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Development and Evaluation of Value-Added Products Using Mulberry Leaf Powder

Shinana Sherin M T[1], Loosiya K P[2]

[1]Post Scholar, [2]Assistant Professor,
Post Graduate Department of Home Science, Korambayil Ahamed Haji Memorial Unity Women's College, Manjeri, Malappuram, Kerala, 676122, India

Corresponding Author: Loosiya K P

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ABSTRACT

The present study aimed to develop and evaluate value-added food products incorporatsing mulberry leaf powder and to assess their nutritional quality, sensory acceptability, and shelf stability. Three products namely mulberry leaf chammanthipodi, laddu, and crackers were formulated with varying levels of mulberry leaf powder (0%, 10%, 15%, and 20%) along with respective control samples. Organoleptic evaluation was conducted using a 9-point hedonic scale by semi-trained panelists to determine the most acceptable formulations. The selected variations (10% incorporation level) were further subjected to nutrient analysis, microbial assessment, and storage studies. The results revealed that products with 10% mulberry leaf powder achieved higher acceptability scores compared to higher incorporation levels, indicating optimal sensory balance. Nutritional analysis showed that the developed products were rich in calcium, iron, and vitamin C, with chammanthipodi exhibiting the highest mineral content. Microbial analysis indicated no initial contamination, while gradual increases in total microbial count were observed during storage; however, values remained within acceptable limits over two months. The study demonstrates that mulberry leaf powder can be effectively utilized in developing nutritionally enhanced, acceptable, and shelf-stable value-added products. This approach supports the utilization of underexploited plant resources and contributes to the development of functional foods for improved public health.

Keywords: Mulberry leaf powder, value-added products, sensory evaluation, nutritional analysis, shelf life, functional foods

1. INTRODUCTION

The growing global emphasis on functional foods and sustainable nutrition has intensified the search for underutilized plant resources with high nutritional and therapeutic potential. Among such resources, mulberry (*Morus spp.*) has gained increasing attention due to its rich phytochemical composition and wide adaptability across diverse agro-climatic conditions. Traditionally cultivated for sericulture, mulberry leaves have long been recognized in herbal medicine systems for their health-promoting properties, yet their utilization in mainstream food systems remains relatively limited, particularly in developing countries (Ahmad et al., 2021).

Mulberry leaves are nutritionally dense and contain a wide array of bioactive compounds, including polyphenols, flavonoids, alkaloids, vitamins, and essential minerals such as calcium, iron, and potassium (Sireesha & Sri,

2020). These compounds are associated with several physiological benefits, including antioxidant, anti-inflammatory, antimicrobial, anti-hyperglycaemic, and lipid-lowering effects, making mulberry leaves a promising ingredient for functional food development (Ahmad et al., 2021). In recent years, research has also highlighted mulberry leaf protein as a novel plant-based protein source with potential applications in nutraceuticals and value-added food formulations (Xue et al., 2025).

Mulberry leaves are also a good source of vitamins, minerals, protein, carbohydrate, and dietary fiber. Carotene, vitamin B1, folic acid, folinic acid, and vitamin D are also present in them. It has been reported that leaves contain glutathione. Manganese, copper, zinc, and boron are found in trace amounts. Despite these advantages, the direct consumption of mulberry leaves is limited due to their fibrous texture and mild bitterness. Converting them into mulberry leaf powder offers a practical solution, enabling incorporation into various food products such as bakery items, snacks, beverages, and traditional foods. Studies have demonstrated that the incorporation of mulberry leaf powder significantly enhances the antioxidant capacity and polyphenol content of food products, thereby improving their functional value (Thongkham et al., 2020).

The concept of value addition in food processing is particularly relevant in the current context of food security, nutrition transition, and waste minimization. Developing value-added products using underutilized resources like mulberry leaves can enhance their economic value, promote dietary diversification, and contribute to sustainable food systems. In India, although mulberry cultivation is widespread due to its association with the silk industry, its potential as a functional food ingredient remains largely untapped at the commercial level (Ahmad et al., 2021). This gap highlights the need for systematic research focusing on product development, sensory evaluation, and nutritional profiling of mulberry-based foods.

Furthermore, with the increasing prevalence of lifestyle-related disorders such as diabetes, obesity, and cardiovascular diseases, there is a growing demand for foods that not only provide basic nutrition but also offer health benefits. Mulberry leaf powder, owing to its hypoglycaemic and antioxidant properties, presents a valuable opportunity for the development of such health-oriented food products. Its incorporation into commonly consumed foods can serve as a practical dietary intervention to improve overall nutritional status and prevent chronic diseases. This approach not only facilitates the utilization of an underexploited resource but also aligns with current trends in functional food innovation and public health nutrition. The evaluation of these products in terms of nutritional composition, sensory attributes, and acceptability is essential to ensure their feasibility for large-scale production and consumer adoption. Thus, based on this background the present study entitled “Development and Evaluation of Value-Added Products Using Mulberry Leaf Powder” was undertaken with the following objectives:

- To develop value added products using dried mulberry leaf powder
- To analyze the organoleptic qualities of the developed products
- To assess the nutrient content of the developed products
- To analyze the microbial content of the developed products

2. EXPERIMENTAL PROCEDURE

Mulberry leaves offer a range of potential health benefits including blood sugar control, cholesterol reduction and immune system support. They are rich in antioxidants and other beneficial compounds that may contribute to improved heart health, digestion and even skin health. The development of value-added products from mulberry leaf is highly beneficial to conserve the potential health aspects of mulberry leaf in our diet. The recipes selected for this

project are in the form of popular culinary items like Chammanthipodi, Laddu, and Crackers and are simple to make, flexible, nourishing, and appealing to customers of all ages. Mulberry leaves are powdered to prepare the products.

2.1 Development of mulberry leaf chammanthipodi

The ingredients used for the preparation of chammanthipodi were mulberry leaf powder, roasted coconut, shallots, red chilli, tamarind and curry leaves. Mix all the ingredients in a bowl and blend them in a mixer grinder and chammanthipodi was prepared. The ingredients used to make the control chammanthipodi were 70g of coconut, 10g of shallot, and 10g of red chilli and 10g of tamarind. For variations C_1, C_2, and C_3 along with a control recipe, C_0 were made for standardization.

2.2 Development of mulberry leaf laddu

The prepared mulberry leaf powder was used for the preparation of laddu. The dough was prepared by combining the mulberry leaf powder with ragi flour in various variations. The other ingredients used for the laddu were peanut and dates. The laddu were prepared by roasting ragi flour and peanut. Then all the ingredients are mixed together and powdered. The prepared powder made to balls and the laddu is prepared. The ingredients used to make the control laddu were 70g ragi flour, 10g peanut and 20g dates. For variations L_1, L_2, and L_3along with a control recipe, L_0 were made for standardization.

2.3 Development of mulberry leaf crackers

In the preparation of mulberry leaf crackers, the mulberry leaves powder, wheat flour, ginger, garlic and pepper powder were mixed in the selected proportions. The flour was kneaded with hot water and 1 teaspoon of sunflower oil. After keeping it aside for 10 minutes, rolled it and cut it into thin square shapes and pierced with fork for baking evenly. Then these shaped ones were placed in a tray over butter paper and kept in a 180 degree in preheated microwave oven for 15 minutes. The baked crackers were allowed to cool for 10 minutes to make it crispier. The ingredients used to make the control crackers were 90g of wheat flour, 5g of ginger, 5g of garlic and 1g of pepper powder. For variations T_1, T_2, and T_3 along with a control recipe, T_0 were made for standardization.

2.4 Standardization of developed products

Different variations of chammanthipodi, laddu and crackers were made by incorporating mulberry leaf powder in various proportions. Four treatments of each product were made as C_0 –C_3, L_0 – L_3, and T_0 – T_3 for chammanthipodi, laddu and crackers respectively. After that organoleptic evaluation of the products were done by 10 panel judges using 9-point hedonic scale. One treatment from each product was then selected based on the acceptability score obtained for different quality attributes for further studies. The selected products were C_1, L_1 and T_1. Nutrients such as calcium, iron and vitamin c were analyzed. The selected three products (C_1, L_1 and T_1) prepared using standard procedure was then packed in air tight glass bottles and was kept for storage in room temperature for 2 months. Organoleptic evaluation was done in every month to evaluate the quality of the products during storage and to determine its shelf life. Microbial analysis of selected products initially and during storage after one and two months was also done.

2.5 Organoleptic Evaluation of the Developed Products

Sensory evaluation of mulberry leaf powder incorporated products were carried out in the nutrition lab of Department of Home Science, KAHM Unity Women's College, Manjeri, Malappuram. The samples were evaluated for their sensory attributes such as Appearance, Colour, Flavour, Texture, Taste and Overall acceptability using a 9 – point hedonic scale. Ten semi trained panel members were selected for the sensory evaluation and they are asked to assign

scores for the sensory characteristics of mulberry leaf powder incorporated products

2.6 Nutrient Analysis

The nutrient content of selected value-added products developed from mulberry leaf powder was analyzed and calculated. The nutrient evaluation was carried out at the STS lab in Coimbatore. The calcium, iron and vitamin C of the most accepted variations of each of the developed products were calculated

2.7 Microbial Analysis

Microbial analysis of the developed mulberry leaf value-added products, namely mulberry leaf chammanthipodi, mulberry leaf laddus, and mulberry leaf crackers, was carried out to assess their microbiological quality and shelf stability during storage. The total microbial count was determined initially (immediately after preparation) and subsequently after one and two months of storage under ambient conditions in airtight containers. Standard microbiological procedures were followed using the serial dilution and plate count method.

2.8 Statistical Analysis

The collected data was consolidated, tabulated, analyzed and interpreted using appropriate statistical analysis. The data should be statistically analyzed to ensure the significance. Kendell's was used for analyzing sensory evaluation and Microsoft excel was used for comparing prebiotic value of each item. Kendell's W (Kendell's coefficient of concordance) is a non – parametric statistics.

RESULT AND DISCUSSION

3.1 Development of Mulberry Leaf Products

The prepared recipes were chammanthipodi, laddu and crackers. Mulberry leaf chammanthipodi were developed in different variations using coconut and mulberry leaf powder as main ingredients. The developed variations were C_0, C_1, C_2 and C_3 in the ratio of coconut: mulberry leaf powder as 70:0, 60:10, 55:15 and 50:20 respectively.C_0 were prepared as controlled recipe. Mulberry leaf laddu was prepared using mulberry leaf powder and ragi flour as main ingredients in the ratio 0:70, 10:60, 15:55 and 20:50 respectively for L_0, L_1, L_2 and L_3. L_0 were prepared as controlled recipe. Different variations of mulberry leaf crackers were made using the key ingredients mulberry leaf powder and wheat flour in the ratio 0:90 for T_0, 10:80 for T_1, 15:75 for T_2 and 20:70 for T_3. T_0 were prepared as controlled recipe. These three products are then organoleptically evaluated

3.2 Organoleptic Evaluation of Mulberry Leaf Chammanthipodi

Table 1: Mean Scores for Organoleptic Evaluation of Mulberry Leaf Chammanthipodi

Variations	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
C_0	8.3 (3.15)	8.3 (3.50)	8.1 (3.20)	8.2 (3.30)	8.3 (3.60)	8.1 (3.55)
C_1	8.2 (2.80)	7.9 (2.95)	7.9 (3.10)	7.2 (2.70)	7.7 (3.15)	7.6 (3.25)
C_2	7.7 (2.15)	7.1 (1.80)	6.9 (2.05)	6.8 (2.05)	6.6 (2.00)	6.7 (1.95)
C_3	7.5 (1.90)	7.1 (1.75)	6.6 (1.65)	6.8 (1.95)	6.0 (1.25)	6.1 (1.25)
Kendall's (W) value	**0.349***	**0.543*****	**0.438****	**0.365***	**0.733*****	**0.802*****

Figures in the parenthesis indicate mean rank scores

*****= Significant at 0.1% level, **= Significant at 1% level, *= Significant at 5% level**

C_0= 70% Coconut + 0% Mulberry leaf powder, C_1 = 10% Mulberry leaf powder + 60% Coconut, C_2= 15% Mulberry leaf powder + 55% Coconut, C_3 = 20% Mulberry leaf powder + 50% Coconut

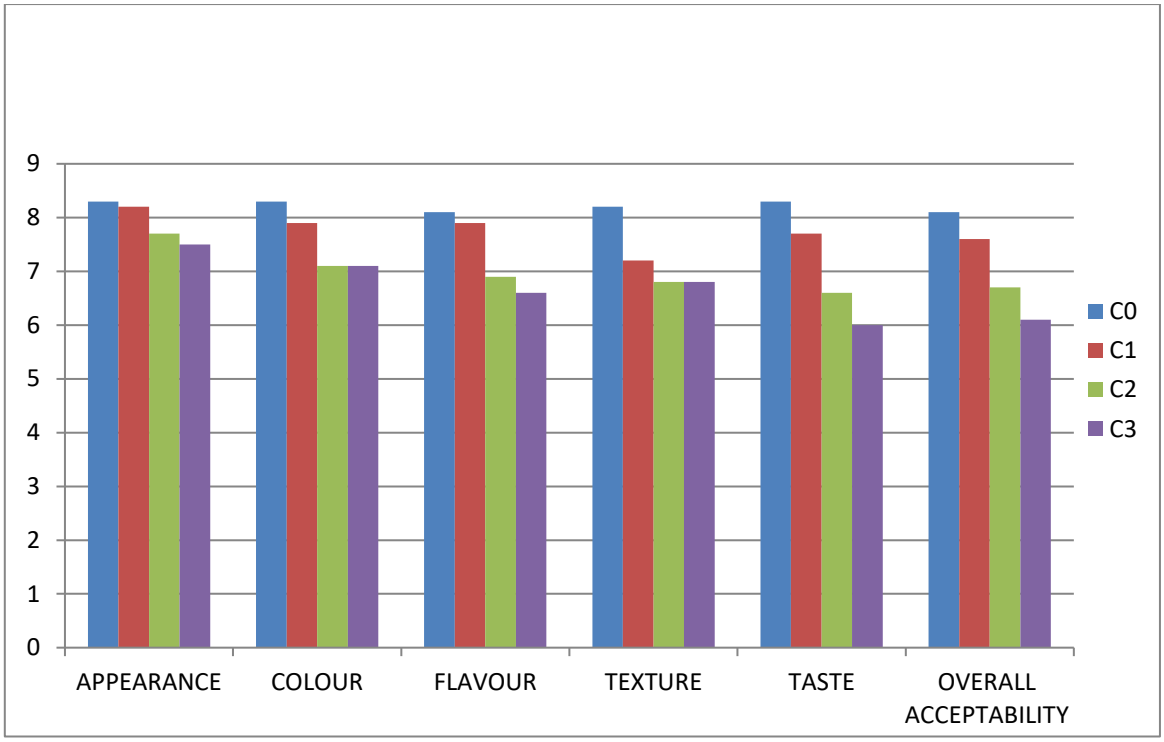

Figure 1: Graphical representation of the mean score for organoleptic evaluation of mulberry leaf chammanthipodi

The table 1 and figure 1 shows that the mean scores obtained for the appearance of the chammanthipodi varied from 7.5 to 8.3 and the mean rank scores from 1.90 to 3.15. Among these, the highest mean score was for C_0, which is the controlled recipe. Next highest mean score was for C_1, prepared with 10% mulberry leaf powder and 60% coconut. The mean score obtained for the colour of samples C_0, C_1, C_2 and C_3 were 8.3, 7.9, 7.1 and 7.1 and the mean rank scores 3.50, 2.95, 1.80 and 1.75 respectively. Among these, the maximum mean score was found on samples C_0, the controlled recipe and next maximum mean score obtained for C_1 (10% mulberry leaf powder and 60% coconut). The mean score for the flavour of the samples ranged from 6.6 to 8.1 and the mean rank score from 1.65 to 3.20. The variation C_0 has the highest mean score and next highest mean score is for C_1. The variation C_0 had scored the highest mean score for texture and the lowest was found for the sample C_2 and C_3. The mean scores for the taste of the samples ranged from 6.0 to 8.3. The variation C_0 had the highest mean score and the mean scores for overall acceptability of the mulberry leaf chammanthipodi varied from 6.1 to 8.1.

3.3 Organoleptic Evaluation of Mulberry Leaf Laddu

Table 2: Mean Scores for Organoleptic Evaluation of Mulberry Leaf Laddu

Variations	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
L_0	8.0 (3.25)	7.5 (3.10)	7.4 (3.25)	7.6 (2.45)	7.0 (3.20)	7.4 (3.45)
L_1	7.5 (2.45)	7.1 (2.35)	7.1 (2.80)	8.0 (3.20)	6.8 (3.15)	7.2 (3.30)
L_2	7.6 (2.75)	7.2 (2.55)	6.7 (2.45)	7.4 (2.40)	6.2 (2.10)	6.2 (2.00)
L_3	6.8 (1.55)	6.9 (2.00)	5.9 (1.50)	7.2 (1.95)	5.7 (1.55)	5.6 (1.25)
Kendall's (W) value	**0.494****	**0.202^{ns}**	**0.414****	**0.252^{ns}**	**0.506****	**0.771*****

Figures in the parenthesis indicate mean rank scores

*****= Significant at 0.1% level, **= Significant at 1% level, ns = Non significant**

L_0= 70% Ragi flour + 0% Mulberry leaf powder, L_1=10% Mulberry leaf powder + 60% Ragi flour, L_2= 15% Mulberry leaf powder + 55% Ragi flour, L_3= 20% Mulberry leaf powder + 50% Ragi flour

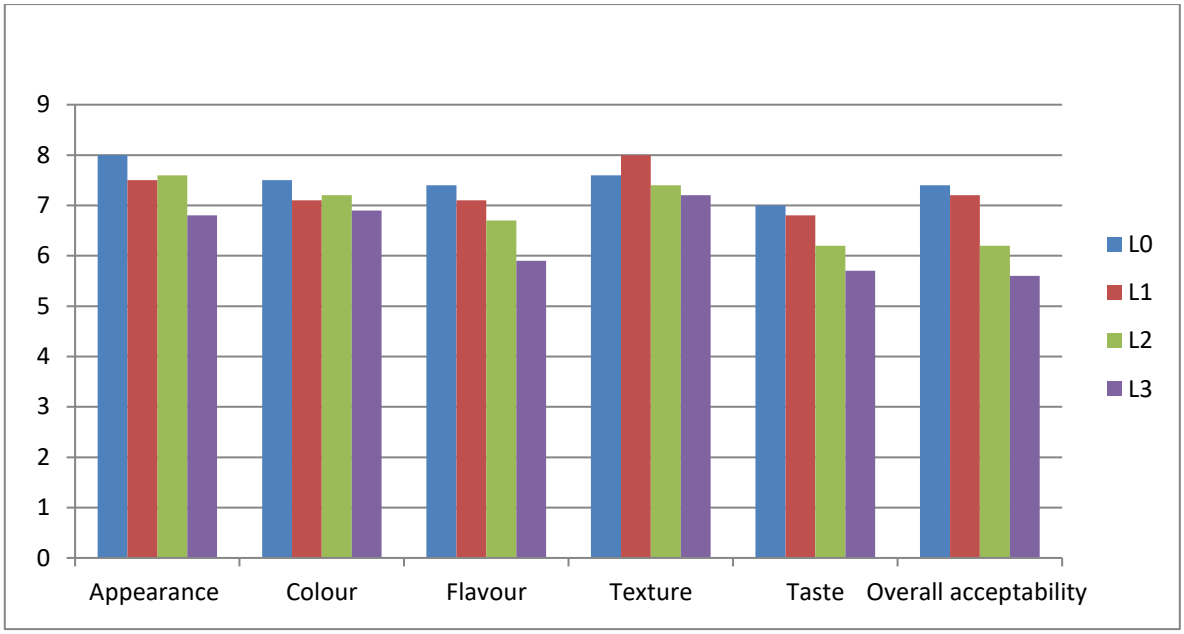

Figure 2: Graphical representation of the mean scores for the Organoleptic Evaluation of Mulberry Leaf Laddu

The mean scores obtained for the appearance of the laddu varied from 6.8 to 8.0 and the mean rank scores from 1.55 to 3.25. Among these, highest mean score was for L_0, the controlled recipe. The next highest mean score was for L_2, prepared with 15% mulberry leaf powder and 55% ragi flour. The mean scores obtained for the colour of samples L_0, L_1, L_2 and L_3, were 7.5, 7.1, 7.2 and 6.9 and the mean rank scores 3.10, 2.35, 2.55 and 2.00 respectively. Among these, the maximum mean score was found on sample L_0, the controlled recipe. Next maximum mean score was for L_2. The mean scores for flavour of the samples ranged from 5.9 to 7.4 and the mean rank scores from 1.50 to 3.25. The variation L_0 had the highest mean score. The variation L_1 had scored the highest mean score for texture and the lowest was found for the sample L_3. The mean rank scores recorded for the taste of the mulberry leaf laddu from L_0 to L_3 were 3.20, 3.15, 2.10 and 1.55 respectively. The variation L_3 had the lowest mean score whereas the highest mean score was found to be for the variation L_0 and the mean scores for overall acceptability of the mulberry leaf laddu varied from 5.6 to 7.4 with mean rank scores from 1.25 to 3.45.

3.4 Organoleptic Evaluation of Mulberry Leaf Crackers

Table 3: Mean Scores for Organoleptic Evaluation of Mulberry Leaf Crackers

Variations	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0	8.0 (3.10)	7.7(2.45)	7.9 (3.30)	7.6 (2.70)	7.8 (3.45)	7.9 (3.20)
T_1	8.0 (3.25)	8.2 (3.25)	7.8 (3.15)	7.9 (3.30)	7.6 (3.15)	8.0 (3.40)
T_2	7.2 (2.05)	7.8 (2.50)	7.1 (2.00)	7.1 (2.00)	6.8 (1.95)	7.2 (2.00)
T_3	6.9 (1.60)	7.4 (1.80)	6.8 (1.55)	7.1 (2.00)	6.4 (1.45)	6.8 (1.40)
Kendall's (W) value	**0.523*** **	**0.358***	**0.561*** **	**0.369***	**0.642*** **	**0.665*** **

Figures in the parenthesis indicate mean rank scores

*****= Significant at 0.1% level, *= Significant at 5% level**

T_0= 90% Wheat flour + 0% Mulberry leaf powder, T_1= 10% Mulberry leaf powder + 80% Wheat flour, T_2= 15% Mulberry leaf powder + 75% Wheat flour, T_3= 20% Mulberry leaf powder + 70% Wheat flour

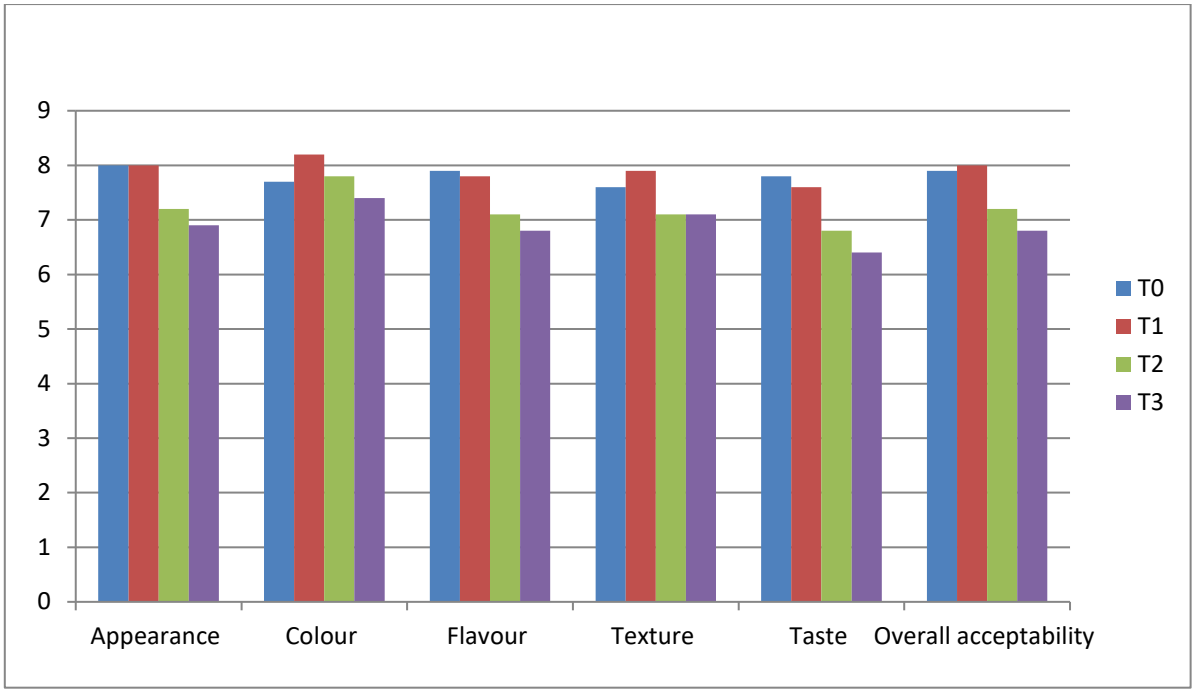

Figure 3: Graphical representation of the mean scores for the Organoleptic Evaluation of Mulberry Leaf Crackers

The mean rank scores acquired for the appearance of the variants T_0, T_1, T_2 and T_3 are 3.10, 3.25, 2.05 and 1.60 respectively. Among these, the highest mean scores were for T_0 (90% Wheat flour + 0% Mulberry leaf powder) and T_1 (10% Mulberry leaf powder + 80% Wheat flour). The mean scores for the colour of the variants from T_0 to T_3 were 7.7, 8.2, 7.8 and 7.4 and the mean rank scores were 2.45, 3.25, 2.50 and 1.80 respectively. Among these, the lowest mean score was for T_3 (7.4), prepared with 20% Mulberry leaf powder + 70% Wheat flour and the highest for T_1 (8.2), prepared with 10% Mulberry leaf powder + 80% Wheat flour. The mean score for flavour of the samples ranged from 6.8 to 7.9. Sample T_0 has the highest mean score. The mean score obtained for texture of the samples T_0, T_1, T_2 and T_3 are 7.6, 7.9, 7.1 and 7.1 respectively. Among these the maximum score was found in sample T_1. The mean rank scores recorded for the taste of the mulberry leaf crackers from T_0 to T_3 are 3.45, 3.15, 1.95 and 1.45 respectively. Sample T_3 had the lowest (6.4) mean score whereas highest (7.8) mean score was found to be in sample T_0. The mean scores for overall acceptability of the mulberry leaf crackers varied from 6.8 to 8.0 with mean rank scores from 1.40 to 3.40. Maximum mean score (8.0) was found to be on T_1.

3.5 Selection of most acceptable products

From the four treatments C_0, C_1, C_2 and C_3 of mulberry leaf chammanthipodi, C_1 is found to be highly acceptable and it was selected for the further studies. C_1 was made of 10% mulberry leaf powder and 60% coconut. In the treatment of mulberry leaf laddu, four treatments were done. Treatments are varied from L_0 to L_3. In sensory evaluation the L_1 scored highest mean score. From the four treatments of mulberry leaf crackers T_0 to T_3, T_1 is found to be highly acceptable and it was selected for the further studies.

Table 4: Nutritive Value of selected value- added products per 100g

Sl. No	Nutrients	Chammanthipodi	Laddu	Crackers
1.	Calcium (mg)	327	191	85
2.	Iron (mg)	11.8	5.6	8.3
3.	Vitamin C (mg)	18.2	10.5	12.5

From the above Table 4, it is clear that the Calcium content of chammanthipodi (C_1) prepared by 10% mulberry leaf powder and 60% of coconut was found to be 327mg per 100g. And it contains 11.8mg of Iron and 18.2mg of Vitamin C. The nutrient content of mulberry leaf laddu (L_1) prepared by 10% mulberry leaf powder and 60% ragi flour was found to be 191mg of Calcium, 5.6mg of Iron and 10.5mg of Vitamin C per 100g. The nutrient content of the mulberry leaf crackers (T_1) prepared by 10% mulberry leaf powder and 80% wheat flour was found to be 85mg of Calcium, 8.3mg of Iron and 12.5mg of Vitamin C per 100g.

3.6 Microbial analysis of mulberry leaf products initially and after storage

Table 5: Microbial analysis of the mulberry leaf chammanthipodi

Sl. NO	PARAMETERS	INITIAL	AFTER ONE MONTH	AFTER TWO MONTHS
Mulberry Leaf Chammanthipodi				
1	Total microbial count	NIL	25 x 10^1 CFU/gm	30 x 10^1CFU/gm
Mulberry Leaf Ladd				
2	Total microbial count	NIL	220 x 10^1 CFU/gm	340 x 10^1CFU/gm
Mulberry Leaf Crackers				
	Total microbial count	NIL	90 x 10^1 CFU/gm	125 x 10^1CFU/gm

Mulberry leaf chammanthipodi was examined for microbial content initially up to 2 months. Initially, there were no microbes present in the chammanthipodi. By one month the total microbial count becomes 25 x 10^1 CFU/gm. By two months the total microbial count becomes 30 x 10^1 CFU/gm. Mulberry leaf laddu was examined for microbial content initially up to 2 months. Initially, there were no microbes present in the laddu. By one month the total microbial count becomes 220 x 10^1 CFU/gm. By two months the total microbial count becomes 340 x 10^1 CFU/gm. Mulberry leaf crackers were examined for microbial content initially up to 2 months. Initially, there were no microbes present in the crackers. By one month the total microbial count becomes 90 x 10^1 CFU/gm. By two months the total microbial count becomes 125 x 10^1 CFU/gm.

CONCLUSION

The present study successfully demonstrated the potential of mulberry leaf powder as a functional ingredient in the development of value-added food products. Among the different formulations, products incorporated with 10% mulberry leaf powder (C1, L1, and T1) showed the highest overall acceptability, indicating that moderate inclusion levels are optimal for balancing nutritional enhancement with sensory quality. Nutritional evaluation confirmed that the developed products are rich sources of essential micronutrients, particularly calcium, iron, and vitamin C, thereby contributing to improved dietary quality. Shelf-life studies revealed that all products were microbiologically safe at the initial stage, with a gradual increase in microbial load during storage; however, the levels remained within permissible limits up to two months under ambient conditions. Among the products, chammanthipodi exhibited better microbial stability compared to laddu and crackers. The findings highlight that mulberry leaf powder can be effectively incorporated into commonly consumed foods to enhance their nutritional profile without compromising acceptability. Overall, this study provides scientific evidence supporting the utilization of mulberry leaves as a low-cost, nutrient-dense, and underutilized resource for functional food development. The developed products have strong potential for commercialization and can play a significant role in addressing micronutrient deficiencies and promoting sustainable nutrition. Future research may focus on extending shelf life, large-scale production, and clinical validation of health benefits.

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