Nutrient Evaluation of Millet-based Laddu using Eleusine Coracana, Cicer Arietinum and Moringa Oleifera

Tehamina[1], A. Annapurna[2], Ch. Gayathri[3], T. Kundana[4]
[1,2,3,4]*Department of Food Science and Technology, S.D.M. Siddhartha Mahila Kalasala, Vijayawada*

***Abstract*—Malnutrition remains a pressing global challenge, particularly deficiencies of protein, iron and calcium among adolescent girls. Adolescence is a crucial stage, especially for girls, who undergo distinct physical, physiological, social, and psychological changes. This phase is characterised by irregular eating and sleeping patterns, leading to deficiency disorders. The present research conducts a comprehensive nutritional evaluation of a novel millet-based traditional Indian sweet, laddu, prepared by using ragi (Eleusine coracana), sattu (Cicer arietinum), jaggery (Saccharum officinarum) and Moringa oleifera. The formulation optimizes positioning it as a cost-effective, nutrient-dense snack for addressing these gaps among adolescent girls. Nutrient evaluation was done on the laddu to estimate protein, iron, calcium, phosphorus and vitamin C. The protein content was 6.41 gm %, iron was 10.88 mg%, calcium was 18.00 mg%, phosphorus was 110.00 mg% and vitamin C was 3.44 mg%, respectively. Such nutrient-dense snacks may have the ability to address micronutrient deficits among young populations.**

***Index Terms*—ragi, sattu, traditional Indian sweets, Moringa oleifera, micronutrient deficiencies**

I. INTRODUCTION

A person may be either undernourished or overnourished due to malnutrition, which occurs when the body does not receive the proper balance of nutrients. It frequently results from inadequate dietary intake, restricted availability to a wide range of foods, recurrent infections, or diseases that disrupt the body's ability to absorb or utilize nutrients. Over time, this imbalance can impair brain development, weaken the immune system, and slow down physical growth, increasing the risk of disease and even death in children and other vulnerable populations (WHO, 2024; Shrivastava et al., 2023).

Malnutrition-related nutrient shortages remain a major public-health challenge in resource-limited settings, especially in India. Iron-deficiency anemia affects more than half of adolescent girls and a large proportion of women of reproductive age, driven by inadequate dietary iron, increased physiological demands, and menstrual blood loss (Shrivastava et al., 2023; Annapurna & Babitha, 2026). In many cereal-based diets, such as those common in Andhra Pradesh, intakes of calcium, protein, vitamin C, and phosphorus are often insufficient, contributing to poor bone health, impaired growth, and weakened immunity (Paul et al., 2020; Gupta et al., 2022). Iron-folic acid supplements and fortified foods are recommended, but their influence is limited by cost and low adherence. This underscores the need for ready-to-eat, culturally acceptable foods made with locally sourced components (WHO, 2024; Annapurna et al., 2024).

Millets and plant-protein-rich foods have emerged as practical options for tackling malnutrition issues or micronutrient deficiencies because they combine relatively high mineral content with good dietary fibre and moderate energy density (Gupta et al., 2025; Annapurna & Babitha, 2026). Ragi or finger millet (Eleusine coracana), for example, contributes about 340–360 mg of calcium, around 11 mg of iron, and roughly 7 g of protein per 100 g, along with appreciable fibre and polyphenols that can either support or limit mineral bioavailability depending on processing and overall diet (Kumar et al., 2016; Gupta et al., 2022).

In addition to significant levels of iron, phosphorus and potassium, sattu prepared from roasted Bengal gram (Cicer arietinum) typically provides about 20 g protein and 10–15 g fiber per 100 g. Although its absorption depends on the presence of enhancers like vitamin C and low phytate type processing, the mixture adds iron to the diet when combined with jaggery (Saccharum officinarum), which contains approximately 10–11 mg iron per 100 g and trace amounts of calcium and other minerals (Gupta et al., 2025; The Blood Project, 2025).

A further micronutrient "boost" is added by adding 5% powdered moringa oleifera leaves to the traditional sweet, laddu. The leaves are rich in iron, calcium (about 180–350 mg per 100 g), vitamin C (often exceeding 50 mg per 100 g) and several other minerals, as well as a significant amount of dietary fiber (Meka et al., 2016; Gupta et al., 2022; Annapurna & Babitha, 2026). By converting ferric iron to the more soluble ferrous form and partially offsetting the inhibitory impact of phytates, vitamin C from Moringa oleifera enhances the absorption of iron from ragi, sattu, and jaggery (Gupta et al., 2025). Because of these synergies, Moringa-fortified cereal-based snacks are appealing functional meals for boosting total micronutrient intakes across vulnerable population groups and treating iron deficiency anemia (Annapurna & Babitha, 2026; Gupta et al., 2025).

Simple processing and blending can increase nutrient content and customer appeal, according to a number of recent studies on millet-based value-added products. Compared to traditional cereal-based diets, millet-based snacks, porridges, and quick mixes—which are frequently enhanced with legumes, nuts, or moringa leaves—tend to offer higher levels of protein, fiber, calcium, iron, and zinc (Kumar et al., 2021; Saraswathi & Hameed, 2023).

In light of this, the current study assesses a novel ready-to-eat Indian traditional sweet, laddu, made with ragi, sattu, jaggery and Moringa oleifera leaf powder. A small amount of ghee was added for binding and to improve palatability.

II. MATERIAL AND METHODS

Procurement of the raw materials: Raw materials required for the present study were procured from local market. Ragi seeds, Roasted Bengal gram, Moringa leaves, jaggery and ghee were purchased and stored in air-tight containers for further processing.

Preparation of the ingredients:

Ragi (Finger millet) flour: Ragi flour was prepared from the seeds (Anjali Chandra). The procedure is as given in Fig. 1.

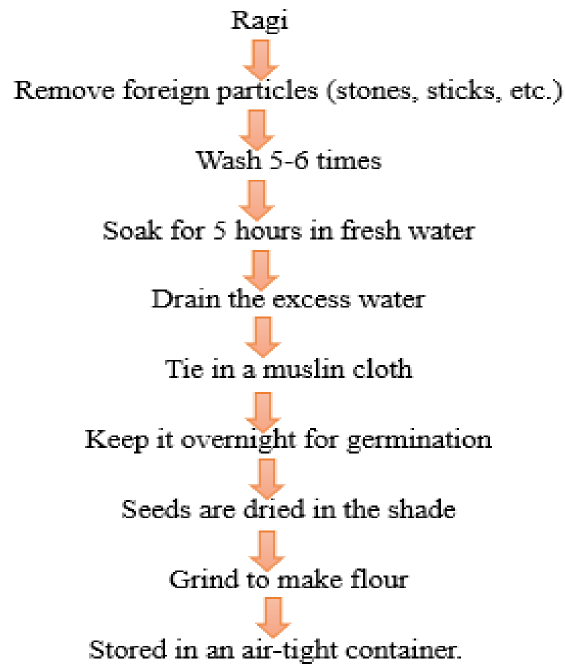

Fig. 1: Ragi flour processing

Sattu processing: Sattu flour processing (Shashi Kant, 2025) prepared as given in Fig. 2.

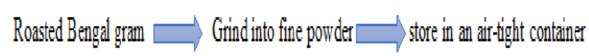

Fig. 2: Sattu flour processing Moringa oleifera powder processing: Moringa Oleifera leaf powder (Satya Prakash .M, 2012) is prepared as given in Fig. 3.

Fig. 3: Moringa oleifera leaf powder

Preparation of millet-based laddu: The ratio of ingredients used to make the traditional sweet, laddu, is as given in Table 1. Each ingredient was weighed and dry-roasted separately for a few minutes over a low flame. Then, the jaggery is melted with a small amount of water and made into a syrup. All the roasted ingredients are then mixed in the syrup and made into small balls. To make it more palatable, a small bit of ghee is added.

Table 1: Ingredients for preparation of laddu

Ingredients	Amount (g)
Ragi	100
Sattu	50
Jaggery	150
Moringa oleifera leaf powder	5
Ghee	15 ml
Cardamom(flavour)	1

Nutrient evaluation: Protein, ash, calcium, iron, phosphorus and vitamin C were estimated using standard procedures.

Estimation of Protein: The protein was estimated in the laddu by the Kjeldahl protein estimation method (Sultana S. 2020).

Calculation:

The amount of nitrogen was calculated according to the following equation:

$$\%\text{Nitrogen} = \frac{(\text{TS} - \text{TB}) \times \text{Strengthof HCl} \times 0.014}{\text{Weight of the sample (g)}} \times 100$$

Where,

TS = Titer value of the sample in ml.

TB = Titer value of the blank

Strength of HCL acid = 0.1 N

The percentage of nitrogen of the sample was multiplied by 5.58 to obtain the total crude protein according to the following equation:

% Crude protein = % Nitrogen x 5.58

Estimation of Ash: The ash obtained by ashing the sample in the muffle furnace at 550°C± 15°C for four hours (AOAC, 1985) was dissolved in 5 ml of concentrated HCl and heated over a burner for complete dissolving. The contents from the crucible were transferred carefully into a volumetric flask and made up to 100 ml with distilled water. This solution was used for the estimation of minerals viz., calcium, iron and phosphorus.

Estimation of Calcium: Calcium in the ash solution was estimated by the titrimetric method (Hawk, Oser and Summerson (Eds), 1957). Two ml of ash solution was pipetted out into centrifuge tubes. A drop of methyl red indicator was added to the tubes and the solution turned light pink. Liquor ammonia was added till it turned to light yellow. This showed that the solution was too alkaline. A drop of glacial acetic acid was added to give a salmon pink colour indicating the correct pH for the precipitation of calcium. This was mixed well, and 1ml of ammonium oxalate solution was added.

The tubes were kept overnight and centrifuged at 2,000 rpm the following day. The supernatant was thrown off by inverting the tubes carefully on a clean filter paper and drained. Care was taken to prevent the precipitate from running along the tubes' sides. Four ml of liquor ammonia was added to the precipitate along the sides of the test tube and were centrifuged again. The supernatant was thrown off and the process was repeated 2 to 3 times. Ten ml of 1N sulphuric acid was added and the contents were made to dissolve. The tubes were kept in a water bath till the contents started simmering and titrated against 0.01N potassium permanganate when still hot. The endpoint was a definite pink colour which persisted for at least one minute.

Standardization of $KMnO_4$ against 0.01N oxalic acid was done. The endpoint was the appearance of a permanent pale pink colour. The titration was repeated till concurrent values were obtained.

Estimation of Iron: The iron in the ash solution was estimated by Wong's method (Raghuramulu et al., 1983), and the working standard solution was taken in the volumes of 1.0, 1.5, 2.0, 2.5 and 3.0 ml which correspond to 0.01, 0.015, 0.02, 0.025 and 0.03 mg of iron respectively in different test tubes. To all the test tubes 1.0 ml of 30% H_2SO_4, 1ml potassium sulphate solution, followed by 1.5 ml of 40% potassium thiocyanate were added. Distilled water was added to make up the volume to 10 ml in each test tube and was allowed to stand for 20 mins. The intensity of the colour developed was read in the colourimeter at 540 nm.

Two ml of ash solution was taken, and all reagents were added as standard. The readings were plotted against different concentrations of the standard and the concentration of unknown was intercepted from the graph.

Estimation of Phosphorus: Phosphorus in the ash solution was estimated by Fiske Subba Rao's method (Raghuramulu et., 1983). Working standard solution was taken in the volumes of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4 ml which correspond to 5, 10, 15, 20, 25, 30, 35 and 40 µg of inorganic phosphorus respectively in different test tubes. To all the test tubes 1.0ml of 3.125% TCA and 1ml of Ammonium Molybdate, followed by 0.4ml of ANSA were added. Distilled water was added to all the test tubes to make up the volume to 10 ml and the tubes were allowed to stand for 15 mins.

Two ml of ash solution was taken in triplicates and treated in the same way as the standards. The intensity of the colour developed was read in the colourimeter at 660nm. The readings obtained were plotted against different concentrations of the standard and the concentration of unknown was intercepted from the graph.

Estimation of Vitamin C: Ascorbic acid was determined by the procedure given by Xiao Z et al. (2012) by using 2.6-dichloroindophenyl and measuring the content by a titrimetric method. The results are expressed as mg of ascorbic acid per 100 g of fresh weight.

III. RESULTS AND DISCUSSION

The nutrient composition of the millet-based laddu is as shown in the Table 2. The protein content of the formulated laddu is 6.41 ± 0.05 g%. Minerals namely iron, calcium and phosphorus estimated in the laddu showed a value of 10.88 ± 0.10mg%, 18.00 ± 0.03 mg%, 110.88 ± 0.08 mg% respectively. The laddu showed a vitamin C content of 3.44 ± 0.002 mg%.

Shrivastava et al., (2021), estimated the protein content of similar laddu to be 12.32 gm%, which is more than the present research. However, the iron content showed to be 3.34 mg%, which is considerably less than the present study. The laddu showed the calcium and phosphorous content to be 107.3 mg% and 166.1 mg%. Ganesh Kumar et al., (2024) reported the protein value of millet morringa based cake and wafer to be 10.26 to 11.67 mg% and 4.87 to 6.49 mg% respectively, which is comparatively more than the present study. Consequently, the iron values are considerably less (1.97 to 3.98 mg% in cake and 1.091 to 2.09 mg% in wafers) than the present millet based laddu.

Table 2: Nutrient composition millet-moringa based laddu

Sl.No	Nutrients	Value
1.	Protein (g%)	6.41 ± 0.05
2.	Iron (mg%)	10.88 ± 0.10
3.	Calcium (mg%)	18.00 ± 0.03
4.	Phosphorus (mg%)	110.00 ± 0.08
5.	Vitamin C (mg%)	3.44 ± 0.002

IV. CONCLUSION

This nutrient-dense laddu formulation made from ragi, sattu, jaggery, and Moringa oleifera is a viable, culturally appropriate way to address the micronutrient deficiencies that affect teenage girls in India. This nutrient rich laddu addresses iron-deficiency anemia, which affects more than 50% of girls between the ages of 10 and 19 as a result of growth spurts, menstruation losses, and inadequate cereal-based diets devoid of accessible minerals.

The synergies between sattu's plant protein and moringa's vitamin C, which increases the absorption of non-heme iron from ragi and jaggery, improve bioavailability and outperform supplements that are hampered by concerns with cost and compliance. Regular consumption may prevent long-term hazards such as maternal anemia, osteoporosis, and cycles of intergenerational starvation. Therefore, this product may be used to alleviate nutrient deficiencies in adolescent girls or young women.

REFERENCE

[1] Annapurna, A., Babitha, B., & Andallu, B. (2024). Millet: Key to alleviate micronutrient deficiencies (calcium & iron) among adolescent girls. Texila International Journal of Public Health, 12(4), Article 052. https://doi.org/10.21522/TIJPH.2013.12.04.Art052.

[2] Annapurna, A., & Babitha, B. (2026). Development of a value-added product from Italian millet and Moringa leaves: Sensory acceptability and microbiological assessment. International Journal of All Research Education and Scientific Methods (IJARESM), 14(2), February 2026. https://www.ijaresm.com.

[3] Gupta, A., Khandelwal, S., & Menon, A. S. (2022). Main nutritional deficiencies: A global overview. Postgraduate Medical Journal, 98(1164), 1167–1173. https://doi.org/...

[4] Gupta, A., et al. (2025). Innovative plant-based nutraceuticals: Enhancing iron bioavailability to address iron deficiency anaemia. Nutrients, 17(11), 2750. https://doi.org/...

[5] Kumar, A., Sharma, S., & Punia, S. (2016). Millets as potential source of functional foods and nutraceuticals. Journal of Food Science and Technology, 53(1), 23–31. https://doi.org/...

[6] Meka, V. S., et al. (2016). Micronutrient composition and acceptability of Moringa oleifera leaf-fortified foods. Food Science and Human Wellness, 5(3), 123–130. https://doi.org/...

[7] Monk, J. M., Karl, J. P., & Robinson, S. L. (2016). Malnutrition and immune function. Current Opinion in Clinical Nutrition and Metabolic Care, 19(3), 25–37. https://doi.org/...

[8] Shrivastava, S. R., Gupta, A., & Shrivastava, S. S. (2023). Prevalence of anaemia among adolescent girls (10–19 years) in India: A systematic review and meta-analysis. National Medical Journal of India, 36(2), 112–117.

[9] The Blood Project. (2025). Oral iron and vitamin C.https://www.thebloodproject.com/oral-iron-and-vitamin-c

[10] World Health Organization. (2024).Malnutrition fact sheet. https://www.who.int/news-room/fact-sheets/detail/malnutrition.

[11] Saraswathi, R., & Hameed, R. S. (2023). Value addition influenced in millet products: A review. Austin Journal of Nutrition and Food Sciences, 11(1), 1161–1169. https://austinpublishinggroup.com/nutrition food sciences/fulltext/ajnfs v11 id1161.php.

[12] Gupta, A., et al. (2024). The nutrition and therapeutic potential of millets: A review of food and value added products. Food and Nutrition Sciences, 15(4), 1–18. https://doi.org/xxxx

[13] Kumar, P., et al. (2021). The nutritional use of millet grain for food and feed: A review. Frontiers in Nutrition, 8, 642–651. https://doi.org/10.3389/fnut.2021.642651

[14] Sultana S. Nutritional and functional properties of Moringa oleifera. Metabol Open. 2020 Oct 9;8:100061. doi: 10.1016/j.metop.2020.100061. PMID: 33145489; PMCID: PMC7596288.

[15] Anjali Chandra*, Ajeet Kumar Singh and Bharat Mahto, Processing and Value Addition of Finger Millet to Achieve Nutritional and Financial Security, International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706 Special Issue-7 pp. 2901-2910 Journal homepage: http://www.ijcmas.com.

[16] Shashi Kant, Hitendra Singh Chauhan and Jyoti Sindhwal, Sattu, the Indigenous Cold Drink of Bihar: Nutritional, Health and Economic Facts; Volume 25, Issue 3, Page 233-238, 2025; Article no. ACRI.131566, ISSN: 2454-7077.

[17] Satya Prakash .M, Pankaj sing and Sanjay Singh; Processing of Moringa oleifera leaves for human consumption, 2012 Dec, ISSN2277-1808, Bull. Env. Pharmacol. Life Sci. Vol 2.

[18] AOAC, 1985. Official methods of analysis, Washington, D. C., Edn no. 14, Association of Official Chemists.

[19] Hawk, Oser and Summerson (Eds), 1957, Practical Physiological Chemistry, 13th edition

[20] Raghuramulu, N., Madhavan, N. K., and Kalyana Sundaram (Eds), 1983, A manual of laboratory techniques, NIN, Hyderabad.

[21] Xiao Z., Lester G.E., Luo Y., Wang Q. Assessment of vitamin and carotenoid concentrations of emerging food products: edible microgreens. J. Agric. Food Chem, Journal of agricultural and food chemistry. 2012; 60:7644–7651. doi: 10.1021/jf300459b.

[22] Shrivastava DC, RK Jhade, PL Ambulkar, Surendra Pannase, Development and fortification of Ragi Millet (Eleusine Coracana) and moringa based health food Sattu. International Journal of Food Science and Nutrition, ISSN: 2455-4898; Impact Factor: RJIF 5.14; 15-01-2021; Accepted: 02-02-2021; Published: 02-03-2021, Volume 6; Issue 2; 2021; Page No. 06-09.

[23] Ganeshkumar Dodde, Uppuluri Naga Krishna Sai, Dr. A. Ravinder, (2024), Development and quality evaluation of Ready to Eat value added products (Cake and Wafer) from composite flour (Moringa leaves powder and Great millet & Finger millet flour), J. Nutrition and Food Processing, 7(14); DOI:10.31579/2637-8914/271