N., Ali, A., Hussain, J., & Hussain, D. (2022). Evaluation of mineral, proximate compositions and anti-oxidant activities of some wild edible vegetables of District Kurram Khyber Pakhtunkhwa, Pakistan. *Plant Sci. Today*, *9*(2), 1-11.

AOAC 2003, Official methods of analysis of the association of official’s analytical chemists, 17th edition. Association of official analytical chemists, Arlington, Virginia.

AOAC 2005, Official Methods of Analysis. Association of Official Analytical Chemists, 13th edition, Washington, D.C.

Arranz, S., Remon, A. M., Raventos, R. M. L., & Estruch, R. (2012). Effects of dietary fiber intake on cardiovascular risk factors. *Recent advances in cardiovascular risk factors*, 459-460.

Badigannavar, A., Girish, G., Ramachandran, V., & Ganapathi, T. R. (2016). Genotypic variation for seed protein and mineral content among post-rainy season-grown sorghum genotypes. *The Crop Journal*, *4*(1), 61-67.

Chadalavada, K., Kumari, B. R., & Kumar, T. S. (2021). Sorghum mitigates climate variability and changes on crop yield and quality. *Planta*, *253*(5), 113.

Chung, I. M., Kim, E. H., Yeo, M. A., Kim, S. J., Seo, M. C., & Moon, H. I. (2011). Antidiabetic effects of three Korean sorghum phenolic extracts in normal and streptozotocin-induced diabetic rats. *Food Research International*, *44*(1), 127-132.

de Oliveira, L. D. L., de Oliveira, G. T., de Alencar, E. R., Queiroz, V. A. V., & de Alencar Figueiredo, L. F. (2022). Physical, chemical, and antioxidant analysis of sorghum grain and flour from five hybrids to determine the drivers of liking of gluten-free sorghum breads. *LWT*, *153*, 112407.

Elleuch, M., Bedigian, D., Besbes, S., Blecker, C., & Attia, H. (2012). Dietary fibre characteristics and antioxidant activity of sesame seed coats (testae). *International Journal of Food Properties*, *15*(1), 25-37.

Kazungu, F. K., Muindi, E. M., Mulinge, J. M., Wamukota, A. W., Muchomba, M. K., Okello, N., ... & Ahmed, H. (2023). Sorghum growth and yield as influenced by farmyard manure and inorganic fertilizer in post mined soils. *Int. J. Plant Soil Sci*, *35*(16), 331-341.

Khalid, W., Ali, A., Arshad, M. S., Afzal, F., Akram, R., Siddeeg, A., ... & Saeed, A. (2022). Nutrients and bioactive compounds of Sorghum bicolor L. used to prepare functional foods: a review on the efficacy against different chronic disorders. *International Journal of Food Properties*, *25*(1), 1045-1062.

Khosravi, M., Rouzbehan, Y., Rezaei, M., & Rezaei, J. (2018). Total replacement of corn silage with sorghum silage improves milk fatty acid profile and antioxidant capacity of Holstein dairy cows. *Journal of dairy science*, *101*(12), 10953-10961.

Kumar, S., & Anand, R. (2021). Effect of germination and temperature on phytic acid content of cereals. *Int. J. Res. Agric. Sci*, *8*, 24-35.

Makokha, A. O., Oniang'o, R. K., Njoroge, S. M., & Kamar, O. K. (2002). Effect of traditional fermentation and malting on phytic acid and mineral availability from sorghum (Sorghum bicolor) and finger millet (Eleusine coracana) grain varieties grown in Kenya. *Food and nutrition bulletin*, *23*(3\_suppl1), 241-245.

Mar, N. N., Linn, K., Wai, H. P., Mon, H., Soe, A. A., & Minn, M. (2019). Efficiency of different N, P, K fertilizer application methods in sorghum to optimize marginal land productivity. *Science*, *4*(2), 511-515.

Njuguna, V. W., Cheruiyot, E. K., Mwonga, S., & Rono, J. K. (2018). Effect of genotype and environment on grain quality of sorghum (Sorghum bicolor L. Moench) lines evaluated in Kenya. *African Journal of Plant Science*, *12*(12), 324-330.

Osman, M. A., & Mustafa Gassem, M. G. (2013). Effects of domestic processing on trypsin inhibitor, phytic, acid, tannins and in-vitro Protein Digestibility of three sorghum varieties.

Pontieri, P., Troisi, J., Calcagnile, M., Aramouni, F., Tilley, M., Smolensky, D., ... & Del Giudice, L. (2024). Nutritional Composition, Fatty Acid Content, and Mineral Content of Nine Sorghum (Sorghum bicolor) Inbred Varieties. *Foods*, *13*(22), 3634.

Rao, B. D. (2019). Sorghum value chain for food and fodder security. In *Breeding sorghum for diverse end uses* (pp. 409-419). Woodhead Publishing.

Rezaei, R., Wu, Z., Hou, Y., Bazer, F. W., & Wu, G. (2016). Amino acids and mammary gland development: nutritional implications for milk production and neonatal growth. *Journal of animal science and biotechnology*, *7*, 1-22.

Sanders, T. A. (2024). Introduction: the role of fats in human diet. *Functional dietary lipids*, 1-28.

Tanwar, R., Panghal, A., Kumari, A., & Chhikara, N. (2025). Nutritional, Phytochemical and Functional Potential of Pearl Millet: A Review. *Chemistry & Biodiversity*, e202402437.

Tasie, M. M., & Gebreyes, B. G. (2020). Characterization of nutritional, antinutritional, and mineral contents of thirty‐five sorghum varieties grown in Ethiopia. *International journal of food science*, *2020*(1), 8243617.

Wahjuningsih, S. B., Azkia, M. N., & Anggraeni, D. (2020). The study of sorghum (Sorghum bicolor L.), mung bean (Vigna radiata) and sago (Metroxylon sagu) noodles: Formulation and physical characterization. *Current Research in Nutrition and Food Science Journal*, *8*(1), 217-225.

Wheeler, E. L., & Ferrel, R. E. (1971). A method for phytic acid determination in wheat and wheat fractions. *Cereal chemistry*, *48*(3), 312-320.