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Development and Quality Evaluation of Finger millet, Flax seed and Skimmed milk powder-based Nutrient-Dense Laddoo

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ABSTRACT

Millets, nuts and seeds are excellent sources of soluble fiber, digestible protein, essential minerals, mono and polyunsaturated fatty acids and vitamins. These nutrients offer numerous health benefits including antioxidant properties, hypocholesterolemic effect, anti-inflammatory effect and cardiovascular protection. Due to these advantages, these are increasingly incorporated into people's regular diets. Laddoo a popular Indian sweet snack, used as the basis for a nutrient-dense variation in this study, made with finger millet, flaxseed, peanut, sesame seed, coconut, jaggery, ghee and skimmed milk powder. The prepared laddoo was a rich source of protein, calcium, iron, carbohydrate and healthy fats, particularly mono and polyunsaturated fatty acids, with negligible cholesterol and transfat content. Hundred grams of the optimized product meets 22% of recommended dietary allowance for protein, 32% of calcium and 23-29% of iron intake for both males and females. Thus, it can be used as a highly nutritious and balanced dietary option for all age group.

Keywords: Finger millet, Flax seed, Skimmed milk powder, Laddoo.

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INTRODUCTION

India offers a wide variety of traditional foods, including various types of laddoo, to cater to the diverse dietary preferences of people. Laddoo is one of the most popular traditional sweet snacks in India, prepared using a range of ingredients like coconut, gram flour, seeds, dry fruits, wheat flour etc. Confectionery made with jaggery is gaining popularity due to increasing awareness of their health benefits. Jaggery, a natural sweetener, is rich in minerals especially iron, calcium and phosphorus.

While a diverse range of ingredients are available for making laddoo, growing health consciousness has led people to incorporate more nutritious ingredients like millet, seeds, and nuts into their regular diets. For instance, flaxseed is one of the richest sources of omega-3 fatty acid, soluble fiber, and digestible protein (Lohan et al., 2020). Finger millet, a minor cereal, is a good source of polyphenols, amino acids, phytates, and minerals like calcium and iron, offering multifunctional benefits such as anti-inflammatory, anti-ulcer, anti-atherosclerogenic, anti-tumour, antimicrobial, and antioxidant properties (Sharma and Yamer, 2022). Sesame seeds are rich in mono and polyunsaturated fatty acids, fiber, essential amino acids, and minerals like potassium, phosphorus, magnesium, iron, zinc, and manganese, contributing to health benefits like antioxidant effects, cholesterol reduction, anti-inflammatory properties, and cardiovascular protection (Wei et al., 2022). Peanuts are also a valuable source of heart-healthy monounsaturated and polyunsaturated fatty acids, bioactive compounds, dietary fiber, B-complex vitamins and minerals like zinc, iron, magnesium, and potassium (Arya et al., 2016).

Given these nutritional benefits, this study focused on developing and evaluating the nutritional parameters of laddoo enriched with ingredients like finger millet, flaxseed, sesame seeds, peanuts, coconut, skimmed milk powder (SMP) and jaggery. These ingredients were selected to enhance the laddoo's content of healthy fats, minerals, and amino acids while minimizing cholesterol and trans-fats.

MATERIAL AND METHODS

Finger millet, flax seed, peanut, white sesame seed, coconut, jaggery, ghee and skimmed milk powder (SMP) were procured from the local market.

Preparation of laddoo

The process was optimized for the preparation of nutritionally rich laddoo. Desiccated coconut was prepared using a stainless-steel coconut shredder. The laddoo mixture consisted of finger millet (1.0 kg), flaxseed (200 g), peanut (300 g), sesame seed (100 g), desiccated coconut (100 g), jaggery (800 g), and ghee (200 g). Additionally, three different

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concentrations of SMP i.e. 200 g, 400 g, and 600 g were used to create three variations of laddoo, labelled as Sample I, Sample II, and Sample III, respectively.

Finger millet, flaxseeds, peanuts, and sesame seeds were roasted on a low flame, cooled to room temperature, and then ground into a fine powder. The roasted finger millet powder was then lightly fried in ghee. These ingredients were combined with SMP and desiccated coconut. A jaggery syrup was prepared by dissolving jaggery in the appropriate amount of water and heating it on low flame. Once the syrup was ready, the mixture of all ingredients was added to the syrup and thoroughly mixed before turning off the heat. The laddoos were shaped by hand and placed on a tray with a cashew nut added on top of each for decoration.

Sensory Evaluation

The prepared products were evaluated for different sensory parameters like colour and appearance, flavour, mouthfeel and overall acceptability by an expert panel of 30 judges using a nine-point hedonic scale.

Physico-chemical parameters

All the three samples were analysed for protein, nitrogen,carbohydrate, total fat, total sugar, calcium, iron, moisture, ash content, energy value, cholesterol, saturated fat, monounsaturated fat, polyunsaturated fat and trans fat.

The nitrogen and protein content were determined by using method IS: 7219 (1973); carbohydrate content by AOAC: 986.25 (2002) method; total fat was analyzed by method IS: 15271 (2003); total sugar was analyzed by method IS:4079 (1999), calcium content by method IS:4285 (1997), iron content by AOAC: 944.02 (1993), moisture and ash content by IS:15271 (2003). The energy value was estimated according to the method proposed by Kays and Barton (2002). The amount of saturated fat, monounsaturated fat, polyunsaturated fat and trans fat were determined by using AOCS (2005) method. The cholesterol content was estimated by using the method AOAC (1996).

Microbial analysis

The prepared sample was analyzed for standard plate count, coliform and yeast and mold count according to the method described in IS: SP 18 (Part XI, 1981).

Statistical Analysis

The results were expressed as means ± standard error of mean. Significance was tested by employing one way analysis of variance (ANOVA) and comparison between means was made by critical difference (CD) value. For computation of data, Microsoft Excel software application programme was used.

RESULTS AND DISCUSSION

The samples were evaluated for various sensory parameters, including color and appearance, flavor, mouthfeel, and overall acceptability (Table 1). Sensory analysis revealed that the color and appearance scores of Sample II and Sample III were significantly higher ($P<0.05$) than those of Sample I, with no significant difference between Sample II and Sample III. Flavor and mouthfeel scores showed no-significant differences ($P>0.05$) among Samples I, II, and III. Regarding overall acceptability, Samples I and III did not differ significantly, but Sample II scored significantly higher ($P<0.05$) than both Samples I and III.

Despite these advancements, it is still challenging to precisely quantify leaf measurements due to variations in leaf morphology, overlapping, and image noise. Our study extends the existing framework by providing a comprehensive and adaptable method for leaf dimension estimation that addresses common problems in image-based measurements.One of the most rigorously specified techniques for accurate and dependable picture detection is the Canny Edge Detection Algorithm. To acquire the best results from the matching process, it is essential to identify the real edges, which is a basic step in image processing. Selecting edge detectors that are most appropriate for the application is crucial because of this. In this case, we selected a clever edge detector. The optimal edge detector is another name for the Canny edge detection technique (Gonzalez and Woods, 2018). The image is initially smoothed by the astute edge detector to remove any noise. After that, it determines the gradient of the image to emphasise areas with high spatial derivatives (Ananthiet al., 2014).The inefficiency and human error potential of traditional manual measurement techniques are their main drawbacks. Leaf parameters are essential for phenotypic characterisation and ecological research, and new developments in image processing provide automated and precise substitutes.

This study offers a technique for very accurate leaf length, width, and aspect ratio estimation that makes use of image processing. We go over the computational methods used, assess the suggested method's performance, and contrast it with manual measurement procedures.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in a mango orchard located in Rehmankhera, Lucknow, Uttar Pradesh, India (latitude,80º 30' to 80º 55' E ;longitude, 26º 45' to 27º. 10' N ; altitude, 123 m). The place has sub humid Subtropical climate. The annual mean temperature is 12.4˚C, and the annual mean rainfallis 592 mm. The average Temperature is around 25°C and average annual rainfall is 726 mm.

Data collection

The Central Institute for Subtropical Horticulture, or ICAR, is a research facility in Rehmankhera, Lucknow, Uttar Pradesh State, where this study was carried out. A variety of plant species' healthy leaves were gathered. Mango (M), guava (G), Jamun (J), and custard apple (CA) leaves of various sizes were gathered

Table 1: Sensory evaluations of Nutrient-dense laddoo

Parameters	Sample I	Sample II	Sample III
Color and Appearance	7.17± 0.19 a	7.87± 0.16 b	7.70± 0.14 b
Flavor	7.43± 0.21 a	7.77± 0.19 a	7.70± 0.14 a
Mouthfeel	7.40±0.18 a	7.80± 0.20 a	7.73±0.14 a
Overall acceptability	7.47±0.18 a	8.10±0.14 b	7.57±0.16 a

The value expressed as Mean ± SE, n=30
abMeans within rows with different uppercase superscript are significantly different (p<0.05) from each other
The nutrient-dense laddoo samples I, II and III were analysed for different chemical compositions.

Compositional study of Nutrient-dense laddoo

Different compositional parameters of the prepared laddoo are presented in Table 2. Samples I, II, and III showing significant differences (P<0.05) in protein and nitrogen content (Table 2). However, Sample III had significantly higher (P<0.05) protein and nitrogen content than Samples I and II, primarily due to the higher concentration of SMP in Sample III. These results align with USITC (2004), which reported that SMP is a good source of protein and nitrogen. According to the ICMR dietary guidelines (2011), the recommended dietary allowance (RDA) for protein intake is 55g for females and 60g for males. As the sample III provide 13g protein per 100g sample, which means that 100g of the prepared laddoo provides about 22% of the RDA for protein intake, as per the ICMR dietary guideline. The total fat, saturated fat, monounsaturated fatty acids, and polyunsaturated fatty acids were significantly higher (P<0.05) in Sample I compared to Samples II and III. The lower SMP concentration in Sample I allowed for a higher proportion of other ingredients, such as finger millet, ghee, flaxseed, sesame seed, peanut and coconut content contributing to its higher fat content. Flaxseeds and sesame seeds are known to be excellent sources of mono and polyunsaturated fatty acids (Asghar et al., 2014; Kajla et al., 2015). Peanuts contain about 50% monounsaturated fatty acids and 14% saturated fatty acids (Arya et al., 2016), while finger millet fat consists of approximately 16-22% palmitic acid, 27-37% oleic acid, 38-40% linoleic acid, and 1-4% linolenic acids (Rao et al., 2018).
The total sugar content of Sample III was significantly higher (P<0.05) than that of Samples I and II, though there was non-significant difference (P>0.05) in total carbohydrate content across the samples. The total ash content of Sample III was also significantly higher (P<0.05) than in Samples I and II. Since SMP was used in varying amounts, highest in Sample III, followed by Sample II and Sample I, consequently the ash content increased with the SMP concentration. This finding was consistent with Pugliese et al. (2017), who reported that SMP contains a high ash content (7-8%).

Finger millet, sesame seeds, peanuts, flaxseeds, and SMP are all good sources of calcium, contributing to the calcium content of the final product (Kajla et al., 2015; Asghar et al., 2014; Arya et al., 2016). Higher SMP content in Sample III resulted in the highest calcium concentration. According to the ICMR dietary guidelines (2011), RDA for calcium intake is 600mg per day for females and males. As the sample III provide 193mg calcium per 100g sample, which means that 100g of the prepared laddoo provides about 32% of the RDA for calcium intake, as per the ICMR dietary guideline.

Differences in iron content were attributed to the varying compositions of sesame seeds, jaggery, and finger millet (Yadav et al., 2019). Jaggery, sesame seeds, finger millet, flaxseeds, and peanuts all contributed as sources of iron in the product (Kajla et al., 2015; Arya et al., 2016; Yadav et al., 2019). Sample III contained about 4.84 mg iron per 100g sample (Table 2). According to the ICMR dietary guidelines (2011), the RDA for iron intake is 21mg for female and 17mg for male. As the sample III provide 4.84mg iron per 100g sample, which means that 100g of the prepared laddoo provides about 23-29% of the RDA for iron intake, as per the ICMR dietary guideline. Moisture content was significantly higher in Samples I and III compared to Sample II. All samples were essentially free of cholesterol and trans fats, making the product heart-healthy.

Moreover, all the ingredients used in the laddoo preparation, including finger millet, flaxseed, peanuts, sesame seeds, and coconut, are gluten-free, making the product suitable for individuals with celiac disease (Devi et al., 2014; Gambus et al., 2009).

Table 2: Chemical compositions of Nutrient-dense laddoo

S.No.	Parameters	Sample I	Sample II	Sample III
1	Protein (g/100g)	9.720 ± 0.022 a	11.520 ± 0.170 b	13.060 ± 0.065 c
2	Nitrogen (g/100g)	1.543 ± 0.007 a	1.833 ± 0.085 b	2.089 ± 0.023 c
3	Total Fat (g/100g)	17.330 ± 0.029 c	16.976± 0.040b	15.648 ±0.057 a
4	Total Sugar (g/100g)	26.150 ± 0.020 a	26.630 ± 0.030 b	27.690 ± 0.037 c
5	Calcium (mg/100g)	126.500± 1.520 a	156.830 ± 3.020 b	193.000 ± 3.750 c
6	Iron (mg/100g)	5.350± 0.027 c	5.080 ± 0.053 b	4.840 ± 0.034 a
7	Moisture (g/100g)	10.451± 0.050 b	9.390 ±0.030 a	10.375 ± 0.018 b

S.No.	Parameters	Sample I	Sample II	Sample III
8	Ash (g/100g)	2.133 ± 0.045 a	2.490 ± 0.020 b	2.730 ± 0.039 c
9	Energy (Kcal/100g)	438.330 ± 4.590 a	432.000 ± 3.250 a	428.500 ± 5.580 a
10	Carbohydrates (g/100g)	57.000 ± 2.977 a	56.667 ± 4.250 a	57.000 ± 2.780 a
11	Cholesterol (mg/100g)	1.000 ±0.000 a	1.000±0.000 a	1.000 ± 0.000 a
12	Saturated fat (g/100g)	5.398 ± 0.127 c	4.773± 0.042 b	4.375 ± 0.050 a
13	Monounsaturated (g/100g)	7.147± 0.020 c	6.492 ± 0.020 b	6.023 ± 0.042 a
14	Polyunsaturated (g/100g)	7.402 ± 0.045 c	6.725 ± 0.040 b	6.240 ± 0.035 a
15	Trans Fat (g/100g)	0.010 ± 0.000 a	0.010 ± 0.000 a	0.010 ± 0.000 a

The value expressed as Mean ± SE, n=3

acMeans within rows with different uppercase superscript are significantly different ($p<0.05$) from each other

Microbiological study

Table 3 exhibited the standard plate count, coliform count, yeast and mold count of the prepared product. There was non-significant difference ($P>0.05$) in the standard plate count of all the three samples, however coliform, yeast and mold count were nil for all the samples.

Table 3: Microbial quality of the prepared laddoo

Sr. No.	Sample Type	Standard Plate count (cfu/g)	Coliform count (cfu/g)	Yeast and Mold count (cfu/g)
1	Sample No. I	668.33±9.45a	Nil	Nil
2	Sample No. II	675.00±7.64a	Nil	Nil
3	Sample No. III	681.66±7.92a	Nil	Nil

The value expressed as Mean ± SE, n=3

abMeans within coloumn with different uppercase superscript are significantly different ($p<0.05$) from each other

CONCLUSION

According to the sensory evaluation, while Sample II received the highest overall score, the acceptability of Sample III was also comparable. Among all the three samples, Sample III stood out for its superior nutritional profile, containing the highest concentrations of protein, total sugar, calcium, and minerals, while having the lowest energy value and saturated fat content. Additionally, it provided a good amount of iron, monounsaturated, and polyunsaturated fats. Based on these factors, Sample III was selected as the best formulation. Hundred gram of the prepared product meets 22% of the recommended daily protein intake, 32% of calcium intake, and 23-29% of the iron intake for males and females, according to RDA guidelines.

The developed product proved to be an excellent source of protein, calcium, iron, minerals, carbohydrates, and healthy fats. This combination offers a balanced mix of essential nutrients, including essential fatty acids, proteins, carbohydrates, and minerals. The high protein content, supported by flaxseed and skim milk powder, is beneficial for muscle health, while the dietary fiber from finger millet, coconut, flaxseed, and sesame seeds promotes gut health and digestion.

This nutrient-rich laddoo also provides a significant amount of monounsaturated and polyunsaturated fats with negligible cholesterol and trans fats. Omega-3 fatty acids from flaxseed, along with the healthy fats from sesame seeds and coconut, contribute to cholesterol-lowering effects and promoting heart health.

Thus, this combination offers a highly nutritious and balanced dietary option, catering to a range of health needs and lifestyles. It is especially convenient for those with busy schedules or anyone needing a quick nutritional boost. This nutrient-dense laddoo is suitable for all age groups, particularly children, pregnant women, and the elderly. It also addresses specific dietary needs such as gluten intolerance, diabetes management, and weight control.

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