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Development of sattu and idli premixes from puffed finger millet

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Abstract
This study aimed to develop value-added products from puffed finger millet. Decorticated finger millet puffed grain was used to create sattu and idli premixes. The physico-chemical and sensory quality characteristics of these products were evaluated. Organoleptic assessment revealed optimal formulation: finger millet puffed grain flour blended with roasted Bengal gram flour for sattu, and finger millet puffed flour combined with finger millet semolina for idli.
The sattu of finger millet puffed flour with roasted Bengal gram was subjected to five different combinations. In the first combination T_1 (0:100), and others T_2 (25:75), T_3 (50:50), T_4 (75:25), T_5 (100:0). Constantly add 30% of jaggery powder in combination of primixes. Similarly, In idli the finger millet puffed flour together with finger millet semolina, were also subjected to five distinct combinations: R1 (100:0), R2 (90:10), R3 (80:20), R4 (70:30) and R5 (60:40). Sodium bicarbonate (0.2%) and common salt (2%) were added in combination of primixes. Organoleptic evaluation revealed T_4 (75:25) and R5 (60:40) as the top-scoring samples for sattu and idli premixes, respectively. These optimal formulations were selected for further analysis. The prepared sattu premix was reconstituted by dissolving 7-10 g in 250 ml of water or milk, to create a supplemented drink powder. Conversely, the idli premix was prepared by soaking it in 200-300ml of water at room temperature for 15-30 minutes add citric acid (0.5%), followed by 10 minutes of steaming, to produce idli.

Keywords: Finger millet, puffed grains, sattu, idli, premix, semolina

Introduction
Finger millet (*Eleusine coracana*), commonly known as *ragi*, is a nutrient-dense cereal crop that has been a staple food source in various regions of India for centuries. With its exceptional nutritional profile, surpassing many common cereals, finger millet contains 6-8% protein and 1-2% fat, comparable to rice, and excels in mineral and micronutrient content compared to rice and wheat (Gull *et al.* 2014). Similarly, it is the richest source of calcium among cereals with an average moisture content of 10.97-12.90% (Ramaya, 2021) [12]. Their unique grain texture and robust seed coat enable long-term storage without insect damage, but pose challenges for efficient preparation and cooking. Recently, advanced processing methods have been employed to create ready-to-eat, value-added products from small millets. These technologies enhance millet characteristics and add value through decortication, milling, puffing/popping, extrusion, fermentation, and malting procedures. Puffing or popping is a simple and economical processing technique employed to produce ready-to-eat cereal products. The puffing mechanism involves rapid heating, generating extremely hot vapor within the grains. As pressure builds, the endosperm expands and escapes forcefully through tiny pores, resulting in the characteristic puffed texture. This method yields a crunchy, porous, and precooked product. Specifically, puffed finger millet grains exhibit a desirable aroma and palatability. This puffing process enhances the nutritional value of finger millet by inactivating certain antinutritional factors, thereby improving protein and carbohydrate digestibility (Nirmala *et al.* 2000) [10].
The rapidly growing global population, coupled with evolving lifestyles, has led to a surge in demand for convenient and healthful food options. To cater to this demand, convenience foods requiring minimal preparation, such as heating, regeneration, or rehydration, have gained popularity. Ready-to-eat (RTE) and ready-to-cook (RTC) millet-based products, including idli, *dosa*, bread, pasta, noodles, and breakfast cereals, have emerged as viable options.

These convenience foods are particularly appealing to the younger generation seeking fast-acting and nutritious diets. As a result, developing innovative finger millet-based recipes is crucial to increase its applications, expand its utilization, and meet the growing need for convenient, nutritious food options that align with modern lifestyles. To enhance food diversity and accessibility, simple processing techniques like popping and processing can be effectively employed at the home and village levels, providing local communities with the means to create nutritious and convenient millet-based products.

Finger millet, a nutrient-rich cereal, has gained significant attention in recent years due to its potential applications in various food products. Specifically, fermented and malted finger millet flours have been increasingly used in weaning foods, instant mixes, beverages, and pharmaceutical products (Verma & Patel, 2013) [14]. One notable application of finger millet is the puffed finger millet flour enhancing the nutritional profile of traditional weaning foods, such as sattu, a popular roasted cereal-legume flour blend consumed across all ages in rural areas (Devi *et al*. 1990) [5]. Sattu, typically made from roasted Bengal gram, is valued for its high protein content, long shelf life, and excellent taste, making it a staple food supplement in rural India, particularly in Bihar and eastern Uttar Pradesh (Mridula *et al*. 2004) [9]. However, research highlights the importance of combining legumes with cereals/millets to achieve balanced nutrition (Mridula *et al*. 2004) [9]. This study aims to explore the potential of integrating puffed finger millet flour into traditional weaning foods to address nutritional deficiencies and promote affordable, accessible, and nutritious options for infants and young children.

Traditionally, millets have been incorporated into idli recipes to enhance their nutritional value. However, conventional idli and *dosa* batter processing poses challenges, including time-consuming fermentation and preparation. To address these issues, ready-mixes have been developed for commercial use. Typically, idlis are made from fermented rice and black gram, but recent innovations involve creating instant idli premixes using puffed finger millet flour and semolina. According to Balasubramanian *et al*. (2015) [3], idli*'s* prepared in a steam cooking environmental chamber using an ideal template exhibit distinct characteristics, including a circular shape (7-8 cm in diameter), flat surfaces with bulging, and a thickness that decreases from the center (2.0-2.5 cm) to the periphery. Building on this research, the present study explores the development of nutrient-rich, instant idli premixes incorporating finger millet flour, aiming to reduce processing time while maintaining the traditional taste and texture of idlis.

Materials and Methods

The present study was carried out in the Department of Food Grains and Seeds, Post Graduate Institute of Post-Harvest Technology and Management, Killa-Roha, Dist. Raigad. The rawmaterials like decorticated finger millets (*ragi*), Bengal gram, jaggery powder, finger millet semolina, salt, sodium bicarbonate, and curd, citric acid were the experimental goods used in the study that were bought from a nearby super market of Roha. Required instruments, continuous hot air puffing unit for puffing and grinder for grinding, sieves available in PGI-PHTM. Sattu is widely recognized as a nutrient-dense flour with numerous health benefits, which is made from puffed finger millet flour and roasted Bengal gram were ground up and sieved. Combine ingredients in different proportions (e.g., T_1-0:100, T_2-25:75, T_3-50:50, T_4-75:25, T_5-100:0) and well mix. The flour mixture added jaggery powder. Similarly, Instant idli mixes were prepared with various ingredients such as puff finger millet flour, finger millet semolina, sodium bicarbonate, common salt, and citric acid. Combine ingredients in different proportions of puffed finger millet flour and finger millet semolina (R1-100:0, R2-90:10, R3-80:20, R4-70:30, R5-60:40). Mix well and add citric acid before cooking

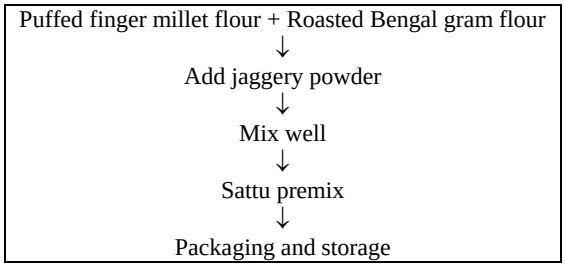

Fig 1: Flour chart for making sattu premix

Table 1: Preparation of sattu with different variations of puffed finger millet flour and roasted bengalgram flour

Ingredients (%)	C / T_1	T_2	T_3	T_4	T_5
FMP	0	25	50	75	100
RBG	100	75	50	25	0
Jaggery	30	30	30	30	30

FMP: Puffed Finger Millet Flour
RBG: Roasted Bengalgram Flour
C: Control product

Preparation of sattu (Energy Drink)

To make fine flour, puffed finger millet flour and roasted Bengal gram were ground up and sieved through 40mesh screen. Combine ingredients in different proportions (e.g., 0:100, 25:75, 50:50, 75:25, 100:0) and well mix. The flour mixture added 30% of jaggery powder constantly. The Sattu premix was prepared for packing and storage. In a ratio of one tablespoon (7-10 g) sattu premix to 250 ml of either milk or water this prepared sattu is served with both.

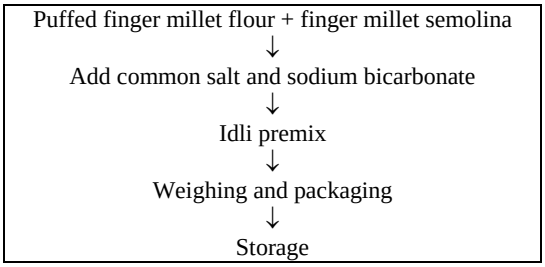

Fig 2: Flowchart for making idli premix

Table 2: Preparation of idli with different variations of puffed finger millet flour and finger millet semolina

Ingredients (%)	C	R1	R2	R3	R4	R5
FMP	0	100	90	80	70	60
FMS	100	0	10	20	30	40
Sodium bicarbonate	0.2	0.2	0.2	0.2	0.2	0.2
Common salt	2	2	2	2	2	2

FMP: Puffed Finger Millet Flour
FMS: Finger Millet Semolina
C: Control product

Preparation of instant Idli

Puffed finger millet flour were added with finger millet semolina in different proportion that is 100:0, 90:10, 80:20, 70:30 and 60:40. Common salt (2%) and sodium bicarbonate (0.2%) were added (Kamaraddi *et al*. 2003) [8]. Then idli premix was ready for packing and storage. For making idli, from idli premix were added 250 ml of water in 200g of premix then rest for 15 min. then add citric acid (0.2%) and well mixed. Prepared batter pour in idli vessel and start cooking. Idli steamed for 10min. Then puffy idli were ready to eat.

Optimization of premixes

The different kinds of premixes developed from finger millet (ragi) puffed grain flour, roasted Bengal gram flour and finger millet semolina.

The suitability of puffed finger millet flour in the preparation of Sattu was studied by incorporating puffed finger millet flour in Standard recipe as depicted in (Fig.1). Roasted Bengal gram flour was replaced by Finger millet flour at 25, 50, 75 and 100 per cent level in the standard recipe (Table 1) and all other ingredients were kept constant. Similarly in Idli prepration Finger millet semolina was replaced by the puffed finger millet flour at 100, 90, 80, 70 and 60 per cent level in the standard recipe as illustrated in (Fig.2 and Table 2) and all other ingredients were kept constant.

Sensory qualities of the value added puffed finger millet flour based Sattu and Idli was conducted in comparison with roasted Bengal gram sattu as control and finger millet semolina idlias control. A nine point hedonic scale was used (Amerine *et al*. 1965) [2], which describes sensory attributes *viz.*, colour, flavor, texture and overall accepting on nine point hedonic scale. Sensory evaluation was done by a panel of 10 judges of institute.

The study's results were subjected to statistical analysis using Factorial Completely Randomized Design (FCRD) to determine significance. Operational Statistics (OPSTAT) – IETF data tracker facilitated data compilation, tabulation, and preliminary analysis. Treatment means were compared at a 5% significance level (p<0.05), following established methodologies (Panse & Sukhatme, 1985) [11]. This statistical approach enabled the identification of significant differences between treatment means, providing a reliable basis for drawing valid conclusions.

Results and Discussion

Organoleptic evaluation of Premixes

Sattu

Organoleptic (sensory) evaluation revealed that Sattu prepared from T_4 (75:25) proportion of puffed finger millet flour and roasted Bengal gram flour had the highest overall acceptability scores followed by T_1 (100:0), T_2 (75:25), T_3 (50:50) and T_5 (0:100) level. Table 1and Fig. 1 shows that the range of values for the mean of different sensory qualities was 6.69 to 7.90. With an average score of 7.90, the sattu produced with finger millet puff flour and roasted Bengal gram flour (T_4) 75:25 had the best value, while the sattu made with finger millet puff flour only (T_5) 100:0 had the lowest average score of 6.69. As the control product, roasted Bengal gram sattu (T_1) was chosen, and it received an average score of 7.82. The most acceptable sattu had the highest scores for colour (7.70), flavour (8.10), texture (7.88) and overall acceptability (7.90). There was not much change in the organoleptic scores of sattu prepared by 100:0 proportions.

Sattu premix was developed by replacing Bengal gram flour with puff finger millet flour in different combinations. Some of the penalty members suggested that the use of milk in the serving of the product it gives better flavor and appearance than water, some like for both mediums in serving. Previous studies have investigated sattu production from various ingredients. Sinha *et al*. (2015) [13] extracted sattu from finger millet, QPM, Bengal gram, and soybean using different blender ratios, employing roasted Bengal gram sattu as a control. Notably, jaggery addition enhances flavor and acceptability. This study incorporated 30% jaggery in premixes, similar to Devi *et al*. (1990) [5], who used a 1:3 chickpea-to-wheat flour ratio with 30% jaggery. Agarwal *et al*. (2016) [1] evaluated traditional sattu from roasted Bengal gram, wheat, and jaggery (1:3 ratio). Jaggery's flavor enhancement surpasses sugar powder and use water, milk as serving media for sattu.

Table 1: Sensory evaluation of sattu made from puffed finger millet (FMP) flour and roasted Bengal gram (RBG) flour in different proportions

Different proportion of (FMP:RBG)	Sensory				Mean A
	Colour	Flavour	Texture	Overall acceptability	
T_1(control)	7.80	7.86	7.80	7.80	7.82[a]
T_2	7.11	7.60	7.70	7.50	7.48[b]
T_3	7.33	7.50	7.70	7.40	7.48[b]
T_4	7.70	8.10	7.88	7.90	7.90[c]
T_5	7.00	6.42	6.55	6.80	6.69[d]
Mean B	7.39[a]	7.50[b]	7.53[c]	7.48[b]	
Factors	C.D., 5%			SE(m)	
Factor (A)	0.029			0.010	
Factor (B)	0.026			0.009	
Factor (A X B)	0.057			0.020	

*Mean of 10 panelists

*The values superscripted by similar letters are at par with each other.

*Each value is mean of three replications.

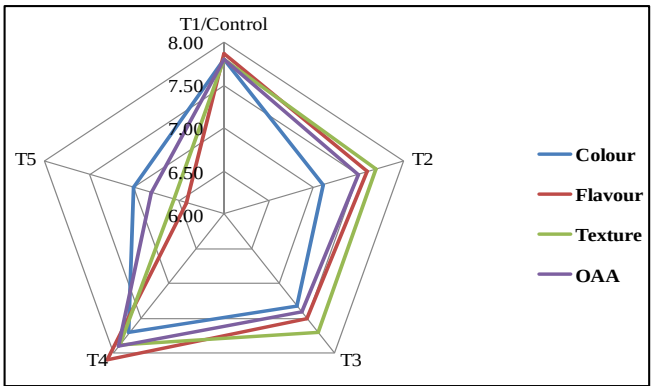

Fig 1: Sensory evaluation of Sattu made from puffed finger millet flour

Idli

Organoleptic Evaluation of idli Prepared with Puffed Finger Millet Flour and Finger Millet Semolina. The sensory evaluation of idli prepared with varying proportions of puffed finger millet flour and finger millet semolina revealed significant differences in overall acceptability. The idli made with a 60:40 ratio (R5) of puffed finger millet flour to finger millet semolina received the highest overall

acceptability score (7.89), followed by the control (0:100) with a score of 7.88. Other blends, R2 (90:10), R3 (80:20), and R4 (70:30), received lower scores.

The mean sensory quality scores varied from 6.87 to 7.89, as shown in Table 2 and Fig. 2. Although there was no thickening or binding agent, the texture and lack of shape retention of the idli made with 100% puffed finger millet flour (R1) were particularly unsatisfactory. As a result, the control product was finger millet semolina idli (0:100). The most acceptable idli (R5) excelled in colour (7.70), flavour (8.00), texture (8.00), and overall acceptability (7.85). In contrast, the control product (0:100) showed minimal variation in organoleptic scores.

In Idli premix, to improve the traditional method of idli making according to time and nutrition, it was replaced by using finger millet flour and finger millet semolina in different combinations. It was seen that there was a rise in idli volume compared to other combinations of idli. The panelists recommended that the idli composition should have more semolina percentage. They also suggested using less water in the batter to avoid stickiness. In the present study, finger millet semolina was used in idli premix. Generally, semolina is a gritty, coarse particle made from a hard type of grain. Durum wheat is used for making semolina, but now semolina is prepared from millets, which replace the wheat semolina. Dhumketi *et al*. (2017) [6] reported semolina made from a hard type of grain (millets). In order to obtain flour-free, uniformly sized semolina, the dehusked/decorticated millet was ground into grits using a flour mill, where the clearance between the rotating discs was adjusted. Chavan *et al*. (2015) [4] also revealed processing in different varieties of sorghum for semolina preparation and used them in different products such as sweet (*shira*) from sorghum semolina and idli from sorghum semolina. Kamaraddi *et al*. (2003) [8] reported that different amounts of little millet semolina and black gram flour were used to create an "instant idli mix" based on millet legumes. The best combination was determined as a 4:1 ratio, with additional additions of sodium bicarbonate at 0.2%, citric acid at 0.05%, and salt at 2% of the dry mix. This study investigates the potential of finger millet semolina in idli premixes.

Table 2: Sensory evaluation of Idli made from puffed finger millet flour (FMP) and finger millet semolina (FMS) in different proportions

Different proportion of (FMP:FMS)	Sensory				Mean A
	Colour	Flavour	Texture	Overall Acceptability	
(Control)	7.80	7.80	8.00	7.90	7.88[a]
R2	6.90	7.10	6.68	6.80	6.87[a]
R3	7.40	7.30	7.20	7.50	7.35[c]
R4	7.30	7.15	7.20	7.30	7.24[d]
R5	7.70	8.00	8.00	7.85	7.89[a]
Mean B	7.42[a]	7.47[b]	7.42[a]	7.47[b]	
Factors	C.D. 5%			SE(m)	
Factor(A)	0.035			0.012	
Factor(B)	0.031			0.011	
Factor(A X B)	0.07			0.02	

*Mean of 10 panelists

*The values superscripted by similar letters are at par with each other.

*Each value is mean of three replications.

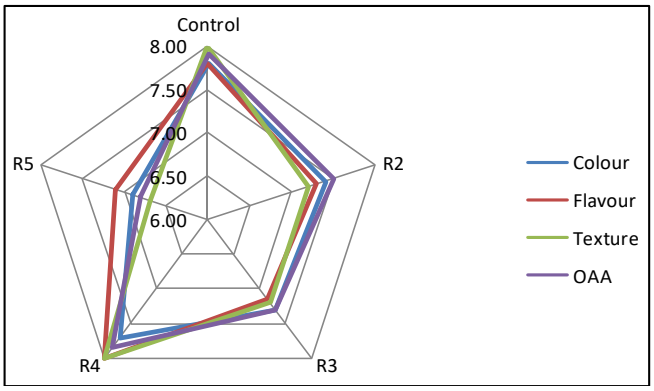

Fig 2: Sensory evaluation of Idli made from puffed finger millet flour

Conclusions

Driven by advancements in food technology, the market is witnessing a rise in convenience foods and ready-to-eat options. Recent standardization trials revealed optimal formulations for sattu and idli premixes, yielding consistent sensory characteristics. Sattu combinations exhibited uniform sensory attributes (color, texture, flavor, and general acceptance) across variants. The (T_4) combination emerged as superior, with significantly higher values.- Similarly, idli premixes showed optimal results with the (R5) combination, surpassing other ratios in sensory evaluation. These findings underscore the potential of strategic formulation optimization in developing high-quality, consumer-acceptable convenience foods.

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