Journal of Clinical Immunology & Microbiology

ATHENAEUM SCIENTIFIC PUBLISHERS

Research Article

Nutritional, Textural and Sensory Quality of Cookies Supplemented with *Moringa oleifera* and *Spinacia oleracea*

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Citation: Ulla MI, et al. Nutritional, Textural and Sensory Quality of Cookies Supplemented with *Moringa oleifera* and *Spinacia oleracea*. J Clin Immunol Microbiol. 2025;6(1):1-10.

http://dx.doi.org/10.46889/JCIM.2025.6102

Received Date: 06-01-2025

Accepted Date: 20-01-2025

Published Date: 28-01-2025

Abstract

Iron deficiency is a prevalent global nutritional issue, especially in developing countries. This study focuses on developing iron-rich cookies by incorporating *Moringa oleifera* and *Spinacia oleracea* leaf powders, which are excellent sources of essential nutrients such as iron, protein, magnesium and vitamins. Both ingredients were selected for their ability to improve the nutritional profile of the cookies while providing a natural source of iron to address anemia. The cookies were subjected to extensive physico chemical analyses, including moisture content, diameter, shape, thickness and color, with results comparable to standard values. Nutritional analysis revealed that the fortified cookies contained increased levels of protein (7.2 g), iron (5.1 mg for sweet cookies and 5.6 mg for khara or savory cookies), magnesium (0.9 mg) and vitamin C (21.1 mg), providing a significant boost over conventional cookies. Sensory evaluation was conducted using a 9-point hedonic scale to assess appearance, texture, taste, flavor and overall acceptability. The panel, consisting of untrained members, showed a favorable response to both sweet and savory varieties of the cookies. The antioxidant properties of the cookies were also evaluated using DPPH free radical scavenging activity, demonstrating strong antioxidant potential with a radical scavenging activity of 95.99% at a concentration of 10 µg/ml. Moreover, work such as stability test has to be done to check the shelf life and storage condition of the product. These nutrient-enriched cookies not only meet sensory quality expectations but also provide health benefits, making them a functional food product with potential market appeal.

Keywords: Cookies; *Moringa oleifera*; *Spinacia oleracea*; Flax Seeds and Iron

Introduction

Foods rich in nutrients, along with health benefits, including cookies, are of great interest to consumers, dietitians and health-conscious people. Cookie preparation is a major part of the bakery industry before the production of different forms of nutrient-enriched cookies [1]. The major thing is to prepare the cookies with better organoleptic properties, disease-resistant properties, or some health benefits. *Moringa oleifera* is the plant which is popular for its iron rich property [2,3]. *Moringa oleifera* is one of the lesser-known vegetables found in Nigerian ecosystem with profoundly nutritious takes off, critical source of ß-carotene, vitamin C, press, potassium and protein. Its protein quality compares very well with that of milk and egg [4,5].

Leaves of *Moringa oleifera* contains high amount of iron content. Cookies were prepared and enriched with iron by adding *Moringa oleifera* leaves and leaves in powdered form. These leaves are rich in iron and help overcome iron deficiency or anemia [6]. *Spinacia oleracea*, commonly known as spinach, is a green, leafy vegetable.). Spinach is a common food plant *Moringa oleifera* in Turkey that is grown for fresh consumption and as a raw material in the canned food industry. Spinach is grown in 24000 hectar areas in Turkey, with a production rate of 2,35,000 t (FAO2007). *Spinacia oleracea* L(spinach) is an economically important leafy vegetable consumed worldwide [7,8]. *Spinacia oleracea* leaves are eaten by people mainly because of their characteristic

green color, nutritional content such as carotenes, vitamin C and minerals such as calcium and iron. The bioavailability of minerals, such as calcium and press, from green verdant vegetables was evaluated and found to be more prominent than 25% [8]. It was observed that the total, insoluble dietary fiber and mineral contents increased with maturity stages, such as tender to mature and then to the coarse stage of spinach [9-12].

Cookies of interest were prepared by adding and *Spinacia oleracea* leaf powder as the main ingredients to fortify the cookies with iron. Organic jaggery powder was added as the natural sweetening agent. The main aim of preparing these cookies is to overcome anemia by enriching the cookies with iron and vitamin C. During the preparation of cookies, *Moringa oleifera* and *Spinacia oleracea* leaves were used as the base flour instead of wheat flour. These cookies have the nutraceutical property which means it is rich in nutrients like iron etc., as well as it has medicinal properties. Owing to their iron-rich properties, these cookies help to increase the hemoglobin level in people suffering from anemia. By the above-mentioned investigation, this research was undertaken in order to produce the cookies fortified with iron content with help of *M. Oleifera* and *S. oleracea* leaves as a fortifying ingredient. Furthermore, the inclusion of *S. oleracea* and *M. oleifera* powder enhances the nutritional profile of cookies, offering a spectrum of iron, vitamins, minerals and antioxidants that are essential for overall health and well-being.

Material and Methods

Refined wheat flour, organic jaggery, baking powder, baking soda, salt, flax seeds, cashews, bananas, chocolate, salted butter, brown sugar, Cardamom, Curry leafs, Cumin seeds, Red chilli powder, Turmeric powder, Green chilli was sourced from the local market in Bhadravathi. The essence was extracted from natural orange peel powder, while moringa leaf was taken from Bhadravathi and spinach leaf powders were collected from local market Bhadravathi, Karnataka. The drying was made using the shade-drying method and make fine powder using blender.

Preparation of Moringa Oleifera Leaves Powder

Fresh moringa leaves (*Moringa oleifera*) shade-dried for a week. After complete drying, the leaves were ground to reduce particle size. The material was shifted through a 50-mesh sieve, with larger particles reground as necessary. The resulting fine powder was stored in airtight containers at room temperature for further analysis.

Figure 1: A: indicates the fresh moringa leaves collected; B: Moringa leaves were shade dried; C: it is the fine powdered of moringa leaves.

Preparation of *Spinacia oleracea* leaves powder: Healthy, mature spinach leaves (*Spinacia oleracea* L.) were taken. After thorough washing with tap and distilled water, excess moisture was removed using muslin cloth. The leaves were shade-dried for 6 to 8 hrs before being ground into a fine powder. The powdered material was sifted through a 50-mesh sieve, with larger particles reground as needed. The final fine powder was stored in airtight containers at room temperature for further analysis.

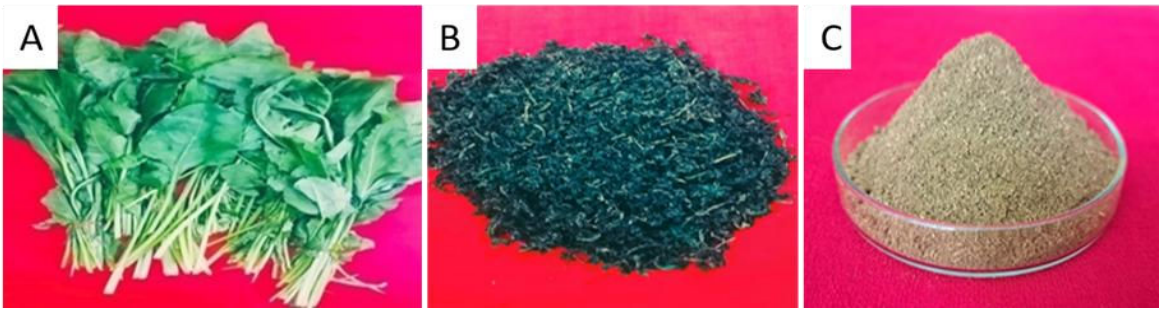

Figure 2: A: Fresh spinach leaves were collected; B: Spinach leaves were shade dried; C: Spinach leaves were finely powdered.

Preparation of Orange Peel Powder

Orange fruits were washed, disinfected and peeled using stainless steel knives. The peels were weighed, cut into small pieces and dried in a tray dryer at 40°C for 24 hours. After drying, the peels were ground and sifted through a 50-mesh sieve to obtain powder. The powder was reweighed to calculate yield and vacuum packed for storage at room temperature for future analysis.

Cookies Preparation

At first it begins by creaming the salted butter in a mixing bowl using a beater until it becomes smooth and fluffy. Next, add the brown sugar and organic jaggery to the butter mixture, continuing to beat until a creamy consistency is achieved, which helps incorporate air for the cookie texture. Then, carefully incorporate all the required dry ingredients as specified in Table 1, typically including flour, baking soda, baking powder and any additional flavorings or spices. Mix the dry ingredients with the creamed butter and sugars to create a homogeneous mixture. Once combined, stir in the salt, baking soda and baking powder, ensuring even distribution. Combine everything to form a cohesive dough, kneading gently on a floured surface until smooth and pliable. Roll out the dough to your desired thickness and use a cookie cutter to cut it into round shapes. Place the cut cookies on a sheet of parchment paper, spaced one inch apart to allow for spreading during baking. Preheat the oven to 130°C and bake the cookies for 15-20 minutes, or until lightly golden. Once baked, remove the cookies from the oven and allow them to cool on the baking sheet for about 5 minutes before transferring them to a wire rack to cool completely.

Sl. No	Ingredients	Amount in Grams	
		C1	C2
1	*Moringa Oleifera* powder.	3 g	3 g
2	*Spinacia Oleracea* powder.	2 g	2 g
3	Refined wheat flour.	100 g	100 g
4	Flax seeds.	5 g	5 g
5	Orange peel powder.	1 g	1 g
6	Salted Butter.	40 g	40 g
7	Organic jaggery.	50 g	40 g
8	Brown sugar.	40 g	30 g
9	Salt.	P inch	4 g
10	Banana.	½	½
11	Baking powder.	1 spoon	1 spoon
12	Baking soda.	P inch	P inch
13	Cashew.	5 g	5 g
14	Chocolates.	15 g	-
15	Peanut.	5 g	5 g
16	Cardamom.	1	1
17	Chilli powder	-	4 g
18	Green chilli	-	3 g
19	Turmeric powder	-	2 g
20	Cumin	-	2 g
21	Curry leaves	-	2 g

Table 1: Formulation of cookies variety.

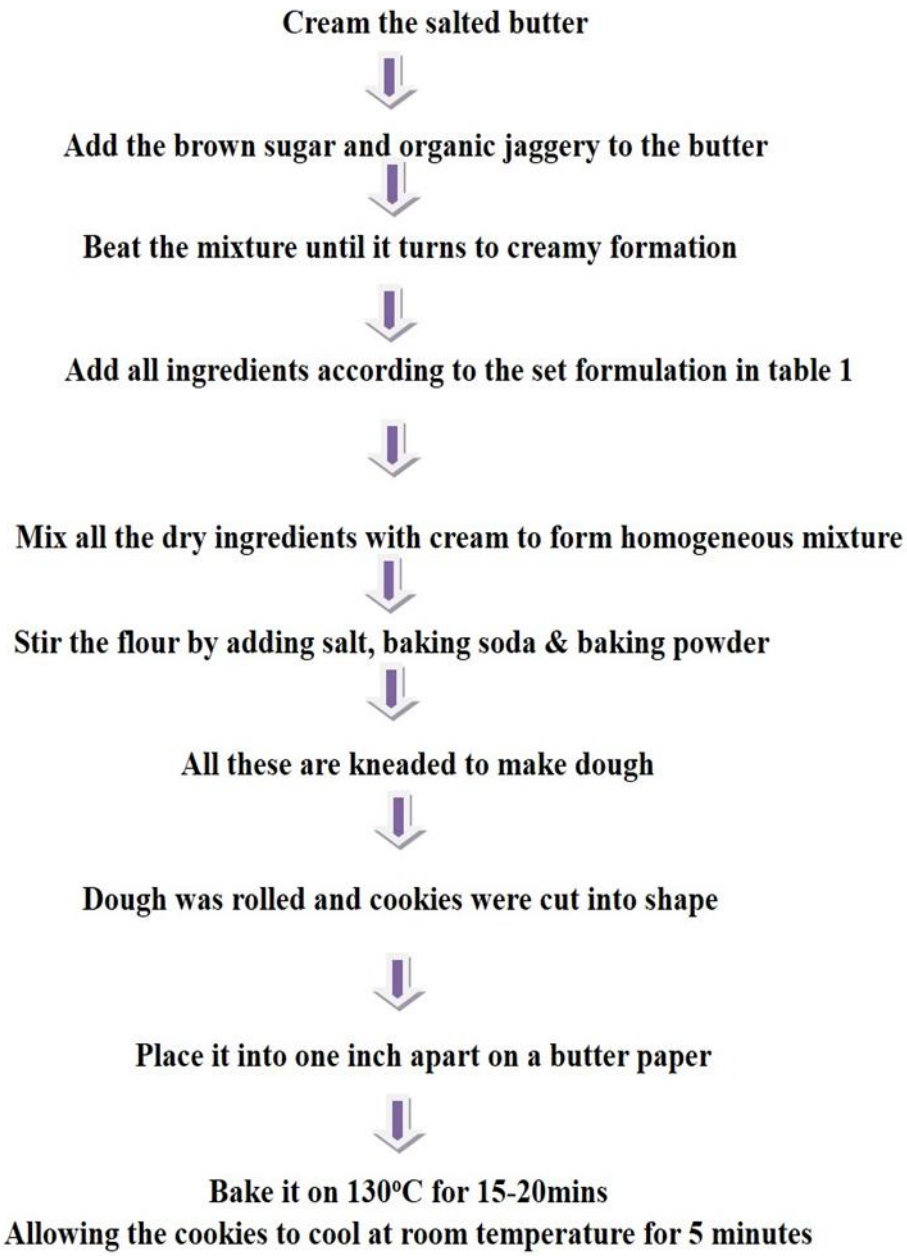

Figure 3: Production flow chart for cookies.

Physicochemical analyses moisture content was analyzed using a moisture analyzer. Diameter of cookies is measured by using vernier caliper, ash is analyzed muffle furnace.

Proximate Analysis

Nutritional analysis of cookies is typically conducted using standardized methods. Protein is analyzed using the Lowry method, total fat is assessed using the Soxhlet extractor method and carbohydrates are measured using colorimetric techniques. Reducing sugars were estimated using the dinitrosalicylic acid (DNS) method, while total sugars were determined using the anthrone method. Micronutrients, including vitamins, magnesium and iron, were analyzed using instrumental methods and antioxidants were quantified.

Sensory Analysis

Sensory characterization of the two different cookie formulations was conducted using untrained panelists and control cookies. The panelists were asked to evaluate the cookies based on various descriptors, including color, appearance, taste, flavor, smell,

texture and crunchiness. They assessed the appearance, flavor and chewiness of each product by assigning scores from 1 (very low intensity) to 9 (very high intensity) for each descriptor on a 9-point hedonic scale.

Total Antioxidant Capacity

The full antioxidant capacity (TAC) was measured by the spectrophotometric strategy of Prieto, et al., which is a measure to estimate the entire antioxidant components of samples. The phosphomolybdenum method of determination of total antioxidant capacity is based on the principle that reduction of Mo (VI) to Mo (V) by the sample mixture which subsequently forms green phosphate/Mo (V) complex at acidic pH.

Antioxidant Activity Measured Using DPPH Radicals

Antioxidant activity values of the cookies were assessed by quenching of DPPH radicals, in accordance with Sumczynski et al., the cookies were weighed and dissolved in water, different concentration such as 2,4,6,8,10 ml were used for free radical scavenging activity, intensity of colour is read at 517 nm and IC50 value is determined.

Result and Discussion

Physico Chemical Analysis

The physical analysis of cookies was conducted to assess weight, diameter, thickness and spread ratio. The diameter of the cookies made with moringa leaf powder and spinach leaf powder was measured at 2 cm, determined by placing the cookies horizontally and using vernier calipers. The thickness of the cookies, incorporating both moringa and spinach leaf powders, was measured at 0.8 cm, also using vernier calipers. Ash content of cookies is 0.91% which is analysed by muffle furnace. Moisture is 4.6 analysed by moisture analyzer which is appropriate for cookies.

Fig. 4 represents the developed cookies with incorporation of moringa and spinach powder. Control(C0), sample(C1) Sweat cookies and sample(C2) Spicy cookies supplemented with spinach and moringa leaf powder.

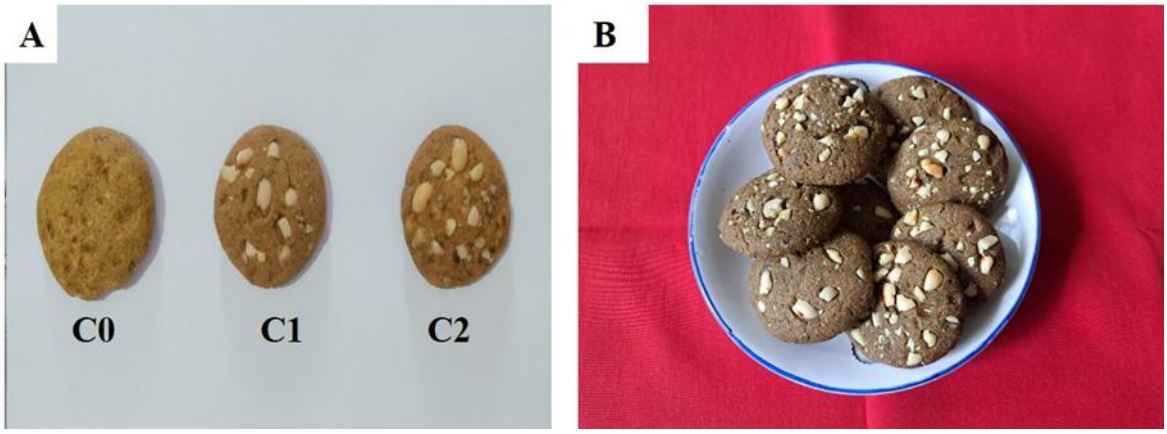

Figure 4: External appearance of developed cookies.

Proximate Analysis

The nutritional analysis of sweet cookies (sample C1) and Spicy cookies (sample C2) was conducted in comparison to control cookies made with wheat flour and jaggery to assess their nutrient content. Sample C1 had a protein content of 7.2 g, while sample C2 contained 7.3 g, both lower than the control cookies, which contained 9.2 g of protein. Our cookies are natural and free from emulsifiers, colors, or additives. In addition to protein, our product is rich in other nutrients.

Sample C1 contains 5.7 g of fat, while sample C2 contains 5.4 g, both of which are lower than the control cookies that have 21.8 g of fat. The reduced fat content in our samples results from using less butter and incorporating ripe bananas, which enhance binding properties and improve the structure and tenderness of the cookies. Consequently, our samples provide a lower fat content, contributing to a reduction in saturated fat consumption compared to the control cookies.

The iron content of the control cookies is 3.1 mg, while our sample C1 shows 5.1 mg, which is higher than the control due to the

addition of moringa and spinach leaf powder. Sample C2 contains even more iron, at 5.6 mg, because it includes curry leaves along with moringa and spinach leaf powder, resulting in a higher iron content.

The vitamin C content of both sample C1 and sample C2 is 21.1 mg, significantly higher than the control cookies, which contain only 0.9 mg. This increase in vitamin C content in our samples is attributed to the addition of orange peel powder.

The fiber content of both cookies is 0.46 g per 100 g, promoting digestive health and enhancing metabolism. The magnesium content is 0.9 mg per 100 g, attributed to the addition of flax seeds, which are rich in minerals. Both cookie samples also contain 0.64 mg of calcium. Both varieties were positively received in sensory evaluations, the results of which are presented using the hedonic scale in graph (Fig. 6, Table 2).

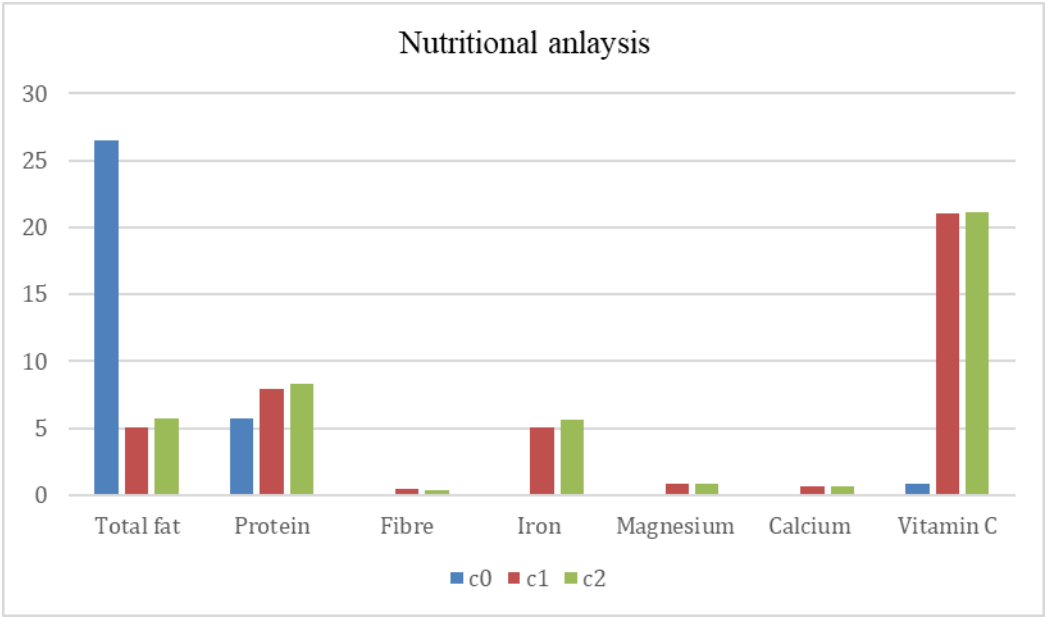

Figure 5: Nutritional analysis for cookies samples (C0, C1, C2).

Sl No	Nutrition	Sweet Cookies	Spicy Cookies
1)	Total fat	5.4 g	5.7 g
2)	Protein	7.2 g	7.3 g
3)	Ash	0.91%	0.91%
4)	Fiber	0.46 g	0.4 g
5)	Iron	5.1 mg	5.6 mg
6)	Magnesium	0.9 mg	0.9 mg
7)	Calcium	0.64 mg	0.64 g
9)	Vitamin C	21.1 mg	21.1 mg
10)	Carbohydrates	130.0 g	130.1 g
11)	Moisture	4.6	4.6

Table 2: Nutritional analysis of cookies variety.

Sensory Analysis

We conducted a sensory characterization of two different cookies, incorporating moringa and spinach powder, referred to as C1 and C2. The sensory evaluation used a nine-point hedonic scale to assess various parameters, including appearance, texture, flavor, taste and overall acceptability. A panel consisting of seven untrained members, which included students and staff from the department, was assembled to provide feedback on these cookies. These parameters are crucial for determining the overall acceptability of the product, as they directly influence consumer preferences and marketability. For the appearance/color parameter, the average scores were as follows: Control (C0) = 7.57, C1 = 6.86 and C2 = 7.29, with corresponding standard

deviations of C0 = 0.975, C1 = 1.069 and C2 = 1.154. In terms of taste and flavor, the scores were C0 = 7.0, C1 = 7.0 and C2 = 7.14, with standard deviations of 1.154, 1.414 and 1.345 respectively, indicating an increase in sample C1. This suggests that while all samples received relatively favorable ratings, the addition of specific ingredients may have enhanced the sensory experience of sample C1.

Regarding smell/odor, the mean scores were C0 = 7.57, C1 = 7.14 and C2 = 6.57, with standard deviations of 0.97, 1.345 and 0.98. These results suggest that sample C1, which included flaxseed powder, exhibited more favorable properties compared to the other samples, potentially influencing the overall perception of the cookies. In conclusion, the sensory quality of cookie sample C2 was found to be more acceptable, indicating that the incorporation of flaxseed powder not only improved specific sensory attributes but also contributed to a more favorable overall experience for the panelists, thereby enhancing its potential for consumer appeal in the market (Table 3).

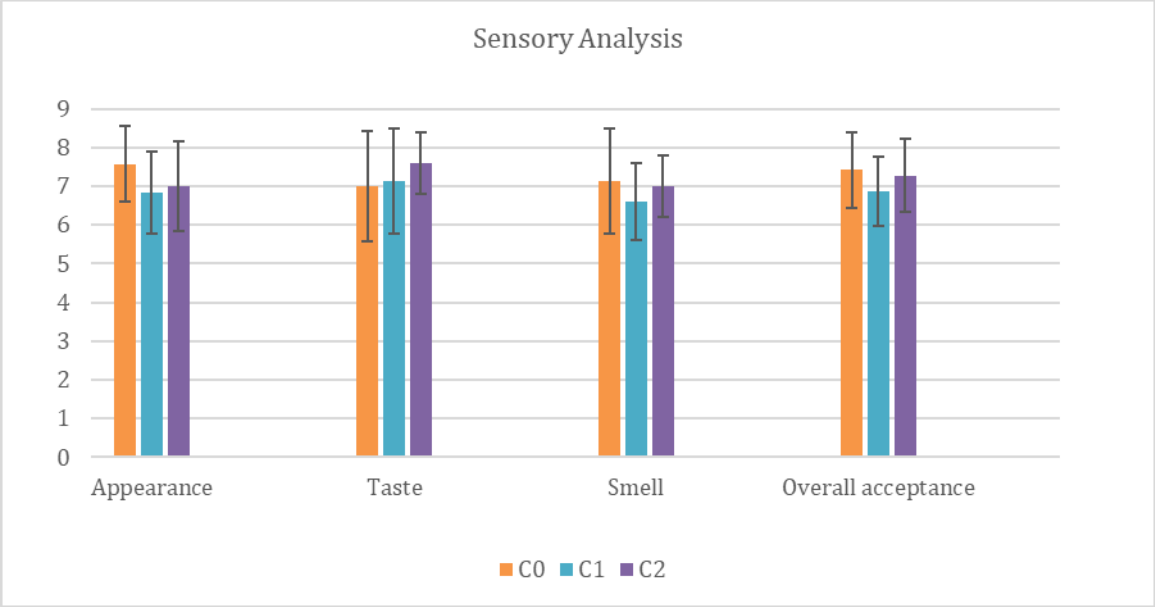

Figure 6: Sensory analysis for cookies sample (C0, C1, C2).

Sl No.	Appearance/colour	Taste/Flavour	Smell/Odour	Over all acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
C0	7.51 ± 0.97	7.0 ± 1.4	7.14 ± 1.34	7.42 ± 0.97
C1	6.87 ± 1.0	7.14 ± 1.34	6.57 ± 0.98	6.85 ± 0.9
C2	7.0 ± 1.1	7.57 ± 0.79	7.0 ± 0.82	7.28 ± 0.95

Table 3: Sensory attributes for cookies sample. C0=Control, C1= Sweet Cookies, C2= Spicy Cookies and SD= Standard Deviation.

Antioxidant

Determination of Total Antioxidant Capacity and Reducing Potency

The cookies samples were analyzed for total antioxidant capacity using a phosphomolybdenum method with an ascorbic acid standard curve. The cookies demonstrated an antioxidant capacity of 255±7 μg/mg equivalent to ascorbic acid. In total reductive capability assay, the cookies showed the reductive capability of the total antioxidants, the reductive capability also increased with higher concentrations of the cookies, as show in Fig 7.

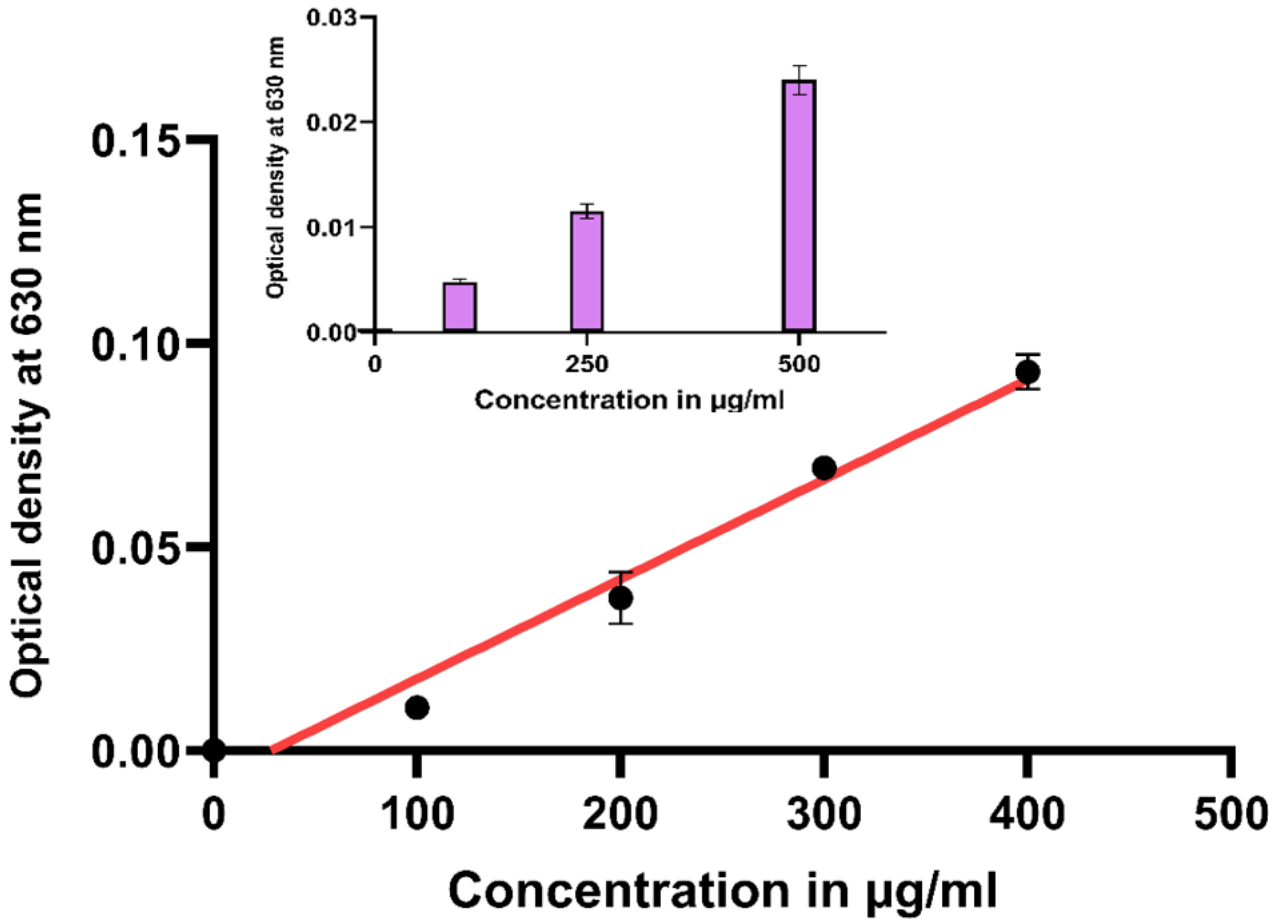

Figure 7: Total antioxidant of cookies.

DPPH Free Radical Scavenging Activity

The antioxidant capacity of the cookie sample was evaluated using the DPPH assay at various concentrations. The results revealed that the highest free radical scavenging activity was observed at 10 µg, reaching 95.99%, while the lowest activity was 22.41% at 2 µg. The scavenging activity increased proportionally with the sample concentration. The IC50 value, which represents the concentration required to inhibit 50% of the free radicals, was determined to be 5.5 µg/ml. These findings suggest that the cookie sample exhibits significant antioxidant properties and could be considered a good source of dietary antioxidants (Table 4).

Sl. No.	Concentration of Cookie Sample in µg/ml	% Radical Scavenging Activity
1	2	22.417
2	4	44.615
3	6	65.494
4	8	74.945
5	10	95.995

Table 4: Antioxidant value of cookies.

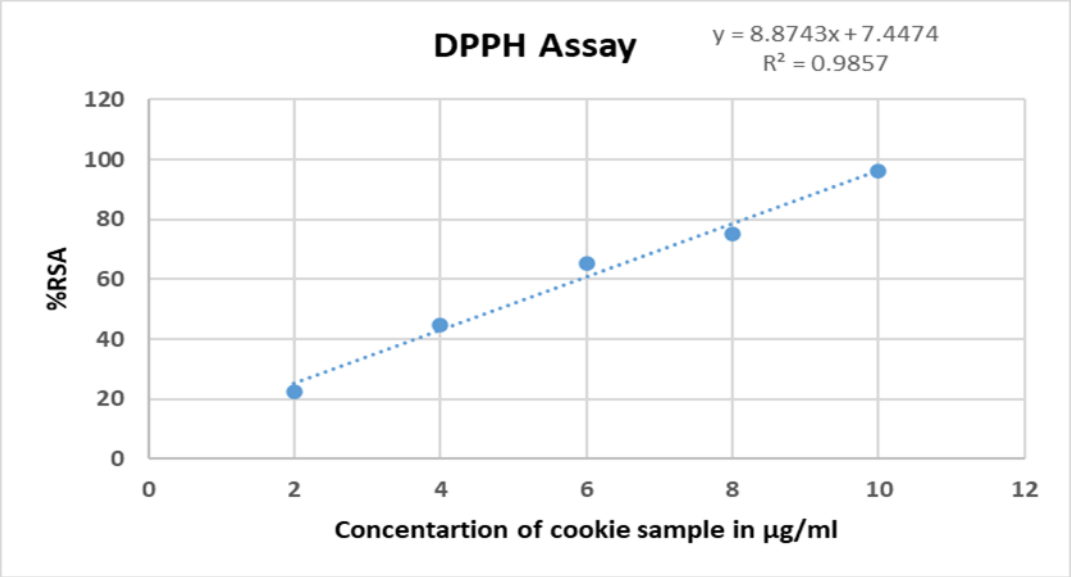

Figure 8: Antioxidant concentration for cookies.

Conclusion

Cookies were developed using a combination of moringa leaf powder, spinach leaf powder and other ingredients. The moringa leaf powder and spinach leaf powder can be promptly chosen and utilized as a exceptional nourishment fixing to define a wide extend of items considering their important nutrient composition with noticeable amount of both macronutrients and micronutrients (vitamin and minerals),moreover these moringa leaf and spinach leaf acquired significant position in terms of its quality attributes, health benefits and cost effective production technology, it can be conclude that cookies prepared by using moringa leaf powder and spinach leaf powder imparts natural colour and flavour to the cookies. In addition, these moringa leaf powder and spinach leaf powder can also be incorporated in bakery products in different ratios which can significantly improve their nutrition value such as dietary fiber, minerals (Fe, Ca, K and Mg) and protein which is beneficial for human health.

Conflict of Interest

All authors have no actual or potential conflict of interest including any financial, personal, or other relationship with other people or organization within three years of beginning the submitted work that could inappropriately influence, their work.

Author Contributions

All authors have contributed equally to the final manuscript.

Acknowledgment

The authors are thankful to the Kuvempu University, Shankaraghatta , Karnataka, 577 451, India, Adminastrative authority and Chairman of Department of PG Studies and Research in Food Technology, Kuvempu University, Shankaraghatta, Karnataka, 577 451 India and College of Agriculture, Navile, Shivamogga 577 412, Karnataka, India for offering the facility to carry out the research work.

Funding

No funding.

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