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RESEARCH ARTICLE

Nutritional, textural and sensory quality of cookies supplemented with *Moringa oleifera* Lam. and *Spinacia oleracea* L.

Mohammad Imdad Ulla[1], T H Anantha Krishna[2, 3], Mahesh Anikisetty[4, 5] & Ullas Prasanna S[1, 6*]

[1]Department of PG Studies and Research in Food Technology, Kuvempu University, Shankaraghatta 577 451, Shivamogga, Karnataka, India
[2]Department of Biochemistry, School of Basic & Applied Sciences, Dayananda Sagar University, Innovation Campus, Bengaluru 560 114, Karnataka, India
[3]Department of Biochemistry, Indian Institute of Science, Bengaluru 560 012, Karnataka, India
[4]Department of Biochemistry, Central Food Technological Research Institute (CFTRI), Mysore 570 020, Karnataka, India
[5]Food Corporation of India, Mysore 572 000, Karnataka State, India
[6]Department of Biotechnology, School of Basic & Applied Sciences, Dayananda Sagar University, Innovation Campus, Bengaluru 560 114, Karnataka, India

*Correspondence email - ullas.p-sbas@dsu.edu.in

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Abstract

Deficiency of iron is a rampant nutritional dispute globally, particularly in developing and underdeveloped countries. Our investigation emphasizes evolving iron-rich cookies by adding *Spinacia oleracea* L. and *Moringa oleifera* Lam. leaf powders. They are abundant in vitamins, iron, magnesium and proteins, which are the nutrients essential to our body. These ingredients are dual delivered to cookies to improve nutritional content to address anaemia. The cookies prepared underwent physicochemical analyses. Here, colour, diameter, thickness, moisture and content were analysed. *S. oleracea* and *M. oleifera* leaf powder fortified cookies increased the nutrition in cookies when compared to conventional cookies. Sensory evaluation studies revealed the overall acceptability, appearance, flavour, taste and texture using a 9-point hedonic scale. The untutored members' panel revealed a favourable retort to the savoury and sweet selection of cookies. Using DPPH free radical scavenging activity antioxidant activity was investigated. 95.99 % of solid antioxidant potential was observed at a concentration of 10 µg/mL. These fortified cookies provide us with benefits to health, good sensory quality, which in turn makes them a quality food product with probable market value.

Keywords: cookies; iron; *Moringa oleifera*; nutrients; *Spinacia oleracea*

Introduction

Cookies rich in nutrients, with health remunerations, are of great interest to dietitians. Cookie preparation is a chief part of the baked food industry, before the production of diverse forms of nutrient-enriched cookies (1). The major objective is to prepare the cookies with enhanced organoleptic properties and health benefits. *Moringa oleifera* Lam. is a plant rich source of iron, as reported in earlier studies (2, 3). This is a very well-known vegetable plant which grows up to 10 feet in height and is an abundant source of proteins, vitamin C and ß-carotene. When it comes to the comparison of the quality of proteins, it is equal to egg and milk (4, 5).

An abundant amount of iron, which is needed for humans to maintain a diet, is found in *M. oleifera*. Preparation of cookies by fortifying iron-rich moringa leaves is achieved because of making cookies rich in iron sources, which helps us to combat anaemia (6). *Spinacia oleracea* L. (Spinach) is a green leafy vegetable grown in almost all countries, mainly for its fresh consumption, because of its high amount of iron content. Both *moringa* and spinach leaves are used as a main source in the canned food industry (7, 8). Consumption of *Spinacia oleracea* leaves is supported by the dietitians due to its abundant source of nutritional contents like iron, calcium, vitamin C and carotenes (9, 10).

In our present investigation, cookies fortified with *S. oleracea* and *M. oleifera* were prepared to develop iron-rich cookies. Sweetening agents like the organically prepared powder of jaggery were added. The main purpose of preparing cookies fortified (base flour) with moringa and spinach leaves was to develop iron and vitamin C-rich cookies (11). Cookies prepared. These cookies have a nutraceutical property. These cookies can boost haemoglobin levels in patients suffering from anaemia due to their iron-rich content. The present investigation was conducted to prepare the iron-rich cookies with some value-added products, which may be helpful for persons suffering from anaemia to consume as a dietary source to improve the haemoglobin content in the body.

Materials and Methods

Materials like turmeric powder, organic jiggery, red chilli powder, orange peel powder, cardamom, salted butter, cumin seeds, salt, baking soda, chocolate, cashews, brown sugar, curry leaves, banana, baking powder, *M. oleifera* and *S. oleracea* were bought to the laboratory from the local market of Bhadravathi, Karnataka, India (12). To fortify the cookies with *moringa* and spinach leaf powder, the plant materials were collected and dried in the shade. Using a blender, they were then finely powdered.

Processing of *Moringa oleifera* leaves powder

Fresh moringa leaves were shade-dried until they were completely dried. Using a pestle and mortar to reduce the particle size, the plant material was ground very well (13). The plant material powder was sieved through a 50-mesh sieve to eliminate larger particles and the resultant fine powder was deposited in a sealed container for future use at room temperature (Fig. 1).

Processing of *Spinacia oleracea* leaves powder

Mature spinach leaves were procured. Using running water, the soil debris was removed, using distilled water and minute debris of dust was removed. By using a muslin cloth moisture on the surface was removed (14). The leaves of spinach were shade-dried to make a fine powder. To get a fine, small powder same procedure that we have used for moringa leaves, as mentioned above, was achieved and was stored (Fig. 2).

Processing of orange peel powder

Using stainless knives fresh orange fruits were peeled. Peeled orange fruits were amended into small pieces and placed inside a hot air oven at 40 °C to remove the moisture. After drying, the procedure was followed which was followed to moringa and spinach leaves and stored at room temperature (15).

Table 1. Formulation of cookie variety

Sl. No	Ingredient composition of formulations (C1 and C2)		
	Ingredients	C1	C2
1	*M. oleifera* powder	3 g	3 g
2	*S. 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	40 g
9	Salt	Pinch	Pinch
10	Banana	½	½
11	Baking powder	1spoon	1spoon
12	Baking soda	Pinch	Pinch
13	Cashew	5 g	5 g
14	Chocolates	15 g	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

Preparation of cookies

In the initial stage salted butter was creamed using a mixer bowl, beater helps in mixing and until it turns fluffy and smooth continue the process. At the second stage, organically prepared jaggery and brown sugar was added to butter mixture, again it was mixed well to incorporate air to add texture to cookies prepared. Ingredients mentioned in Table 1 were incorporated carefully into the mixture which included additional flavourings, baking powder and soda (16). To create a homogeneous mixture

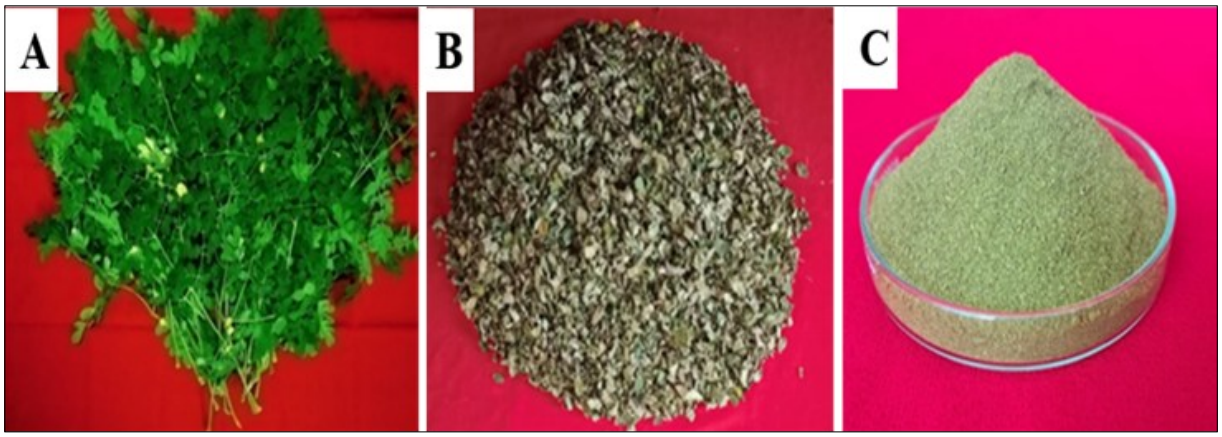

Fig. 1. Different processing stages of *Moringa oleifera* leaves. A- freshly collected leaves; B- shade-dried leaves; C- fine leaf powder.

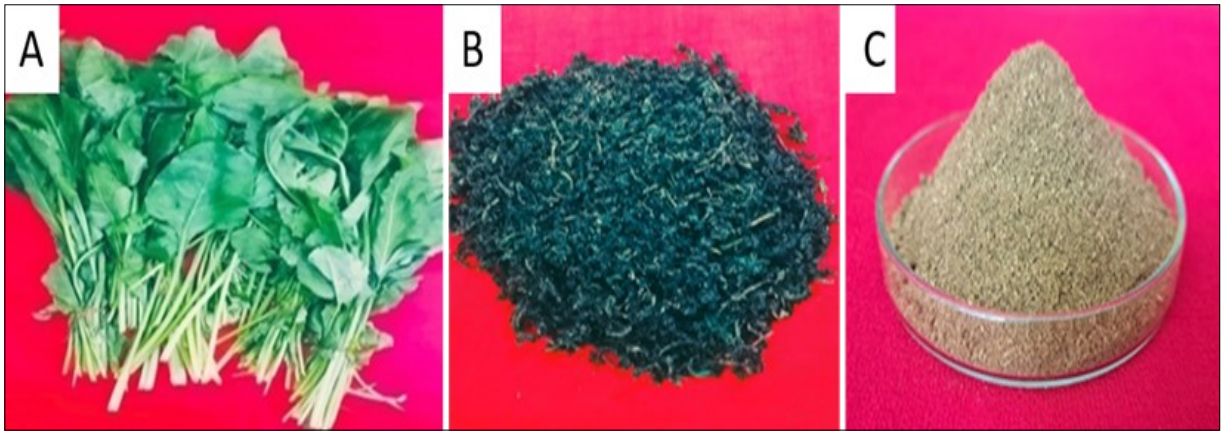

Fig. 2. Processing stages of spinach (*Spinacia oleracea*) leaves. A- freshly collected leaves; B- shade-dried leaves; C- finely powdered leaves.

of all the dry ingredients and butter, they were again mixed well. By ensuring the distribution, baking powder, salt and baking soda were mixed.

A cohesive dough was formed after mixing all of them thoroughly and mixing gently on a floured surface till it became pliable and smooth. Dough was rolled out into our desired thickness and cookies were cut into small pieces by using a cookie cutter into our desired size. Cut cookies were placed on parchment paper and a one-inch space between the cookies was left to blowout through baking (17). The oven was preheated to 130 °C, the cookies were baked for 15–20 min or check the cookies every 10 min until the cookies will turn a light golden colour. After the cookies were baked, they were removed from the oven and allowed to cool for 5–10 min on a baking sheet. Using a moisture analyser, moisture content in the baked cookies was analysed. Using a vernier calliper, diameter of the cookies was measured and a muffle furnace was used to analyse the ash content (Table 1 & Fig. 3) (18).

Proximate analysis

Using some standardized methods to get the nutritional analysis, like the Lowery method, was followed to analyse protein (19). Using Soxhlet extraction, total fat was assessed and by using colourimetric techniques, total carbohydrates were analysed. The dinitrosalicylic acid (DNS) method gave a clear estimation of reducing sugars and total sugar estimation was achieved using the anthrone method (20). Antioxidants were quantified, vitamins, iron and magnesium were all analysed using instrumental methods.

Sensory evaluation studies

Using untrained panellists, sensory evaluation studies were carried out on two different cookies. For the evaluation of cookies, here appearance, flavour, taste, smell, crunchiness and texture were calculated. The panellists assessed the chewiness, flavour and appearance of both cookies and assigned the scores range from very low intensity-1 to very high intensity-9 for each indicator on 9-point hedonic scale (21).

Overall antioxidant capability

This was estimated by the spectrophotometric approach followed by previous researchers, which is a measure to evaluate the complete antioxidant constituents of samples. The phosphomolybdenum process of determination of overall antioxidant capability is centred on the principle that decline of Mo (VI) to Mo (V) by the sample combination, which successively forms green phosphate/Mo (V) complex at acidic pH (22).

Evaluation of antioxidant activity by DPPH radicals

As per the earlier method, total antioxidant activity was evaluated by DPPH radical scavenging activity (23). The cookies were creased and liquefied in water. Diverse concentrations of cookies dissolved in water were evaluated from 2, 4, 6, 8 and 10 mL to evaluate free radical scavenging activity. The concentration of colour was noted at 517 nm and half maximal inhibitory concentration (IC_{50}) values were determined (23).

Results and Discussion

Physicochemical analysis

To assess the diameter, thickness, spread ratio and weight was carried out physical analysis. Using vernier calipers, the diameter of the cookies prepared from spinach and moringa leaves and their thickness were measured, which were 2 cm in radius and 0.8 cm respectively. 0.91 % of ash content was analysed in cookies by muffle furnace. Using a moisture analyzer, moisture was identified, i.e. 4.6 % (Fig. 4).

Proximate analysis

In this analysis, comparative studies were carried out between samples C1, sweet cookies and sample C2, spicy cookies, with cookies made with organic jaggery and wheat flour as control C0

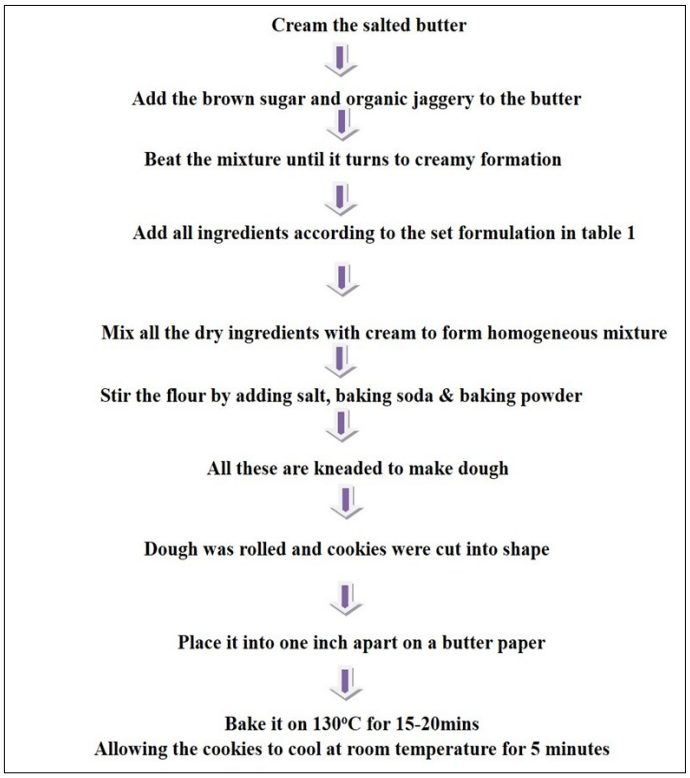

Fig. 3. Production flow chart for cookies.

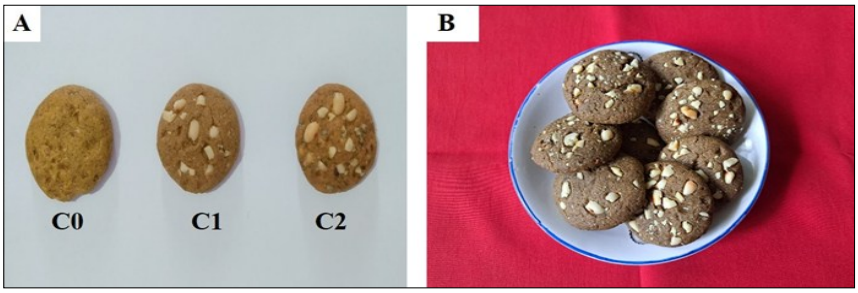

Fig. 4. External appearance of developed cookies. A & B represent the developed cookies with the incorporation of *moringa* and spinach powder. Control (C0), sample (C1), Sweat cookies and sample (C2) Spicy cookies supplemented with spinach and moringa leaf powder.

one to assess the nutrient contents. Samples C1 and C2 had protein content of 7.2 and 7.3 g respectively, which was less when compared to Control C0, i.e. 9.2 g. The cookies prepared were organic and they were free from additives and emulsifiers.

Samples C1 and C2 contained 5.7 and 5.4 g of fat respectively, but this was much less when compared to sample C0, i.e. 21.8 g. Incorporating ripe bananas instead of butter results in improving the tenderness and structure of cookies, also enhancing the binding properties. Compared to control cookies, our samples C1 and C2 provide lower fat content, which contributes to reducing saturated fat consumption.

The iron content in C0, C1 and C2 cookie samples was noted. Cookies exhilarated with curry leaves to C3 sample recorded the highest iron content, i.e. 5.6 mg, followed by the least recorded was the control C0 sample with 3.1 mg and C2 sample showed 5.1 mg. With the addition of orange peel powder, an increase in vitamin was noted in samples C1 and C2, i.e. 21.1 mg, which was higher than the Control sample C0, i.e. 0.9 mg.

The samples C1 and C2 cookies contained 0.46/100 g of fibres, which enhances metabolism and promotes digestive health. Magnesium was 0.9 mg/100 g endorsed from flax seeds and samples C1 and C2 contained 0.64 mg of calcium. All the samples underwent sensory evaluation and the results were calculated using the hedonic scale and are presented using a bar graph (Table 2 & Fig. 5).

Table 2. Nutritional analysis of cookie varieties

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

Sensory evaluation studies: Sensory characterisation of the samples C0, C1 and C2 was achieved. For assessing texture, flavour, taste, appearance and overall acceptability, the nine-point hedonic scale was used. Seven untrained panel members from our department were selected to provide feedback on the three different samples of cookies. The parameters mentioned above directly influenced marketability and consumer preference. To determine the colour/appearance of the 3 samples, the average scores was C0= 7.57, C1= 6.86 and C2= 7.29, concerning the standard deviation of C0= 0.975, C1= 1.069 and C2= 1.154. For flavour and taste, the scores reported were C0 = 7, C1 = 7 and C2 = 7.14 with standard deviation of 1.154, 1.141 and 1.345 respectively, giving a clear significance of increase in C1 sample. The above investigation gave a clear indication that after the addition of some value-added ingredients, this has enriched the sensory capability of the C1 sample. The odour/smell's mean scores were C0 = 7.57, C1 = 7.14 and C2 = 6.57 through standard deviation of 0.97, 1.345 and 0.98 respectively. The above results suggest that the C1 sample, added with flaxseed powder, boosted the favourable attributes in cookies when associated with additional samples, hypothetically influencing the overall acuity of the cookies. In inference, the sensory superiority of sample C2 cookies remained more tolerable, specifying that the merging of flaxseed powder not only amended definite sensory attributes but also subsidized to a more favourable general experience for the panellists, thereby augmenting its impending for consumer demand in the market (Table 3 & Fig. 6).

Antioxidant

Reducing influence and evaluating the overall antioxidant capability

Assessment of overall antioxidant capability utilizing the phosphomolybdenum technique, using an ascorbic acid standard curve, was investigated. Antioxidant capacity of 255 ± 7µg/mg, which was equal to ascorbic acid, was noted. As shown in Fig. 5, the reductivity capability of total antioxidants increased with an increase in the highest concentration of cookies (Fig. 7).

Table 3. Sensory attributes for cookies sample

Sl. No.	Appearance/Colour	Taste/Flavour	Smell/Odour	Overall 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

C0=Control, C1= Sweet Cookies, C2= Spicy Cookies and SD= Standard Deviation

Table 4. Antioxidant value of cookies

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

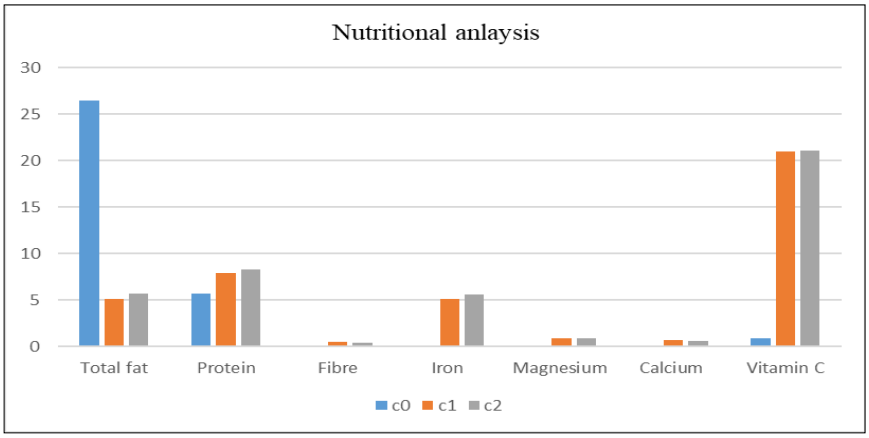

Fig. 5. Nutritional analysis for cookies samples (C0, C1, C2).

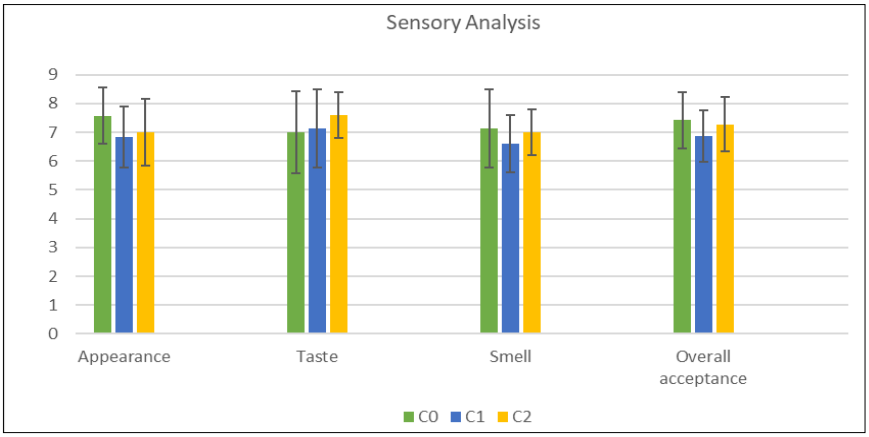

Fig. 6. Sensory analysis for cookies sample (C0, C1, C2).

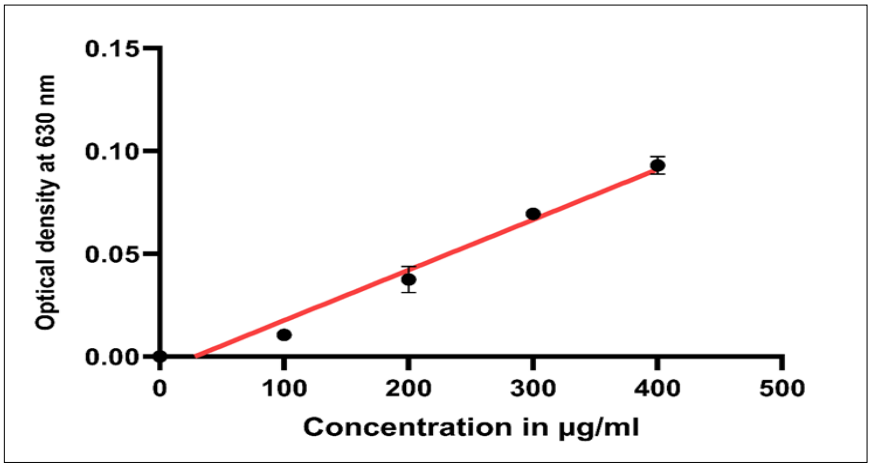

Fig. 7. Total antioxidant capacity of cookies.

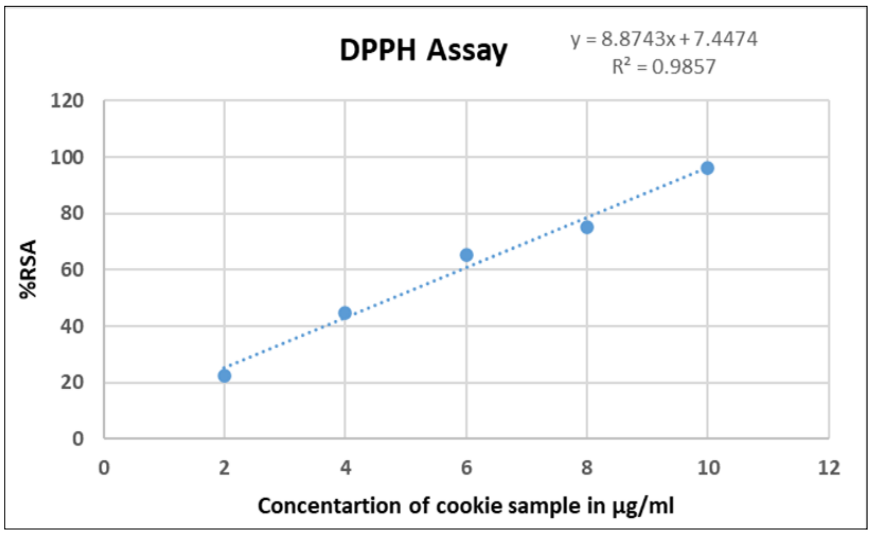

Fig. 8. Antioxidant concentration for cookies.

Free radical scavenging activity by DPPH assay

At various concentrations, the cookie samples were evaluated for their antioxidant capacity against different concentrations. Maximum permitted radical scavenging activity was noted at 10 µg, reaching to 95.99 %. The lowest activity noted was 22.41 % at 2 µg (Table 4 & Fig. 8). Free radical scavenging activity increased with an increase in sample addition. Half maximal inhibitory concentration, i.e. IC_{50} value, was noted at 5.5 µg/mL. The above results gave a clear-cut idea about the significant antioxidant properties and the cookie samples C1 and C2 can be considered as a better dietary source of antioxidants.

Conclusion

We can conclude that cookies were fortified and developed with *S. oleracea*, *M. oleifera* leaf powder and other ingredients. Both leaf powders can be openly chosen and can be added as a value-adding ingredient and the main source to enhance the nutrients (vitamins & minerals) in sample food preparation. These leaf powders acquired substantial site concerning cost effectiveness, health attributes and quality production technology. Sample cookies prepared using these powders retain natural flavour and colour. In addition to the above results, these leaf powders can also castoff in supplementary baked products in diverse ratios to enhance the nutritional values like proteins, minerals and dietary fibres, which are beneficial to health.

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Authors' contributions

MIU carried out the laboratory research work. THAK analyzed the statistical data. MA assisted during the research work. UPS designed the study, critically evaluated the generated data, wrote the manuscript and handled communication. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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