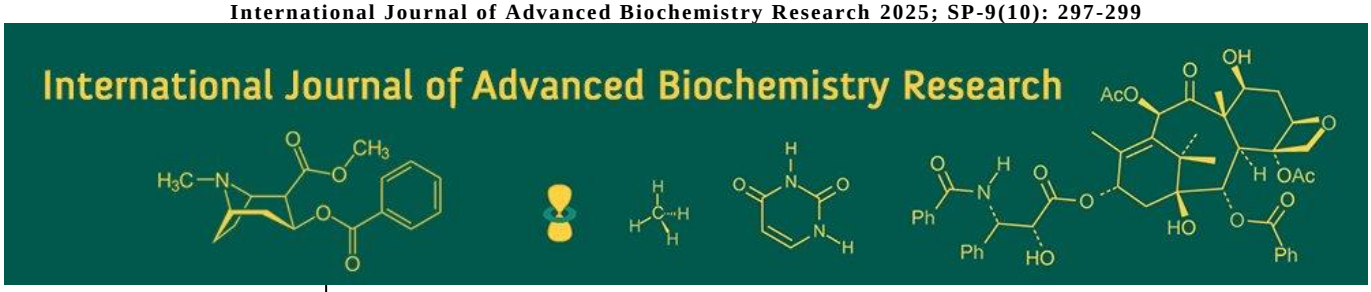

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Development of beetroot (*Beta vulgaris* L.) candy

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Abstract
The present study evaluated the storage behaviour of beetroot (*Beta vulgaris* L.) candy under ambient conditions Among them the best candy was identified on the basis of overall acceptability and physicochemical analysis. The steam blanching with 7 minutes blanching period was found to be most preferred candy. Further this candy was assessed for overall quality during storage at room temperature for 3 months and analysed at 30-day intervals for physicochemical, microbial and sensory attributes. Candy can be preserved safely for 3 months in LDPE packaging material. Storage led to a gradual decrease in moisture content while total soluble solids, reducing sugar and total sugar and titratable acidity was increased slightly. Microbial counts remained within acceptable limits throughout storage. Sensory evaluation indicated that beetroot candy retained good acceptability for up to 90 days without significant quality deterioration.

Keywords: Beetroot candy, blanching, steam blanching

1. Introduction
Beetroot (*Beta vulgaris* L.), commonly known as red beet, garden beet or table beet, is a root vegetable belonging to the family Chenopodiaceae. It is cultivated primarily for its swollen taproot and, in some cases, for its nutrient-rich leaves. Beetroot is rich in biologically active compounds, including betalains (betacyanins and betaxanthins), phenolic acids, flavonoids, dietary nitrates and vitamins, which contribute to its health-promoting properties (Clifford *et al*., 2015; Georgiev *et al*., 2010) [3, 5]. In addition, beetroot provides essential minerals such as iron, potassium, magnesium and manganese, making it a valuable functional food (Chaudhary and Shaikh, 2020) [2].

Betalains, the natural pigments responsible for beetroot's characteristic red-purple colour, possess strong antioxidant and anti-inflammatory activities and have been linked to potential chemopreventive effects (Lechner and Stoner, 2019) [9]. Dietary nitrates from beetroot are converted into nitric oxide in the body, which improves blood flow, reduces blood pressure and enhances exercise performance (Kapil *et al*., 2015; Dominguez *et al*., 2018) [7, 4]. Additionally, beetroot's vitamin C content enhances iron absorption, making it a strategic food for combating iron deficiency anaemia (Teucher *et al*., 2004) [16].

The development of value-added beetroot products presents opportunities to improve dietary intake of these bioactive compounds while reducing postharvest losses. Candy, prepared through osmotic dehydration followed by drying, is a popular ready-to-eat confectionery product with extended shelf life and high consumer acceptance (Nayak *et al*., 2012) [12]. Processing beetroot into candy not only provides a natural-colour sweet snack but also retains significant nutritional value, potentially increasing vegetable consumption among children and health-conscious consumers.

Despite the increasing demand for functional snacks, limited research has been conducted on the storage stability of beetroot candy under ambient conditions. Quality changes during storage, including variations in physicochemical composition, microbial load and sensory acceptability, determine the market potential of such products. Understanding these changes is essential for establishing shelf life and ensuring consumer satisfaction.

The present study was undertaken to investigate the storage behaviour of beetroot candy during ambient storage, focusing on changes in physicochemical, microbial and sensory attributes over a three-month period.

2. Materials and Methods

2.1 Material

Fresh, healthy beetroots (*Beta vulgaris* L.) of uniform size, free from insect damage and mechanical injury, were procured from the local market. The roots were washed thoroughly under running water to remove soil and dirt.

2.2 Preparation of beetroot candy

Fresh beetroots were washed and blanched using two methods: hot water blanching (whole beetroots blanched, then cut) and steam blanching (cut pieces blanched). After cooling, beetroot pieces were subjected to osmotic treatment in sugar syrup of gradually increasing concentrations (40°Bx → 65°Bx → 70°Bx → 75°Bx), with soaking times of 24 hours at each step and one week at 75°Bx. Finally, the pieces were drained, tray-dried and packed in LDPE pouches for storage at ambient temperature.

2.3 Packaging and storage

The dried beetroot candies were cooled to room temperature and packed in low-density polyethylene (LDPE) pouches. The pouches were sealed and stored under ambient conditions (27-32 °C) for a period of 90 days.

2.4 Observations recorded

Samples were analysed at 0, 30, 60 and 90 days of storage for the following parameters:

2.4.1 Physicochemical properties:

Moisture content, ash content, total soluble solids (°B), titratable acidity (%), reducing sugar (%) and total sugar (%) were determined as per AOAC methods.

2.4.2 Microbial count

Determined as colony forming units (cfu g^{-1}).

2.4.3 Sensory evaluation

Colour, flavour, texture and overall acceptability were evaluated using a 9-point hedonic scale.

2.5 Statistical analysis

The experiment was conducted using factorial completely randomized design (FCRD). The data obtained were analysed statistically as per the method described by Panse and Sukhatme (1985) and the significance of differences among means was tested at the 5% probability level.

3. Results and discussion

3.1 Physicochemical analysis

3.1.1 Moisture (%)

Reduction in moisture content was recorded from 14.20% at the time of preparation to 13.70% at the end of storage, which could be attributed to gradual evaporation of water from the product. Similar decreasing trends in moisture content have been reported in bottle gourd candy during storage (Ahmad and Ahmad, 2021) [1].

3.1.2 Ash (%)

Ash content increased slightly from 0.940% to 0.990% over the storage period. This rise may be related to the concentration effect caused by moisture loss, leading to a higher proportion of mineral constituents in the product. An increase in ash content during storage was reported in bottle gourd candy (Ahmad and Ahmad, 2021) [1].

3.1.3 TSS (°B)

The total soluble solids (TSS) content showed a significant increase from 66.86°B to 67.45°B during storage. This may be due to hydrolytic conversion of complex carbohydrates into simple sugars through enzymatic or non-enzymatic reactions, as observed in quince candy during storage (Mir *et al*., 2015) [10].

3.1.4 Titratable acidity (%)

Titratable acidity also increased significantly (0.335% to 0.415%) during storage. This could be due to the breakdown of polysaccharides and other components into organic acids or the hydrolysis of sugar molecules over time. A similar increase in acidity has been observed in amla candy (Sohshangrit *et al*., 2022) [15].

3.1.5 Reducing sugar (%)

The reducing sugar content increased from 13.10% to 15.80%, possibly due to the hydrolysis of sucrose into glucose and fructose as well as continued breakdown of polysaccharides. Similar finding was observed in orange peel candy (Kumar *et al*., 2022) [8].

3.1.6 Total sugar (%)

Total sugar content increased from 62.24% to 63.69% during storage, due to the conversion of non-reducing carbohydrates into simple sugars, similar results observed in guava candy (Patel *et al*., 2022) [13].

Table 1: Changes in physicochemical properties of beetroot candy during ambient storage

Storage period (days)	Moisture (%)	Ash (%)	TSS (°B)	Titratable acidity (%)	Reducing sugar (%)	Total sugar (%)
0	14.2	0.94	66.86	0.335	13.1	62.24
30	14.1	0.95	66.97	0.354	14.0	62.72
60	13.9	0.97	67.14	0.382	14.9	63.2
90	13.7	0.99	67.45	0.415	15.8	63.69
CD (P=0.05)	0.02	0.003	0.037	0.008	0.01	0.12
SE(m)±	0.05	0.009	0.122	0.025	0.033	0.399

3.2 Microbial analysis

Microbial analysis indicated that beetroot candy remained free from microbial contamination throughout the storage period. This can be attributed to the high sugar concentration and low moisture content, which create unfavorable conditions for microbial growth. Similar microbial stability was noted in pumpkin candy (Muzzaffar *et al*., 2016) [11] and tomato candy (Hasanuzzaman *et al*., 2014) [6].

3.3 Sensory evaluation

Sensory evaluation revealed a gradual decline in colour, flavour, texture and overall acceptability scores during storage.

3.3.1 Colour

As regards storage, the mean score for colour of the beetroot candy was significantly decreased during storage period. The decrease in colour intensity during storage was correlated with betalain degradation due to blanching, Maillard browning reactions and during storage, residual betalains undergo further breakdown, leading to fading of colour in the final product. Similar findings were observed

by Mir *et al*. (2015) [10] in quince candy and Muzzaffar *et al*. (2016) [11] in pumpkin candy.

3.3.2 Flavour
The mean score for flavour of the beetroot candy was significantly decreased during storage period. Similar findings were observed by Sehrawat *et al*. (2023) [14] in mango candy.

3.3.3 Texture
As regards storage, the mean score for texture of the beetroot candy was significantly decreased during storage period. Similar findings were observed by Sehrawat *et al*. (2023) [14] in mango candy.

3.3.4 Overall Acceptability
The highest score for Overall acceptability (8.54) of beetroot candy was obtained at the time of preparation and lowest score for Overall acceptability (8.02) was obtained at the 90 days after storage. Similar findings were observed by Mahato *et al*. (2020) in unripe mango candy and Muzzaffar *et al*. (2016) [11] in pumpkin candy. Despite this decline, the product maintained acceptable sensory qualities up to 90 days.

Table 2: Changes in sensory parameters of beetroot candy during ambient storage

Storage period (days)	Colour	Flavour	Texture	Overall acceptability
0	8.04	8.50	8.65	8.54
30	7.92	8.40	8.55	8.40
60	7.75	8.20	8.35	8.24
90	7.70	8.00	8.15	8.02
CD (P=0.05)	0.03	0.03	0.02	0.02
SE(m)±	0.09	0.11	0.07	0.08

4. Conclusion
The present study evaluated the storage behaviour of beetroot (*Beta vulgaris* L.) candy under ambient conditions among various treatments the best candy was identified on the basis of overall acceptability and physicochemical analysis. The steam blanching with 7 minutes blanching period was found to be most preferred candy. Further this candy was assessed for overall quality during storage at room temperature for 3 months and analysed at 30-day intervals for physicochemical, microbial and sensory attributes. Candy can be preserved safely for 3 months in LDPE packaging material. Storage led to a gradual decrease in moisture content while total soluble solids, reducing sugar, total sugar and titratable acidity increased slightly. Microbial counts remained within acceptable limits throughout storage. Sensory evaluation indicated that beetroot candy retained good acceptability for up to 90 days without significant quality deterioration.

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