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Technology for tender sweet sorghum (*Hurda*) production and its health benefits: A review

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Abstract
Sweet sorghum grains are used by people who often do not have the means to feed themselves with food sources of energy, rich in protein, vitamins, and minerals. Sweet sorghum grains are rich in energy and non-energy nutrients. In these areas, they are intended for consumption as pasta, boiled and traditional beverages. Sweet sorghum has nutritional composition similar to or better than rice and wheat in some aspects. The grains contain high fiber and non-starchy polysaccharides and starch with some unique characteristics. There is a considerable variation in Sweet sorghum for levels of proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine and niacin. Protein quality and essential amino acid profile of Sweet sorghum is better than many of the cereals and millets. Sweet sorghum in general is rich source of fiber and B-complex vitamins. It provides dietary fiber by 48% of the recommended daily value.
The requirement of special skill in preparing sorghum *roti*s and non-availability of ready-made sorghum flour in the market are deterrents for wider use of sorghum as food. Dough prepared with cold water has poor adhesiveness and is difficult to roll thin *roti*s. There is a need to popularize sweet sorghum food (tender sweet sorghum- *hurda*) with its high mineral and fiber content and with low or slow starch digestibility makes an ideal food for diabetic and obese population in the urban as well as rural society.

Keywords: sweet sorghum, *hurda*, nutritional composition, dietary fiber

Introduction
Sweet sorghum, similar to grain sorghum except for its juice-rich sweet stalk, is being grown in USA (for syrup) and Africa (for fodder) since many centuries and is considered to be a potential bioethanol feedstock, expected to meet food, feed, fodder, fuel and fiber demands. Some sweet sorghum lines attain juice yields of 78 % of total plant biomass, containing 15–23 % soluble fermentable sugar (Srinivasarao *et al.*, 2009) [24]. Sorghum (*Sorghum bicolor* L) is an important cereal crop for food and fodder of Indian next to rice, wheat and maize. Largest share of country's production is contributed by Maharashtra and Karnataka states. Due to its ability to grow in dry lands of tropical Africa, India and China it has become the staple diet of these countries also (Shobha *et al*., 2008) [22]. Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley. It is the main cereal food for over 750 million people living in semi-arid tropical regions of Africa, Asia and Latin America (CCCF, 2011) [3]. Sorghum is the main staple food of Maharashtra, Karnataka, and is also an important food of Madhya Pradesh, Tamil Nadu and Andhra Pradesh. Sorghum grains are polished with a pearling machine and processed in to flour as well as *rava* (*suji*) of different particle size (coarse *rava*, medium *rava* and fine *rava*). Nowadays sorghum can be processed in to various products such as pops, starch, and grits (*semolina/rava*) from which many ethnic/niche food products can be made. This reduces the coarseness of the product made and also removes the bitterness that is associated with the pericarp of the grain. Sorghum does not have gluten and hence becomes a very good ideal gluten free energy source for the people suffering from wheat or gluten allergies. Normally sorghum for consumption is used in the form of *Roti*, unleavened breads, porridges, boiled grains and steam cooked products such as couscous (Rao and Murty, 1981; Chavan *et al*., 2009; Sajjanar *et al*., 2009; Unhale *et al*., 2012) [19, 5, 20, 26].
The requirement of special skill in preparing sorghum *roti*s and non-availability of ready-made sorghum flour and suji in the market are deterrents for wider use of sorghum as food. The grain sorghum is utilised in preparation of many traditional foods and in bakery preparations like bread, cakes and biscuits. Dough prepared with cold water has poor adhesiveness and is difficult to roll thin. Higher water uptake, low gelatinization temperature, high peak paste viscosity and high setback are the starch properties that have been shown to be associated with good quality of *roti*, the unleavened bread that is the most common form in which sorghum consumed on the Indian subcontinent. There is a need to popularize sorghum food (tender sweet sorghum - *hurda*) with its high mineral and fiber content and with low or slow starch digestibility makes an ideal food for diabetic and obese population in the urban as well as rural society.

Botanical plant structure
Sorghum bicolor (L.) is a plant of 1 to 3 meters high, solid cylindrical rod with a terminal inflorescence compact panicle. This includes one or two spike lets bisexual flowers. The seed is a caryopsis of about 4 mm (Hadbaoui, 2007) [12]. It produces an upright stem 50 to 70 cm for the present forms cultivated and elongate leaves similar to those of maize. At the end, develops a panicle of flowers and fruits containing seeds that mature in autumn.

Structure of sorghum seed
The principal anatomical components are pericarp, germ or embryo and endosperm. The pericarp is the outer structure of the caryopsis (the largest component of the cereal grain is the

endosperm, which is a major storage tissue) the embryonic axis and the scutellum are the two major parts of the germ (FAO, 1995).

Nutritional value of sorghum

Sorghum has nutritional composition similar to or better than rice and wheat in some aspects. The grains contain high fiber and non-starchy polysaccharides and starch with some unique characteristics. There is a considerable variation in sorghum for levels of proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine and niacin (Shobha *et al.*, 2008; Chavan *et al*., 2009) [22, 5]. Protein quality and essential amino acid profile of sorghum is better than many of the cereals and millets. Sorghum in general is rich source of fiber and B-complex vitamins (Gopalan *et al*., 2000; Patil *et al*., 2010) [11, 5, 16].

Grain sorghum is rich in fiber and minerals apart from having a sufficient quantity of carbohydrates (72%), proteins (11.6%) and fat (1.9%). Starch is the major constituent of the grain. Grain sorghum protein contains albumin globulin (15%), prolamin (26%) and glutelin (44%). Minimal amounts of flavan-4-ols and phytic acid are present in white sorghum (Chavan and Patil, 2010) [5, 16]. The protein content of grain sorghum are between 7 and 17%, starch between 60 and 75% and the weight of 1000 grains between 25 and 30 g according to the results of the essential amino acids. The amount of amino acids is around 168.42 mg / g in red sorghum and 126.72 mg / g in white sorghum (Linko *et al.*, 2005) [15].

Fig 1: Sweet sorghum

Production areas

World sorghum production was 60 million tons in 2000, and a little less specifically 58,626,758 tons in 2005 (FAO).

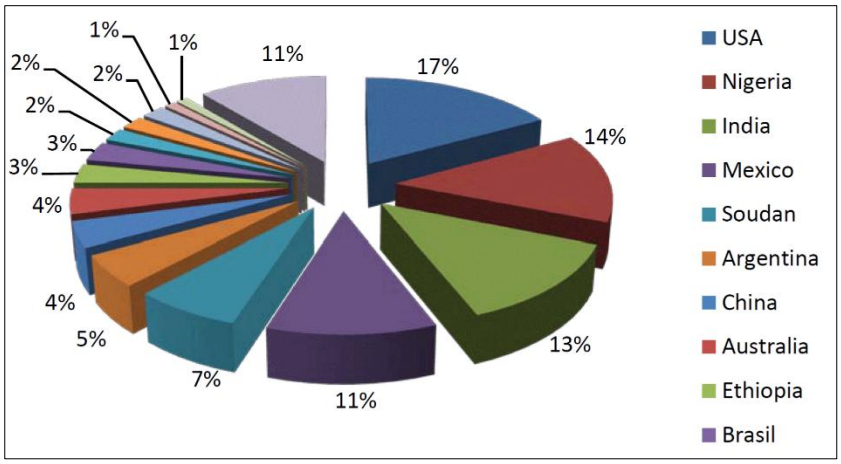

Fig 2: Sorghum production in 2005 (FAO)

Sweet sorghum varieties of Maharashtra

Phule madhur, Phule uttara, Surthi and Gulbhendi etc. are some important varieties for production of tender sweet sorghum *(hurda)* of Maharashtra in which Phule madhur found superior over other varieties for good quality *hurda* preparation (Shinde M.S. *et al.*, 2016) [21].

Different methodology for preparation of tender sweet sorghum (*hurda*) given by Chavan *et al.*, (2013) [4]

1. **Gas shegadi (HP gas) method:** Use gas shegadi for roasting of sorghum grains (sorghum *hurda* preparation). At soft dough stage for *hurda* quality testing the sorghum grains separated from the earhead by holding the panicle in both the hands and then rubbing it with palm. The gas supply at medium flame of 95-100oC temperature for 5 minute.
2. **Micro-wave method:** The sorghum grains subject to micro-wave treatment at 98^0C for 5 min for making sorghum *hurda* or roasted sorghum grains.
3. **Traditional method:** The sorghum tender panicles subject for baking in cow dung fire for 5 min. Then the roasted sorghum grains are separated by hand by holding the panicle in both the hands and then rubbing it with palm.

Storage of tender sweet sorghum *(hurda)*

The cloth bag is more suitable for storage of tender sweet sorghum (*hurda)* for 2 days at room (27 ± 2oC) and 4 days at refrigerated conditions (10 ± 2oC). The brown bags get wet with tender sorghum grains and lost their storage life. Plastic bags get wet with water droplets accumulation due to the grains respiration and got damaged within 1-2 days (Chavan *et al.*, 2013) [4].

Health Benefits of Sweet sorghum

1. **Assists in digestion:** The dietary fiber assists in the proper functioning of the digestive system. However, Sweet sorghum is rich in dietary fiber. A single serving of Sweet sorghum provides the dietary fiber by 48% of the daily recommended value. This assist in preventing the health conditions such as bloating, cramping, stomach aches, constipation, diarrhea and excess gas. The high amount of fiber helps to eliminate LDL cholesterol level which upgrades the heart health and also prevents heart attacks, atherosclerosis and strokes (Porter *et al.*, 1977) [18].
2. **Prevents cancer:** Various important antioxidants are possessed in the bran layer of the Sweet sorghum. These antioxidants reduce the risk of cancer such as esophageal cancer. Antioxidants eliminate the free radicals from the body which leads the healthy cells to mutate into cancer cells (Joseph *et al.*, 2005) [13].
3. **Controls diabetes:** The breakdown of excessive carbohydrates into simple sugars is the cause for diabetes. Sorghum possess high amount of tannin which prohibits the starch absorption by the body that regulates the glucose and insulin level in the body. Sorghum helps to balance these levels which eliminates the plunges and spikes in the glucose levels and also prevents the health complications and diabetics shock (Chung *et al.*, 2011) [7].
4. **Celiac disease:** Celiac disease is an allergy to gluten found in wheat-based products. Normally wheat or gluten in found in various food items, it makes the situation worse. But Sorghum helps to relieve the nausea, painful inflammation and gastrointestinal damage caused by the gluten (Ciacci *et al.*, 2007) [8].
5. **Maintain bone health:** Sorghum possess high amount of magnesium which helps to maintain the calcium levels by increasing the absorption of calcium in the body. These two minerals are essential for the bone tissue development and to speed up the healing process of aging or damaged bones. This helps to forbid the health conditions such as arthritis and osteoporosis in the old age (Tai *et al.*, 2015) [25].
6. **Prevents anaemia:** Sorghum possesses iron, copper and magnesium which help to increase the iron absorption in the body. This reduces the chances of anaemia that is led by iron deficiency. An adequate amount of iron and copper increases the development of red blood cells, enhance the blood circulation, cellular growth, increases the hair growth and boost the level of energy (Pinto *et al.*, 2004) [17].
7. **Level of energy:** Vitamin B_6 is essential to transform food to the usable fuel and energy in the body. This helps to stabilize the energy throughout the day. Sweet sorghum provides 28% of Vitamin B_6 of the daily recommended value (Kathleen, 2006) [14].
8. **Assist thyroid health:** Manganese is a vital component of thyroxine which is an essential hormone in the thyroid gland. Sweet sorghum is rich in manganese which helps to function the thyroid glands properly which results in losing weight, appetite, efficient organ systems and metabolism (Soldin and Aschner, 2007) [23].
9. **Improves cognitive power:** The function of brain and neurotransmitter is based on the phosphorus. Phosphorus helps to maintain the response of emotions, neurons and hormones. The phosphorus deficiency is associated with the decrease in cognitive power and age related neurodegenerative disorders such as dementia and Alzheimer's disease (Basheer *et al.*, 2016) [1].
10. **Improves mood:** The research shows that Vitamin B_6 has a huge role in the production of serotonin and GABA neurotransmitters in the brain which controls the mood. Vitamin B_6 is essential for to hinder pain, depression, anxiety and fatigue. This shows that Vitamin B_6 helps to prevent mood disorders and raise mood. Vitamin B_6 also assists in the production of hormone in the brain which treats the brain diseases and mood disorders. The research shows that the supplements of Vitamin B_6 assist to uplift the mood, relieve pain with energy and concentration (David, 2016) [6].

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