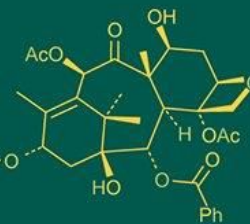
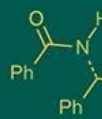
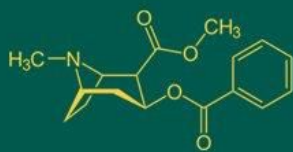


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Development and evaluation of millet based fermented beverages

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Abstract

Millet is the small grain belongs to *poaceae* family and are called as nutri-rich cereals. Millet-based traditional fermented beverages are an integral part of various cultures. These beverages are produced through natural fermentation, involving lactic acid bacteria, yeast, and fungi, which contribute to their unique flavors, textures, and health benefits. The present study aimed to develop fermented beverages from the selected millets. The three millets viz. White Ragi, Foxtail and Sorghum were used for the development of beverages followed by sensory evaluation from panelist through 9-point hedonic scale. Among the developed beverages, Foxtail Millet Fermented Beverage (FMFB) scored highest in all sensory attributes compared to others. The developed beverages were subjected to physico-chemical, proximate and mineral composition and microbial analysis. All the three products were found to be acidic with 3.9, 4.10 and 4.90 in SFMB (Sorghum Fermented Millet Beverage), FMFB and WRFB (White Ragi Fermented Beverage) respectively. The titrable acidity of the products ranged from 1.60% and 1.80% whereas total suspended solids were ranged from 8.40 to 10.0%. The nutrient composition of the developed products found to have minimum changes in carbohydrate, protein, ash, calcium, iron and magnesium. Result of microbial analysis reported that microbes like *E. coli*, moulds and fungus were absent in the developed beverages. The findings suggest that the development of millet-based fermented beverages presents a promising avenue for creating nutritious, functional, and sustainable alternatives to conventional drinks.

Keywords: Millets, fermentation, White Ragi, beverages

1. Introduction

Millets are the small grains belongs to *poaceae* family which contains all the nutrients which are necessary for human development and well being and they are called as nutri-rich cereals. Millets are nutritionally rich in carbohydrates, energy, serve as good source of protein, fibre, micronutrients and phytochemicals in comparable to major cereals like rice and wheat. Millets contains 7-12% of protein, 2-5% of fat, 65-75% of carbohydrates, and 15-20% of dietary fibre.

Millet is known to be cultivated from the past 10,000 years in Eastern Asia and is a widely eaten food in the history of human civilization. In the entire world, India stands at the first place as the most gigantic producer of millets (Zhang *et al.*, 2009) [26].

More than 1/3rd of the world's population is consuming millets. The top producer of millets is Karnataka. Millets account for more than 58% of global production, yet very few Indians are learning about its nutritional worth and health advantages (Upadhyaya *et al.*, 2007) [24].

Millets contains phenol, sterol, dietary fiber, lignan, inulin, β -glucan, tocopherol, and carotenoids, among other phytoconstituents. These play vital role in building the body's immunity. These help in reducing the weight and packed with fibers, protein and iron. Folic acid, phosphorus, iron, potassium, and vitamin B are all abundant in millets. Compared to maize, finger millet has roughly 16 percent more calcium. Additionally, it also content amount of Niacin is much greater in Pearl Millet when compared to all other cereals. Millets are also a great source of antioxidants and easy to digest due to absence of gluten (Dykes and Rooney, 2006) [8].

Traditional foods are those which are prepared and eaten by many generations in the family. Traditional food and beverage practices are location-centric and deeply associated with socio-religious and cultural norms and form a part of socio-cultural and ecological life of indigenous folks. Evidence showed that there are more than 3500 traditional

fermented foods available worldwide (Monika and Dabur, 2021) ^[18]. Fermented foods and beverages are contributing to food security because they add value, enhance nutritional quality and digestibility, improve food safety, and are traditionally acceptable and accessible and have minimal production cost, labor cost and relying on locally obtainable raw materials and have more shelf life under ambient conditions. Fermented beverages are the important part of their day to day meal and which stimulate and refreshing properties and occupy important position among tribal groups (Shrivastava *et al.*, 2012) ^[14].

It has been reported that between 5 to 40 per cent of people worldwide eat fermented foods (Tamang *et al.*, 2016) ^[23]. In the process of fermentation uses microorganisms to make different types of alcohol, CO₂ and other organic acids mainly from sugars and mostly in anaerobic environments. The accumulation of these organic acids and alcohols, which increase the acidity of food substrates and prevents enzyme and other bacteria from developing within the food system, results in the longer shelf life of the food products. Among various types of indigenous fermented beverages prepared and consumed by different ethnical groups of Arunachal Pradesh for centuries, *Apong* and *Madua Apong* are millet based fermented beverages are two most commonly used drinks (Shrivastava *et al.*, 2015) ^[13] and *Shhang* or *Ccharo-kham* fermented drinks from barley, *Themsing* is an alcoholic beverage prepared from finger millet, *Bankhe-kham* is the fermented beverage prepared from Tapioca (*Mannihot esculenta*) (Greeshma *et al* 2006) ^[9], *Apo* is a rice based beverage, *Rakshi* is prepared from finger millets, rice as well as from barley grains "*Ogi*", "*iru*" and "*gari*" are fermented Nigerian foods that have been widely commercialized (Afolayan *et al* 2017; Mokoena *et al.*, 2016) ^[2, 20] "*Borde*" and "*Shamita*" are important traditional fermented Ethiopian drinks, produced by the overnight fermentation of certain cereals by LAB (Mokoena *et al.*, 2016, Diaz *et al.*, 2019) ^[20, 6].

The traditional beverages prepared by millets are crucial for human diets. Studies from various continents have shown strong correlations between the microorganisms present in

fermented foods (such as agave fructans, kefir, yoghurt, kombucha, chungkook jang, cheeses, and vegetables, among others) and weight maintenance, lowered risk of cardiovascular disease, benefits for preventing diabetes and constipation, improved glucose and lipid levels, stimulation of the immune system, anticancer effects, and, most importantly, a reduction in the risk of colon (García *et al.*, 2022) ^[10].

With the raising concerns about lactose intolerance and in order to increase the bioavailability of nutrients from the millets, the present study was aimed to develop fermented beverages from selected millets such as sorghum, white ragi and foxtail millet.

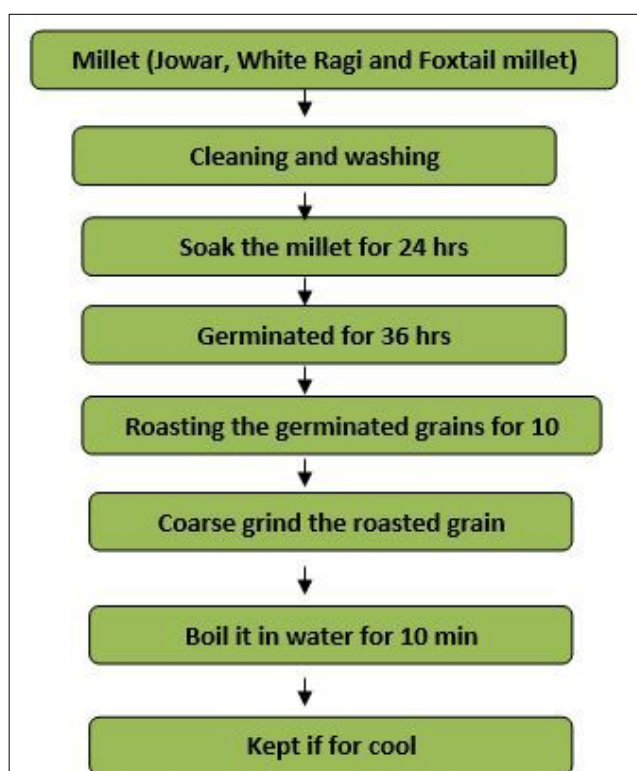
2. Material and methods

2.1 Procurement of Raw Materials

Millets, including sorghum and foxtail millet were procured from the local market whereas white Ragi was obtained from University of Agricultural Sciences, Bangalore. The other ingredients such as flavoring agents like pineapple, vanilla, and sugar, were procured from the local market in Vijayapura district. Every sample was separated, cleaned, and kept in airtight containers until needed.

2.2 Process flow of millet based fermented beverages

The preparation process began with the cleaning and washing of the millets. Cleaned grains were soaked for 24 hours. After soaking, the grains were tied in a cotton cloth and allowed to germinate for 36 hours. The germinated seeds were then shade-dried to preserve their nutrients and later roasted in a pan for 10 minutes to enhance their flavor. Once roasted, the seeds were coarsely ground using a mixer grinder. For beverage preparation, 500 ml of distilled water was added to the grinded mixture and boiled at a temperature range of 78 °C to 80 °C. The boiled mixture was then allowed to cool and added sugar then kept for the fermentation of 24 hours then sugar and flavoring agents were added to enhance taste. Finally, the prepared beverage was poured into bottles for storage.





Flow chart 1: Preparation of millet based fermented beverage

2.3 Organoleptic Evaluation of the developed products

The sensory evaluation of the developed beverages was conducted using the 9-point hedonic scale to assess consumer acceptability. A semi-trained panelist, from Department of Food Processing and Nutrition in Karnataka State Akkamahadevi University, Vijayapura were employed for sensory evaluation. The evaluation was carried out under controlled conditions to minimize external influences. Each panelist was provided with coded beverage samples in identical containers to prevent bias. The beverages were evaluated based on key sensory attributes, including appearance, color, aroma, taste, consistency and overall acceptability. The 9-point hedonic scale, ranging from 1 = Dislike Extremely to 9 = Like Extremely, was used to record the degree of liking or disliking for each attribute. The mean sensory scores for each attribute were calculated and analyzed statistically to determine the general acceptability of the beverages.

2.4 Physico-chemical analysis of developed beverages

The prepared beverages were subjected to physico-chemical analysis *viz.*, pH, titrable acidity and TSS. The titratable acidity of the product was determined by method described in the Indian standards (IS: 1479-Part I, 1960) and 25 g sample was titrated with 0.1N of NaOH according to the method described. The pH was measured by a pH meter against a standard buffer of 4.0 pH and TSS was measured by Determination of total Solids Content -reference method, Bureau of Indian Standards, New Delhi.

2.5 Determination of Proximate and mineral composition of developed beverages

Moisture, fat, protein (%N x 6.25), ash and crude fibre were carried out according to standard methods described by AOAC (2000). The difference methods were used to determine the total carbohydrate content after deducting the sum of the moisture, protein, fat, ash, and crude fibre values from 100. Analysis of trace elements such as Calcium, Magnesium, Potassium and iron in the sample was carried out by Inductively Coupled Plasma-Atomic Emission Spectroscopy Using Microwave Assisted Digestion.

2.6 Microbial analysis of the developed products: The prepared beverages were given to Bio Chemical Laboratory Hubli for microbial analysis *viz.*, E coil, yeast and moulds.

3. Results and Discussion

3.1 Sensory evaluation of developed products

Table 1 showed the results of sensory evaluation of developed beverages, FMFB scored highest (8.5), indicating the most visually appealing beverage. FMFB (8.75) had the most appealing color followed by SMFB (7.5) had the least favorable color perception, FMFB (8.25) was rated highest and SMFB (6.5) lowest Flavor rating, FMFB (8.5) had the best Consistency, FMFB (8.75) had the best taste, indicating a well-balanced flavor profile. WRFB was acceptable (7.5) but not as preferred. SMFB had the lowest score (7.0), suggesting a less appealing taste. FMFB was the most preferred beverage overall (8.75). WRFB was moderately accepted (7.5).

Table 1: Sensory evaluation of developed products

Sl. No.	Parameters	FMFB	WRFB	SMFB
1	Appearance	8.5	8	7.75
2	Color	8.75	8.25	7.5
3	Flavor	8.25	7.5	6.5
4	Consistency	8.5	7.5	7.25
5	Taste	8.75	7.5	7
6	Overall acceptability	8.75	7.5	6.75

FMFB Foxtail millet Fermented Beverages, **WRFB:** White Ragi Fermented beverages, SMFB Sorghum millet Fermented Beverages

3.2 Physico-chemical analysis of developed products

Result of pH showed that WRFB had highest pH (4.90) least was observed in SFMB (3.9). The study done by Arup reported that pH value of *landa*, the millet-based traditional drink from the Gadaba district of Orissa was 3.62. The pH of the fermented pearl millet beverages *koozh* varied from 4.3 to 4.9 in all samples by the study conducted by Ilango *et al.* (2014) [11]. This indicated that the observations varied slightly from the study described above. The result of titrate

acidity showed 1.70% in FMFB, 1.60% in WRFB and 1.80% in SMFB and results of total suspended solids were 8.40% in FMFB, 8.90% in WRFB and 10% in SMFB. Lyumugabe *et al.* 2007^[16] reported that *Ikigage*, fermented sorghum millet beer from African contained 2.2% (v/v) of ethanol, 9.2 g/l of soluble protein, 2.3 of reducing sugars, 1.7% of total acidity, 3.9 of pH and 11.5 bx of total soluble sugar. Alemu and Naga (2022) reported that *Oshikundu*, Nonalcoholic sorghum and pearl millet based beverage contains total solids 2 to 4.2%, the approximate ranges for pH was 3.3 to 3.7 and titrable acidity from 1.2 to 1.7%.

Table 2: Results of physico-chemical analysis of developed products

Sl. No	Parameters	FMFB	WRFB	SMFB
1	pH	4.10	4.90	3.9
2	Titrate acidity	1.70%	1.60%	1.80%
3	Total suspended solids	8.40%	8.90%	10%

FMFB: Foxtail millet Fermented Beverages, **WRFB:** White ragi Fermented beverages, **SMFB:** Sorghum millet Fermented Beverages

3.3. Proximate and mineral composition of developed products

Table 3 represents the proximate and mineral composition of developed products in which carbohydrate content was found higher in SMFB (18.6 g), followed by 15.2g in WRFB and 12.2g in FMFB. The protein content was found

low in all the developed products (0.60g in FMFB, 0.80g in WRFB and 1.10g in SNFB).

Arup *et al.*, (2021) reported the nutritional value of the two main millet-based traditional drinks, *landa* and *pej*, from the Gadaba tribe in Odisha. Accordingly, 1.026 mg/mL of protein was present in landa, while 0.228mg/mL was present in pej. The amount of carbohydrates in the samples ranged from 3.6 mg/mL in Landa to 3.424 mg/mL in Pej. The higher content of carbohydrates in the developed samples might be due to addition of sugar.

The Ash content was found to be 0.65%, 0.80% and 0.60% for FMFB, WRFB and SNFB respectively. The calcium content was found highest in WRFB (12.8mg) followed by 10.6mg in SNFB and lowest of 10.2mg in FMFB. Iron content was found highest in WRFB (3.20 mg) followed by FMFB (2.90 mg) and SNFB (2.40 mg). Magnesium and potassium were found higher in WRFB (Mg: 3.40 mg & K: 7.40 mg).

Shrivastava *et al.* 2015^[13] reported that Apong and Madua Apong, traditional millet-based fermented beverages of Himalayan states had carbohydrate (7.1g/100g), total reducing sugar (5.2%) and ash (1.02%) in Apong and carbohydrate of 5g/100g and total reducing sugar-3.2% in Madua Apong. Alemu and Naga (2022) reported on *Oshikundu*, Non alcoholic sorghum and pearl millet based beverage and found ash 0.07 to 0.11%, protein 0.13 to 0.18 mg/mL, insoluble fiber 0.025 to 0.031 on wet basis.

Table 3: Proximate and mineral composition of developed products

Sl. No.	Nutrients	FMFB	WRFB	SMFB
1	Carbohydrates (g)	16.2	15.2	18.6
2	Protein(g)	0.60	0.80	1.10
3	Fat (g)	Nil	Nil	Nil
4	Ash (%)	0.65	0.80	0.60
5	Calcium (mg)	10.2	12.8	10.6
6	Iron (mg)	2.90	3.20	2.40
7	Magnesium (mg)	2.40	3.40	2.30
8	Potassium (mg)	5.20	7.40	4.80

FMFB: Foxtail millet Fermented Beverages, **WRFB:** White Ragi Fermented beverages, **SMFB:** Sorghum millet Fermented Beverages

3.4 Microbial analysis of the developed beverages

The shelf life the developed products were analysed by microbial analysis. The results represent that, microbes were absent in all three developed beverages from foxtail, white ragi and sorghum upto to 1 week meaning none of the samples contain *E. coli*, moulds and fungus which ensuring that there is a microbiological safety for consumption. Kiruthika *et al.*, 2018^[7] reported that Yeast-mould and coliform count were nil which was indicative for hygienic conditions followed during production, processing, handling and storage and the microbial load in the sorghum-based fermented milk beverages was reported by Kumar and Das (2015)^[4] and found the standard plate count of 13-15x 10² cfu/ml for the yeast and 10-11x10² cfu/ml for mould and the coliforms were nil.

Table 4: Microbial analysis of developed products

Sl. No	Parameters	FMFB	WRFB	SMFB
1	E. coli	Absent	Absent	Absent
2	Moulds and Fungus	Absent	Absent	Absent

FMFB: Foxtail millet Fermented Beverages, **WRFB:** White Ragi Fermented beverages, **SMFB:** Sorghum millet Fermented Beverages

4. Conclusion

The development of millet-based fermented beverages presents a promising avenue for creating nutritious, functional, and sustainable alternatives to conventional drinks. Millets, being rich in fiber, protein, and essential micronutrients, serve as an excellent base for fermentation, enhancing their digestibility, bioavailability, and probiotic potential. Various fermentation techniques, including traditional and controlled fermentation, have been explored to improve flavor, shelf life, and health benefits. Despite challenges such as optimizing fermentation conditions, improving sensory attributes, and ensuring large-scale production feasibility, millet-based fermented beverages hold great potential in the functional food and beverage market. Future research and technological advancements can further enhance their commercial viability, making them a valuable addition to the growing demand for health-focused and sustainable food products.

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