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Development and characterization of functional vegan panna cotta enriched with Blue Pea Flower and Lemongrass extract

Tanvi Chavan[1], Dr. Priya Sundarrajan[2*]
[1] Department of Foods, Nutrition and Dietetics, College of Home Science, Nirmala Niketan Mumbai, Maharashtra, India
[2] Department of Life Science and Biochemistry, St. Xavier's College, Mumbai (Empowered Autonomous Institute) Maharashtra, India
Corresponding Author: Dr. Priya Sundarrajan
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Abstract
The demand for plant based, clean label desserts have been increased due to increasing health consciousness and dietary restrictions like lactose intolerance. This research is mainly focused on the development and characterization of an antioxidant-rich vegan panna cotta using a blend of little millet milk and coconut milk as a dairy-free base. Also to enhance the functional profile bioactive extracts of blue pea flower and lemongrass are incorporated.
The study mainly analyzed the proximate composition, micronutrient content, and sensory acceptability of various formulations. Results indicated that while the protein content was relatively low (0.25–0.62g), the product served as a significant source of essential minerals, meeting over 40% of the RDA for calcium and 50% for phosphorus. Sensory analysis using a 7-point hedonic scale revealed that the lemongrass-infused variant (Sample C3) was highly preferred for its distinct aroma and smooth texture.
Physicochemical analysis showed a shift from a mildly alkaline control (pH 9.50) to near-neutral values (pH 7.01–7.57) in the fortified samples. Shelf-life studies concluded that the product remains stable for 10 days under refrigeration (4°C), compared to only one day at room temperature. This research demonstrates that underutilized millets and botanical extracts can be effectively leveraged to create a nutritious, culturally relevant, and commercially viable functional dessert.

Keywords: Vegan panna cotta, little millet, antioxidants, Blue Pea Flower, functional food

Introduction
Veganism has shifted from a niche lifestyle to a globally accepted food choice over the past decade. In India, growing environmental awareness and the COVID-19 pandemic accelerated this shift. The Indian plant-based food sector is projected to reach a market value of $33.3 billion by 2030, at a CAGR of 8.1% (2022–2030), with approximately one in eleven individuals identifying as vegan (Kotebagilu *et al*., 2023) [8]. Since much of traditional Indian cuisine is inherently plant-based, transitioning to vegan diets requires minimal dietary adjustment (Devi *et al*., 2024) [3]. Panna cotta, a classic Italian dessert prized for its creamy, smooth, and light texture, is traditionally prepared using heavy cream, milk, sugar, and animal-derived gelatin (Handani *et al*., 2016) [7]. This formulation renders it unsuitable for lactose-intolerant individuals and those avoiding animal products. Developing a vegan alternative requires substituting dairy with plant-based milks and replacing gelatin with vegetable-derived gelling agents. Natural antioxidants including polyphenols, flavonoids, and anthocyanins offer anti-inflammatory, anti-aging, and disease-preventive benefits and are preferred over synthetic alternatives for their safety and bioavailability (Sen *et al*., 2013). Blue pea flower (*Clitoria ternatea*) is rich in anthocyanins, exhibits pH-sensitive colour change, and possesses neuroprotective and anti-inflammatory properties (Sutakwa *et al*., 2021) [14]. Lemongrass (*Cymbopogon citratus*) contributes phenolics, flavonoids, and citral with antioxidant and antimicrobial activity, alongside a distinctive citrus aroma (Omotayo *et al*., 2024) [11]. Together, these extracts enhance both the nutritional value and sensory appeal of a functional vegan panna cotta, positioning it well within the growing health-conscious market.

Materials and Methods
1. Preparation of vegan panna cotta:
The vegan panna cotta was prepared by combining little millet milk and coconut milk, followed by the addition of khandsari and pineapple essence. The mixture was heated on a low flame with constant stirring, agar-agar was added in the last and heated for 3-4 minutes until fully dissolved, then cooled and refrigerated for 1-2 hours to set. Floral and herbal extract were prepared separately to add in variation samples. Mahua flower extract was prepared by boiling 10g of cleaned flowers in 100ml of water, reduced to 50ml. Blue pea flower extract was prepared by steeping 0.5g dried petals in 100ml of hot water for 5-7 minutes. Lemongrass extract was prepared by boiling 2g of cleaned lemongrass in 200ml of water, reduced to 100ml. These extracts were added in variation samples and allowed to be set. Based on pilot sensory analysis 4 samples were selected for detailed analysis: Sample A(Control), Sample B2 (7.30% blue pea flower extract), Sample C3(10.54% lemongrass extract) and Sample D3 (10.54% combined blue pea flower and lemongrass extract in equal proportion)

2. Nutritional Analysis
Nutritional analysis was done to determine the appropriate amount of macro and micro nutrients, phenolic content and shelf life of the product. Estimation of protein was done by Kjeldahl method (Emaikwu, 2022) [4] and fat by Soxhlet

method (AOAC official method 920.39). Carbohydrate was determined by difference method (Beshaw *et al*., 2023). Micronutrients like calcium, iron and phosphorus were determined by EDTA method (Nielsen, 2010) [10], Wong's method (Fatima and Fatima, 2025) [5] and Fiske and Subbarow's method (Fiske and Subbarow 1925) [6] respectively. Total phenolic content was determined by using Folin-Ciocalteu reagent (Singleton *et al*., 1999) [13].

3. Microbial and shelf-life analysis

Microbial analysis was carried out using total plate count method (Mailoa *et al*., 2017) [9] whereas shelf-life studies were tested at refrigerated temperature (4 ºC) for 0,3,12 and 15 days and at ambient temperature (30 ºC) for 0-5 days period.

4. Sensory evaluation

Sensory evaluation was done using a 7-point hedonic scale to understand overall acceptability of the product into the market using different sensory parameters (Mailoa *et al*., 2017) [9]. It involved a sample size of 51 participants, which has major semi trained and some untrained participants within the age group of 19-25. The product was evaluated for its appearance, color, aroma, taste, texture and overall acceptability. The evaluation was done in a proper set up by providing an offline score card sheet.

Results and Discussion

1. Preparation of Vegan Panna Cotta

Four preliminary trials were done to obtained optimized base of coconut and little millet milk based on which further ten pilot trials were conducted for vegan panna cotta formation which includes incorporation antioxidant rich ingredient extract at various concentration such as 5ml (3.78%), 10ml (7.30%) and 15ml (10.54%). Out of which 3 formulations i.e. sample B2 (10ml blue pea extract), sample C3 (15ml lemongrass extract) and sample D3 (15 ml combined extract) got selected for a further analysis. Figure 1 depicts the various samples prepared.

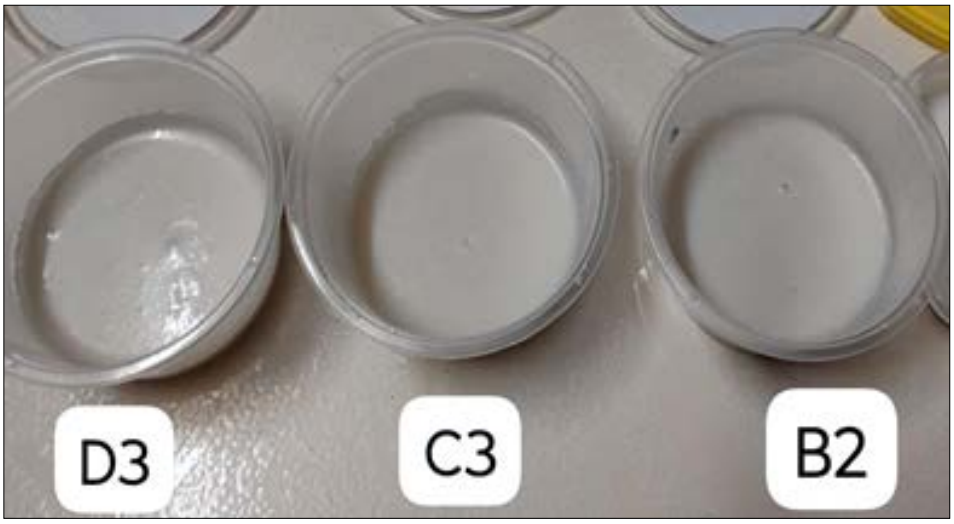


Fig 1: Final formulations of vegan panna cotta samples

2. Moisture Content

The moisture content of the developed vegan panna cotta samples was analyzed by hot air oven method, ranging from 75.4% to 79.05%. Among all samples, Sample C6 showed the highest moisture content (79.05%), followed by Sample B2 (78.95%) and Sample D9 (78.7%), while Sample A showed the lowest moisture content (75.4%).

3. Proximate Analysis

Table 1: Nutritional analysis of vegan panna cotta sample per 100g

Parameters	Sample A	Sample B2	Sample C3	Sample D3
Energy	186	115	117	121
Carbohydrate	6.56	13.76	13	12.74
Protein	0.50	0.60	0.35	0.70
Fat	17.65	6.35	7.10	7.50
Calcium	640	500	580	600
Phosphorous	700	760	440	460
Iron	20	20	24	10

The proximate and mineral composition differed notably across the four vegan panna cotta samples (Table 1). Among all formulations, Sample A, which served as the control containing no plant extracts, yielded the highest energy (186 kcal/100g), fat (17.65g/100g), and calcium (640mg/100g) values. Sample B2 recorded the greatest carbohydrate (13.76g/100g) and phosphorus (760mg/100g) content, while Sample D3 Exhibited the highest protein level (0.70g/100g) despite overall low protein values across all samples. Iron content was greatest in Sample C3 (24mg/100g). These variations suggest that the incorporation of blue pea flower and lemongrass extracts at differing concentrations in Samples B2, C3, and D3 exerted a measurable influence on their respective nutritional profiles compared to the control (Figure 2).

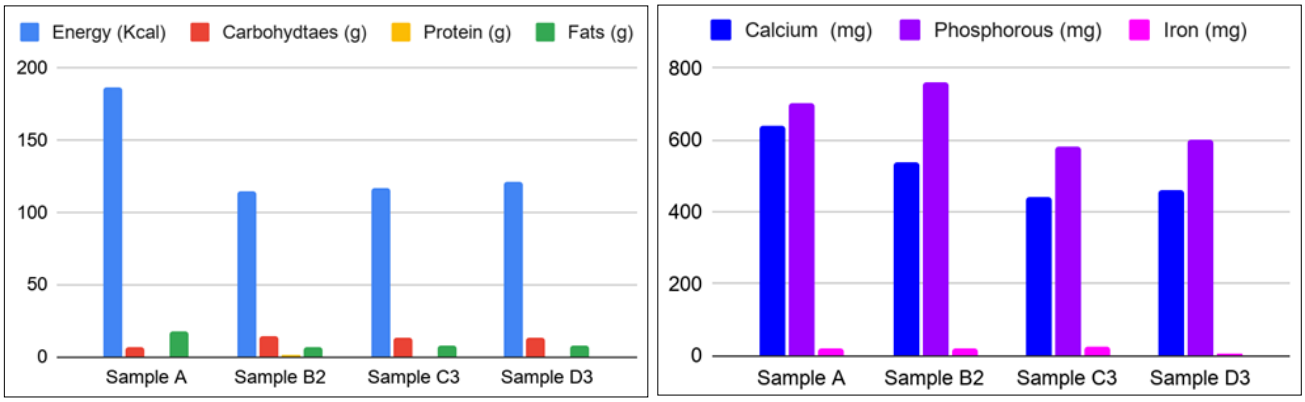


Fig 2: Variation among macro and micronutrients of Vegan Panna Cotta samples

4. Ash Content

Ash content was analyzed by using a muffle furnace. Ash content of developed vegan panna cotta samples ranged from 0.14%/100g to 0.39%/100g. Sample B2, C3 & D3 shows the higher values i.e. 0.34%/100g, 0.39%/100g & 0.36%/100g respectively as compared to sample A control).

5. Total Phenolic Content

Total phenolic content (TPC) analysis showed no detectable phenolic compounds in Sample A. Samples B2, C3, and D3 recorded low but measurable TPC values of 0.08, 0.06, and 0.075 GAE mg/100 g, respectively. Sample B2 exhibited the highest phenolic content, followed by D3 and C3, indicating that the incorporation of plant extracts contributed to the phenolic composition of the vegan panna cotta. Among the extracts used, mahua flower extract and blue pea flower extract showed the highest TPC (0.2 GAE mg/100 g), while lemongrass extract had a lower value (0.07 GAE mg/100 g).

6. Microbial Analysis

Total plate count analysis could not yield reliable results despite repeated trials, likely due to contamination, lack of aseptic laboratory conditions, and technical limitations during sample handling. Therefore, microbial quality could not be accurately assessed and requires evaluation under controlled microbiological laboratory conditions.

7. Shelf-life Study

Shelf-life studies were carried out for 19 days under refrigerated conditions (4°C) and five days at room temperature (30°C). The developed vegan panna cotta remained acceptable for only 1 day at room temperature, after which spoilage signs such as sliminess, off-odour, and microbial growth appeared. Under refrigeration, all samples maintained acceptable sensory quality for up to 10 days, with deterioration observed thereafter. Therefore, the product demonstrated a refrigerated shelf life of 10 days and is recommended to be consumed immediately when stored at room temperature.

8. Sensory Analysis

The sensory evaluation was done using a 7–point hedonic scale test with 51 semi trained and untrained individuals participating in it. The comparative analysis of all 3 samples is presented in the spider web diagram below. The results as depicted in Figure 3, revealed that sample C3 which has 15ml lemongrass extract received more acceptability than sample B2 and D3.

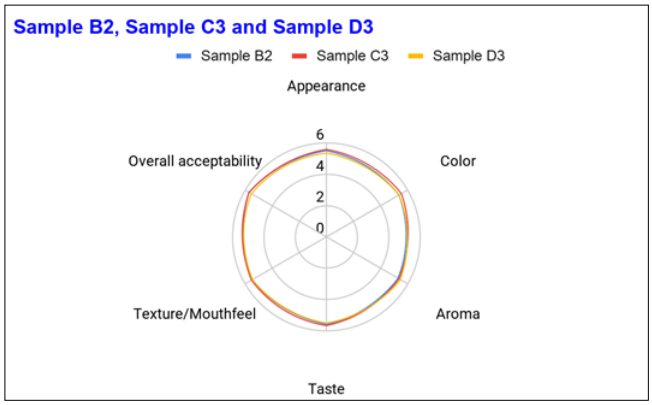


Fig 3: Comparative analysis of all 3 Variation Samples

Conclusion

The present study developed a functional vegan panna cotta using little millet milk, coconut milk, blue pea flower extract, and lemongrass extract. The optimized formulations showed good sensory acceptability, appreciable mineral (calcium, phosphorous and iron) content, and detectable phenolic compounds. Among the developed samples, lemongrass extract incorporated panna cotta demonstrated the highest overall acceptability. The product remained stable for up to 10 days under refrigeration and offers a promising plant-based, clean-label dessert alternative with potential nutritional and functional benefits. Further studies can focus on comprehensive antioxidant evaluation using advanced assays, detailed microbial analysis under controlled laboratory conditions, and product fortification to enhance its nutritional and functional properties. The commercial feasibility and consumer acceptance of the product can also be explored on a larger scale.

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Conflicts of Interest

The author declares that there are no conflicts of interest with respect to this article.

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