**Development and Sensory Evaluation of Guava Leaf-Enriched Khakra: Enhancing Nutritional Value of a Traditional Snack**

**ABSTRACT**

**Background:** Guava (Psidium guajava L.), a tropical and subtropical fruit, is known for its high nutritional value and medicinal properties. **Aim:** This study aimed to develop and evaluate a food product enriched with guava leaf powder, specifically focusing on khakra, a traditional Indian snack. **Method:** The "Allahabad Safeda" variety of guava leaves was collected, dried, and powdered to incorporate into the khakra preparation. Four khakra variants were developed, including a standard version without guava leaf powder and three enriched versions containing varying amounts (4g, 7g, and 10g) of guava leaf powder. Sensory evaluation based on color, taste, texture, odor, and overall acceptability was conducted by 20 panelists using a 9-point hedonic scale. Nutritional analysis of the samples was performed to assess moisture, ash, carbohydrate, protein, fat, iron, and calcium content. **Results:** The results showed that the sample with 10g of guava leaf powder (Sample A) had the highest acceptability. Nutritional analysis revealed that the guava-enriched khakras had improved protein, fat, ash, and mineral content, making them a more nutritious alternative. **Conclusion:** This study demonstrates the potential of incorporating guava leaf powder into food products to enhance their nutritional profile while maintaining consumer acceptability.

**Keywords:** Guava leaves, Bioactive compounds, Nutrition analysis, Khakra, Sensory evaluation

1. **INTRODUCTION**

Guava (*Psidium guajava* L.) plant belongs to Myrtaceae family. It is one of the important tropical and subtropical fruit crops in the world as it can be grown in different soils and climate conditions and has high nutritional profile. India holds first position worldwide in the cultivation of guava and Uttar Pradesh, Madhya Pradesh, Maharashtra and Bihar are some important states of growing guava in country and from which Allahabad district of Uttar Pradesh is famous for growing excellent quality of guava fruit in the world [1,2]. The various parts of guava tree are utilized for several purposes like root, bark, stem, leaves and fruits are used for treating diabetes, stomachache, diarrhea etc. The guava leaves are high are considered to be rich in phytochemicals like tannins, flavonoids, alkaloids, saponins, carotenoids, lectins, phenols, terpenoids, essential oils etc. They are considered to be one of the non-conventional food products as they are not commonly used by people as its health benefits are not very well known [3,4]. They are widely used in teas, capsules, and essential oils, offering therapeutic effects like improving insulin function and protecting against oxidative damage [5,6]. Rich in flavonoids, tannins, and other compounds, guava leaves and other parts of the plant have been shown to provide antibacterial, antioxidant, antidiabetic, and anti-inflammatory benefits. This makes guava leaves an important resource in traditional and modern medicine for promoting health and well-being [7,8]. It plays an important role in ancient medicine and helps in preventing and treating various diseases. It is believed that many parts of this plant are useful in treating diseases like diarrhea, malaria, ulcers, vomiting, cough, gastroenteritis, dysentery, obesity, diabetes, hypertension etc. [9,10]. This study aims to develop the guava leaves enriched food products and conduct its sensory and nutritional evaluation.

1. **MATERIALS AND METHODS**
   1. **Collection and preparation of sample** – The "Allahabad Safeda" variety of guava leaves was collected from the Krishi Vigyan Kendra at Banasthali Vidyapith in Newai, Rajasthan, India. This specific variety was identified by an expert at the center. The leaves were carefully handpicked from the tree, washed under running water to remove any dirt, and then rinsed with distilled water. Afterward, they were air-dried at 80°C for 20 hours. Once dried, the leaves were ground into a fine powder and stored for future use.
   2. **Development of food product** – The food product was made using the dried guava leaf powder, and the dish prepared was Khakra. The ingredients for making the khakra were sourced from the local market in Banasthali Vidyapith, Newai, Rajasthan, India. Four different khakra samples were made. One sample was the standard version, with no changes, and the other three included different amounts of the dried guava leaf powder. The ingredients and their quantities used to prepare the khakra samples are listed in Table 1.

**Table 1: Composition of khakra prepared by using dried guava leaves powder**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ingredients** | **Amount (g)** | | | |
| **Standard** | **Sample A** | **Sample B** | **Sample C** |
| Gram flour | 20 | 16 | 10 | 34 |
| All-purpose flour | 38 | 20 | 20 | 20 |
| Black gram dal | 20 | 30 | 20 | 20 |
| Rice | 10 | 12 | 31 | 10 |
| Sesame seeds | 2 | 2 | 2 | 2 |
| Oil | 10 | 10 | 10 | 10 |
| Red chilli powder | A pinch | A pinch | A pinch | A pinch |
| Salt | A pinch | A pinch | A pinch | A pinch |
| Asafoetida | A pinch | A pinch | A pinch | A pinch |
| Dried guava fruit powder | Not incorporated | 10 | 7 | 4 |

The khakra was prepared by using the following method:

Step 1: The flour and ingredients used were mixed together and dough was formed by kneading it and milk was used for binding it.

Step 2: The dough was kept aside by covering it for atleast 30 minutes at room temperature.

Step 3: The equal balls of dough were made and flatten very thin by using a rolling pin.

Step 4: The prepared chapatti was cooked on a pan on a slow flame by pressing it with heavy wooden material covering with muslin cloth to give it a crunch and served / presented.

* 1. **Sensory evaluation of developed food product** – The sensory evaluation was based on attributes such as color, taste, texture, odor, and overall acceptability. A 9-point hedonic scale was used for the evaluation. Twenty panelists from the Department of Food Science and Nutrition at Banasthali Vidyapith were selected for this purpose. The panelists tasted the food samples and rated them on a scale from 1 to 9 based on their sensory experience, where a score of 9 indicates "extremely liked" and a score of 1 indicates "extremely disliked."
  2. **Nutritional analysis of sample** – The prepared samples were analyzed for their nutritional content. Moisture content was determined using the air-oven method, ash content by the muffle furnace method, protein using the Micro-Kjeldahl method, fat with a Soxhlet apparatus, and carbohydrates by calculation using the difference method [11,12]. The minerals iron and calcium were analyzed using an atomic absorption spectrophotometer [13].

**2.5 Statistical analysis** – The results were expressed in the form of mean ± standard deviation (SD).

1. **RESULTS AND DISCUSSION**
   1. **Prepared food product -** The developed food product, khakra, with varying amounts of guava leaf powder added, is shown in Figure 1. The standard version is without any guava leaf powder, while Sample A contains 10g of guava leaf powder, Sample B has 7g, and Sample C includes 4g.

**Figure 1: Prepared food product enriched with guava leaves powder**

* 1. **Sensory evaluation** - The sensory evaluation was done of 4 samples i.e., standard, sample A, B and C. According to the color acceptability, standard was having the highest and sample A was having the lowest color acceptability. According to the taste acceptability, sample A was having the highest while sample C was having the lowest taste acceptability but among the all samples, standard was having the highest acceptability. According to the texture acceptability, sample A was having the highest texture acceptability while sample B was having the lowest acceptability. According to the odour acceptability, sample A was having the highest while sample C was having the lowest odour acceptability. According to the overall acceptability, sample A was having the highest while standard was having the lowest overall acceptability. In conclusion, sample A was having the highest acceptability.

**Table 2: Sensory evaluation of developed food product**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Samples** | **Standard** | **Sample A** | **Sample B** | **Sample C** |
| **Color** | 7.90±0.85 | 7.30±0.94 | 7.65±1 | 7.55±0.96 |
| **Taste** | 8.05±0.91 | 9.10±0.91 | 7.55±0.99 | 7.35±0.94 |
| **Texture** | 7.85±1.09 | 7.91±1.04 | 7.30±0.94 | 7.85±0.99 |
| **Odour** | 7.65±0.93 | 7.81±0.92 | 7.70±0.94 | 7.60±0.94 |
| **Overall acceptability** | 8.05±0.81 | 9.30±0.68 | 7.90±0.61 | 7.65±0.75 |

(Values are expressed in Mean±SD)

**Figure 2: Average sensory evaluation of developed food product**

* 1. **Nutritional analysis of sample:** The nutritive value of the samples was per 100g. The moisture (g) content of standard, sample A, B and C were 10.44±0.82; 9.43±0.73; 8.18±0.65; 7.85±0.45 respectively, showing standard to have maximum moisture content and sample C having lowest moisture content. The ash (g) content of standard, sample A, B and C were 1.42±0.25; 2.24±0.35; 2.13±0.38; 2.04±0.45 respectively, showing sample A to have highest ash content while standard having lowest ash content. The carbohydrate (g) content of standard, sample A, B and C were 54.09±0.55; 34.61±0.45; 34.23±0.33; 33.84±0.42 respectively which shows that among the variants, sample A was having the highest and sample C was having the lowest carbohydrate content and among all the samples, standard was having the highest carbohydrate content. The protein (g) content of standard, sample A, B and C were 4.18±0.22; 14.57±0.48; 13.64±0.55; 12.69±0.35 respectively which shows that among the variants, sample A was having the highest and sample C was having the lowest protein content and among all the samples, standard was having the lowest protein content. The fat (g) content of standard, sample A, B and C were 3.33±0.45; 15.77±0.58; 13.78±0.55; 11.76±0.54 respectively which shows that among the variants, sample A was having the highest and sample C was having the lowest fat content and among all the samples, standard was having the lowest fat content. The iron (mg) content of standard, sample A, B and C were 5.36±0.54; 4.91±0.65; 4.47±0.77; 4.03±0.73 respectively which shows that among the variants, sample A was having the highest and sample C was having the lowest iron content and among all samples, standard was having the highest iron content. The calcium (mg) content of standard, sample A, B and C were 124.35±0.28; 124.76±0.38; 115.98±0.24; 107.2±0.54 respectively which shows that among the variants, sample A was having the highest and sample C was having the lowest calcium content.

**Table 3: Nutritional analysis of developed food products**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Nutrients** | **Standard** | **Sample A** | **Sample B** | **Sample C** |
| Moisture (g/100g) | 10.44±0.82 | 9.43±0.73 | 8.18±0.65 | 7.85±0.45 |
| Ash (g/100g) | 1.42±0.25 | 2.24±0.35 | 2.13±0.38 | 2.04±0.45 |
| Carbohydrates (g/100g) | 54.09±0.55 | 34.61±0.45 | 34.23±0.33 | 33.84±0.42 |
| Protein (g/100g) | 4.18±0.22 | 14.57±0.48 | 13.64±0.55 | 12.69±0.35 |
| Fat (g/100g) | 3.33±0.45 | 15.77±0.58 | 13.78±0.55 | 11.76±0.54 |
| Iron (mg/100g) | 5.36±0.54 | 4.91±0.65 | 4.47±0.77 | 4.03±0.73 |
| Calcium (mg/100g) | 124.35±0.28 | 124.76±0.38 | 115.98±0.24 | 107.2±0.54 |

(Values are expressed in Mean±SD)

The results for the nutrient analysis of the khakhra content vary by adding the guava leaves. The results of the nutrient analysis of khakhra were similar to the study conducted by [14] of masala khakhra developed with fortification of the moringa leaves powder. The moisture, ash, protein, and fibre were increased after increasing the incorporation of the moringa leaves powder in the masala khakhra. The levels of carbohydrate decreased when the concentration of the moringa leaves powder increased. But in contrary to the current study results, crude fat increased as the levels of the incorporation increased. Another study by [15] investigate the sensory and nutritional value of khakhra supplemented by the mushroom powder at 5%, 10%, and 15% respectively. The khakhra incorporated by (5% mushroom powder) scores highest acceptability but lowest as compared with the control. The nutrient analysis was carried out the most accepted khakhra and the control. The result of the conducted study was in similarity with the present study as the experimental sample have higher amounts of moisture, protein, crude fat and fibre in comparison with the control. Also, ash and carbohydrate content were contrary with the current study because in the reported study ash and carbohydrate content was higher in the experimental sample as compared with the control. A study was conducted on development of the value added khakhra with incorporation at various levels such as 10%, 20%, 30%, 40%, 50%, 60%, and 70% of kodo millet flour and control with 100% of wheat flour by [16]. The nutrient analysis of the control and most accepted kodo masala khakhra were carried out. The nutrient analysis results of ash, fibre, calcium, and iron were similar as ash was higher in control and fibre, calcium, and iron were higher in kodo millet khakhra as compared to the control sample. But contrary for the moisture, and crude fat because control had higher amount. Furthermore, also contrary for the protein and carbohydrate because both control and accepted kodo millet khakhra contained almost similar value.

1. **CONCLUSION**

The study successfully developed and evaluated guava leaf-enriched khakra, highlighting the potential of incorporating guava leaf powder into traditional food products. Sensory evaluation showed that while the khakra with 10g of guava leaf powder stood out for its pleasant aroma and moderate sensory appeal. This indicates that the addition of guava leaf powder can enhance the nutritional value of the product without significantly compromising consumer acceptance. Nutritional analysis revealed that the enriched khakras exhibited notable changes, with increased protein, fat, and ash content compared to the standard khakra, making the product more nutritious. The guava leaf powder contributed additional minerals like calcium and iron, further enhancing the health benefits of the food product. In conclusion, guava leaf powder has the potential to be incorporated into everyday food products like khakra, providing an opportunity to improve both the nutritional profile and health benefits of traditional snacks. Further studies can explore optimizing the guava leaf powder concentration to balance sensory qualities and nutritional advantages while ensuring broader consumer acceptance.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Authors declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**REFERENCES**

1. Jolhe, P., Sahu, G. D., & Kumar, V. (2020). Preparation and evaluation of guava jelly (Psidium guajava). *Journal of Pharmacognosy and Phytochemistry*, *9*(6), 2061-2063.
2. Kumar M, Tomar M, Amarowicz R, Saurabh V, Nair MS, Maheshwari C, Sasi M, Prajapati U, Hasan M, Singh S, Changan S. Guava (Psidium guajava L.) leaves: Nutritional composition, phytochemical profile, and health-promoting bioactivities. Foods. 2021 Apr 1;10(4):752.
3. Khanna S, Singh P, Chauhan ES. Nutritional analysis of Guava (Psidium guajava L.) and its incorporation in Bhakarwadi. International Journal of Food and Fermentation Technology. 2022;12(2):117-20.
4. Sharma A, del Carmen Flores-Vallejo R, Cardoso-Taketa A, Villarreal ML. Antibacterial activities of medicinal plants used in Mexican traditional medicine. Journal of ethnopharmacology. 2017 Aug 17;208:264-329.
5. Ashraf A, Sarfraz RA, Rashid MA, Mahmood A, Shahid M, Noor N. Chemical composition, antioxidant, antitumor, anticancer and cytotoxic effects of Psidium guajava leaf extracts. Pharmaceutical biology. 2016 Oct 2;54(10):1971-81.
6. Deguchi Y, Miyazaki K. Anti-hyperglycemic and anti-hyperlipidemic effects of guava leaf extract. Nutrition & metabolism. 2010 Dec;7:1-0.
7. Khanna, Somya, Pragati Singh, and Ekta Singh Chauhan. 2025. “Comparative Analysis of Bioactive Compounds in Guava (Psidium Guajava L.) Fruit and Leaves”. Asian Journal of Research in Biochemistry 15 (2):53-58.
8. Nantitanon W, Yotsawimonwat S, Okonogi S. Factors influencing antioxidant activities and total phenolic content of guava leaf extract. LWT-Food science and technology. 2010 Sep 1;43(7):1095-103.
9. Díaz-de-Cerio E, Verardo V, Gómez-Caravaca AM, Fernández-Gutiérrez A, Segura-Carretero A. Health effects of Psidium guajava L. leaves: an overview of the last decade. International journal of molecular sciences. 2017 Apr 24;18(4):897.
10. Khanna S, Singh P, Chauhan P, Chauhan ES. Medicinal and Nutritional Potential of Guava Leaves: A Natural Remedy for Health and Wellness. Journal of Advances in Food Science & Technology. 2025 Jan 27;12(1):13-20.
11. Raghuramulu N, Nair KM, Kalyanasundaram S. (2003). A Manual of Laboratory Techniques (2nd edition). National Institute of Nutrition-Indian Council of Medical Research (ICMR).
12. A.O.A.C. (1995). Official methods of Analysis of the Association of Official Analytical Chemists. Hornitz, W.ed Washington D.C., Association of Official Analytical Chemists.
13. NIN. (2003). A manual of laboratory techniques. Hyderabad, National Institute of Nutrition, Indian Council of Medical Research.
14. Ambawat, S., and Sharma, A (2023). Development and quality evaluation of masala khakhra fortified with moringa leaves powder. *Annals of Biology*, *39*(1), 130-135.
15. Verma, S., and Bhatnagar, V. (2017). Enhancement of nutritional value of khakhra. *International Journal of Food and Nutritional Science*, *6*(1), 14-18.
16. Umarji, V. K., and Vijayalaxmi, K. G. (2020). Organoleptic, physical, nutritional characteristics and storage stability of value added Kodo masala khakhra. *Journal of Pharmacognosy and Phytochemistry*, *9*(5), 326-333.