

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(10): 564-570
www.agriculturaljournals.com
Received: 01-08-2026
Accepted: 08-09-2026
Published: 15-10-2026

Deepika Singh
Department of Food Science and Nutrition, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Vinita Singh
Department of Food Science and Nutrition, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Corresponding Author:
Deepika Singh
Department of Food Science and Nutrition, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Development, optimization, quality assessment and shelf-life evaluation of value-added energy laddoo prepared from beetroot powder (*Beta vulgaris* L.)

Deepika Singh[1], Vinita Singh[2]

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066

Abstract
The present study was conducted to develop, optimize, evaluate the nutritional quality and shelf-life of value-added energy laddoo prepared using beetroot powder (*Beta vulgaris* L.). Four formulations, T_0 (control), T_1, T_2 and T_3, containing 0, 5, 10 and 15 per cent beetroot powder, respectively, were developed and evaluated for sensory and nutritional characteristics. Sensory evaluation was carried out using a 9-point hedonic scale, while moisture, ash, crude fibre, protein, fat, carbohydrate, energy, iron and calcium contents were estimated using standard methods. The results showed that beetroot powder incorporation improved the sensory and nutritional quality of the laddoos. T_3 recorded the highest overall acceptability. Moisture content decreased from 26.08 per cent in T_0 to 20.20 per cent in T_3, while crude fibre, protein, carbohydrate, energy, iron and calcium contents increased with beetroot powder incorporation. The energy value increased from 318.90 to 380.95 kcal/100 g and iron content from 18.14 to 103.13 mg/100 g. T_3 also showed better expected storage stability, with an estimated shelf-life of 12–15 days at ambient conditions and 30–45 days under refrigeration. Thus, beetroot powder can be effectively utilized for developing a nutritious and acceptable value-added energy laddoo.

Keywords: Beetroot powder, *Beta vulgaris* L., Energy laddoo, Sensory evaluation, Nutritional composition, Shelf-life, Value-added food

Introduction

Beetroot (*Beta vulgaris*) is an edible taproot derived from an herbaceous plant belonging to the Chenopodiaceae family. The plant typically bears wide, dark green foliage, while the fleshy root portion is consumed as a vegetable (Sawicki *et al.,* 2016) [1]. Beetroot is known by several common names, including table beet, garden beet, dinner beet, red beet, and golden beet, reflecting the diversity of cultivated varieties (Yulia *et al.,* 2020) [2]. It is a widely consumed traditional vegetable that has gained increasing scientific attention in recent years due to its rich nutrient profile and potential health-promoting properties (Jeffrey, 1982) [3].

The cultivation of beetroot dates back to ancient civilizations such as the Greeks, Romans, and Jews, who initially utilized the leaves rather than the root. The medicinal use of the beetroot was first documented by the Romans, who employed it in the treatment of fevers and various other ailments. Beetroot acquired significant economic importance in the 19th century following the realization that it could serve as a source of sugar. Its popularity expanded in England, where it became a common ingredient in soups, salads, desserts, and other culinary preparations. In contemporary agriculture, beetroot is commercially produced in several countries, including the United States, Russia, France, Poland, and Germany. Traditional beetroot-based dishes are especially prominent in Central and Eastern European cuisines, with "borscht" being one of the most notable examples (Dwivedi *et al.,* 2017) [4]. The red beetroot has been cultivated for many years in all temperate climates even in India. The bulb colours of beetroots are ranging from yellow to red. Deep red-coloured beetroots are the most popular for human consumption. Beets were cultivated as a winter vegetable in the abbey gardens of Spain, France and Italy. It is grown throughout Europe, America and India besides being native to the Mediterranean region (Chawla *et al.*, 2016) [5].

Beetroot in its fresh form has high water content thus it can be processed into powder form in order to enhance its shelf life. There is growing interest in the use of natural food colors, because synthetic dyes are becoming more and more critically assessed by the consumer. But in food processing, as compared with anthocyanins and carotenoids, betalains are less commonly used, although these water-soluble pigments are stable between pH 3 and 7. To improve the red color of tomato pastes, sauces, soups, desserts, jams, jellies, ice creams, sweets and breakfast cereals, fresh beet/beet powder or extracted pigments are use four colorants (control, carmine, beetroot extract and beetroot extract powder) and two methods (fermentation and heat

2664844X.2026.v8.i10h.2066, Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

treatment) in the production of sausages. The study revealed that use of beetroot extract and powder significantly prevented further development of lipid oxidation in sausages due to the antioxidant properties of beetroot, with a prevalence of betalains and phenolic compounds. Also, the use of beetroot extract and powder positively affected sensory appearance, color, flavor and overall acceptance of the sausages

The bakery sector represents one of the most significant segments of the food processing industry in India and has made a substantial contribution to the nation‟s economic progress. India ranks as the second-largest food producer globally, after China, and possesses considerable potential to emerge as the leading producer due to the strength of its agricultural and food systems. The growing demand for bakery products can be attributed to their nutritional value, cost-effectiveness, rapid population growth, increasing exposure to international food trends, the rising participation of women in the workforce, and changing dietary preferences. These factors have collectively driven the expansion and sustained growth of the Indian bakery industry (*Majid et al.,* 2014).

Materials and Methods

Procurement of material

Beetroot and other food ingredients used for product development were procured from the local market of Kanpur city in different batches.

Preparation of beetroot powder

Fresh beetroot was selected and washed to remove foreign materials. It was then peeled off and grated into thin fragments. Fragmented beetroot was dried using lyophilizer at -80℃ for 24 hours Dried beetroot was ground into a fine powder and packed in airtight bags.

Developed energy laddoo from beetroot powder

Ingredients (g)	T_0	T_1	T_2	T_3
Beetroot powder	-	5	10	15
Flour	60	55	50	45
Sweetner	20	20	20	20
Fat	10	10	10	10
Nuts Seeds	10	10	10	10

Method:

- Ingredients were weighed accurately as per the formulation.
- Flour was roasted in fat until a light golden color developed.
- Beetroot powder was added and mixed uniformly with the roasted flour.
- Nuts and seeds were lightly roasted and added to the mixture.
- Sweetener was added and mixed thoroughly.
- The mixture was shaped into round ladoos while warm.
- The ladoos were cooled at room temperature.
- Prepared ladoos were packed in airtight containers and stored for further use.

Sensory evaluation of developed products

The samples were rated on 9 points hedonic rating scale (Larmond 1982) for quality attributes according to following grade description and scoring..

Moisture

Moisture content was estimated using the standard analysis method (AOAC, 2010). Five gram sample was weighed in a petriplate and kept in oven at 100℃ for 6 hours. After cooling in a desiccator, it was weighed again at a constant weight. Moisture was calculated from the following equation.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100$$

Ash

Ash content in the sample was estimated by employing the standard analysis method (AOAC, 2010). Five grams of oven-dried sample was weighed in a silica crucible. Each sample was charred on a hot plate to cease smoking. The charred samples were placed in muffle furnace at 550℃ for 5-6 hours till the ash becomes clean and white in appearance. Then the crucible was cooled in a desiccator and weighed. The loss in weight represented the organic matter and residue being the ash content. It was calculated as follows:

$$\text{Ash (\%)} = \frac{\text{Weight of ash(g)}}{\text{Weight of sample (g)}} \times 100$$

Crude fibre

The crude fibre in the sample was estimated as per AOAC, 2010 methodology. Weighed 2 g of fat free sample in a 1 litre tall beaker and added 200 ml 1.25 % hot H_2SO_4 and few drops of antifoam. It was heated to boiling in the crude fibre apparatus. The solution was kept on boiling exactly for 30 minutes under bulb condensers and the beakers were rotated occasionally to mix the contents and remove the particles from the sides. The contents of the beaker were filtered using muslin cloth through Buchner funnel and washed back into the tall beaker with 200 ml 1.25 % sodium hydroxide. Again, it was brought to boil for exactly 30 minutes. Then, the insoluble matter was transferred to the sintered crucible using boiling water till acid free. Dried at 100 °C to constant weight and kept in muffle furnace for at 550 °C for 1 hour. The crucibles were cooled in a desiccator and reweighed.

$$\text{Crude fibre (\%)} = \frac{W2 - W3}{W1} \times 100$$

Where,

W_1 = Weight of sample (g)

W_2 = Weight of insoluble matter (wt. of crucible + insoluble matter– wt. of crucible)

W_3 = Weight of ash (wt. of crucible + wt. of ash – wt. of crucible)

Crude protein (AOAC, 1990)

Crude Protein was estimated by Kjehdhal's Method using fully automatic instrument FOSS Kjeltek 8400 machine. One gram of sample was taken in a long-necked digestion flask and added with 12 ml of conc. H_2SO_4 and 8g of catalyst mixture. Samples were digested on Kjeldahl's heating unit at 400℃ till the solution became clear meanwhile scrubber unit was started and jars were filled with 15 % NaOH and distilled water to remove fumes from the digestion unit. After cooling the digestion tube along with the rack was loaded into the main unit of the instrument and the tanks were filled with 2 % boric acid, 40 % NaOH and 0.1N HCl. The samples were titrated in auto

2664844X, 2026, 8(10), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

matic mode and the protein (%) readings in respective samples were displayed on the screen.

Crude fat

Crude fat was estimated by standard analysis method (AOAC, 2010) using the Automatic SOCS Plus Solvent Extraction System. Took 2g finely ground moisture free sample in an extraction thimble. The beaker was washed thoroughly and dried in a hot air oven at 60 °C and weighed after cooling. A weighed flask having 100 ml of petroleum ether was connected to the thimble in the extractor. Connect the extractor to a reflux condenser. Extracted the sample under reflux for 5-6 hours and then petroleum ether extract was evaporated to dryness and added 2 ml acetone. Blow air gently into the flask to remove the last traces of solvent. Dry the beaker containing the fat residue in an air oven at 100 °C for 10-15 minutes. It was weighed after cooling in a desiccator.

$$\text{Fat (\%)} = \frac{W2 - W1}{W} \times 100$$

Carbohydrates (by difference)

The total carbohydrates were calculated by the difference method.

$$\text{Total carbohydrate (\%)} = 100 - \left[\text{crude protein (\%)} + \text{crude fat (\%)} + \text{crude fibre (\%)} + \text{total ash (\%)}\right]$$

Energy (by calculation)

The energy content was calculated by factorial method.

$$\text{Energy (Kcal)} = \left(4 \times \text{protein}\right) + \left(9 \times \text{fat}\right) + \left(4 \times \text{carbohydrate}\right)$$

Iron

Iron was estimated calorimetrically by Wong's method as given by Ranganna (1986) using the principle that ferric ion gives blood red colour with potassium thiocyanate.

Calcium

Calcium content of value added products sample was estimated by titrimetric method of AOAC (1995).

Statistical analyses

The statistical tools used for analysis of sensory quality, physical characteristics and nutrient composition were mean± SD. The aim of the analysis was to identify the significant difference in the nutrient content, physical characteristics and organoleptic qualities of value added products formulated in the current study.

Result and Discussion

Organoleptic evaluation of control and incorporated smoothie mix

Colour

As presented in Table 1, the colour scores of control and beetroot powder incorporated smoothie mix ranged from 7.60 to 8.50. The highest colour score was recorded in T_3 (8.50), followed by T_1 (8.10) and T_2 (8.10), whereas the lowest score was observed in T_0 (7.60). The differences among treatments were found to be significant at the 5 per cent level of significance. The significantly higher colour score obtained by T_3 may be attributed to the increasing incorporation of beetroot powder in the smoothie mix. Beetroot is rich in betalain pigments, which impart an attractive red-purple colour and enhance the visual appeal of food products. The present findings are in agreement with Ravichandran *et al.* (2013) [6], who reported that beetroot incorporation improved the colour acceptability of value-added food products. Similarly, Clifford *et al.* (2015) [7] stated that the natural pigments present in beetroot contribute positively to the sensory characteristics and consumer preference of food formulations.

Taste

The taste scores presented in Table 1 varied from 7.70 to 8.60. The highest taste score was recorded in T_3 (8.60), followed by T_2 (8.40) and T_1 (8.20), while the lowest score was observed in T_0 (7.70). The differences among treatments were found to be significant. The highest taste score observed in T_3 indicates that beetroot powder incorporation improved the palatability of the smoothie mix. The natural sweetness and characteristic flavour compounds of beetroot may have enhanced the taste profile of the product. Similar findings were reported by Sharma *et al.* (2018) [8], who observed improved taste acceptability in beetroot-fortified products. The significant differences among treatments suggest that the level of beetroot powder incorporation had a positive influence on taste.

Texture

As shown in Table 1, the texture scores ranged from 7.60 to 8.90. The highest texture score was obtained by T_3 (8.90), followed by T_2 (8.60) and T_1 (8.40), whereas the lowest score was recorded in T_0 (7.60). The differences among treatments were found to be significant. significantly higher texture score recorded in T_3 may be attributed to the fiber content and solids present in beetroot powder, which contributed to a desirable consistency and mouthfeel of the smoothie mix. These findings are supported by Kaur *et al.* (2017) [9], who reported that beetroot powder improved the textural quality of food products due to its functional properties. The results indicate that beetroot powder incorporation enhanced the texture of the smoothie mix.

Flavour

The flavour scores depicted in Table 1 ranged from 7.40 to 8.70. The highest flavour score was observed in T_3 (8.70), followed by T_2 (8.50) and T_1 (7.90), while the lowest score was recorded in T_0 (7.40). The differences among treatments were found to be significant. The highest flavour score obtained in T_3 may be due to the pleasant flavour imparted by beetroot powder. The characteristic flavour compounds present in beetroot complemented the overall sensory profile of the smoothie mix, resulting in greater consumer acceptance. Similar observations were reported by Ravichandran *et al.* (2013) [6], who found improved flavour scores in beetroot-enriched products. The significant differences among treatments indicate that beetroot powder positively influenced flavour acceptability.

Appearance

As evident from Table 1 the appearance scores varied from 7.70 to 8.60. The highest appearance score was recorded in T_3 (8.60), followed by T_2 (8.50) and T_1 (8.30), whereas the lowest score was observed in T_0 (7.70). The differences among treatments were found to be significant at the 5 per cent level of significance. The appealing appearance produced by beetroot pigments enhanced the visual quality and acceptability of the product. Similar findings were reported by Janiszewska (2014) [10], who stated that beetroot pigments improve the appearance and consumer appeal of food products. The significant differences among treatments confirm the positive effect of beetroot powder on product appearance.

26648458, 2026, 8(10), Downloaded from https://www.doi.org/10.33545/26648458.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

Overall acceptability

The overall acceptability scores presented in Table 1 ranged from 7.40 to 8.50. The highest overall acceptability score was recorded in T_3 (8.50), followed by T_2 (8.30) and T_1 (8.00), while the lowest score was observed in T_0 (7.40). The differences among treatments were found to be significant. The highest overall acceptability score observed in T_3 indicates that the incorporation of beetroot powder improved the overall sensory quality of the smoothie mix. The combined effect of enhanced colour, taste, texture, flavour, and appearance contributed to greater consumer preference. These findings are in accordance with Clifford *et al.* (2015) [7], who reported that beetroot-based products exhibit high consumer acceptability due to their attractive sensory attributes and nutritional benefits. The significant differences among treatments suggest that beetroot powder can be successfully utilized in the development of acceptable and nutritious smoothie mixes

Nutritional composition of control and value added beetroot laddoo's (in 100g)

Moisture content

As presented in Table 2, the moisture content of control and value-added beetroot laddoos ranged from 20.20 to 26.08 per cent. The highest moisture content was observed in T_0 (26.08%), followed by T_1 (24.25%) and T_2 (23.31%), whereas the lowest moisture content was recorded in T_3 (20.20%). A significant decrease in moisture content was observed with increasing levels of beetroot powder incorporation. The reduction in moisture content may be attributed to the low moisture nature of beetroot powder. The differences among treatments were found to be significant. The moisture content of beetroot laddoos decreased significantly with increasing levels of beetroot powder incorporation. This reduction may be attributed to the low moisture content and dehydrated nature of beetroot powder, which reduced the overall moisture level of the product. Similar findings were reported by Kaur *et al.* (2017) [9] and Singh *et al.* (2015) [11], who observed a decrease in moisture content in beetroot-fortified food products. Chhikara *et al.* (2019) [12] also reported that dehydrated beetroot powder contributes to reduced moisture levels and improved storage stability of value-added products.

Ash content

The ash content of beetroot laddoos varied significantly from 1.81 to 4.40 per cent, as shown in Table 2. The maximum ash content was recorded in T_1 (4.40%), followed by T_2 (3.60%) and T_3 (3.35%), while the minimum ash content was observed in T_0 (1.81%). The increase in ash content indicates an improvement in the mineral composition of the laddoos due to beetroot powder incorporation. The significant increase in ash content with beetroot powder incorporation indicates enhanced mineral content in the developed laddoos. Similar findings were reported by Kujala *et al.* (2002) [13], who highlighted the mineral-rich nature of beetroot. Chhikara *et al.* (2019) [12] further reported that beetroot contains appreciable amounts of essential minerals, which contribute to increased ash content and improved nutritional quality of fortified foods.

Crude fibre content

As evident from Table 2, the crude fibre content increased from 12.15 to 14.95 per cent with increasing levels of beetroot powder incorporation. The highest crude fibre content was observed in T_3 (14.95%), followed closely by T_2 (14.85%) and T_1 (13.90%), whereas the lowest value was recorded in T_0 (12.15%). The increase in fibre content may be attributed to the naturally high dietary fibre content of beetroot powder. The differences among treatments were statistically significant. The crude fibre content increased significantly with increasing levels of beetroot powder incorporation. This increase may be attributed to the high dietary fibre content naturally present in beetroot. Similar findings were reported by Clifford *et al.* (2015) [7] and Chhikara *et al.* (2019) [12], who emphasized that beetroot is a valuable source of dietary fibre and contributes to enhanced nutritional quality and digestive health benefits.

Protein content

The protein content of beetroot laddoos ranged from 6.35 to 8.10 per cent. The highest protein content was recorded in T_3 (8.10%), followed by T_2 (7.24%) and T_1 (6.55%), while the lowest value was observed in T_0 (6.35%). As shown in Table 2, protein content increased significantly with increasing levels of beetroot powder incorporation, thereby improving the nutritional quality of the product. The significant increase in protein content observed with increasing levels of beetroot powder incorporation indicates an improvement in the nutritional quality of the laddoos. Similar observations were reported by Janiszewska (2014) [10] and Singh *et al.* (2015) [11], who found that beetroot-enriched products exhibited improved nutrient composition and enhanced protein content compared to control products.

Fat content

The fat content varied significantly among treatments and ranged from 7.10 to 8.79 per cent. The highest fat content was recorded in T_3 (8.79%), followed by T_2 (8.13%) and T_1 (7.35%), whereas the lowest value was observed in T_0 (7.10%). The increase in fat content may be associated with the concentration effect caused by the addition of dry ingredients in the formulation. The fat content increased significantly with beetroot powder incorporation. This increase may be associated with the concentration effect resulting from lower moisture content and the addition of dry ingredients. Similar observations were reported by Singh *et al.* (2015) [11] and Chhikara *et al.* (2019) [12], who found higher fat content in beetroot-fortified products due to changes in formulation and dry matter concentration.

Carbohydrate content

The carbohydrate content of beetroot laddoos ranged from 57.40 to 67.36 per cent, as presented in Table 2. The highest carbohydrate content was observed in T_3 (67.36%), followed by T_2 (66.45%) and T_1 (64.38%), whereas the lowest value was recorded in T_0 (57.40%). A significant increase in carbohydrate content was observed with increasing levels of beetroot powder incorporation, contributing to the enhanced energy value of the product. The carbohydrate content increased significantly with increasing levels of beetroot powder incorporation. Beetroot contains natural sugars and carbohydrates that contribute to the overall carbohydrate content of food products. Similar findings were reported by Clifford *et al.* (2015) [7], Wootton-Beard *et al.* (2011) [14], and Chhikara *et al.* (2019) [12], who highlighted beetroot as a rich source of carbohydrates and energy-enhancing nutrients.

Energy value

The energy value of beetroot laddoos varied from 318.90 to 380.95 kcal/100 g. The highest energy value was recorded in T_3 (380.95 kcal/100 g), followed by T_2 (367.93 kcal/100 g) and T_1 (349.87 kcal/100 g), while the lowest energy value was observed in T_0 (318.90 kcal/100 g). The increase in energy value may be attributed to the higher levels of carbohydrates and fat present in the beetroot powder incorporated treatments. The differences among treatments were significant. The significant increase in energy value observed in beetroot-incorporated laddoos may be attributed to increased carbohydrate and fat content. Similar observations were reported by Wootton-Beard *et al.* (2011) [14], Janiszewska (2014) [10], and Singh *et al.* (2015) [11], who found that beetroot-enriched products possess higher energy values and improved nutritional quality.

Iron content

The iron content showed a remarkable increase with beetroot powder incorporation and ranged from 18.14 to 103.13 mg/100 g. The highest iron content was recorded in T_3 (103.13 mg/100 g), followed by T_2 (96.45 mg/100 g) and T_1 (82.02 mg/100 g), whereas the lowest value was observed in T_0 (18.14 mg/100 g). As shown in Table 2, the increase in iron content was statistically significant, indicating the potential of beetroot powder to enhance the micronutrient content of

2664-8458, 2026, 8(10), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

laddoos. A remarkable increase in iron content was observed with increasing levels of beetroot powder incorporation. This enhancement may be attributed to the naturally occurring iron present in beetroot. Similar findings were reported by Clifford *et al.* (2015) [7], Kujala *et al.* (2002) [13], and Chhikara *et al.* (2019) [12], who documented the mineral-rich composition of beetroot and its potential contribution to dietary iron intake.

Calcium content

The calcium content of beetroot laddoos ranged from 6.42 to 9.75 mg/100 g. The highest calcium content was observed in T_3 (9.75 mg/100 g), followed by T_2 (9.70 mg/100 g) and T_1 (9.11 mg/100 g), while the lowest value was recorded in T_0 (6.42 mg/100 g). The increase in calcium content with increasing levels of beetroot powder incorporation was found to be significant, indicating improved mineral enrichment of the product. The calcium content increased significantly with increasing levels of beetroot powder incorporation, indicating improved mineral enrichment of the product. Similar observations were reported by Kujala *et al.* (2002) [13], Chhikara *et al.* (2019) [12], and Singh *et al.* (2015) [11], who reported increased calcium and mineral content in beetroot-fortified food products.

Shelf life of beetroot laddoo

Treatment T_0 (control)

The beetroot laddoo prepared under treatment T_0 recorded the highest moisture content of 26.08 percent. The high moisture content favours the growth of spoilage microorganisms, resulting in faster deterioration of the product during storage. Foods containing higher moisture generally exhibit lower keeping quality because moisture promotes microbial activity and accelerates biochemical changes. Therefore, the shelf life of T_0 is expected to be comparatively shorter than the other treatments. Based on the moisture content and available literature on similar traditional sweet products, the prepared beetroot laddoo may remain acceptable for approximately 5–7 days under ambient storage conditions (25–30 °C) and 15–20 days under refrigerated storage (4–8 °C) when packed in airtight containers. Similar findings were reported by Ranganna (2010) [15], who stated that products with higher moisture content are more susceptible to microbial spoilage and quality deterioration. Fellows (2009) [16] also reported that moisture is one of the principal factors influencing the shelf life of processed foods.

Treatment T1

Treatment T_1 contained 24.25 percent moisture, which was lower than the control treatment. The reduction in moisture content improves the storage stability of the product by reducing the availability of free water necessary for microbial growth. Consequently, T_1 is expected to possess better keeping quality than T_0. Under normal storage conditions, the prepared laddoo may remain acceptable for approximately 7–10 days at room temperature and 20–25 days under refrigeration. Ranganna (2010) [15] explained that lowering the moisture content enhances the shelf life of fruit- and vegetable-based products by minimizing microbial activity. Likewise, Manay *et al.* (2008) [17] reported that reducing moisture content is an effective method of improving the storage stability of processed food products.

Treatment T2

Treatment T_2 recorded a moisture content of 23.31 percent, indicating a further reduction compared to T_0 and T_1. Lower moisture content decreases the rate of microbial growth and delays enzymatic and chemical deterioration during storage, thereby improving the keeping quality of the product. Based on the moisture level and published literature, the expected shelf life of T_2 may be approximately 8–12 days under ambient conditions and 25– 30 days under refrigerated conditions. Similar observations were reported by Fellows (2009) [16], who stated that reduced moisture content improves the stability and safety of processed foods during storage. Ranganna (2010) [15] also observed that products with lower moisture content possess better storage stability and extended shelf life.

Treatment T_3

Treatment **T_3** exhibited the lowest moisture content (20.20 percent) among all the formulations. The lower moisture content is expected to provide greater resistance to microbial spoilage and slow down undesirable biochemical changes during storage. Therefore, T_3 is anticipated to have the highest keeping quality among all the treatments. Based on available literature on traditional laddoos and dehydrated vegetable products, the prepared beetroot laddoo may remain acceptable for approximately 12–15 days under ambient storage conditions and 30–45 days under refrigerated conditions. Ranganna (2010) [15] reported that products with lower moisture content generally exhibit superior shelf stability. Similarly, Fellows (2009) [16] concluded that lowering the moisture level is one of the most effective means of extending the shelf life of processed food products.

Conclusion

The study successfully developed and optimized *a* value-added energy laddoo using beetroot powder (*Beta vulgaris* L.). Incorporation of beetroot powder improved the nutritional and functional value of the product while maintaining acceptable sensory quality. The optimized formulation showed good overall acceptability and satisfactory shelf stability during storage, indicating its potential as a nutritious and convenient functional food product.

Table 1. Organoleptic evaluation of control and Incorporated laddoo's

Parameter	T_0	T_1	T_2	T_3	CD (5%)	S.Em ±	F Value
Colour	7.6	8	8.2	8.4	0.84	0.256	NS
Taste	7.5	8	8.5	8.2	0.85	0.260	NS
Texture	8	8.4	8.8	8.6	0.89	0.272	NS
Flavour	7.7	8	8.2	8.4	0.84	0.256	NS
Appearance	7.2	7.7	8.7	7.9	1.0	0.307	S
Overall Acceptability	8	8.2	8.4	8.6	0.89	0.272	NS

(continued on next page)

2664844X, 2026, 8(10), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

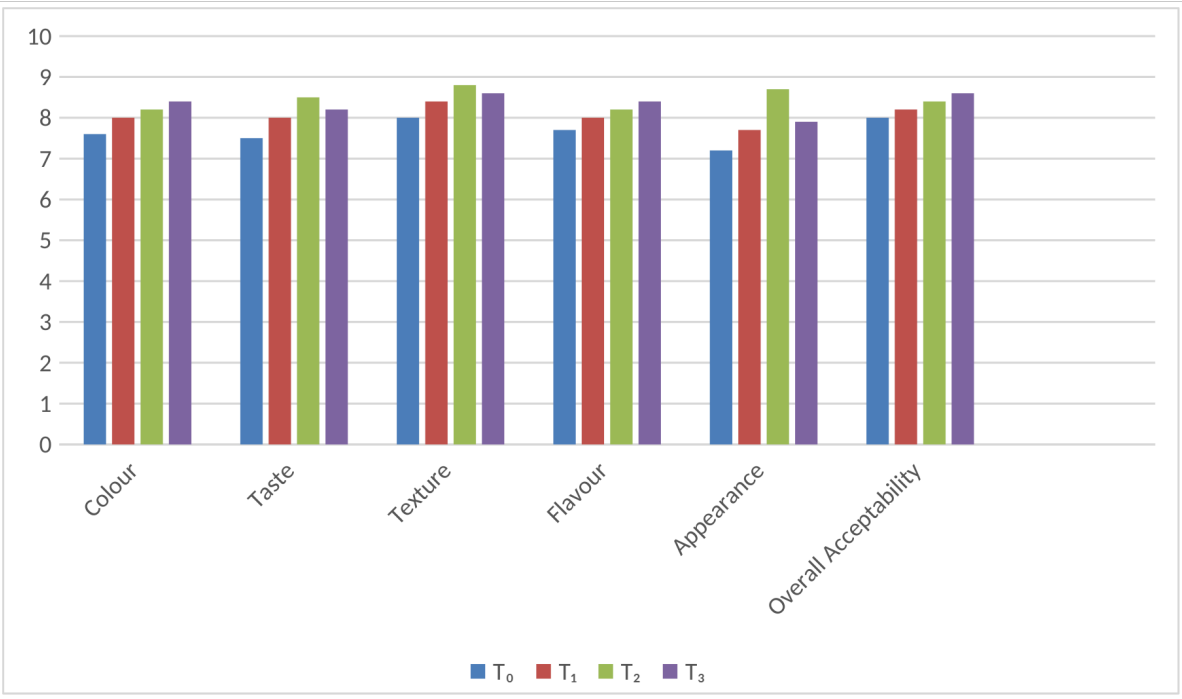
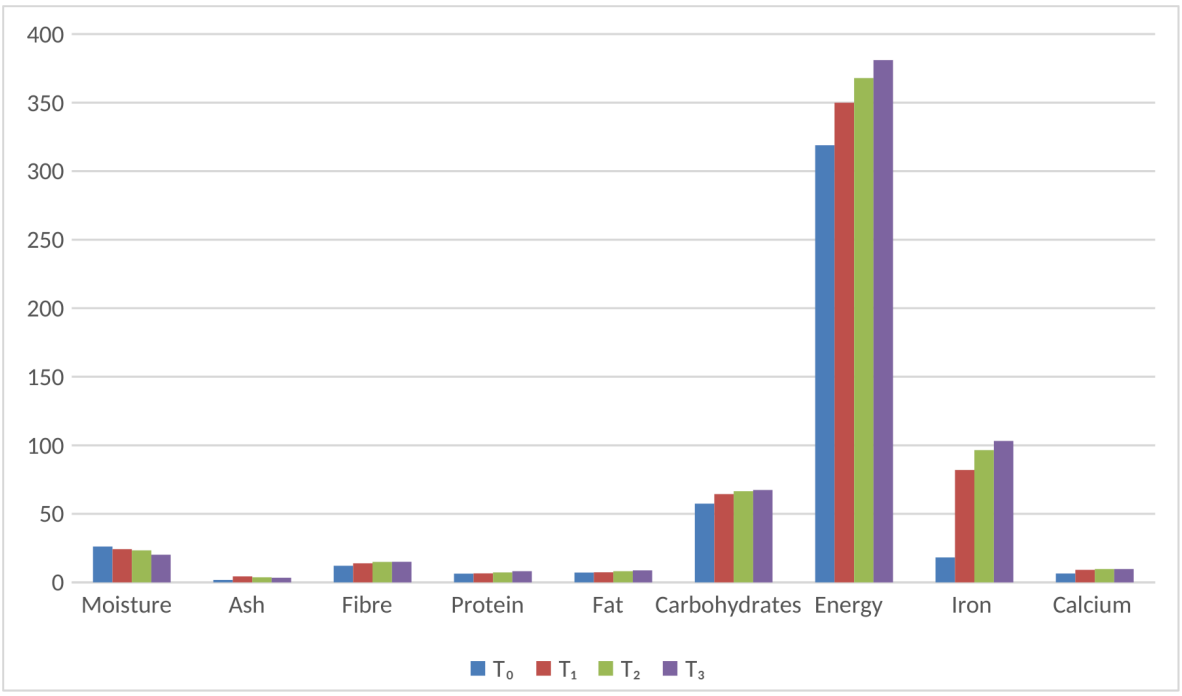


Table 2. Nutritional composition of control and value added Beetroot laddoo's (in 100g):

Nutrients	T_0	T_1	T_2	T_3	CD (5%)	S.Em ±	F Value
Moisture	26.08	24.25	23.31	20.2	2.53	0.775	S
Ash	1.81	4.4	3.6	3.35	0.37	0.115	S
Fibre	12.15	13.9	14.85	14.95	1.61	0.486	S
Protein	6.35	6.55	7.24	8.1	0.83	0.255	S
Fat	7.1	7.35	8.13	8.79	0.92	0.281	S
Carbohydrates	57.4	64.38	66.45	67.36	7.28	2.232	S
Energy	318.9	349.87	367.93	380.95	40.67	12.471	S
Iron	18.14	82.02	96.45	103.13	10.01	3.071	S
Calcium	6.42	9.11	9.7	9.75	1.02	0.314	S



26648458, 2026, 8(10), Downloaded from https://www.doi.org/10.33545/26648458.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

Conclusion

The study successfully developed and optimized *a* value-added energy laddoo using beetroot powder (*Beta vulgaris* L.). Incorporation of beetroot powder improved the nutritional and functional value of the product while maintaining acceptable sensory quality. The optimized formulation showed good overall acceptability and satisfactory shelf stability during storage, indicating its potential as a nutritious and convenient functional food product.

References

1. Sawicki T, Baczek N, Wiczkowski W. Betalain profile, content and antioxidant capacity of red beetroot dependent on the genotype and root part. Journal of Functional Foods. 2016;27:249–261.
2. Yulia R, Putra A, Rahmi Y. Determination of total flavonoid levels in packaged tea bags combination of Dayak onion and beet root with UV-visible spectrophotometric method. Proceedings of the International Conference on Health Informatics and Medical Application Technology. 2020:356-363.
3. Jeffrey C. Introduction Plant Taxonomy. London: Cambridge University Press; 1982.
4. Dwivedi N, Singh A, Jaiswal M, Agrahari K. Standardization and dvelopment of beetroot-based product. International Journal of Home Science. 2017;3(2):26–30.
5. Chawla H, Parle M, Sharma K, Yadav M. Beetroot: A health promoting functional food. Inventi Rapid: Nutraceuticals. 2016;1(1).
6. Ravichandran K, Ahmed AR, Knorr D, Smetanska I. Impact of processing on betalain content and antioxidant properties of beetroot products. Food Research International. 2013;48(1):16–20.
7. Clifford T, Howatson G, West DJ, Stevenson EJ. The potential benefits of red beetroot supplementation in health and disease. Nutrients. 2015;7(4):2801–2822.
8. Sharma S, Chauhan P. Sensory evaluation of beetroot supplemented value-added food products. Journal of Food Science and Technology. 2018.
9. Kaur S, Sharma S. Quality evaluation of dehydrated beetroot powder. International Journal of Food and Nutritional Sciences. 2017;6(4):45–49.
10. Janiszewska E. Microencapsulated beetroot juice as a potential source of betalain. Powder Technology. 2014;264:190–196.
11. Singh B, Hathan BS, Kaur A. Development and nutritional evaluation of beetroot supplemented food products. International Journal of Food and Nutritional Sciences. 2015;4(3):78–84.
12. Chhikara N, Kushwaha K, Sharma P, Gat Y, Panghal A. Bioactive compounds of beetroot and utilization in food processing industry: A critical review. Food Chemistry. 2019;272:192–200.
13. Kujala TS, Loponen JM, Klika KD, Pihlaja K. Phenolics and betacyanins in red beetroot (*Beta vulgaris*) root: Distribution and effect of cold storage on the content of total phenolics and three individual compounds. Journal of Agricultural and Food Chemistry. 2002;50(18):5338–5342.
14. Wootton-Beard PC, Ryan L. A beetroot juice shot is a significant and convenient source of bioaccessible antioxidants. Journal of Functional Foods. 2011;3(4):329-334.
15. Ranganna S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products (2nd ed., reprint). *Tata* McGraw-Hill Publishing Company Limited, New Delhi; 2010.
16. Fellows PJ. Food Processing Technology: Principles and Practice (3rd ed.). Woodhead Publishing; 2009.
17. Manay NS, Shadaksharaswamy M. Foods: Facts and Principles (2nd ed.). New Age International Publishers, New Delhi; 2008.

How to cite this article: Singh D, Singh V. Development, optimization, quality assessment and shelf-life evaluation of value-added energy laddoo prepared from beetroot powder (*Beta vulgaris* L.). *International Journal of Agriculture and Food Science*. 2026;8(10):564-570. doi: https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066

2664844X, 2026, 8(10), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i10h.2066 by International Journal of Agriculture and Food Science on [15/10/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License