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Development and evaluation of Bael fruit jelly enriched with herbal leaf extracts

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Abstract
The present study describes the development and assessment of a delectable herbal jelly rich in healthy, plant-based ingredients. The Jelly is made from dragon fruit. It is deliciously sweet and packed with nutrients. To enhance the health benefits of the Jelly, powdered Bael fruit and extracts from guava, mango, jamun, and pomegranate leaves were used. These ingredients are known to provide a host of benefits, including antioxidant, anti-diabetic, anti-inflammatory, antimicrobial, and digestive benefits. To keep things light, Stevia was used as a low-calorie sweetener and pectin as a gelling agent. Beetroot extract and dragon fruit seeds were used to enhance the Jelly's vibrant colour and appearance. The Jelly was cooked to a sweet spot of 62-68 ° Brix and evaluated for sensory quality, nutritional composition, and shelf life. Evaluations showed that panellists rated it highly, giving it an impressive 8.5 out of 9 on a satisfaction scale. The nutritional analysis showed a good composition of 39 grams of carbs, 1.2 grams of protein, 33.15% hydration, 1% ash, and 67% total soluble solids per 100 grams. Shelf-life analysis of Jelly revealed that samples stored at room temperature spoiled on day 31, whereas the refrigerated samples remained fresh and stable. Overall, this study successfully emphasises the visual appeal and nutrient-rich properties of a herbal jelly with promising potential in the functional food industry.

Keywords: Bael fruit, jelly, stevia, herbal jelly

Introduction
Consumer awareness of health and nutrition has boosted demand for functional foods and herbal products that offer nutritional and therapeutic benefits. Traditional fruit products such as jams and jellies are widely consumed, but there is growing interest in their functional value, which can be enhanced by incorporating medicinal plants and herbal ingredients. Medicinal fruits and herbs can be used to prepare herbal jellies as convenient nutraceutical foods with desirable sensory characteristics [1].

The Bael (*Aegle marmelos*) is a traditional medicinal fruit widely used in Ayurvedic medicine for its therapeutic properties, including antimicrobial, anti-inflammatory, and digestive benefits. Bioactive compounds in Bael fruit, such as phenolics, flavonoids, vitamins, and dietary fibre, contribute to its antioxidant properties [2]. Bael fruit has been traditionally used to treat gastrointestinal disorders such as diarrhea and dysentery, and is therefore an important functional ingredient in the development of food products [3].

Bael fruit is of nutritional and medicinal importance. However, the use of Bael fruit in processed food products is limited due to its hard shell, seasonal availability, and limited consumer familiarity with Bael-based processed products. Processing of Bael fruit into value-added products like jelly can increase the acceptability, market potential and shelf-life of Bael fruit. The jelly preparation also allows the addition of other herbal ingredients, which may enhance the nutraceutical and functional properties of the final product [4].

Functional foods are gaining popularity, and fruit-based products with added plant-based benefits are being developed. Fruit jellies are popular snacks and may provide important nutrients. The dragon fruit was used in this study because of its bright colour, mild taste, and antioxidant properties. Leaves from plants such as mango, [5] jamun, [6] guava, [7] and pomegranate contain beneficial phytoconstituents with antioxidant and antimicrobial properties [8]. Bael fruit is known for its digestive benefits, while beetroot adds natural

colour. Orange peel powder provides pectin and fibre, and stevia is a low-calorie sweetener [9].

These ingredients aim to create a nutritious and tasty herbal jelly with enhanced health benefits.

Although several fruit-based jellies are commercially available, most products rely mainly on sugar and fruit pulp and contain limited functional ingredients. The incorporation of plant extracts with nutraceutical properties into jelly remains relatively unexplored, particularly when combined with natural sweeteners and plant-derived gelling agents. Developing such products may enhance both the nutritional and functional value of traditional jelly products while maintaining consumer acceptability [10].

Materials and Methods

Raw materials collection

All analytical-grade chemicals and reagents used in this study were obtained from Hi Media Laboratories Pvt. Ltd. and SDFCL (S D Fine-Chem Limited), India. Food-grade ingredients such as orange-5tpeel powder, stevia, and Pectin, required for jelly preparation, were purchased from online suppliers. The ingredients were carefully selected to ensure purity and consistency. Fresh leaves of *Syzygium cumini* (jamun), *Mangifera indica* (mango), *Punica granatum* (pomegranate), *Psidium guajava* (guava), and *Aegle marmelos* (Bael) were collected from the college botanical garden.

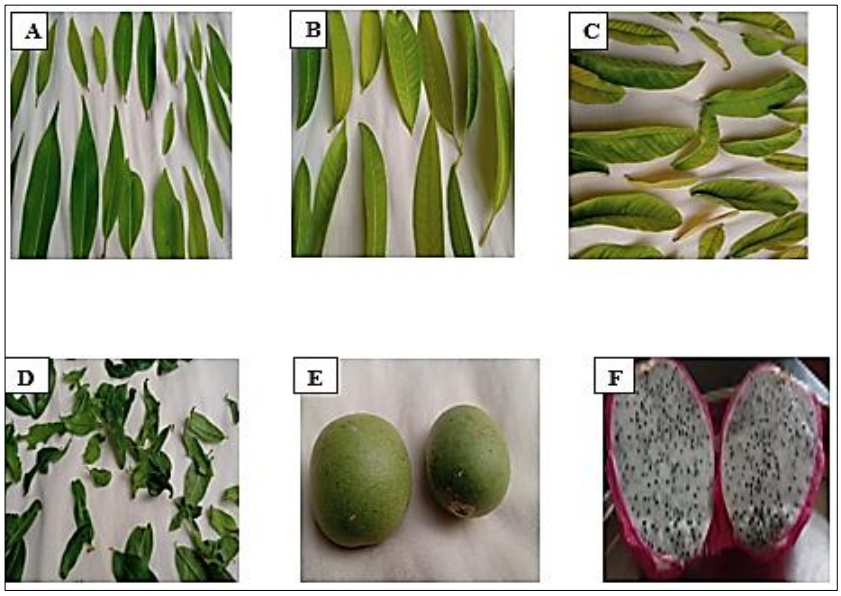

Fig 1: Collection of Raw Materials, A: Jamun leaves, B: Mango leaves, C: Guava leaves, D: Pomegranate leaves, E: Bael fruit, F: Dragon Fruit

Preparation of Leaf Extract for making herbal jelly

Collect fresh leaves and wash them thoroughly with distilled water to remove any dirt or foreign materials. The leaves are washed and dried in the shade for several days. Then grind the dried leaves to a fine powder with a laboratory grinder [11]. To extract the bioactive compounds, add about 10 grams of the powdered leaves to 100 mL of distilled water. Boil this mixture at 60-70 °C for 20-30 minutes. Once it cools, filter the mixture to obtain a clear leaf extract. Use this filtrate as an herbal extract for making jelly. The fresh fruits of *Aegle marmelos* were washed with distilled water, and the outer hard shell was removed. The pulp was separated, uniformly spread on stainless steel trays, and dried in a hot-air oven at 50-60 °C until moisture was completely removed. Dried pulp of Bael fruit was powdered by grinding in a laboratory grinder and passed through a fine mesh. The powder was stored at 4 °C in sealed containers for further experimental analysis and product development [12].

Standardisation of the Herbal jelly

All raw materials were washed thoroughly with clean water to remove any dust or impurities before processing. The herbal jelly was prepared by extracting pulp from selected fruits and herbal leaf extracts. The pulp and extracts were mixed with sweeteners and gelling agents, then heated to the desired jelly consistency (Table 1, Figure 1 & 2). Multiple trials were conducted to optimise the formulation by varying the concentrations of fruit pulp, herbal extracts, and gelling agents (Table 2).

Table 1: Formulation of the Herbal jelly

S.No.	Name of the ingredient	Per 200gm
1.	Dragon fruit pulp	100 gm
2.	Leaf Extract	20
3.	Bael fruit powder	4
4.	Sugar	70
5.	Pectin	2
6.	Orange peel Powder	2
7.	Stevia Powder	0.2 - 0.4
8.	Beet root Extract	2-3 ml
9.	Dragon fruit seeds	2

Table 2: Different Formulations of the Herbal Jelly

S.No.	Formulation Tested	Description
Trial 1	Initial formulation with fruit pulp, herbal leaf extracts, gelling agents, and sweeteners	Jelly was prepared by mixing fruit pulp, herbal leaf extracts, gelling agents, and sweeteners. The concentrations of ingredients were varied to achieve a suitable taste, colour, and consistency.
Trial 2	Evaluation of different gelling agents	Dragon fruit pulp was used as the main fruit base. Three gelling agents were tested: corn starch, gelatin, and orange peel powder.
Trial 3	Optimisation of ingredient proportions	The concentrations of fruit pulp, herbal leaf extract, and the gelling agent were adjusted based on previous trials. The amount of herbal leaf extract was reduced to minimize bitterness and undesirable aroma, and the selected gelling agent was optimised.

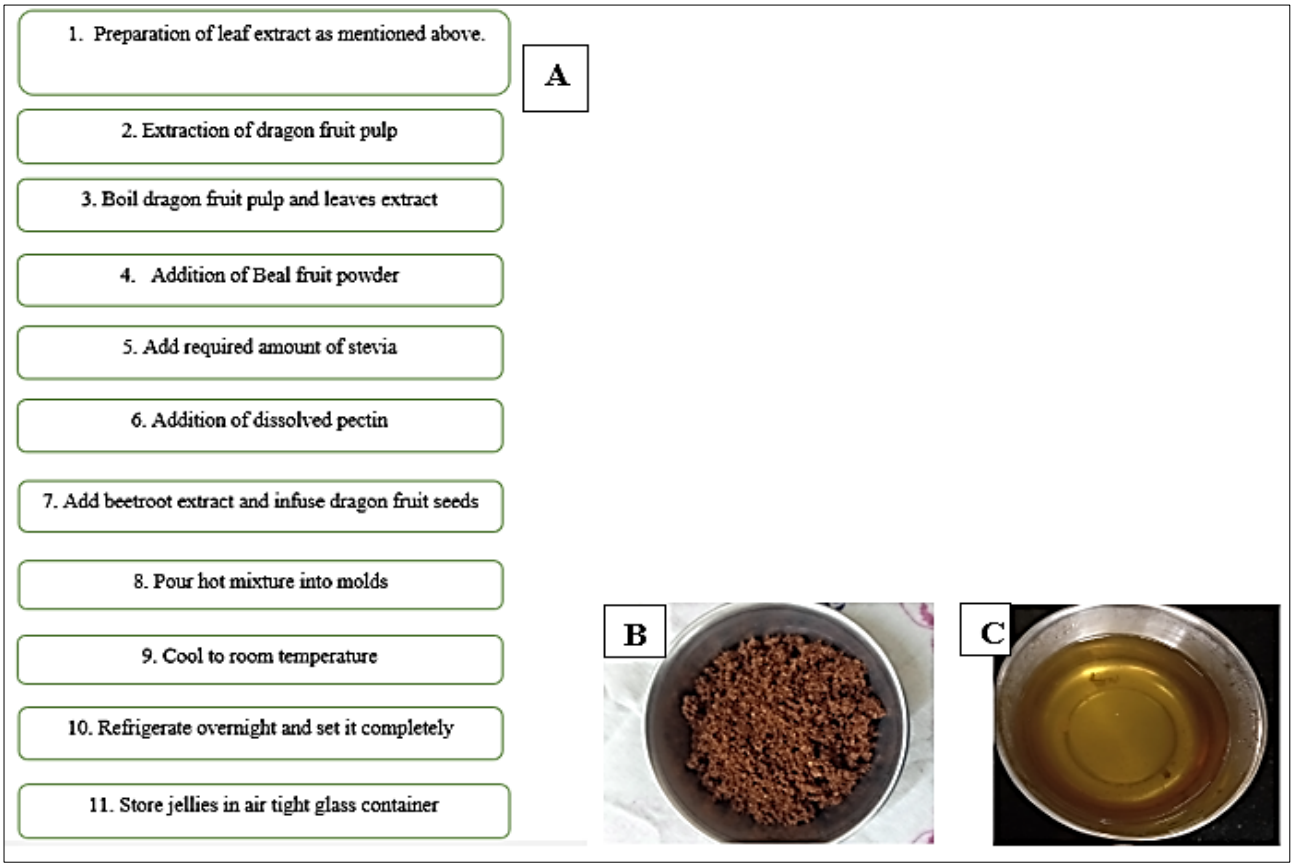

Fig 2: A: Preparation of Herbal Jelly, B: Bael fruit extract, C: Herbal leaf extract

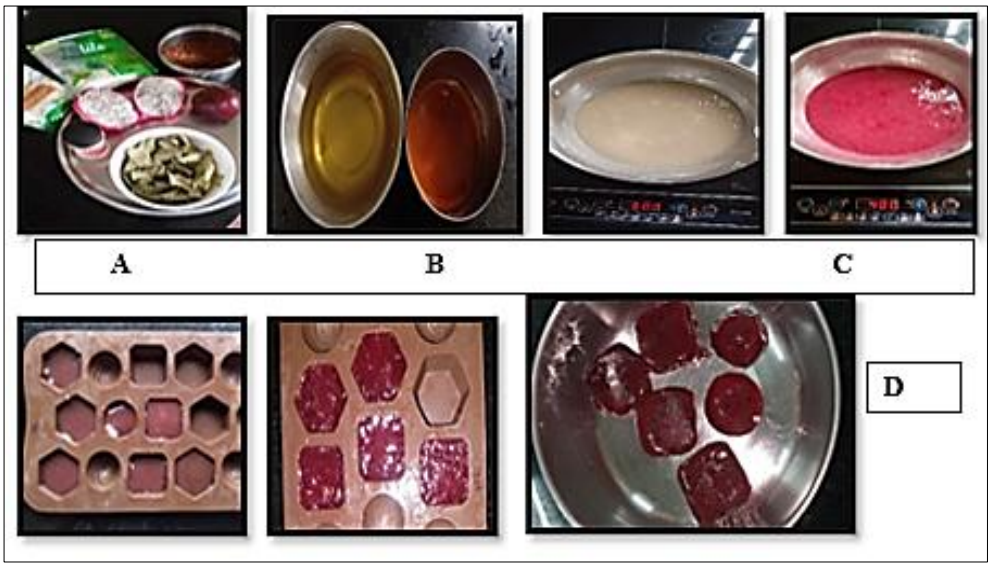

Fig 3: Optimisation of Herbal Jelly, A: Raw materials, B: Preparation of leaf extract and beetroot extract, C: Preparation of the fruit pulp, D: Moulding of the herbal jelly

Proximate Analysis of Herbal Jelly

The moisture and ash contents of the prepared jelly were determined using standard AOAC methods 2000 [14]. Moisture content was analysed by drying a known amount of the sample in a hot air oven at 100-110 °C to constant weight. The percentage was calculated gravimetrically. The ash level was calculated by charring the sample at 500-600 °C to produce a light grey ash. The ash content present has been determined from the combustion residue. The estimated nutritional composition of carbohydrates, protein, and fat was calculated from the proportions of the ingredients used to prepare the jelly. Nutritional values of the ingredients were obtained from the Indian Food Composition Tables published by the ICMR National Institute of Nutrition, India, and the contribution of each macronutrient was estimated based on the percentage of each ingredient present in the final product to obtain an approximate nutritional profile [15].

Total Soluble Solids (TSS)

The total soluble solids (TSS) of the prepared jelly were determined using a hand-held refractometer, following AOAC International (2019) [16]. About 1 drop of the jelly sample was placed on the refractometer prism, and readings were recorded directly as °Brix, which measures the soluble solids content of the samples [17].

Sensory Analysis

The sensory quality of fresh and stored guava jelly samples was evaluated using colour and appearance, texture, taste and overall acceptability as parameters [18]. The evaluation was conducted using a nine-point hedonic rating scale, in which panellists rated the samples according to their preference. Sensory evaluation scores were statistically analysed using descriptive statistics and expressed as mean± standard deviation. A radar chart was used to illustrate the sensory profile and overall acceptability of the developed product [19].

Shelf-Life Studies

The stability of the developed jelly over shelf life was determined by periodic microbiological analysis during storage. The jelly samples were transferred aseptically to sterilised containers and stored under ambient conditions (room temperature and Refrigeration) after preparation. The 15th and 31st days of storage were selected for microbial analysis to assess the presence and growth of microorganisms and evaluate the product's microbial safety and stability over time. For microbial enumeration, 1 g of the jelly sample was aseptically homogenised with 10 mL of sterile peptone water to obtain the initial dilution. Serial dilutions were then prepared in sterile peptone water up to a 10^{-3} dilution. Appropriate dilutions were spread-plated onto selective media to enumerate different microbial populations [20].

Plate Count Agar (PCA) was used for the enumeration of total viable bacterial count, Rose Bengal Agar (RBA) for the detection of moulds, and Yeast Glucose Chloramphenicol Agar (YGCA) for.

The enumeration of yeasts. The plates were incubated at 35°C for 24-48 hours for bacterial counts, and the RBA and YGCA plates were incubated at room temperature for the same period. The plates were examined after incubation for bacterial, yeast, and mould colonies. The microbiological quality and shelf stability of the developed jelly during storage were evaluated by counting colony formation on appropriate media [21].

Results

Preliminary Trials and Optimisation

Initial trials were conducted by varying the concentrations of leaf extracts, fruit pulp, gelling agents, and sweeteners to achieve the desired taste and texture of the jelly. The first trial resulted in a dark greenish colour, bitter taste due to leaf extracts, dominant raw leaf aroma, and poor jelly consistency. Based on these observations, modifications were made using dragon fruit pulp as the primary fruit base, and various gelling agents, including corn starch, gelatin, and orange-peel powder, were tested. These changes helped reduce bitterness and improve the consistency of the jelly. However, the colour remained slightly dark due to the presence of leaf extracts and dragon fruit seeds. Among the gelling agents tested, orange peel powder provided a better taste, whereas gelatin improved gel consistency with increasing concentration. Further trials resulted in improved consistency, reduced bitterness, better aroma, and higher overall acceptability; the final formulation was selected based on sensory evaluation results.

Proximate Analysis

The new product is carbohydrate-rich and low in fat, making it a good source of quick energy and acceptable for reduced-fat diets. A high TSS value indicates good gel formation and sweetness, while moderate moisture provides the desired texture. These traits indicate good sensory and nutritional quality of the Jelly (Table 3).

Table 3: Proximate analysis

Sl. No	Parameters	Results per 100grams
1.	Total carbohydrates	39g
2.	Added sugars	31g
3.	Total protein	1.2g
4.	Fat	0g
5.	Saturated fat	0g
6.	Moisture	33.15%
7.	Ash	1%
8.	TSS	67%

Sensory Analysis

Sensory evaluation of the prepared herbal jelly was conducted by 25 panelists using a 9-point hedonic scale. The results suggested that the product achieved high levels of acceptance in all the aspects tested. The sensory attribute with the highest score (8.76±0.44) was colour, indicating strong visual appeal. The results showed that panelists showed a strong preference for appearance (8.48±0.51), texture (8.44±0.51), and overall acceptability (8.48±0.51). The flavour/taste score (8.16±0.55) was slightly lower than the other criteria, but still showed outstanding consumer liking. The low standard deviation indicates strong agreement among the panelists regarding the product's sensory quality. (Table 4 & 5, Figure 3).

Table 4: Sensory Analysis of the Jelly

S.NO.	Panelist	Appearance	Color	Flavour/Taste	Texture	Overall acceptance
1.	1	8	9	8	8	8
2.	2	9	9	8	9	9
3.	3	8	8	8	8	8
4.	4	9	9	9	8	9
5.	5	8	9	8	9	8
6.	6	9	9	8	9	9
7.	7	8	8	7	8	8
8.	8	9	9	9	9	9
9.	9	8	9	8	8	8
10.	10	9	9	8	9	9
11.	11	8	9	8	8	8
12.	12	9	9	9	8	9
13.	13	8	8	8	8	8
14.	14	9	9	8	9	9
15.	15	8	9	8	8	8
16.	16	9	9	9	9	9
17.	17	8	8	7	8	8
18.	18	9	9	8	9	9
19.	19	8	9	8	8	8
20.	20	9	9	9	9	9
21.	21	8	8	8	8	8
22.	22	9	9	8	9	9
23.	23	8	9	8	8	8
24.	24	9	9	9	9	9
25.	25	8	8	8	8	8

Table 5: Sensory Evaluation of Herbal Jelly Using 9-Point Hedonic Scale (n = 25)

Sensory Attribute	Mean Score	Standard Deviation (SD)	Interpretation
Appearance	8.48	±0.51	Liked very much
Color	8.76	±0.44	Liked very much
Flavour/Taste	8.16	±0.55	Liked very much
Texture	8.44	±0.51	Liked very much
Overall Acceptability	8.48	±0.51	Liked very much

(Values are expressed as Mean±Standard Deviation (n = 25). Evaluation was performed using a 9-point hedonic scale (1 = Dislike extremely, 9 = Like extremely)

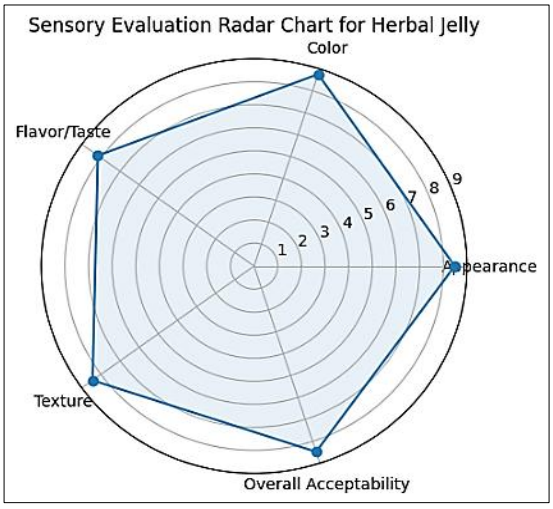

Fig 4: Sensory Evaluation Radar Chart for Herbal Jelly

Shelf-life studies

Microbial examination of the herbal jelly fruit product was performed on the 15th and 31st days under RT(Room Temperature) and RF (Refrigeration) storage conditions. Under both storage conditions, the microbial counts were reasonably low on the 15th day. However, at room temperature, microbial load increased dramatically on the 31st day, with yeast and mould counts recorded as TNTC (Too Numerous to Count), indicating rapid microbial growth and poor product stability. In contrast, samples stored under refrigerated conditions showed minimal microbial growth. Although the bacterial count slightly increased on the 31st day, no yeast or mould was detected, suggesting that refrigeration effectively inhibited fungal growth. Overall, the results indicate that refrigerated storage is more suitable for maintaining microbial stability and extending the shelf life of the developed herbal jelly fruit product (Tables 6 & 7; Figures 4 & 5).

Table 6: Microbial analysis of Herbal Fruit jelly at Room Temperature

S. No.	RT	Parameter	CFU		
			10^1	10^2	10^3
1.	15TH DAY	Total bacterial count (PCA)	3	1	0
		Total yeast and mold count (YGCA)	73	04	0
		Total yeast count (RBA)	102	20	01
2.	31ST DAY	Total bacterial count (PCA)	47	45	08
		Total yeast and mould count (YGCA)	TNTC	TNTC	TNTC
		Total yeast count (RBA)	TNTC	TNTC	TNTC

Table 7: Microbial analysis of Herbal Fruit jelly at Refrigeration

S. No.	RF	Parameter	CFU		
			10^1	10^2	10^3
1.	15TH DAY	Total bacterial count (PCA)	4	0	0
		Total yeast and mould count (YGCA)	40	01	01
		Total yeast count (RBA)	01	0	0
2.	31ST DAY	Total bacterial count (PCA)	54	26	20
		Total yeast and mould count (YGCA)	00	00	00
		Total yeast count (RBA)	00	00	00

Fig 5: Microbial analysis of the sample at Room Temperature. A: Sample stored at room temperature (15th & 31st day). B: Serial dilution done on 15th & 31st day. C-D: Plate count assay on Plate Count Agar (PCA) on (15th & 31st day). E-F: Plate count assay on Yeast Glucose Chloramphenicol Agar (YGCA) media on (15th & 31st day). G-H: Plate count assay on Rose Bengal Agar (RBA) media on (15th & 31st day).

Fig 6: Microbial analysis of the sample at refrigeration temperature. A: A sample stored at room temperature (15th & 31st day). B: Serial dilution done on 15th & 31st day. C-D: Plate count assay on Plate Count Agar (PCA) on (15th & 31st day). E-F: Plate count assay on Yeast Glucose Chloramphenicol Agar (YGCA) media on (15th & 31st day). G-H: Plate count assay on Rose Bengal Agar (RBA) media on (15th & 31st day).

Discussion

Based on preliminary studies, the composition of herbal jelly was optimised by varying the ratios of leaf extracts, fruit pulp, gelling agents, and sweeteners. The first formulation had undesirable qualities, including bitterness, a dark colour, a strong raw-leaf fragrance, and poor gel consistency. The incorporation of dragon fruit pulp increased flavour and overall acceptability. Among the gelling agents examined, orange peel powder enhanced flavour, while gelatin enhanced gel strength and uniformity. The sensory evaluation results indicated high consumer acceptance, with colour receiving the highest score, followed by look, texture, and overall acceptability [22, 23]. The proximate analysis indicated that the product was carbohydrate-rich and low in fat. The high TSS value suggested proper gel formation. A microbial study demonstrated that refrigeration can reduce microbial growth and increase the shelf stability of the herbal jelly compared with room-temperature storage [24]. Further, the shelf life of the jelly can be enhanced by incorporating food-grade preservatives

Conclusion: The study successfully developed an herbal jelly using selected plant extracts and dragon fruit pulp with acceptable sensory and nutritional qualities. Optimising the formulation improved the product's taste, aroma, colour, and gel consistency. Sensory evaluation indicated high consumer acceptance among the panelists. The proximate analysis showed that jelly had a high carbohydrate content and low-fat content, while the high TSS value indicated ideal gel formation and sweetness. A study of microbes indicated that refrigeration can inhibit their growth, thereby extending the product's shelf life compared to storage at room temperature. Hence, the developed herbal jelly might be a value-added product with nutritional benefits, suitable for consumers when refrigerated.

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Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this scientific paper.

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