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Physicochemical analysis and product development from malted and unmalted sorghum millet

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Abstract
Sorghum (*S. bicolor*) is a gluten-free fifth most important cereal crop in the world, which distribution is across the semi-arid and tropical regions of Africa and Asia. Sorghum is composed of various antinutrients like phytates which inhibit the absorption of essential nutrients by the body. It can be inactivated by various processing techniques such as soaking, germination, fermentation, malting etc. The malting process aids in the improvement of the organoleptic quality, enhancing the nutritional quality and inactivating the anti-nutritional factors of the grain and make suitable for the development of various food products. Hence, in the present study investigation of the proximate composition of unmalted and malted sorghum millet flour, the development of the Unmalted Sorghum Based Chapati Flour (USBCF) and Malted Sorghum Based Chapati Flour (MSBCF) with the incorporation of lentil and wheat flour was done, organoleptic evaluation of developed products and shelf life study namely Peroxide Value (PV) and Free Fatty Acid (FFA) content across the storage period of 6o days was also done. Results showed that the malting process significantly ($p<0.05$) increased the nutritional quality of sorghum. Chapati prepared from the developed USBCF and MSBCF was highly acceptable for consumption. In a shelf life study, it was found that both the developed product is desirable to consume for 60 days. This study reveals that sorghum flour can be used as a potential ingredient for the development of value-added food mix products with different processing techniques to raise the nutritional status of the masses and help to combat Protein Energy Malnutrition and reduce the food insecurity problem in our country.

Keywords: Sorghum, nutritional composition, organoleptic evaluation shelf life study

Introduction

Globally sorghum (*Sorghum bicolor*) is grown in 104 countries in Africa, Asia, Oceania and the Americas. Sorghum is the main source of macro and micronutrients for poor people, it is a widely consumed staple food in subtropical and semi-arid regions of Asia and Africa (Casa *et al.* 2005, Kumar Ashok *et al.* 2010) [8, 21]. Among cereals, only sorghum is a gluten-free grain used in food and has been characterized as a staple food for more than 500 million people in over 30 countries (FAO, 2012) [15]. Within the widely consumed energy-producing staple foods sorghum come after rice, wheat, maize, and potatoes (Dahlberg *et al.* 2012) [10].

Sorghum is composed of various anti-nutrients which inhibit the absorption of essential nutrients by the body. Processing treatments such as soaking, malting, baking, roasting and fermentation have been reported to inhibit anti-nutrients and ensure the nutritional availability of the grains (Khattab *et al*. 2009) [20]. Malting is a process in which grain is allowed to sprout at controlled conditions and then dried ata controlled temperature and time. It changes and alters the flavor, cooking properties and nutritional quality of foods. Malting of cereal grains and legumes increases the availability of minerals by breaking some anti-nutritional factors such as saponins and phytic acids. Malting also increases enzyme activities and helps in breakdown of macro substances into micro substances this in turn helps in easy digestion (Kumar *et al.* 2015) [34].

The phenomenal economic growth in India in recent decades has resulted in significant improvements in living conditions, as reflected in people's expanded choices of the food they eat. Lifestyle changes have also occurred due to other factors, including increased interest in better health. All of these developments have contributed to major shifts in food consumption patterns, people are expressing more preference towards healthier foods. In this context, millet especially sorghum is playing an increasingly important role as people rediscover its high nutritive value and health-enhancing features in an affordable and easily available market.

Hence, the present study has been undertaken to determine the difference in nutritional components of raw and malted sorghum, development and shelf life study of un-malted and malted sorghum-based chapati flour and organoleptic quality evaluation chapati from developed flour.

Materials and Method

Collection of samples: Sorghum grain was procured from the local market of Ranchi, Jharkhand.

Packaging materials

High density polyethylene (HDPE) virgin containers were used for storing all the fresh and processed ingredients.

Processing of raw sorghum into sorghum flour

Raw Sorghum
↓
Sorting and washing
↓
Draining
↓
Oven drying (6hr at 60 °C)
↓
Devegetation by hand abrasion
↓
Milling (Hammer mill machine)
↓
Sieving (100 mesh size)
↓
Un-malted Sorghum flour
↓
Stored in an air tight container

Processing of raw sorghum in to malted sorghum flour: Malting of raw sorghum was done by modified method of Sengev *et al*. (2012) [29]

Raw Sorghum
↓
Sorting and washing
↓
Soaking (12 hr at 30 °C; four times of water)
↓
Draining
↓
Dab in muslin cloth for Germination (72 hr at 30 °C)
↓
Washed and spread on bloating paper
↓
Oven drying (12 hr at 60 °C)
↓
Devegetation by hand abrasion
↓
Milling (Hammer mill machine)
↓
Sieving (100 mesh size)
↓
Malted Sorghum flour
↓
Stored in an air tight container

Proximate Analysis

The proximate analysis consists in determining the chemical components, including moisture content, crude protein, crude fat, crude fiber, total carbohydrate and reducing sugar. Protein value was analyzed by multiplying the kjeldahl nitrogen analysis by the factor 6.25. Crude fat is the extractable material of diethyl ether or petroleum ether and crude fiber is determined as an organic matter which is not solubilized by either hot dilute sulfuric acid or dilute sodium hydroxide solutions.

Moisture, crude protein, crude fat, and crude fibre: The moisture, crude protein, crude fat, and crude fibre content of the samples was determined following the A.O.A.C. (2000) [4] method.

Total Carbohydrate: The carbohydrate content was determined by difference, i.e., by subtracting the sum of the values (per 100 g) for moisture, crude fat, crude protein, total minerals and crude fibre from 100 (Gopalan *et al.* 2000) [17].

Development of malted and un-malted sorghum-based chapati flour

Collection of samples

Sorghum, Lentils and wheat were procured from the local market of Ranchi, Jharkhand, India. And its processing was done in the food processing lab of KVK, Ranchi. Unmalted and malted sorghum flour was prepared by a modified method by Sengev *et al*., (2012) [29].

Lentil and wheat grains were cleaned to remove the foreign particles, washed properly and dried in a hot air oven at 60˚C temperature for 6 hours, separately. Dried grains were processed into flours using a Hammer milling machine and sieved through 60 mesh sizes separately.

Development of Un-Malted Sorghum Based Chapati Flour (USBCF)

The development of un-malted sorghum-based chapati flour was done using a modified method of Tangariya *et al.*, 2018 [30]. Malted sorghum flour, lentil flour and wheat flour were mixed at 65%, 20 % and 15 % respectively (Table 1).

Table 1: List of ingredients used for the development of Unmalted and malted sorghum based chapati flour

Sl. No	Un-malted Sorghum-Based Chapati Flour (USBCF)		Malted Sorghum-Based Chapati Flour (MSBCF)	
	Ingredients	**Ratio**	**Ingredients**	**Ratio**
1	Malted sorghum	65	Un-malted sorghum	65
2	Lentil flour	20	Lentil flour	20
3	Wheat flour	15	Wheat flour	15

Development of Malted Sorghum-Based Chapati Flour (MSBCF)

The development of Un malted sorghum-based chapati flour was done using a modified method of Tangariya *et al.*, 2018 [30]. Sorghum flour, Lentil flour and Wheat Flour were mixed at 65%, 20 % and 15 % respectively (Table 1).

Preparation of malted and unmalted sorghum-based chapati

Chapati was prepared following the guidelines outlined by the AACC method (Anon., 1990). The chapati was prepared using the developed chapati flour based on both unmalted and malted sorghum flour, lentil flour and whole wheat flour. For roti's 120 ml of water and 100 gm of flour were used in each preparation. and then kneaded nicely to make soft dough of uniform consistency. The dough was well kneaded, divided into small balls, flattened on a hard wooden or metal surface sprinkled with a small quantity of flour and baked on both sides in a hot pan. The prepared rotis were subjected to organoleptic quality evaluation.

Sensory evaluation of malted and unmalted sorghum-based chapati

Chapati was prepared to evaluate the colour, flavour, texture, appearance, taste, and overall acceptability and was presented simultaneously at room temperature along with the sensory scorecard. The sessions for testing were held in a well-lighted, airy and cool laboratory by a semi-trained panel of 12 judges from KVK, Ranchi, on a 9-point hedonic scale (9- like extremely to 1- dislike extremely) and sensory score card method (Amerine *et al.*, 1965) [3].

Shelf life studies of the developed malted and unmalted sorghum-based chapati flour

Shelf life is the period of time in which food is kept under certain conditions of storage maintain its optimum quality and safety. Shelf life begins from the moment in which food is produced and depends on many factors such as the type of raw ingredients, the production process, the type of packaging material and storage conditions. In the present study the shelf life studies were carried out by storing the developed malted and unmalted sorghum-based chapati flour High Polyethylene bag at room temperature (20 to 35 °C) for a period of 60 days and free fatty acid and peroxide values were analyzed at regular intervals of 0, 15 and 30, 45 and 60 days using the standard method of AOAC, 2000 [4].

Results and Discussion

Impact of malting on the nutrient composition of malted and unmalted sorghum flour

The impact of malting on the nutrient composition of *Sorghum* flour is presented in Table 2.

Table 2: Impact of Malting on the nutrient composition of Sorghumflour.

Ingredients	Nutrients (per 100 g of sample in dry weight basis)					
	Moisture (g)	Total carbohydrate (g)	Crude protein (g)	Crude fat (g)	Reducing sugar(g)	Crude fibre (g)
Raw sorghum	8.78±0.32[a]	71.64±3.19[a]	11.29±0.20[a]	3.22±0.5[a]	4.43±0.62[a]	3.76±0.3
Malted sorghum	6.95±0.14[b]	73.5±0.27[b]	11.87±0.48[b]	5.81±1.08[b]	11.20±0.14[b]	5.90±0.38

Values are expressed in mean ± SD (Standard Deviation)

****** Significant at $p<0.05$, NS= Non significant

Moisture: The moisture content of malted sorghum flour was significantly ($p<0.05$) lower (8.78±0.32 g/100 g) compared to raw sorghum flour (6.95±0.14 g/100 g). The low moisture content may be due to the inactivation of some enzymes during malting. The germination process activates enzyme systems at a large level which is responsible for the hydrolysation and solubilisation of food reserves, subsequent drying after germination in order to prevent the growth of microorganisms and increase durability reduce the moisture level of grains from about 40% to 50% down to least 4% to 6% (Adhikari N. and Acharya DR 2015; Phattanakulkaewmorie N. *et al.* 2011) [15, 27]. The decreased moisture level helps to reduce the losses during the storage period and improve the shelf life of the grain (Agoreyo *et al.* 2011) [2].

Protein: There was a significant difference found in the crude protein content of the raw and malted sorghum flour. The crude protein of raw sorghum was 11.29±0.20 g /100 g increased significantly and malted sorghum flour was 11.87±0.48 g /100 g after the process of germination and malting. The process of malting significantly increased ($p<0.05$) the protein content probably due to an increase in the free amino acids resulting from the germination of the grains (Nkama *et al.* 2015) [24]. The decreased moisture level helps in minimizing deterioration during storage which in turn increases the shelf life of the product and also increases the concentration of the nutrients and may make some nutrients more available (Hussen *et al.* 2021) [18]. The apparent increase in protein content could evenbe attributed to a loss in dry matter, particularly carbohydrates through respiration and the synthesis of some amino acids during germination (Uppal and Bains 2012) [33]. This reawakening of protein synthesis upon imbibitions leads toan increase in protein content in germinated sorghum seed (Vijay *et al.* 2015) [34].

Total Carbohydrate and Reducing Sugar: Total carbohydrate content of sorghum flour increased significantly after the malting from an initial value of 71.64±3.19 g/100 g to 73.5±0.27±0.27 g/100 g respectively. The malting process activates the hydrolytic and amylolytic enzymes such as α-amylase which breakdown the carbohydrates into simple sugars thereby improving digestibility as a result of the degradation of starch to provide energy for growing the embryo within the seeds, so increases in simple sugar (Oghbaei & Prakash, 2016; Zhang *et al.*, 2015; El-Tinay *et al.* 1979) [25, 35, 13].

Reducing sugar of the malted sample increased significantly ($p\leq0.05$) from 4.43±0.62 to 11.20±0.14. This significant increase could be due to the activity of enzymes. Amylolytic enzymes may have been breakdown the carbohydrates into simple sugars (Elkhier *et al.* 2008) [12].

Crude fat: The crude fat content of sorghum flour increased after malting from an initial value of 3.22±0.5 g/100 g to 5.81±1.08/100 g respectively. Inyang and Zakari, 2008 [19] reported that the germination of seeds increases the activity of lipolytic enzymes resulting in fat availability.

Crude fibre: Table. 2 depicts a significant increase in crude fibre in malted sorghum flour from an initial value of 3.76±0.3 g/100 g to 5.90±0.38 g/100 g respectively. This increase could be attributed to the synthesis of structural carbohydrates and bran matter such as cellulose, and hemicellulose and due to the building of dry matter during the germination process (Banusha and Vasantharuba 2013) [7].

Development of malted and un-malted sorghum-based chapati flour

Protein-energy malnutrition is a serious public health problem in the Jharkhand state of India, as per National Family Health Survey, 2019-21, 6.7% of children under the age of 5 years are severely acute malnourished (SAM) in Jharkhand state (NFHS 5, 2019-21). Cereals and millets are the staple food of the Jharkhand population, contributing significant amounts of energy, protein, phytonutrients but limiting in essential amino acid lysine, and have adequate amount of sulfure amino acid in contrast legume proteins are a rich source of lysine but also lacking in sulphur-containing amino acids (Temba *et al.*, 2016) [31]. Therefore, incorporation of lentil with cereals and millets has been advocated as a way of combating Protein Energy Malnutrition (Mohammed, *et al.*, 2011) [22]. Wheat sorghum and legume is recommended as a good ingredient for developments of cereal based product for children (FAO 1979) [14].

Sensory evaluation of malted and unmalted sorghum-based chapati

Sensory evaluation is a valuable tool for solving problems involving food acceptability. It is useful for product development and market research (Larmond, 1977) [36] Academic research on foods and materials, their properties and processing often require sensory tests. In the present study, chapattis were prepared using unmalted and malted sorghum-based chapati flour separately for the sensory quality evaluation. It was evaluated using the Score-Card method for colour, flavour, texture, appearance, taste, and overall acceptability. The results showed that malted sorghum-based chapati flour chapatti scored average values of 7.9, 8.5, 8.2, 8.5, 7.3 and 8.4 whereas malted sorghum-based chapati flour chapatti scored 7.0, 8.1, 7.8, 8.0, 7.1 and 8.0. out of 10 for colour, flavour, texture, appearance, taste, and overall acceptability respectively. Both the chapati was highly acceptable. Significant difference was observed among all the sensory parameters for both the chapattis at $p \leq 0.05$ level of significance (Table 3).

Table 3: Sensory evaluations of malted and unmalted sorghum-based chapatti

Sl. No.	Parameters	Malted sorghum-based chapati	Unmalted sorghum-based chapati
1	Colour	7.9* ±0.17	7.0*±0.13
2	Flavour	8.5* ±0.15	8.1*±0.11
3	Texture	8.2* ±0.16	7.8*±0.14
4	Appearance	8.5* ±0.13	8.0*±0.12
5	Taste	7.3*±0.14	7.1*±0.16
6	Overall acceptability	8.4*±0.14	8.0*±0.09

All values are average of 3 observations ± standard deviation, *= $p \leq 0.05$

Shelf life studies of the developed Un Malted Sorghum-Based Chapati Flour (USBCF) and Malted Sorghum-Based Chapati Flour (MSBCF)

Peroxide value and free fatty acid are indicators of rancidity. These parameters help determine the keeping quality of the developed product (Divakar, and Prakash, 2021) [11].

The mean peroxide value of developed unmalted and malted sorghum-based chapati flour are presented in Fig.1. Peroxide value increased with an increase in storage days, it varied from 3.2 to 7.9.chapati prepared from malted sorghum-based flour increased from 3.6 to 8.2 mmoles kg/fat respectively. Similar increased peroxide values from 0.59 to 7.4 mmol/kg fat were recorded in a shelf-life study of homemade extruded products formulated using malted millet-based composite flour (Gautam and Gupta, 2017) [16]. Baby Latha *et al.*, 2014 [6] also reported gradually increase in peroxide value from 2.24 to 9.02 meq. O_2/kg in cereal based instant products. However, the peroxide values of the present study were within the standard specified by PFA, 1991 i.e 10 milli moles per kg fat.

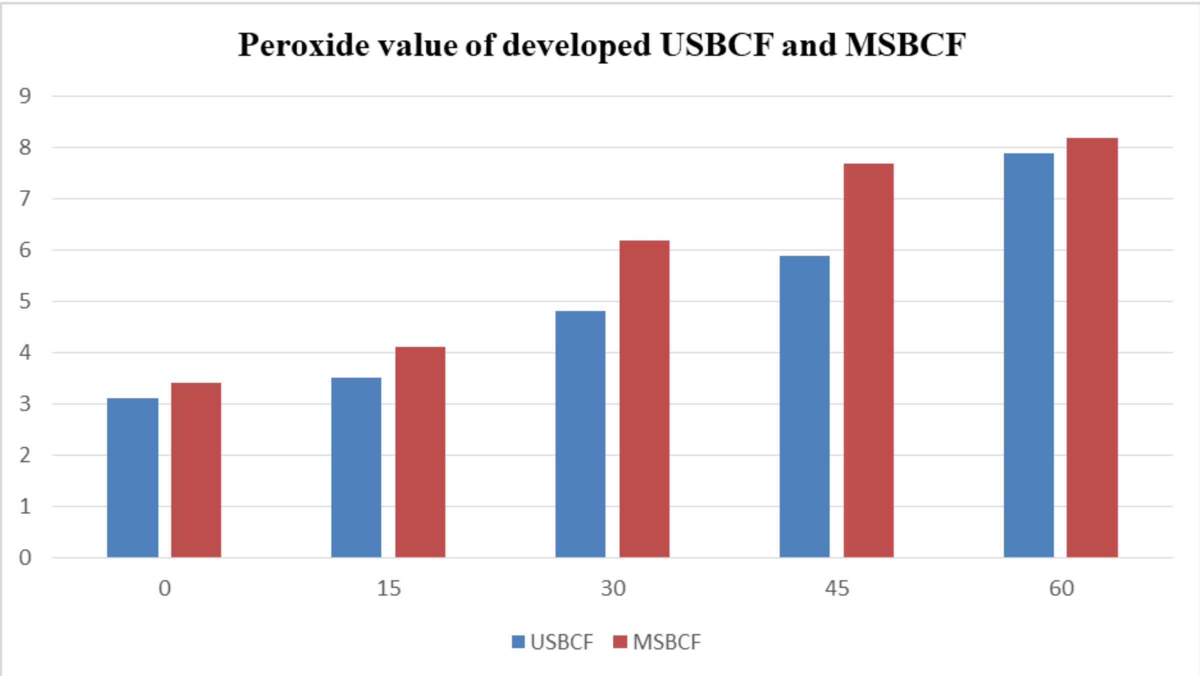

Fig 1: Peroxide value of developed USBCF and MSBCF (g/100 g of samples) across 60 days of storage period

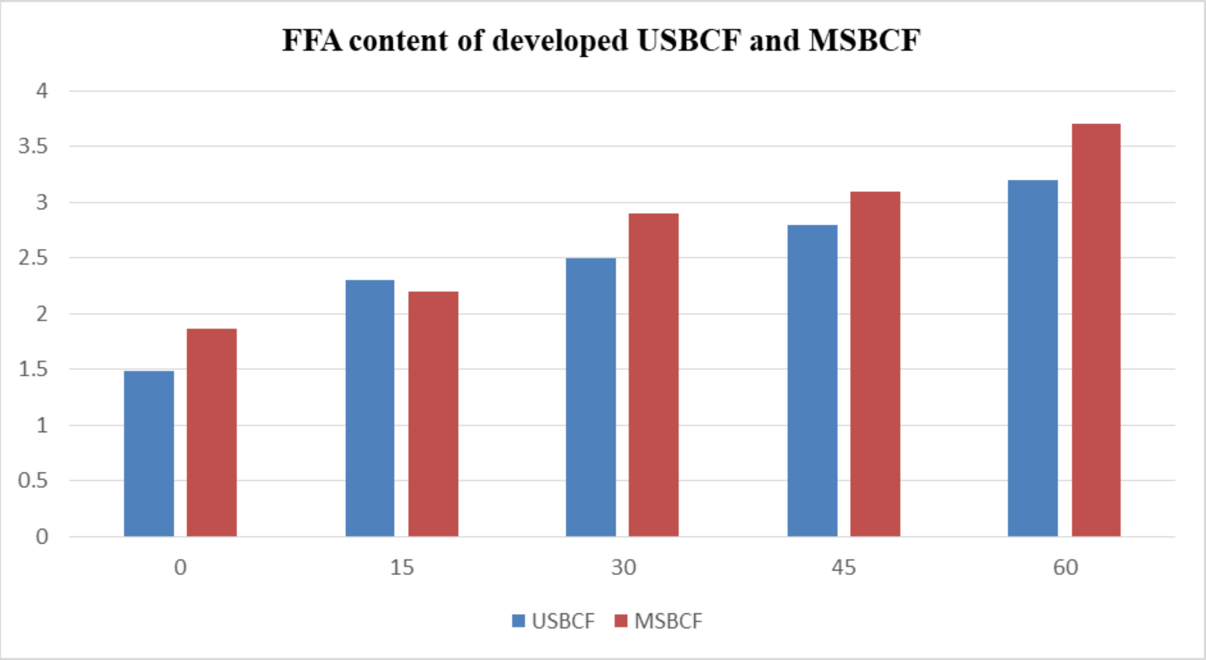

Fig 2: Free Fatty Acid (FFA) of developed USBCF and MSBCF (g/100 g of samples) across 60 days of storage period

The mean increase in FFA content of developed unmalted and malted sorghum-based chapati flour is presented in Fig. 2. It was observed that the FFA content increased with an increase in storage days, it varied from 1.49 to 3.2 g/100 g and chapati prepared from malted sorghum based chapati flour is increased from 1.87 to 3.7 g/100 g respectively. Similar with the present study in 2009, Tiwari *et al.* reported to increase free fatty acids linearly with the storage period in cereal based processed foods. Increased FFA content was higher in MSBCF than USBCF this may be due to the activity of the malt lipase enzyme which would not have been completely inactivated during processing (Pradeep *et al.*, 2014). However, the free fatty acid was within the permissible limit by Codex Alimentarious, 2005 i.e 4 g/100 g of sample.

Conclusion

This study reveals that the malting process significantly improves the nutritional content of sorghum millet. Both unmalted and malted sorghum, with lentil and wheat flour, can be used to develop chapati flour mix which is suitable for children, helps to combat Protein Energy Malnutrition and reduce the food insecurity problem in our country. The production methodology can be easily adopted at home and onan industrial scale using locally available cereal, millets and pulses. Sensory analysis revealed that chapati prepared from Un Malted Sorghum-Based Chapati Flour (USBCF) and Malted Sorghum-Based Chapati Flour (MSBCF) exhibited good overall acceptability by the consumer, and storage studies revealed that the developed USBCF and MSBCF is desirable to consume for 60 days. This indicates ample possibilities for the value-addition of sorghum, thereby ensuring food security amongst the poor.

Reference

1. Adhikari N, Acharya DR. Effect of incorporation of malted sorghum flour on quality of biscuit. Sunsari Technical College Journal. 2015;2(1):33-37.
2. Agoreyo BO, Akpiroroh O, Orukpe OA, Osaweren OR, Owabor CN. The effects of various drying methods on the nutritional composition of Musa paradisiaca, *Dioscorea rotundata* and *Colocasia esculenta*. Asian Journal of Biochemistry. 2011;6(6):458-464.
3. Amerine MA, Pangborn RM, Roseller EB. Principles of sensory evaluation of foods, Academic Press, New York, 1965, 265.
4. AOAC. Official Methods of Analysis, Association of Official Analytical Chemists, 16th ed. Washington DC; c2000.
5. AOAC. Association of Official Analytical Chemists. 17th Edn., AOAC, Washington, DC; c2000. p. 21-447.
6. Baby Latha R, Debnath S, Sarmandal CV, Hemavathy J, Khatoon S, Gopala Krishna AG, *et al*. Shelf-life study of Indian traditional food based nutraceutical (oryzanol) enriched instant mixes Bhath-OZ and Upma-OZ. Journal of food science and technology. 2014;51(1):124-129. https://doi.org/10.1007/s13197-011-0460-7
7. Banusha S, Vasantharuba S. Effect of malting on nutritional contents of finger millet and mung bean. American-Eurasian Journal of Agriculture and Environmental Science, 2013;13(12):1642-1646.
8. Casa AM, Mitchell SE, Hamblin MT, Sun H, Bowers JE, Paterson AH, *et al*. Diversity and selection in sorghum: simultaneous analyses using simple sequence repeats. = Theoretical and applied genetics, 2005;111(1):23-30.
9. Codex Alimentarious, All standard; c2005. ao.org/fao-who-codexalimentarius/codex- texts/all-standards/en/
10. Dahlberg J, Berenji J, Sikora V, Latković D. Assessing sorghum [*Sorghum bicolor* (L) Moench] germplasm for new traits: food, fuels & unique uses. Maydica. 2012, 56(2).
11. Divakar SA, Prakash J. Quality parameters and shelf stability of millet based 'Khakhra'; c2021.
12. Elkhier MKS, Hamid AO. Effect of malting on the chemical constituents, antinutrition factors and ash composition of two sorghum cultivars (feterita and tabat) grown in Sudan. Research Journal of Agriculture and Biological Sciences. 2008;4(5):500-504.
13. El-Tinay AH, Gadir AA, El Hidai M. Sorghum fermented

kisra bread. 1. Nutritive value of kisra. Journal of the Science of Food and Agriculture. 1979;30(9):859-863.
14. FAO. Human nutrition in tropical Africa. Food and Agriculture Organization of the United Nations. Rome, Italy; c1979.
15. FAO U. Food outlook: Global market analysis. Rome, Italy; c2012.
16. Gautam L, Gupta A. Study on Storage Stability of Different Homemade Extruded Foods Products Prepared by Using Malted Composite Flour. Nat Prod Chem Res 2017;5:264. doi: 10.4172/2329-6836.1000264
17. Gopalan C, Ramasastri BV, Balasubramanian SC. Nutritive value of Indian foods. National institute of nutrition (icmr), Hyderabad; c2000. p. 47.
18. Hussen A. Impact of grain storage method on sorghum grain quality in Ethiopia: A review. Journal of Current Research in Food Science. 2021;2(1):40-45.
19. Inyang CU, Zakari UM. Effect of germination and fermentation of pearl millet on proximate, chemichal and sensory properties of instant Fura - A Nigerian cereal food. Pak. J. Nutr. 2008;7(1):9-12.
20. Khattab RY, Arntfield SD. Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional factors. LWT-Food Science and Technology. 2009;42(6):1113-1118.
21. Kumar AA, Reddy BV, Sahrawat KL, Ramaiah B. Combating micronutrient malnutrition: Identification of commercial sorghum cultivars with high grain iron and zinc. Journal of SAT Agricultural Research, 2010, 8.
22. Mohammed MAE, Makki HMM. Production of cereal-based infant food from sorghum [Sorghum bicolor (L) Moench] and pigeon pea (Cajanus cajan). Pakistan Journal of Nutrition; c2011.
23. National Family Health Survey (NFHS-5), 2019-21, International Institute for Population Sciences (IIPS) and ICF; c2021.
24. Nkama I, Gbenyi DI, Hamaker BR. Effects of Malting and Roasting of Millet and Sorghum on Protein Digestibility, Mineral Availability, Soluble Sugar Composition and Consumer Acceptability of Dakuwa; c2015.
25. Oghbaei M, Prakash J. Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review. Cogent Food & Agriculture. 2016;2(1):1136015.
26. PFA, Prevention of Food adulteration; c1991. https://fssai.gov.in/upload/uploadfiles/files/ pfa-acts-and-rules.pdf
27. Phattanakulkaewmorie N, Paseephol T, Moongngarm A. Chemical compositions and physico-chemical properties of malted sorghum flour and characteristics of gluten free bread. World Academy of Science, Engineering and Technology, 2011;5(7):532-538.
28. Pradeep PM, Dharmaraj U, Sathyendra Rao BV, Senthil A, Vijayalakshmi NS, Malleshi NG, *et al*. Formulation and nutritional evaluation of multigrain ready-to-eat snack mix from minor cereals. Journal of food science and technology, 2014;51(12):3812-3820.
29. Sengev IA, Akpapunam MA, Ingbian EK. Physicochemical and sensory properties of instant Kunun-Zaki flour blends from sorghum and mango mesocarp flours. Nigerian Food Journal, 2012;30(2):8-16.
30. Tangariya P, Sahoo A, Awasthi P, Pandey A. Quality analysis of composite flour and its effectiveness for Chapatti formulation. Journal of Pharmacognosy and Phytochemistry, 2018;7(4):1013-1019.
31. Temba MC, Njobeh PB, Adebo OA, Olugbile AO, Kayitesi E. The role of compositing cereals with legumes to alleviate protein energy malnutrition in Africa. International journal of food science & technology. 2016;51(3):543-554.
32. Tiwari U, Gunasekaran M, Jaganmohan R, Alagusundaram K, Tiwari BK. Quality characteristic and shelf life studies of deep fried snack prepared from Rice broken and legumes by–products. Food and Bioprocess Technol; c2009. doi:10-1007/S11947-009-02196 May 2009.
33. Uppal V, Bains K. Effect of germination periods and hydrothermal treatments on in vitro protein and starch digestibility of germinated legumes. Journal of food science and technology. 2012;49(2):184-191.
34. Vijaya Kumar B, Sivudu SN, Reddy OV. Studies on physico-chemical analysis of probioticated malted cereals with Lactobacillus casei and their possible applications. Int. J Sci. Eng. Res. 2015;6(2):95-99.
35. Zhang G, Xu Z, Gao Y, Huang X, Zou Y, Yang T. Effects of germination on the nutritional properties, phenolic profiles, and antioxidant activities of buckwheat. Journal of Food Science. 2015;80(5):H1111-H1119.
36. Larmond E. Laboratory methods for sensory evaluation of food. Research Branch, Canada Dept. of Agriculture; c1977.