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Formulation, proximate and sensory evaluation of value added finger millet bites

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Abstract
The objective of this study was to develop nutrient dense finger millet bite by incorporating jaggery, skimmed milk powder, nut and seeds. Five treatments were formulated with roasted ragi flour, raisin, cashew nut, flaxseed and pumpkin seed, jaggery and skimmed milk powder. The proximate analysis and sensory evaluation of finger millet bite was done using standard methods. Sample was compared using One-way Analysis of variance (ANOVA) for the significant differences in sensory attributes of the treatments. In sensory evaluation treatment 5 (T_5) received highest score for colour (8.0), mouthfeel/texture (8.0) and overall acceptability (7.6), among other treatments. Proximate analysis of the preferred product (T_5) revealed that the product is high in energy (370.78 kcal), protein (14gm), carbohydrate (73.22gm), calcium (150 mg) and iron (7.03 mg) contents and low in crude fat (3.7gm) and moisture (9.3gm) content. The findings indicated the developed product is rich in calcium and iron, therefore its supplementation significantly meet the demand of calcium and iron of different age groups. It helps to improve the bone health, maintain blood glucose level, fighting anemia and serving as a valuable tool in addressing widespread nutritional deficiencies and promoting public health.

Keywords: Calcium, finger millet bite, iron, jaggery, pumpkin seed, organoleptic evaluation, skimmed milk powder

Indtroduction
Finger millet (*Eleusine coracana*), popularly referred to as ragi, is one of the oldest crops in India. In literature of ancient Indian Sanskrit, it is addressed as "Natta kondaka" and rajika or markataka means dancing grain [1]. Finger millet is widely regarded as the "nutritional power house". It is a significant source of essential dietary components such as soluble and insoluble fibers and resistant starch. Finger millet offers an economical solution to combat micronutrients deficiencies due to its high levels of calcium, iron, zinc, copper etc. Finger millet contains 5-8% protein, 65-75% carbohydrates, 15-20% dietary fibres, 2.3-3.5 % minerals and 1-2% ether extractives. Among all cereals and millets, finger millet is exceptionally high in calcium (344mg), potassium (408 mg) and low in fat (1.3%). Every 100 grams of finger millet provides 336 Kcal of energy [2]. This millet is a good source of amino acids such as tryptophan, threonine, valine, isoleucine and methionine [3].
A distinctive aspect of finger millet's nutritional profile is its abundance of phytochemical compounds, such as polyphenols and tannins. These compounds, traditionally viewed as "anti-nutrients" that reduce the bioavailability of minerals. However, currently they are recognized as nutraceuticals due to their beneficial antioxidants and health-promoting activities. Traditional processing (*viz.* roasting, soaking, fermentation, malting and milling) mitigate the effects of these anti-nutrients. Antioxidants and phytochemicals present in finger millet have anti-inflammatory, anti-cancer, anti-tumorigenic, anti-diabetic and cholesterol-lowering properties, contributing to overall health and disease prevention [4]. Finger millet is a great alternative for people with celiac disease or are sensitive to gluten, since it does not contain gluten.
Despite the inherent nutritional superiority of finger millet, the consumption of finger millet-based products has substantially declined in modern diets, perhaps due to limited awareness of its health benefits and current shift in eating habit. Several attractive snack foods that are high in calories but of low nutrient density are available on the market. The nutri finger millet bite is one way to meet the calorie, protein, calcium and iron demands of an individual especially for growing children. With this context, the present research is carried out to formulate finger millet bites characterized as convenient, ready to eat (RTE) and offer concentrated nutrition along with rapid energy supply.
The development of finger millet bites represents strategic innovation and an endeavour to transform a traditional grain into highly accessible, ready to eat functional food. These bites offer a concentrated dose of macro and micronutrients. Maintenance of bone health, blood glucose management, fighting anaemia, relaxing the body from anxiety, stress, and weight control are the potential health benefits of developed bites. It also serve as valuable tools in addressing widespread nutritional deficiencies and promoting public health.

Materials And Methods
Procurement of raw materials
The organic finger millet (Ragi/Manduaa seed), cashew nut, raisins, jaggery, and Puramio 100% natural skimmed milk powder, Framely pumpkin seed and flaxseed were purchased from the local market of Prayagraj, Uttar Pradesh, India. Analytical grade chemicals were procured from Sigma Aldrich (Seelze, Germany) and Lab-Scan (Dublin, Ireland) available in the local market.

Processing of raw materials
Cleaned and destoned finger millet seed was washed and sundried for 4 hours to remove moisture. After sun drying, seed was roasted at low flame for 15 minutes until it turn in

brown colour. After cooling the roasted seeds, it was ground into powder. Flax seed, cashew nut and pumpkin seed were roasted at low flam for 15min separately; and allow them cooling at room temperature for 15 minutes. To make fine powder of roasted flax seed, cashew nut and pumpkin seed were ground separately for 5 minute. After cleaning the raisins, paste was prepared. Jaggery syrup was prepared by dissolving it in 15 ml water at low flame until it reached thread consistency, then strained.

Optimization factors and ingredient levels of Nutri finger millet Bites

Central Composite Design (CCD) within Response Surface Methodology (RSM) was employed for the optimization of product. For optimization of product, jaggery and skimmed milk powder were taken as independent variables whereas; finger millet (40%) seeds (5%), nuts (5%) and raisins (5%) were used in fixed quantity. A combination of generated five trials is given in Table 1 and Figure1.

Table 1: Compositional ratio of five possible formulations (100/g)

Ingredients	Sample code				
	T_1	T_2	T_3	T_4	T_5
Finger millet (g)	40	40	40	40	40
Flaxseed(g)	5	5	5	5	5
Pumpkin seed(g)	5	5	5	5	5
Cashew nut(g)	5	5	5	5	5
Raisins (g)	5	5	5	5	5
Jaggery (g)	32.9	30.98	35.0	32.0	32.5
Skimmed milk powder (g)	7.1	9.02	5	8.0	8.5

Preparation of Nutri Finger Millet Bite

Five treatments were prepared as per result exhibited by RSM. All ingredients used to formulate this recipe were weighed beforehand. The flour made from roasted finger millet, flaxseeds, pumpkin seeds, cashew nut and raisin paste were thoroughly mixed in jaggery syrup until a uniform mixture obtained. The warm mixture was spread on a greased tray and allow setting at room temperature for 10-12 hours. Then cooled spread was cut into standard pieces with the help of knife.

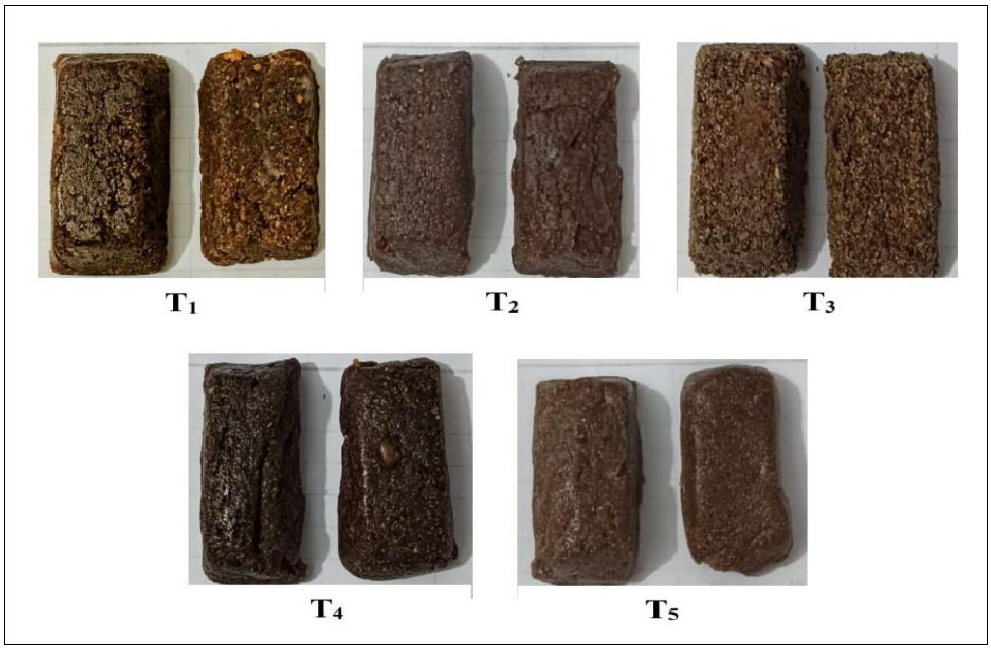

Fig 1: Trials of Nutri Ragi Bite

Organoleptic Evaluation

The developed five trails were presented as Treatment 1, Treatment 2, Treatment 3, Treatment 4 and Treatment 5. An organoleptic evaluation of these products was carried out with a trained sensory panel of 10 members and subjects with different age groups (children and adolescents) using 9 point hedonic scale with a scores ranging from 9 to 1 (*viz*. 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much and 9- like extremely). The sensory quality of whole finger millet bite includes five major attributes such as appearance, color, flavor/sweetness, mouthfeel/texture and overall acceptability.

Proximate Analysis

The final product (i.e. T 5) underwent a thorough analysis which included energy (Kcal), carbohydrate (g), protein (g), fat (g), calcium (mg), iron (g), total ash (g) and moisture (g). This analysis was carried out at a NABL- accredited laboratory accordance with standard protocols and procedures.

The total energy content of sample was determined using Association of Analytical Chemists Method [5]. Total carbohydrate content was obtained by equation method [6]. Crude protein content was evaluated using Kjeldahl method as recommended by Ranganna (2005) [7]. Crude fat of the sample was estimated by the Soxhlet extraction method using petroleum ether [7]. Calcium content of the sample was

evaluated by visible titration method [7]. Iron content was determined by atomic absorption spectrophotometry [7]. Oven drying at 105°C was used to determine moisture content of the sample.Ash content was obtained by heating the sample in a Muffle Furnace at 550°C [7].

Statistical analysis

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) software, version 22. The data obtained from organoleptic assessment were examined by calculating mean and ± standard deviation (SD). One-way analysis of variance (ANOVA) was used to compare the samples for statistical significance at $p \leq 0.05$.

Results and Discussion

The experiment was undertaken to develop calorie-dense, high-protein, high-mineral content (*viz*. calcium and iron) nutri finger millet bites. Results pertaining to the development and standardization of the Nutri Ragi bite (*viz*. organoleptic evaluation and nutritional analysis) are discussed under this section.

Organoleptic Attributes Of Nutri Finger Millet Bite

The organoleptic assessment was carried out to assess the consumer preference of the alternatives, indicating that the nutri finger millet bite was well accepted by the panellist for all sensory attributes evaluated. Table 2 and Figure 2 present the average score of the treatments from the organoleptic evaluation (*viz*. appearance, taste, colour, flavour, texture and overall acceptability). The mouth feel/texture (p=0.001) and overall acceptability (p=0.025) were significantly different among all the treatments. However, no significant difference ($p \geq 0.05$) was observed for colour, appearance and flavour among the treatments.

The organoleptic evaluation showed that Treatment1 (T1) was the most preferred in appearance among others. The mean values for the appearance, colour, mouthfeel/texture, and flavour/sweetness of this treatment were 7.6±0.54, 6.8±0.8, 7.2±0.4 and 7.2±0.83, respectively. Treatment 2 (T2) mean value for colour was 7.0±1.2, mouthfeel / texture was 7.0 ±1.0, appearance was 6.6±1.1 and flavour/sweetness was 7.4±0.89. The average score of Treatment 3 (T3) for colour was 6.8±1.3, mouthfeel/texture 5.0±1.2, appearance was 6.4±1.6 and flavour/sweetness was 6.4±0.89. Average scores of Treatment 4 (T4) for colour, mouthfeel/texture, appearance and flavour/sweetness were 7.8±0.83, 6.0±1.2, 6.2 ±0.8 and 7.0 ± 1.0, respectively.

Among the five developed treatments, T5 scored highest for sensory attributes, *viz*., colour (8.0±1.2), mouthfeel/texture (8.0±0.0), and overall acceptability (7.6±0.54). T5 was determined to be the preferred treatment based on the average sensory score (Table 2). Higher F value for mouthfeel (6.74), overall acceptability (3.250), followed by flavour/sweetness(1.472) and colour (1.17) suggest greater difference between group means relative to the variability within each group for under reference sensory parameters (Table 2).

Table 2: Average score of sensory evaluation

Treatments	Sensory characteristics				
	Colour	Mouthfeel/texture	Appearance	Flavour /Sweetness	Overall acceptability
T_1	7.6 ± 0.54	6.8± 0.8	7.2±0.4	7.2± 0.83	7.6 ± 0.54
T_2	7.0 ± 1.2	7.0±1.0	6.6±1.1	7.4±0.89	7.2 ± 0.83
T_3	6.8±1.3	5.0±1.2	6.4±1.6	6.4±0.89	6.4 ± 0.89
T_4	7.8±0.83	6.0±1.2	6.2±0.8	7.0±1.0	7.2 ± 0.83
T_5	8.0±1.2	8.0±0.0	7.0±2.0	7.6±0.54	8.0 ± 0.0
Total Mean	7.4±1.08	6.5± 1.3	6.6±1.2	7.1± 0.88	8.00± 0.0
F value	1.17	6.74	0.478	1.472	3.520
P = ≤ 0.05	0.352	0.001*	0.752	0.248	0.025**

*Significant difference is at 0.05 levels; Values are means (± SEM).

Proximate analysis

Five variations in ingredient composition were used to develop the Nutri finger millet bite, presented in Table 1. The primary ingredients, jaggery and skimmed milk powder, were incorporated in varying proportions across treatments. As per the organoleptic evaluation score, T5 received the highest score among all the formulations. Hence, this treatment was selected for further analysis to determine its nutritive value, using standard protocols.

Nutritional analysis of the T5 reveals high contents of energy (370.78 kcal), carbohydrate (73.22g), protein (14g), calcium (150 mg) and iron (7.03 mg) per 100 g of developed product. The fat content was found to be 3.7g. The total ash content present in the finger millet bite was 2.9 g. The product has a low moisture content (9.3g), which indicates prolonged shelf life and minimal microbial growth. Products having high moisture content have minimal shelf stability [8].

The developed product comprises a high-energy value of 370.78 kcal / 100 g, indicating an adequate calorie content. The high-energy value of the product is due to the addition of jaggery, cashew nut and skimmed milk powder in finger millet flour. Nuts and seeds are naturally high in calories and provide the double benefits of being rich in essential nutrients while contributing significantly to energy intake even when consumed in small amounts. Their inclusion in finger millet bite not only enhances the product's energy density but also improves its overall nutritional profile.

The addition of skimmed milk powder and nuts /seeds boosts the protein content in finger millet bites, making them a good source of plant-based protein. Finger millet contains around 44.7 % essential amino acids [9]. The key protein content present in ragi is highly enriched with cysteine, tryptophan and methionine and other aromatic amino acids support optimum growth and development [10]. Low fat content (3.7 g) is present in the product. Nuts and seeds used in products are good sources of healthy fats. Their incorporation into the product offers good fat content (*viz*. monounsaturated and polyunsaturated fatty acids, omega -3 and omega-6 fatty acids).

The total ash characterizes the mineral content present in food products. Minerals are essential for maintaining the

optimum functioning of the body [11]. The newly developed finger millet bite contains 2.9 g of ash. Finger millet is rich in calcium and iron, it offers the highest level of calcium, about 10-fold higher as compared to other food grains [12]. The product is dense in calories, high in calcium, high in protein and moderate carbohydrate and low in fat. Hence, it could be a healthier option as a supplement or as a base for daily meals. The research reported that the finger millet bite is appropriate for every age group due to its high content of essential nutrients, particularly calcium and iron. In contrast to this, a study by [13] highlighted that finger millet is a crucial diet for children as well as for pregnant women and breastfeeding mothers.

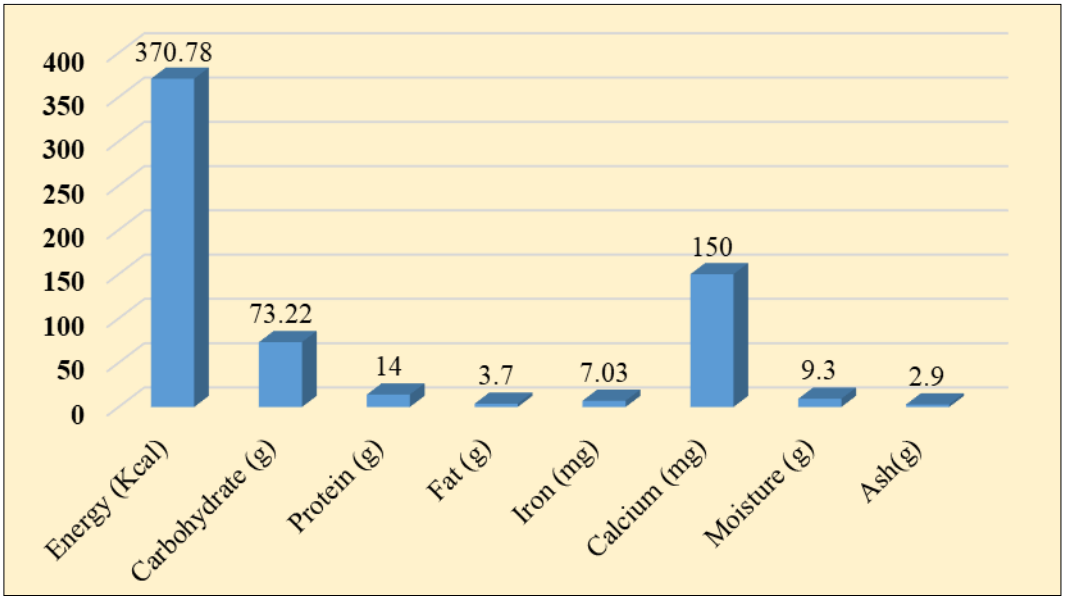

Fig 2: Nutritive value of finger millet bite (100/g)

Conclusion

In this study, the formulation of a health-oriented finger millet nutri bite incorporating jaggery, skimmed milk, nuts and seeds was done. The bite had a distinctive flavor and improved nutritional profile. This product is thought to be a healthier choice compared to traditional bars available on the markets, which often provide too many empty calories. Finger millet bites incorporated with jaggery, skimmed milk and nuts and seeds are a good source of macro and micronutrients, particularly calcium and iron, which are crucial for children, adolescents, pregnant and lactating mothers. The formulated product may help in preventing calcium, iron and protein deficiency and boost the overall nutrition of the community when combined with a healthy lifestyle. Further research may explore the supplementation of this product for optimum growth and development of growing children.

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Conflicts of Interest: The authors declare no conflict of interest.

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