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# Development of sorghum rich multigrain flour for preparation of roti

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**Abstract**
India is a land of millets. Millets are the most nutritious grains. India contribute to worlds 35% production but the consumption of millet and their products is limited. As a result of this women and young ones are suffering from malnutrion. To solve this, an attempt was made to produce sorghum rich multigrain flour to attain a complete nutritional balance. Four millets namely, sorghum, pearl millet, finger millet, and foxtail millets were analyzed for primary processing followed by milling. The flours were mixed in a given combination and sorghum rich multigrain flour was prepared. Chemical analysis of flours indicates that (T1, T2, T3 and T4) was superior than control (Jowar flour). The rotis were prepared out of them. Sensory evaluation results that, T4 multigrain roti had highest acceptability compared to control (Jowar roti). Hence from the present study, the sorghum rich multigrain roti (T4) was superior than control.

**Keywords:** sorghum, millets, multigrain flour, millet roti, chemical and sensory evaluation

## Introduction
Malnutrition including undernutrition and overnutrition is one of the important factor of child mortality (MoPHS, 2011) [17]. Malnutrition is the outcome of inadequate food intake among children, the elderly as well as expectant and lactating mothers (Mohajan, 2014) [16]. The people from urban poor and semiarid areas lack a variety of foods due to low purchasing power, high reliance on rice and wheat which are comparable or less superior to millets (Ragaee *et al*. 2006) [21]. Therefore, the development of nutritious millet flours using cheap techniques may greatly improve the nutritional status of these vulnerable groups.

Millets are tiny in size, round in shape and minor cereals of the small seeded-grass family (*Poaceae*). Millets are cultivated from antient time for food and fodder purpose. On an average 90% of the world's millet production is being used in the developing countries of the world. India is the largest producer of millet with 38.6% of the world's millet being grown. Millets are known to be more tolerant than other cereals over a wide range of climatic conditions. Sorghum (*Sorghum bicolor* L. Moench) is the king of cereals and is one of the important food crops in dry lands of tropical Africa, India and China (Shobha *et al*., 2008) [28]. India ranks second in the world for sorghum production and first with respect to many regionally important crops like millets and pseudo-cereals. More than 35% of sorghum is grown directly for human consumption. The rest is used primarily for animal feed, alcohol and industrial products (Joseph and Lloyd, 2004). Millets contain 60-70% carbohydrates, 7-11% proteins, 1.5-5% fat, and 2-7% crude fibre and are also rich in vitamins and minerals. Millet proteins are good source of essential amino acids except lysine and threonine but are relatively high in sulphur containing amino acids methionine and cysteine (Singh, *et, al*., 2012) [25]. Millets are full of nutraceutical properties that are helpful to prevent many health problems such as lowering blood pressure, risk of heart disease, prevention of cancer and cardiovascular diseases, decreasing tumour cases etc. The most important health benefits are increasing the time span of gastric emptying, provides roughage to gastro intestine (Gupta *et, al*., 2012) [11]. Millet are alkaline in nature. Alkaline diet is often recommended to achieve optimal health. It helps to maintain a healthy pH balance in the body, crucial to prevent illnesses. Celiac Disease is a chronic entheropathy produced by gluten intolerance, which causes atrophy of intestinal villi, mal-absorption and clinical symptoms that can appear in both childhood and adulthood and it can be controlled by consumption of gluten free foods like sorghum and other millet based products (Osella *et al.*, 2014) [14]. Most of the studies have mainly focussed on millet products from composite flour (Anju and Sarita 2010) [3].

The primary and secondary processing practices like cleaning, sorting, dehulling and milling of Sorghum and millets improves the quality of foods made from them. It may be possible to select grain types with improved milling quality that will make these crops competitive with other cereals in terms of utilization. Wheat milling technology with suitable modification can be effectively used for grinding millet grains.

Sorghum *roti*, the important product of flour, is popular in villages and small towns of India as main part of meal and accompany gravy (meat and vegetable curries). It is round, flat, unleavened bread, known by various names in the different languages of India: *chapati* (Hindi), *bhakri* (Marathi), *rotla* (Gujarati) and *rotte* (Telugu), etc. (Subramanian and Jambunathan, 1981) [30]. Typically *bhakri* is accompanied by various curries, chutney (*thecha* – a thick paste of really hot green or red chilies) and raw onion (Murty and Subramanian, 1981) [30]. Sorghum flour is gluten-free, it is very tough to spread the dough without breaking the shape. It is the matter of experience. Sorghum roti consists of only sorghum flour, warm water and tosting on fire, no leavening agents, and oil/ghee are added. Considering positiveness of millet grains, an attempt was made to produce composite flour using four millets, namely, Sorghum, Finger millet, Pearl millet and Foxtail millet. This compo site flour could be further utilized for production of jowar rich multigrain roti.

## Materials and Methods

All the millet grains namely Sorghum of M35-1 (Maladandi) cultivar, pearl millet, finger millet and foxtail millet were made available from local market of Aurangabad, MS, India. The sorghum was analyzed for moisture, protein, ash, crude fibre and total carbohydrates as per the procedure suggested by Ranganna (1986) [24]. All the grains were cleaned, sorted manually using different sieves and winnowing technique. Millet grains were milled in Brabender quandrumat junior (AACCI 26-50.01 method) and screened through suitable mesh sizes.

### Chemical analysis of millet flour

Moisture content of the samples were determined by hot-air oven method (AOAC 2002) [5]. Protein content of the samples was determined by Kjeldhal method (AOAC, 2002) [5]. Soxhlet apparatus (SOXPLUS – SCS4 was used to determine the fat content of sorghum kernels. Dietary fibers were determined using AOAC 2002 [5]. Total starch content was analyzed by measuring the absorbance at 510 nm (UV-visible spectrophotometer). Ca, P and Fe were amalyzed using atomic absorbance spectrophotometer (AOAC 1990) [4]. The results obtained are the mean of three determinations.

### Processing of millet grains

First step of millet processing is cleaning to remove foreign materials such as stones, chaffs, stalks etc. then passed through abrasive or friction mills to separate out glumes (non-edible cellulosic tissue) and then pulverized. Due to difference in the grain morphology between millets and other cereals, the efforts to decorticate millet by known cereal milling methodologies including abrasion, friction mills or other dehulling techniques have not been successful to date (Shobana and Malleshi 2007) [27]. Decorticatication improves sensory quality and bioavailability of nutrients also removes the germ and pericarp reducing the anti-nutrients but at the same time resulting in a decrease of fibre, lipid, minerals and phenolic acids (Shobana and Malleshi 2007) [27]. Centrifugal sheller can also be used to dehull/decorticate the small millets (Amir Gull, et,al., 2016) [2]. Wheat milling technology with suitable modification can be effectively used for grinding millet grains. Milling of millet is done traditionally by hand operated grain mill especially in rural areas for household uses. Now a dats it is pulverized in mechanical stone mill or iron disc or emery coated disc mills. It was observed that steaming the millet at elevated pressure and temperature increased the milling yield, and steaming beyond the threshold level showed a detrimental effect on the yield of head grains (Dharmaraj, et al., 2011) [9]. The bran-rich fraction, a by-product of flour-milling contained higher ash content (Suma and Urooj 2011a) [31]. Sieving decreased the content of both nutrients and antinutrients in whole millet flour but increased their digestibility/bioaccessibility (Oghbaei and Prakash 2012) [19]. It leads to decrease the nutritive value and potential health benefits of grains, thus using whole grains flour in human nutrition is suggested more beneficial in health promotion. Milling operation was done with Brabender Quadrumat Jr. Laboratory mill. A seperate 60 mesh U.S. standard siece (strand shaker) was used to give a flour of approximately 60% extraction (Ebler and Walker 1983) [10]

### Preparation of multigrain flour with different millet combinations

The data in Table 1 shows recipe for preparation of multigrain flour with different levels of Sorghum and other millets. Four recipe combinations (T1, T2, T3 and T4) were made to standardize the multigrain flours for the preparation of *roti*. The sample T1 consists of 85g of sorghum flour, 5g of each pearl millet flour, Finger millet flour and foxtail millet flour out of 100 g. The sample T2 consists of 70g of sorghum flour, 10g of each pearl millet flour, Finger millet flour and foxtail millet flour. The sample T3 consists of 55g of sorghum flour, 15g of each pearl millet flour, Finger millet flour and foxtail millet flour. The sample T4 consists of 40g of sorghum flour, 20g of each pearl millet flour, Finger millet flour and foxtail millet flour. All the measured flours were mixed together with hand uniformly as the improper mixing results in uneven quality of final product.

**Table 1:** Chemical composition of individual millet flour

| Grains | Moisture (g) | Protein (g) | Fat (g) | Minerals (g) | Crude fibre (g) | Carbohydrates (g) | Calcium (mg) | Phosphorus (mg) | Iron (mg) | Energy (Kcal) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sorghum | 11.70±0.10 | 10.20±0.12 | 2.10±0.12 | 1.80±0.11 | 1.80±0.10 | 72.00 ±0.36 | 27.00±0.11 | 220.00±0.53 | 4.10±0.11 | 355.00±0.28 |
| Pearl millet | 12.10±0.20 | 11.10±0.21 | 5.20±0.11 | 2.60±0.16 | 1.40±0.12 | 67.00±0.23 | 41.00±0.40 | 290.00±0.82 | 8.00±0.13 | 361.00±0.34 |
| Finger millet | 13.90±0.20 | 7.90±0.33 | 1.30±0.14 | 2.70±0.18 | 3.60±0.11 | 72.00±0.15 | 344.000.33± | 280.00±0.30 | 3.90±0.15 | 330.00±0.44 |
| Foxtail millet | 12.80±0.10 | 8.10±0.25 | 1.40±0.16 | 2.50±0.13 | 6.90±0.16 | 65.00±0.21 | 29.00±0.49 | 189.00±0.46 | 0.80±0.23 | 310.00±0.18 |

Results are mean of 3 determinations

**Roti making**

Approximately 100 g flour was mixed with sufficient quantity of warm water (45$^0$C) and kneaded by hand on a smooth wooden board into dough (Subramanian and Jambunathan 1980) [29]. The dough of uniform consistency was divided into small balls, flattened into a 6 cm diameter disc and pressed by hand into circular disc. This disc was placed on wooden board and flattened by left hand stokes into a thin circle sprinkled with a small quantity of flour to avoid stickiness. The diameter of *roti* was 20 cm and 3 mm thickness. This *roti* was placed on a hot concave hot iron pan. Small quantity of water was sprinkled on top of the *roti* when the underside is cooked (40 seconds) then *roti* was turned over. The *roti* was removed from the pan after a minute and placed near the fire, with the unmoistened side exposed to limited heat from the fire that completely puffs the *roti* (Shobha *et al.,* 2008) [28]. The prepared *rotis* were cooled and sensory evaluation was done.

**Sensory evaluation of *Roti***

A good *roti* should be smooth, soft, and slightly sweet with characteristic sorghum aroma. Quality of *roti* influences by grain, flour paritcle size, and dough properties. For organoleptic quality test of the sorghum *roti*, the trained panelists (10 Number) were asked to evaluate taste, texture, colour, aroma, mouthfeel and overall acceptability of *roties* served immediate after roti making. Finally an average of score obtained from them was considered for the evaluation of each test entry. Nine points hedonic scale were used for the various organoleptic characteristics (Amerine *et al*. 1980) [1] as the following: 9 = like extremely to 1= dislike extremely.

**Results and Discussion**

It was observed that sorghum flour M 35-1 (*Maldhandi*) were white pearly and very bold. This sorghum cultivar is known for its good quality of *roti* (Chavan *et al.* 2009). The proximate analysis of the sorghum flour (Table 2) showed that it is a rich source of carbohydrate (72±0.36%), protein (10.20±0.12%), crude fiber (1.80±0.10%), fat (2.10±0.12%) and total minerals (1.80±0.11%). Shobha *et al.,* 2008; Unhale, *et, al.*, 2012 [28] had studied different sorghum cultivars and found similar results. Milling and heat treatment during *chapati* (An unleavened bread) loweres polyphenols and phytic acid and improves protein digestibility and starch digestibility to a significant extent (Chowdhury and Punia 1997). Pearl millet flour observed highest proteins (11.10±0.21%) and fat (5.20±0.11) and thus yields more energy (361.00±0.34Kcal) whereas lowest crude fibers (1.40±0.12%) among all the millet flours taken for analysis. It is richest source of phosphorus (290.00±0.82mg/100g) and iron (8.00±0.13mg/100g). The moisture, minerals and calcium content of finger millet was found highest (13.90±0.20%), (2.70±0.18%) and (344.00±0.30mg/100g) respectively whereas lowest protein (7.90±0.33% and fat (1.30±0.14%) was observed. These values were compared with the results of Chethan and Malleshi (2007) [7] and found at par. The values of protein, fat, mineral content for foxtail millet observed were (8.10±0.25%), (1.40±0.16%) and (2.50±0.13%) respectively. The lowest values were observed for phosphorus, iron and total energy, (189.00±0.46%), (0.80±0.23%) and (310.00±0.18%) respectively. On an average the proximate composition of millets was found superior to wheat, maize and rice with regard to dietary fiber, calcium and few micronutrients. The seed coat of this millet is rich source of phenolic compounds, minerals and dietary fiber (Shobana, *et al*, 2009) [27].

**Table 2:** Standardization of recipe for Multigrain flour with different compositions of millets for the preparation of multigrain *roti*

| Sample no | Sorghum flour (gm) | Pearl millet flour (gm) | Finger millet flour (gm) | Foxtail millet flour(gm) |
|---|---|---|---|---|
| T1 | 85 | 5 | 5 | 5 |
| T2 | 70 | 10 | 10 | 10 |
| T3 | 55 | 15 | 15 | 15 |
| T4 | 40 | 20 | 20 | 20 |
| Control | 100 | - | - | - |

The data dipicted in (Table 3) indicates that the highest moisture content was observed in T4 sample (12.44±0.04%). The protein content of control sample (sorghum flour) was slightly high than that of T1 sample. Sample T4 was found highest source of minerals (2.28±0.09%), crude fibres (3.10±0.32%), calcium (93.60±3.23mg/100g), Phosphorus (239.80±4.22mg/100g) and Iron (4.18±0.12mg/100g). Hence it could be concluded from the above findings that, sample T4 was found nutritionally superior among other samples and control.

**Table 3:** Chemical analysis of multigrain flours with different compositions of millet flours

| Sample no. | Moisture (g) | Protein (g) | Fat (g) | Minerals (g) | Crude fibre (g) | Carbohydrates (g) | Ca (mg) | Phosphorus (mg) | Iron (mg) | Energy (Kcal) |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 11.89±0.02 | 10.02±0.12 | 2.18±0.10 | 1.92±0.09 | 2.12±0.11 | 71.40±0.59 | 43.65±2.00 | 224.95±2.00 | 4.12±0.01 | 351.80±0.21 |
| T2 | 11.93±0.01 | 9.85±0.23 | 2.26±0.11 | 2.04±0.10 | 2.45±0.12 | 70.80±0.38 | 60.30±1.00 | 229.90±1.35 | 4.14±0.01 | 348.60±0.33 |
| T3 | 12.26±0.03 | 9.69±0.13 | 2.34±0.13 | 2.16±0.08 | 2.78±0.14 | 69.48±0.44 | 76.91±1.98 | 234.80±2.58 | 4.17±0.02 | 345.40±0.18 |
| T4 | 12.44±0.04 | 9.50±0.22 | 2.42±0.12 | 2.28±0.09 | 3.10±0.32 | 69.60±0.37 | 93.60±3.23 | 239.80±4.22 | 4.18±0.12 | 342.20±0.65 |
| Cotrol | 11.7±0.02 | 10.2±0.32 | 2.10±0.10 | 1.8±0.10 | 1.80±0.12 | 72.00±0.75 | 27.00±2.16 | 220.00±2.38 | 4.10±0.02 | 355.00±0.26 |

Results are mean of 3 determinations

***Sensory evaluation of sorghum* roti**

For organoleptic quality test of the sorghum *roti*, the trained panelists (10 Number) were asked to evaluate taste, texture, colour, aroma, mouthfeel and overall acceptability. *Roti* samples were served to the trained panel members with traditional green chilli paste (Thecha) (Amerine *et al*., 1980) [1]. Colour of the roti becomes dark as the sorghum content of multigrain flour decreases (Table 4). The scores for aroma and mouthfeel increases as the percentage of millets increases in the sample. The texture of the multigrain samples was corelated with the control rotis as the rotis were served immediately after preparation. Hence it can be concluded from the sensory evaluation of sorghum rich multigrain roti that T4 sample scored highest among all and was at par with control sample.

**Table 4:** Sensory Evaluation of sorghum rich multigrain roti with different compositions of millet flours

| Sample No | Taste | Texture | Colour | Aroma | Mouthfeel | Overall acceptability |
|---|---|---|---|---|---|---|
| T1 | 8 | 8 | 8 | 7 | 7 | 7.6 |
| T2 | 7 | 8 | 8 | 7 | 8 | 7.6 |
| T3 | 8 | 8 | 7 | 8 | 8 | 7.8 |
| T4 | 9 | 8 | 7 | 8 | 8 | 8 |
| Control | 9 | 9 | 9 | 8 | 9 | 9 |

Results are mean of 3 determinations

## Conclusion

Millets are staple food source that is not only providing major nutrients like protein, carbohydrate, fat etc. but also provide ample of vitamins and minerals. In developing country, occurrence of malnutrition and various health problems like obesity, diabetes, cardiovascular disease, skin problems, cancer, celiac disease etc. are most prominent because of inadequate supply of nutrition. This is mainly due to the little utilized agricultural crops as food and unawareness of people and lack of knowledge to people. Millets are easily available and cheap in cost. Millets contain many major and minor nutrients like carbohydrate, good protein, fat, dietary fibre, vitamins and minerals as well as antioxidant and phytochemicals. This study emphasized on developement of sorghum rich multigrain flour and roti preparation using three nutritiious millets namely pearl millet, finger millet and foxtail millet. Millets serves as alternative cereals, potentially healthy and can be used as "food medicine" for malnutrition among children and women.

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