
**ISSN Print:** 2664-844X
**ISSN Online:** 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2026; 8(1): 85-88
www.agriculturaljournals.com
Received: 07-10-2025
Accepted: 10-11-2026

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# Utilization of flax seeds and chia seeds for the development of a nutrient-dense laddu

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**DOI:** https://www.doi.org/10.33545/2664844X.2026.v8.i1b.1124

**Abstract**
The present study focused on the development of a nutrient-dense functional laddu with incorporation of flax seeds (*Linum usitatissimum*) and chia seeds (*Salvia hispanica*) into a traditional Indian sweet formulation. Conventional laddus are predominantly energy-dense but nutritionally limited, particularly in terms of essential fatty acids, dietary fiber, and high-quality protein. Flax and chia seeds are well-established functional ingredients due to their high levels of α-linolenic acid (omega-3 fatty acids), dietary fiber, protein, and bioactive phytochemicals. Four laddu formulations were developed with graded levels of flax and chia seed incorporation. The products were analyzed for proximate composition such as total ash, moisture, fat, protein, carbohydrates, energy and total sugar along with sensory evaluation and storage stability to identify the most acceptable formulation. Sensory evaluation results indicated favorable consumer acceptability without compromising organoleptic properties. The products also exhibited satisfactory storage stability under ambient conditions. The study demonstrates that the incorporation of flax and chia seeds is a scientifically viable approach to improving the nutritional and functional quality of traditional laddus. The developed nutrient-enriched laddus have potential as a health-promoting snack suitable for all age groups specially children, adolescents, and women with increased nutritional requirements, including pregnancy, lactation, and menopause.

**Keywords:** Flax seeds, chia seeds, functional laddu, nutrient enrichment, traditional foods

## Introduction
Traditional Indian sweets such as laddu serve as suitable carriers for nutrient enrichment due to their wide acceptability and flexibility in formulation (Gopalan *et al*., 2012) [4] are an integral part of the Indian diet and culture. Despite their popularity, these products are generally high in sugar and fat while being low in essential nutrients. With increasing prevalence of lifestyle-related disorders and growing consumer awareness, there is a need to improve the nutritional quality of traditional foods without compromising their acceptability. The incorporation of functional ingredients such as seeds rich in dietary fibre and bioactive compounds into traditional foods enhances their nutritional density and health-promoting potential (Mudgil & Barak, 2013) [9]. Flax seeds (*Linum usitatissimum*) are rich in alpha-linolenic acid (ALA), dietary fiber, protein, and bioactive compounds such as lignans. Their incorporation into food products has been shown to enhance nutritional profiles, providing benefits related to cardiovascular health and digestive function (Goyal *et al*., 2014; Talwar *et al*., 2025) [5, 11]. Recent reviews also highlight the potential of flaxseed by-products as nutrient sources in food applications, reflecting their functional versatility and positive health implications (Talwar *et al*., 2025) [11]. Flaxseed is a rich source of alpha-linolenic acid (ω-3 fatty acid), dietary fibre, and lignans, which are known for their cardio-protective, antioxidant, and anti-inflammatory properties. Incorporation of flaxseed into traditional food products can significantly enhance their nutritional quality (Morris, 2007) [8].
Similarly, chia seeds (*Salvia hispanica* L.) are recognized for their remarkably high fiber content, essential fatty acids, protein, minerals, and bioactive antioxidants, which contribute to metabolic health and antioxidant activity (Nutritional and Functional New Perspectives, 2025; Chia as a functional "superfood," 2025). Contemporary studies have shown successful incorporation of chia seeds into baked goods and other food formulations to improve nutritional value and antioxidant bioaccessibility without compromising sensory quality (Journal of Food Measurement and Characterization, 2025; IJES, 2025).

Chia seeds are an excellent source of dietary fibre, high-quality protein, omega-3 fatty acids, and essential minerals such as calcium, iron, and magnesium. Their functional properties make them suitable for incorporation into value-added food products (Ullah *et al*., 2016) [12].

Incorporating these functional ingredients into traditional foods can help bridge the gap between nutrition and cultural food practices and it can significantly elevate its nutrient density and functional quality. Such product innovation aligns with current trends in functional foods and provides a culturally acceptable approach to enhance nutritional intake in diverse populations.

This study is also aligns with trends in healthy snacking, plant-based nutrition, and disease prevention through diet. Therefore, the present study aims to develop a nutrient-dense laddu enriched with flax seeds and chia seeds, focusing on improved nutritional attributes and potential health benefits.

## Materials and Methods

**Raw Material procurement:** Flax seeds, chia seeds, peanuts, oats, roasted bengal gram, dates, coconut, and cardamom were procured from the local market in Baramati, Maharashtra.

**Preparation of Seed Powder and other ingredients**

Flax and chia seeds were cleaned lightly roasted to enhance flavor and reduce antinutritional factors, and ground into fine powder. Peanuts, roasted Bengal gram, and oats were also roasted separately. Cardamom was finely ground, coconut and jaggery were grated, and dates were deseeded and ground. All processed ingredients were stored in airtight containers until use.

**Product Formulation and Standardization**

In the present study standardized control sample i.e. (V0) was formulated with changing proportions of ingredients and highly accepted trail was selected as control variation. A nutrient-dense FSCS laddus were prepared with mixing seeds powder in the standardized formula of Control (V0) laddue in the selected amount of different three variations such as V1 (4%), V2 (8%) and V3 (16%). Control standard product along with three variations was formulated and after standardization they were kept for organoleptic analysis.

**Table 1:** Formulation of Control and Experimental FSCS Laddus

| Ingredients (g) | Control (V0) | V1 (4%) | V2 (8%) | V3 (16%) |
|---|---|---|---|---|
| Flax seed powder | 0 | 2 | 4 | 8 |
| Chia seed powder | 0 | 2 | 4 | 8 |
| Peanuts | 10 | 10 | 8 | 6 |
| Coconuts | 14 | 14 | 12 | 10 |
| Oats | 10 | 8 | 8 | 6 |
| R Bengal gram | 10 | 8 | 8 | 6 |
| Dates | 40 | 40 | 40 | 40 |
| Jaggery | 15 | 15 | 15 | 15 |
| Cardamom | 1 | 1 | 1 | 1 |

**Fig 1:** Ingredients used in FSCS Laddu

**Fig 2:** Developed Flax Seeds & Chia Seeds Laddu

**Organoleptic Analysis:** The standardized variations and control variation were evaluated for its sensory characteristics using a score card with five point ranking scale includes colour, texture, taste, flavor and overall acceptability. Organoleptic analysis was performed by 15 semi trained panel members for analyzing consumer acceptability of product. Most accepted variation of nutrient dense laddu was selected by means of highest scores using statistical analysis. Lawless, H. T., & Heymann, H. (2010) [7].

**Nutritional Analysis:** The developed flaxseed and chia seed mix laddu variations and control were evaluated for its nutritional composition using standardized chemical analytical procedures. Proximate parameters such as moisture, total ash, fat, protein, carbohydrates, total sugar, and energy value were determined following prescribed analytical methods and relevant Indian Standards. The analysis was carried out to assess the nutritive potential of the developed product, and results were expressed per 100 g of sample**.** Nutritional analysis was carried out using standard AOAC methods (AOAC, 2016) [1].

**Storage study:** A storage study was conducted to evaluate the sensory quality of the developed flaxseed and chia seed mix laddu. The product was packed in food-grade airtight containers and stored under ambient conditions. Sensory evaluation was carried out by a semi-trained panel at 0, 7, 14, 21, and 28 days of storage. The samples were assessed for colour, texture, taste, flavour, and overall acceptability

using a five-point hedonic scale, where higher scores indicated greater preference. Sensory scores recorded at each storage interval were documented for further analysis.

## Results and Discussion

**Organoleptic Analysis:** Sensory evaluation of the developed product was conducted using a 15-member panel. The results indicated that variation V2 recorded the highest mean scores for colour, texture, taste, and overall acceptability when compared to the control (V0) and other variations. The control sample showed acceptable sensory quality, while V1 and V3 exhibited comparatively lower scores for most attributes but satisfactory overall acceptability. Based on sensory scores, variation V2 was identified as the most preferred formulation. The scores were consolidated and analyzed using mean and standard deviation (Table. 2).

**Table 2:** Mean sensory score of developed flax seeds & chia seedsl laddu

| Sample | Colour | Texture | Taste | Flavour | Overall Acceptability |
|---|---|---|---|---|---|
| V0 (Control) | 4.20±0.25 | 3.90±0.22 | 3.80±0.24 | 3.90±0.23 | 3.80±0.26 |
| V1 | 2.90±0.28 | 3.40±0.26 | 3.30±0.27 | 3.10±0.25 | 4.00±0.24 |
| V2 | 4.50±0.20 | 4.00±0.22 | 4.10±0.21 | 3.90±0.23 | 4.50±0.20 |
| V3 | 2.80±0.30 | 3.00±0.28 | 3.30±0.26 | 3.20±0.27 | 4.10±0.24 |

Values are expressed as Mean ± SD (n = 15)

**Nutritional Analysis:** The nutritional composition of the developed flaxseed and chia seed mix laddu was determined using laboratory-recommended standard analytical methods. Proximate parameters including moisture content, total ash, fat, protein, carbohydrates, total sugar, and energy value were analyzed following prescribed chemical Standard Operating Procedures (SOPs) and relevant Indian Standard methods as indicated in the test report. Protein estimation was carried out using IS 7219:1973 (RA 2020), while other parameters were analyzed using validated chemical SOP methods. All values were expressed on a per 100 g basis to assess the nutritional quality of the product (Table No. 3)

**Table 3:** Proximate composition of flaxseed and chia seed mix laddu

| Sr. No. | Parameter | Result | Unit | Method of Analysis (as per test report) |
|---|---|---|---|---|
| 1 | Moisture Content | 12.91 | g/100 g | CHEM/SOP-F/01 |
| 2 | Total Ash | 0.43 | g/100 g | CHEM/SOP-F/02 |
| 3 | Fat Content | 13.43 | g/100 g | CHEM/SOP-F/03 |
| 4 | Protein | 12.00 | g/100 g | IS 7219:1973 (RA 2020) |
| 5 | Carbohydrates | 61.23 | g/100 g | CHEM/SOP-F/04 |
| 6 | Energy | 413.8 | kcal/100 g | CHEM/SOP-F/05 |
| 7 | Total Sugar | 31.00 | g/100 g | CHEM/SOP-F/06 |

The nutritional analysis demonstrated that the flaxseed and chia seed mix laddu is a nutrient-dense food product with high energy value (413.8 kcal/100 g). The product contained appreciable amounts of fat (13.43 g/100 g) and protein (12.0 g/100 g), enhancing its nutritional quality. Carbohydrates constituted the major macronutrient (61.23 g/100 g), contributing significantly to the energy content. The moisture and ash content were within acceptable limits, indicating product stability and presence of essential minerals. The nutritional assessment revealed that the flaxseed and chia seed mix laddu possessed a high nutritive profile. The product showed moderate moisture content, indicating acceptable stability. A notable proportion of carbohydrates contributed to the energy value, while the presence of protein and fat enhanced its overall nutritional quality. The ash content reflected the contribution of mineral components. The high energy value suggests that the developed product can serve as a concentrated source of nutrients**.**

**Storage study:** The sensory quality of the flaxseed and chia seed mix laddu was evaluated at 0, 7, 14, 21, and 28 days of storage under ambient conditions. The product showed highest sensory scores on day 0. A gradual but marginal decline in colour, texture, taste, flavour, and overall acceptability was observed with increasing storage period; however, the product remained sensorially acceptable up to 28 days. After 35 days of storage, a slight bitter taste was noted, which negatively affected flavour and overall acceptability. Hence, the product was considered acceptable for consumption up to 28 days under ambient conditions.

**Table 4:** Effect of Storage on Overall Acceptability of selected V2 variation of Flaxseed and Chia Seed Mix Laddu

| Storage Period (Days) | Colour | Texture | Taste | Flavour | Overall Acceptability |
|---|---|---|---|---|---|
| 0 | 4.8 | 4.7 | 4.8 | 4.7 | 4.8 |
| 7 | 4.7 | 4.6 | 4.6 | 4.6 | 4.6 |
| 14 | 4.6 | 4.5 | 4.5 | 4.5 | 4.5 |
| 21 | 4.4 | 4.3 | 4.3 | 4.2 | 4.3 |
| 28 | 4.2 | 4.1 | 4.0 | 4.0 | 4.1 |
| 35 | 3.5 | 3.8 | 3.2 | 3.1 | 3.3 |

## Conclusion

The findings of the present investigation demonstrate that the flaxseed and chia seed mix laddu developed in this study possessed desirable sensory characteristics along with substantial nutritional value. The selected formulation achieved higher acceptability scores across key sensory attributes, indicating good consumer preference. Nutritional evaluation confirmed that the product is a concentrated

source of energy and essential macronutrients, including carbohydrates, protein, and fat. The observed moisture and ash levels suggest adequate product stability and contribution of mineral content. In view of its favorable sensory appeal, nutrient composition and 30 days storage stability, the developed product may be considered a promising functional food with potential applications in health-oriented dietary practices. This study suggests that traditional Indian sweets can be modified into functional foods without compromising sensory properties

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