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Development and Evaluation of Ready to Eat Breakfast Cereal Mix Formulated using treated Sorghum Flour

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Abstract **– The objective of the study was to develop RTE breakfast cereal mix using fermented sorghum flour (Sorghum bicolor) thereby reducing its Anti-nutritional factors and increasing the bioavailability of nutrients. The Breakfast cereal was prepared by mixing fermented (FBC1-12 hours and FBC2- 28 hours) and baked sorghum flake, popped amaranth, roasted watermelon seeds, and raisins. Breakfast cereal with untreated flour was used as control. Sensory (9 point hedonic scale), nutritional and Anti-nutritional analysis were conducted for all the three samples. Sensory attributes of FBC1 (fermented - 12 hours) was highly accepted and had a bowl life of 5 minutes. There was a significant increase in the carbohydrate and protein content of treated sample, FBC1 (74.582 g/100g and 13.51% respectively) from the control sample (72.431g/100g and 11.16% respectively). Minerals such as Mg, Ca, Fe in the treated sample, FBC1 were also found to increase (108.64 mg, 25.564mg, 5.39 mg respectively) from the control sample (106.55 mg, 22.642 mg, 2.636 mg respectively). Tannin and phytate content was found to be 2.22 mg and 228 mg respectively for FBC1 and 4.57 mg and 386 mg respectively for Control. Tannins and phytate content were found to be reduced significantly ($P \leq 0.05$) in fermented RTE- BC mix (FBC1 and FBC2) compared with the control. The increase in protein content for Fermented Breakfast Cereal can be attributed to microbial synthesis of proteins from metabolic intermediates during their growth circles. Ready to eat breakfast cereal mix from minor cereals was found to be containing adequate amount of protein and minerals and was suitable for all age groups.**

Keywords **– RTE Breakfast Cereal, Sorghum, Anti Nutritional Factors, Fermentation.**

I. INTRODUCTION

Breakfast cereal is a processed food made from grains, served with hot or cold milk and to be eaten as a main course in the morning. They are relatively shelf-stable, lightweight, and convenient to ship and store. They are made primarily from corn, wheat, oats, or rice usually with added flavor and fortifying ingredients. Hot breakfast cereals, on the other hand, are made primarily from oats or wheat. Breakfast cereals can be categorized under two segments: Hot Cereals and Ready-to-eat (RTE) cereals. While the hot cereals need preparation before they are consumed, the RTE cereals do not need any preparation, and are ready for consumption.

Most ready-to-eat (RTE) breakfast cereals may be grouped into different categories: flaked cereals (corn flakes, wheat flakes, and rice flakes), including extruded flakes, gun-puffed whole grains, granola cereals, compressed flake biscuits, extruded and other shredded cereals, oven-puffed cereals, extruded gun-puffed cereals, extruded expanded cereals, baked cereals, compressed flake biscuits, muesli-type products, and filled bite-size shredded wheat [2].

Sorghum (*Sorghum bicolor*) is one of the most underutilized crops in the semi-arid tropics of Asia and Africa. It is the principal source of energy, protein, vitamins and minerals for millions of the poorest in these regions. Sorghum products are deficient in essential amino acids such as lysine, methionine, tryptophan and the presence of anti-nutritional factors such as tannins and phytates limit their nutritional value. Sorghum has some limitations, due to the presence of anti-nutritional factors, such as trypsin and amylase inhibitors, phytic acid, and tannins. These compounds are known to interfere with protein, carbohydrates and mineral metabolism. Processing techniques such as fermentation, malting and dehulling techniques have been used to improve nutritional value of ready to eat weaning mixes. Hence attempt has been made to use it as breakfast cereal as well. Lactic, yeast, and mixed fermentations are old methods for food processing and preservation. Today, defined starter cultures and controlled conditions are frequently used [1].

Amaranth *(L. Amaranthus*) grain is a rich source of dietary fiber. It provides 13 grams of fiber per uncooked cup contrasted to 2 grams of a similar quantity of long-grain white rice [3]. Amaranth's protein content is about thirteen percent [4] and is higher than most other grains. It is a great choice for a breakfast meal as it does not require the need to include added refine sugar. Amaranth porridge is an old-style breakfast in India, Mexico, Peru and Nepal.

Raisins (*Vitis Vinifera*) are dried grapes and are one of the most commonly consumed dried fruits [5]. Raisins are consumed across the globe and is highly nutritious. Raisins are low–medium energy dense, and provide important minerals and dietary fiber including fructo oligosaccharides. One snack serving (43 g) of raisins contributes 129 kcal, 1.6 g dietary fiber, 0.2 g total fat, 25 g total sugar, 322 mg potassium, 14 mg magnesium, and 0.8 mg iron [6].

Watermelon (*Citrullus lanatus*) seeds are known to be highly nutritional as they are a rich source of protein, vitamins B, minerals (such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese and copper) and fat among others as well as phyto-chemicals [7]. The seeds of watermelons are known to have economic benefits especially in countries where cultivation is on the increase. They can be used to prepare snacks, milled into flour and used for sauces thereby controlling the food wastage. Oil from the seeds are used in cooking and incorporated into the production of cosmetics. In spite of the various potential applications it has, the seeds are often discarded while the fruit is eaten.

Therefore, considering the nutritional benefits of sorghum flour, a ready to eat breakfast cereal (RTE) based on Sorghum flour with popped amaranth grains, roasted watermelon seeds and raisins was developed and evaluated for its nutritional content, bowl life and sensory characteristics.

II. Materials and Methods

A. *Formulation of the Product*

Sorghum flour (*Sorghum bicolor)*, Grain amaranths (*L. Amaranthus*), Watermelon Seed (*Citrullus lanatus*) and other ingredients such as sugar, honey and raisins were procured from local market. The grains were cleaned to remove dust and other non essential materials and stored at room temperature in plastic containers.

Popping of Amaranth Grains:

Amaranth grains were popped in an iron pan at around 220°C with stirring continuously.

Roasting of Water Melon Seeds:

Watermelon seeds were roasted at a temperature of about 70°C until the seeds turned to light brown color.

Fermentation of Sorghum Flour:

Sorghum flour was mixed with 300 ml of boiled and cooled water to form a thick paste. It was covered and left to ferment at room temperature (25ºC) for 12 hours and 28 hours (FBC1 and FBC2 respectively).

Preparation of Sorghum Flake:

Sugar and vanilla essence were added to the fermented sorghum flour batter for taste and was poured thinly on a cleaned flat greased stainless tray. The batter was baked in the oven until a semi dried product was obtained. The semi dried product were cut with a sharp knife, placed back into the oven for further drying and toasted it at 280°C.

Preparation of RTE Breakfast Cereal mix:

Baked sorghum flake was mixed manually with measured popped amaranth grain, roasted water melon seeds, raisins in a stainless steel bowl. (Table 1) Sugar syrup for coating was prepared using sugar and water. This mixture was continuously heated at a temperature of 50-60°C with addition of sunflower oil and honey. Finally this prepared syrup mixture was added to the dry ingredients and mixed until it was homogenously dispersed. The resulting mix was spread on baking tray and baked at 50-60°C for 15 min. Baked breakfast cereal was cooled and stored in an air-tight container (Fig. 1).

Baked sorghum flake was mixed manually with popped amaranth, roasted water melon seed, raisins in a stainless steel bowl.

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The resulting mix was spread on baking tray and baked at 50–60°C for 15 min.

Fig. 1. Preparation of RTE Breakfast cereal mix.

Table 1. Recipe Formulation for the development of Sorghum based Breakfast cereal mix.

Ingredients	**Quantity (g)**
Baked sorghum flakes	45
Watermelon seeds	10
Raisins	5
Popped amaranth grain	15
Honey	5
Sugar (coating)	20
Total	100

B. *Nutritional Analysis*

Moisture, Crude protein, Fat content were determined according to the methods outlined in AOAC (2000). Carbohydrate was determined by Anthrone method. Total calcium, Iron and Magnesium content in the samples were estimated as per AOAC. The Folin-Denis colorimetric method as described by Kirk and Sawyer was used for the determination of tannin content in the samples. Phytate was determined using the method described by AOAC. The analysis was performed in triplicates [8].

C. *Bowl Life*

Bowl life is measured as the length of time that the cereal can retain its crispness after being soaked in milk. The breakfast cereal samples (5 g) were soaked in 30 ml of milk taken in ten beakers separately. The breakfast cereal was separated from milk at every 2 min interval and was pat dried carefully to remove the superfluous milk without breaking the breakfast cereal. Weight gain was recorded and reported on per cent basis [12].

D. *Sensory Analysis*

Sensory evaluation of standard breakfast cereal was evaluated along with breakfast cereals with variations in the fermentation period of sorghum flour to obtain a product with high acceptability. Breakfast cereal samples were served along with milk for the evaluation. 25 untrained panelists who represented the common consumer evaluated the product using 9-point Hedonic scale (from Like extremely to dislike extremely). Evaluation was done to determine the acceptability of product with respect to appearance, flavor, taste, texture and overall acceptability.

E. *Processing and Analysis of Data*

All the determinants were carried out in triplicates and results were expressed as Mean ± SD. To test the significant differences between the experimental samples, t-test (two tail) method using MS Excel data were applied for nutritional and sensory analysis.

III. RESULTS AND DISCUSSION

A. *Nutritional Analysis*

The mean values of the nutritional composition of the formulated samples are as shown in Table 3. The moisture content of the formulated trials ranged from 3.7-3.6%. Low moisture contents observed in the formulated breakfast cereal samples maybe beneficial in extending the shelf life of the product with proper packaging and storage. The ash content ranged from 1.46 to 1.47 %.

Highest carbohydrate content was observed in FBC2 (77.231%). Sorghum is a rich source of carbohydrate hence contributing to the overall carbohydrate content of the product. Carbohydrate content between control and FBC2 showed significant differences i.e. ($P \leq 0.05$).

The protein content of the formulated breakfast cereals ranged from 11.16% to 13.8%. There was increase in the protein content of the fermented sorghum flake FBC1 and FBC2 when compared to the control sample. (13.51%, 13.8% and11.16% respectively). Protein content between the Control and the two samples FBC1 and FBC2 showed significant differences ($P \leq 0.05$). The variation in the protein content is due to the treatment of the samples (FBC1 and FBC2) by fermentation. Various studies have also shown that fermentation can increase the concentrations of vitamins, minerals and protein [9]. The increase in protein content for fermented food can be attributed to microbial synthesis of proteins from metabolic intermediates during their growth circles. Its protein content will further be increased when taken with milk.

The fat content in the samples ranged from 6.70 to 6.62% due to similar formulation of ingredients in the samples. The values obtained for fat between the control and the two samples did not exhibit any significant differences i.e. ($P \geq 0.05$). Fermentation of sorghum did not have any effect on the fat content of RTE-BC mix.

Tannins and phytate content were found to be reduced significantly ($P \leq 0.05$) in fermented RTE- BC mix (FBC1 and FBC2) compared to the control sample. Tannin content initially in control sample was observed to be 4.59 mg and was reduced to 2.22 mg and 1.85 mg in FBC1 and FBC2 respectively. Phytate content was found to be least in FBC2 (230 mg) when compared to control sample (386 mg). The results of this study are in agreement with those reported by [3], who reported that fermentation of sorghum, produces significant loss in phytate. Reduction in tannin contents due to fermentation might have been caused by the activity of polyphenol oxidase present in food grain or microflora [10]. The results revealed that fermentation enhances the removal of the anti-nutritional factors which are believed to be responsible for unavailability of both proteins and divalent minerals.

Minerals such as iron, calcium and magnesium were found to be increased in FBC1 and FBC2 due to the process of fermentation. Iron, Calcium and magnesium (8.14, 27.63, 111.21mg respectively) in FBC2 had the highest content due to the increased fermentation period of 28 hours when compared to FBC1(5.39, 25.564,108.641 mg respectively) that underwent 12 hours fermentation. Mineral content were found to exhibit significant difference between the control and the samples ($P \leq 0.05$). This was in accordance to the study in [10].

Table 2. Nutritional composition of RTE-BC mix.

Nutrients per 100g	**CONTROL(C)**	**FBC1**	**FBC2**
Moisture (%)	3.723 ± 0.09	3.513 ± 0.07	3.620 ± 0.04
Ash (%)	1.46 ± 0.04	1.46 ± 0.03	1.47 ± 0.03
Total carbohydrates (g)	72.431 ± 0.48*	74.582 ± 0.7	77.231 ± 0.6*
Protein (%)	11.16% + 0.1*	13.51% ± 0.4*	13.8% ± 0.3*
Fat (%)	6.703 ± 0.3	6.61 ± 0.3	6.624 ± 0.3
Tannin (mg)	4.57 ± 0.3*	2.22 ± 0.2*	1.852 ± 0.2*
Phytate (mg)	386 ± 3*	228 ± 4*	230 ± 3*
Iron (mg)	2.636 ± 0.3*	5.39 ± 0.4*	8.144 ± 0.1*
Calcium (mg)	22.642 ± 0.2*	25.564 ± 0.3*	27.634 ± 0.2*
Magnesium (mg)	106.55 ± 0.4*	108.64 ± 0.3*	111.21 ± 0.3*

Values are presented as means ± standard deviation of triplicate samples.

*Significant difference between the samples ($P<0.05$)

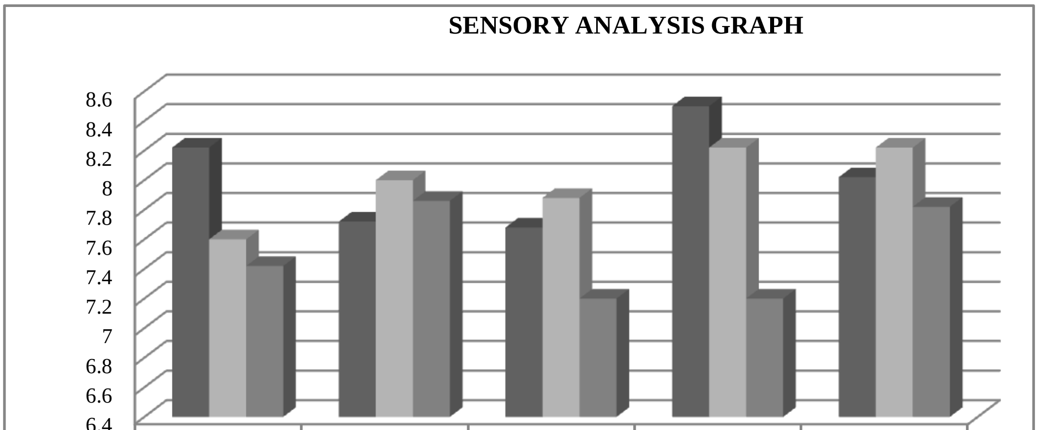
B. *Bowl Life*

The bowl life of the samples was found to be 5 minutes. It was according to the studies reported in [12] Addition of cold or warm milk transforms the texture of the breakfast cereal. Low moisture content and the coating applied in the breakfast cereal increased the bowl life of the product.

C. *Sensory Analysis*

The sensory scores of the formulated breakfast cereal samples are shown in Table 2. The sensory parameters evaluated include appearance, flavour, taste, texture and overall acceptability of the formulated RTE-BC mix. The sample FBC1 did not show any significant difference with the control ($p \leq 0.05$) whereas Sample FBC2 showed slight significant difference ($p \geq 0.05$) with the control. Overall acceptability of FBC1 was found to be 8.22 when compared to control -8.02. FBC1 was overall accepted in terms of appearance, flavor, taste and texture with highest score for flavor -8. Due to the increased fermentation period in FBC2 (28 hours), it had least acceptability in terms of flavor and taste. Hence fermentation period of 12 hours (FBC1) produced BC-mix with highest overall acceptability. Breakfast cereal mix is recommended to be served as 40 g of the mix with 150 ml of warm milk to provide high sensory appeal.

Table 3. Sensory evaluation of RTE-BC mix.



	Appearance	Flavour	Taste	Texture	Overall acceptability
C	8.22	7.72	7.68	8.5	8.02
S1	7.6	8	7.88	8.22	8.22
S2	7.42	7.86	7.2	7.2	7.82

Fig. 2. FBC2

Fig. 3. RTE-BC with addition of milk.

IV. Conclusion

One of the major deterrents for use of sorghum as food is the lower availability of protein, starch, and minerals due to the presence of anti-nutritional factors like tannins and phytic acid. However, processing like fermentation has proven to reduce the anti-nutritional factors, thus improving the nutritional availability and the functional properties of sorghum. It can be noted that protein, Carbohydrate and mineral content was increased significantly in the treated sorghum flour. FBC1 had better Sensory appeal due to the fermentation period of 14 hours. The advantages of LAB fermentation include inhibition of enteropathogenic bacteria, improvement of palatability and acceptability as results of change in texture, flavour and colour, enrichment of nutrients by microbial synthesis of vitamins, reduction in anti-nutritional factors like phytic acid and tannins and improvement in protein digestibility. High iron content of the BC mix is beneficial to treat anemia. It can thus be concluded that treatment of sorghum flour by fermentation reduced the Anti-Nutritional factors in the sorghum flour and increased the Nutrient contents in the breakfast cereal suggesting the use of the product on a commercial level for its High Nutrient and low cost value.

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Ms. Taniya Kapoor has contributed in product formulation, experimentation of the product analysis, writing and editing of the paper. She completed her undergraduate in (B.Sc.) Food science and management from M.O.P. Vaishnav college for women, Chennai ((2015-2018) and is currently her post graduation in Food technology and management at M.O.P Vaishnav College for Women, Chennai (2018-2020). Ms. Taniya has a great interest in the field of new product development. She has attended several national and international conferences and seminar pertaining to the field of food science and technology. She has also presented research posters at few conferences. She has internship experience at qu--ality assurance and quality control department in analytic labs, hospitality industry and food industries like Hatsun Agro products Ltd.

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Ms. Alisha Rachel Abraham contributed in the investigation, product formulation, analysis, experimentation for the study and writing, editing the paper as part of her Post-graduate research study. She completed her undergraduate (B.Sc) in Nutrition, Food service management and dietetics, Department of Home Science, Women's Christian College, Chennai (2015-2018) and is currently pursuing her post graduation in Food technology and management at M.O.P Vaishnav College for Women, Chennai (2018-2020). Ms. Alisha has shown a lot of interest in the field of food science, technology and its research. She has attended many conferences and workshops pertaining to the field of food sciences a--nd interned at hospitals and food industries such as Brittania industries Ltd.

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Dr. Simmi Jain contributed in formatting and guiding by giving in insights. She is currently the Assistant Professor *and Head* of the Department of Food Technology and Management, School of Food Science, M.O.P. Vaishnav College for Women (Autonomous), Chennai, Tamil Nadu, India. She has work experience in the field of Food Science and Nutrition at various Institutions and Colleges for more than 17 years. She completed her Masters and Doctoral degree from Jai Narain Vyas University, Jodhpur, Rajasthan and started career from the same University in 2002.She has also undergone a variety of internship programs in Hospitals and Taj Group of Hotels. She has also undertaken the Baking Technician c--ourse by National Skill Development Corporation under the Pradhan Mantri Kaushal VikasYojna (PMKVY), Chennai, Tamil Nadu. She has presented a number of papers in Conferences and Seminars on Child's Mental Health, Sports nutrition, Food Processing and Preservation, Challenges to the Changing Status of Aged, to name a few. Areas of research and core areas of expertise include are Beverage Technology, Baking Technology, Product Development, Sensory Science, Food Science and Nutrition, Food Processing and Preservation. Published 16 papers in National and International Journals and also is on the Editorial Board for "International Journal of Food Science and Nutrition" and Food and Agriculture Spectrum Journal. Few recently published scientific findings are as follows: (1) Janaki, K., Mahalaxmi, S., Malavika, M., Simmi Jain and Nirupa Shyam Mogili (February, 2017). Formulation and Quality Assessment of Curry Leaf Soup Powder by using Dehydrated Peas Powder as a Thickening Agent. Asian Journal of Science and Technology, 8(2): 4294-4296. ISSN: 0976-3376. (Impact factor 6.315). (2) Dr. Simmi Jain and Pooja Sree, K.M. (December 2017). Physicochemical and Organoleptic properties of Cookies made using Tender Coconut Pulp as a Fat Replacer. Asian Journal of Science and Technology, *8(12), 7089-7091*, ISSN: 0976-3376. (Impact factor 6.315). (3) Pooja Mohan, Indrani Mukherjee, Simmi Jain. (January 2018). Study on the physico-chemical and sensory characteristics of cookies made using avocado as a fat (Butter) substitute. International Journal of Food Science and Nutrition, 3(1), 68-72, ISSN: 2455-4898 (Impact Factor: RJIF 5.14) UGC Approved Additionally, Dr. Simmi Jain is a Life Member of The Indian Science Congress Association. Membership No. L31879.