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A Study on Physicochemical, Nutritional, and Organoleptic Properties of Wheat-Based Crackers Incorporated with Moringa Leaf Powder

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Abstract

The consumption of snacks has seen an increase in today's world. Among them, healthy varieties of snack products seem to be increasingly consumed. Thus, incorporating various nutritionally significant products are developed. Moringa oleifera (Drumstick) leaves are found to improve the nutritional content when incorporated in crackers. Hence, research was done on developing crackers incorporated with Moringa leaf powder and a study was done to analyze the physicochemical, nutritional, and organoleptic properties of these wheat-based Crackers. Moringa leaf powder was incorporated along with wheat flour in different proportions, to formulate the crackers. The incorporation of 25g of the leaf powder seemed to have good consumability. The overall acceptability of the treatment 2 formulation had a value of 8.7±0.5. The energy, carbohydrate, protein, fat, dietary fibre, ash, moisture, vitamin C, iron and calcium contents of the selected treatment group per 100g was analyzed and found to have 266.2 kcals, 7.44g, 44.9g, 6.36g, 4.33g, 2.19%, 7.68%, 0.08mg, 99.2mg, and 238.3mg respectively. Hence it is a wholesome ready-to-eat food product rich in protein, fiber, iron, and calcium, and low in calories and fat.

***Key words*:** Incorporation, *Moringa oliefera*, Drumstick, Crackers, Snack

Snack food consumption has increased because of urbanization and modernization. However, most snacks have high levels of fats, sugars, and salts, as well as low levels of dietary fiber, which can lead to health problems [1]. Crackers are biscuits known for their flaky interior layers. Moringa species, native to Asia, are utilized as a medication due to their rich content of various phytochemicals, making them useful for both prevention and treatment of various conditions. All parts of the Moringa plant are utilized for various purposes. Hence, the consumer demand for nutritious snacks is rising. One of the most desirable snacks with outstanding eating quality is crackers. These are one of the fastest growing segments of bakery products due to their long shelf life, good eating quality, and appealing look. Crackers are biscuits with flaky interior layers. Moringa species, native to Asia, are utilized as a medication because of their claim to contain various phytochemicals, making them useful for both prevention and treatment. all parts of the plant are utilized for various purposes [2]. As the leaves are rich in iron, they benefit pregnant mothers. Incorporating such wonder sources into crackers can help ensure nutrient security [3]. The objectives of this study include:

- To formulate crackers incorporated with moringa leaf powder and wheat flour in different proportions
- To evaluate the organoleptic, physicochemical, nutritional (Energy, Carbohydrates, Protein, Fat, Ash content, Vitamin-C, Calcium, and Iron), and antioxidant properties of the moringa leaf powder incorporated crackers.
- To analyze the microbial growth and storage quality of the developed product

MATERIALS AND METHODS

Phase 1

Selection of ingredients

The ingredients required to prepare the incorporated cracker were wheat, moringa leaf powder, butter, palm sugar, dried ginger powder, and salt [3-6].

Phase 1I

Preparation of Moringa oleifera leaves powder

The moringa leaves were washed, cleaned, and dried using clean water. Then the leaves were oven-roasted and ground into powder using a bullet blender. It was kept in an airtight container.

Formulation and standardization of crackers

To formulate and standardize the incorporated crackers, the step represented in (Fig 3) were involved. The equipment utilized for this step included measuring cups, measuring spoons, electronic weighing machine, mixing bowl, aluminum tray, whisker, cookie cutter, rolling pin, fine mesh strainer, microwave oven, and butter paper.

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Variations of crackers incorporated with moringa leaves powder

Variations of the crackers by incorporation of moringa leaf powder in different ratio is given in (Table 1).

Table 1 Variations in cracker preparation

Treatments	Wheat flour (g)	Moringa leaf powder (g)	Butter (g)	Palm sugar (g)	Salt (g)	Dried ginger powder (g)
Control	100	0	20	20	0.5	0.5
Treatment 1	85	15	20	20	0.5	0.5
Treatment 2	75	25	20	20	0.5	0.5
Treatment 3	65	35	20	20	0.5	0.5

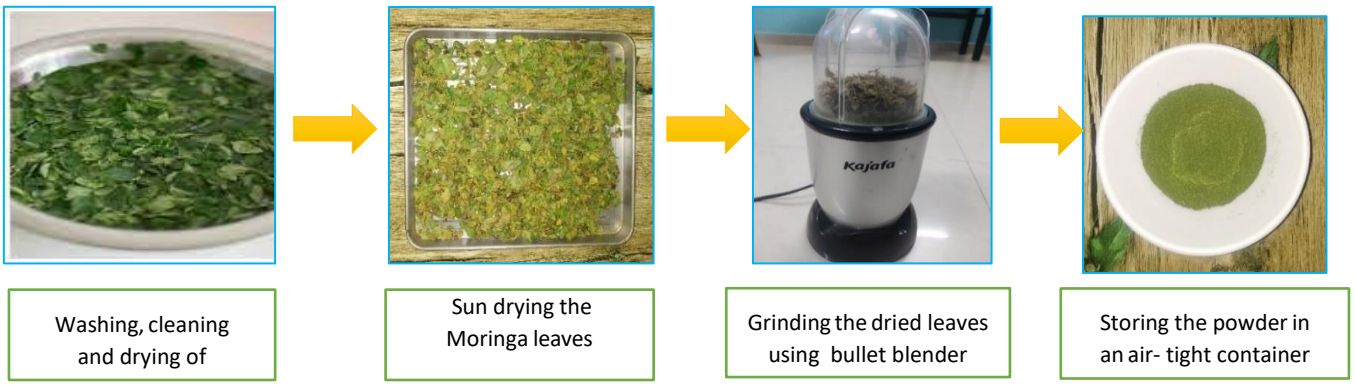

Fig 2 Preparation of moringa leaf powder

Fig 3 Preparation of crackers

Phase III

Consumer acceptability of the formulated products

The consumer acceptability of the developed product was carried out by determining the sensory characteristics of one control group and three experimental treatments by involving 20 untrained panelists [7].

Physico-chemical properties of the developed crackers

The physicochemical properties of the raw materials were first analyzed for thousand-grain weight, thousand-grain volume, swelling capacity, and bulk density [8-10]. After the product was developed further analyses like water absorption, oil absorption, texture analysis, color analysis, pH, weight, diameter, and thickness of the crackers were done [8-15].

Phase IV

The proximate, antioxidant analysis [16], total phenol content, flavonoid content, microbial analysis, and shelf-life analysis [17] were done for the control and Treatment 2 group.

Phase V

Statistical analysis

The data obtained from the analyses were interpreted using descriptive (mean and standard deviation) and represented graphically or diagrammatically. Student t-test was employed.

RESULTS AND DISCUSSION

The present research focuses on the physicochemical, organoleptic, nutritional composition, microbial growth, and shelf-life analysis of the wheat-based crackers incorporated with moringa leaves powder (*Moringa oleifera*).

Table 2 Mean acceptability and standard deviation scores of the crackers

Samples	Appearance	Color	Taste	Texture	Flavor	Overall acceptability
Control	6.6±0.7	6.5±0.6	6.4±0.6	6.5±0.7	6.5±1.35	6.2±0.7
Treatment 1	4.89±1.19	4.63±1.06	4.63±0.5	4.52±0.9	4.47±0.9	4.68±0.9
Treatment 2	8.3±0.64	8.5±0.6	8.6±0.4	8.5±0.6	8.5±0.5	8.7±0.5
Treatment 3	3.63±1.11	3.63±1.11	3.57±1.21	3.57±1.38	3.47±1.30	3.73±1.28

Consumer acceptability of the formulated product

The prepared crackers were organoleptically evaluated by 20 untrained panelists with 'a 9-point Hedonic Rating Scale' and the data was collected using Google Forms. Appearance, color, taste, texture, flavor and overall acceptability were considered. The mean scores of the organoleptic evaluation were presented in (Table 2).

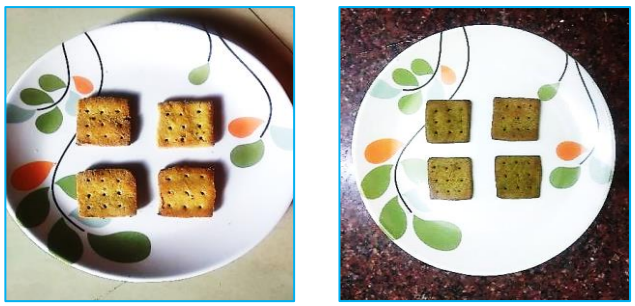

Fig 4 Crackers of control group and treatment 2

The results in (Table 2) clearly show the order of acceptability rate with treatment-2 (75g of wheat flour and 25g of moringa leaves powder) being the highest acceptable, followed by Treatment-1 (85g wheat flour and 15g moringa leaves powder) and Treatment-3 (65g of wheat flour and 35g of moringa leaves powder). Therefore, Control and Treatment-2 were selected for further analysis.

Colour

Colour is one of the major attributes, which stimulates the appetite for all the food products. The color of the Treatment-2 (8.5) cracker was found to be the highest acceptable among the developed crackers, followed by Treatment-1 (4.8), and Treatment-3 (3.63) respectively. The control group had around 6.5.

Taste

Taste involves the perception of constituents that are identified by the taste receptors in the taste buds, found superficially on the tongue and other parts of the mouth or gullet. The taste of Treatment-2 (8.5) has gained higher acceptability followed by Treatment-1 (4.63), and Treatment-3 (3.57). The flavor of the control group was found to be 6.4.

Texture

The texture is perceived by a combination of senses (i.e.) touch, mouthfeel, sight, and hearing. It refers to the physical attributes and involves characteristics such as crispy, soft, hard, and crunchy by consumers to describe the texture of food. The texture of Treatment-2 (8.5) has gained higher acceptability followed by Treatment-1 (4.52) and Treatment-3 (3.57). The texture parameter of the control group was found to be 6.5.

Flavor

Flavor is a sensory phenomenon to denotes sensations like odor, taste, and mouthfeel and is one of the essential criteria to make the product liked or disliked. The flavor of Treatment 2 (8.5) was found to be with higher acceptability, followed by Treatment 1 (4.47), and Treatment 3 (3.47) The flavor of the control group was 6.5.

Appearance

Appearance is one of the characteristic traits that is perceived by the human senses, it is important in identification, and the visual perception of food is comprised of color, shape, size, dullness, and transparency. The appearance of Treatement-2 (8.3) has gained higher acceptability, followed by Treatment-1 (4.89), and Treatment-3 (3.63). The flavor of the control group was found to be 6.6.

Overall acceptability

One of the important factors to describe the sensory of the food produced is Overall Acceptability. The overall acceptability rate of Treatment 2 (8.7) was found to be the most acceptable one as represented in (Fig 5), followed by Treatment 1 (4.68) and Treatment 3 (3.73). The overall acceptability of the control cracker was found to be 6.2.

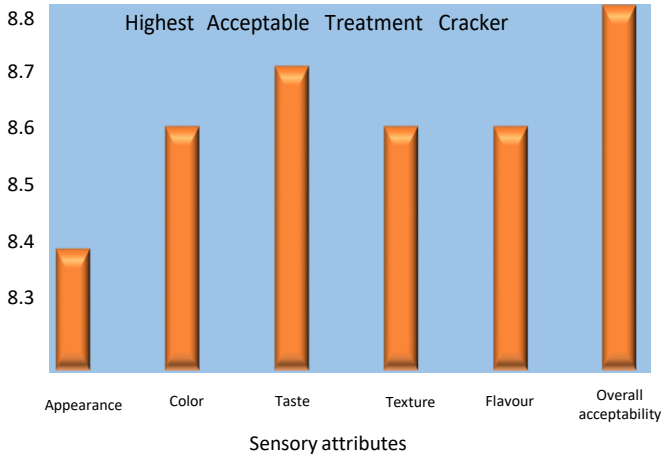

Fig 5 Crackers of control group and treatment 2

Physico-chemical properties of raw materials

The physicochemical properties of the raw materials used in this study were evaluated and the results are tabulated in (Table 3).

Table 3 Physico-chemical properties of raw materials

Properties	Results
Thousand-grain weight	46.18 ± 0.36g
Thousand-grain volume	32.36 ± 0.38ml
Bulk density	
Wheat	0.573 ± 0.25g/ml
Moringa leaf powder	0.42 ± 0.03g/ml
Swelling capacity	
Wheat flour	15.32 ± 0.02ml
Moringa leaves	1.08 ± 0.07ml

Physico-chemical properties of the product

Water and oil absorption of the control and treatment cracker

The quantity of water (moisture) absorbed by food or flour to produce high-quality food products and attain the required consistency is known as water absorption capacity, or WAC. The water absorption capacity of the control and Treatment-2 cracker was evaluated. It was found that the water absorption capacity of the Treatment-2 cracker was found to be 2.62±0.08 ml and the control cracker was found to be 3.69±0.9ml.

The binding of fat to the non-polar side chain of proteins is known as oil absorption capacity (OAC), or simply oil absorption. The Oil absorption capacity is an essential functional property that contributes to enhancing mouth feel while retaining the food product's flavor. Food proteins' ability to bind oil is determined by internal elements such protein structure, amino acid makeup, and surface polarity or hydrophobicity. Treatment-2 and control crackers were analyzed and were found to be 1.12±0.14 ml and 2.45±0.5ml respectively.

pH

pH is one of the important functional properties in determining the hydrogen ion concentration of the food product. The pH obtained for the control cracker was 6.34±0.03 and that of treatment-2 cracker was found to be 6.23±0.02.

Weight of the crackers

The weight was measured using an electronic compact scale. The weight of the control cracker was found to be 3.29±0.34g and the weight of the Treatment-2 cracker, which had 25g of moringa leaves powder, was about 4±0.2g.

Thickness of the crackers

The thickness of the cracker was measured using a Vernier caliper. The thickness of the control cracker was found to be 0.90±0.03cm and that of Treatment-2 cracker was found to be 1±0.05cm.

Diameter of the crackers

The diameter of the cracker was measured using a Vernier caliper. The diameter of the control cracker and treatment 2 was found to be 4.9±0.2cm and 4.1±0.8cm respectively.

Colour analysis

The characteristic of color is an important criterion that affects the quality of the product. The L* value (lightness index scale) ranges from 0 (black) to 100 (white) while the a* value indicates the redness (+a) or greenness (−a*) and the b* value refers to the yellowness (+b) or blue (−b*). The color of the cracker was analyzed using an instrument called HunterLab color analyzer. The summarized results are shown in (Table 4).

Table 4 Colour analysis of the control and treatment 2 crackers

Samples	L*	a*	b*
Control	63.4±0.3	1.5±0.3	35.4±0.4
Treatment 2	50.8±0.12	3.7±0.23	31.7±0.8

Texture analysis of the crackers

Textural properties are very important quality attributes for crackers. The Fracturability and the hardness of the crackers were analyzed. The fracturability (9423.24 ± 14) and hardness (15344.61 ± 98) of the Treatment-2 cracker were found to be higher than the control cracker due to its low moisture content. Thus, the texture of the Treatment-2 cracker was found to be acceptable when compared to the control cracker.

Proximate composition

Nutrient analysis

The following tables show the proximate composition of control and Treatment 2 (25g of moringa leaves powder) crackers. Nutrients like energy, carbohydrates, protein, fat, dietary fiber, total ash, moisture content, and vitamin-c were evaluated and the results are discussed.

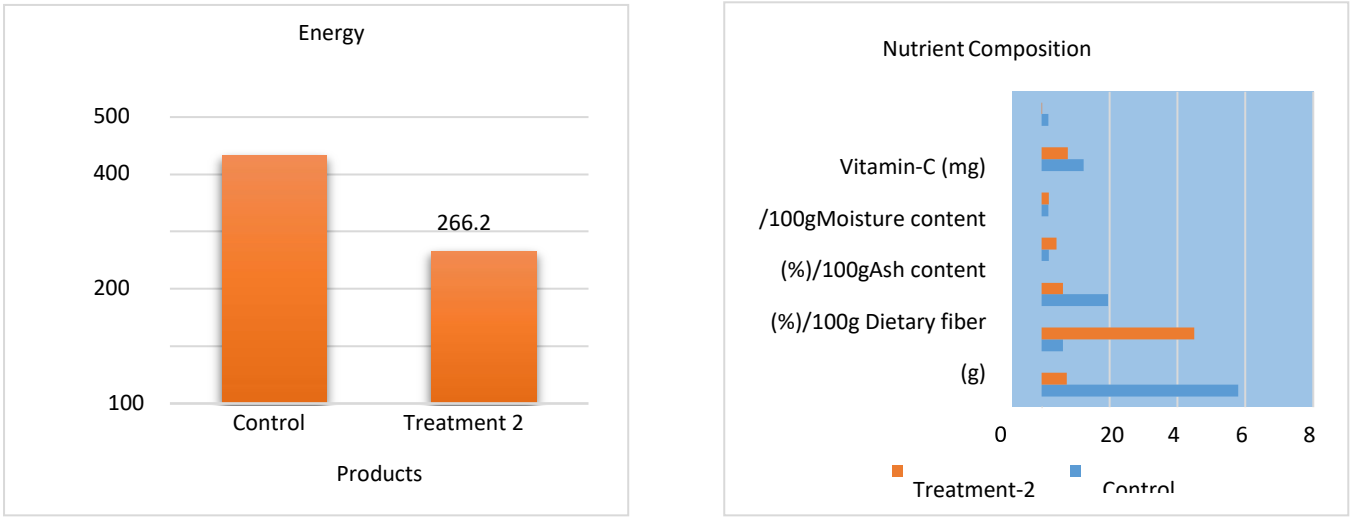

Fig 6 Nutrient composition of the Crackers – Control group and Treatment 2

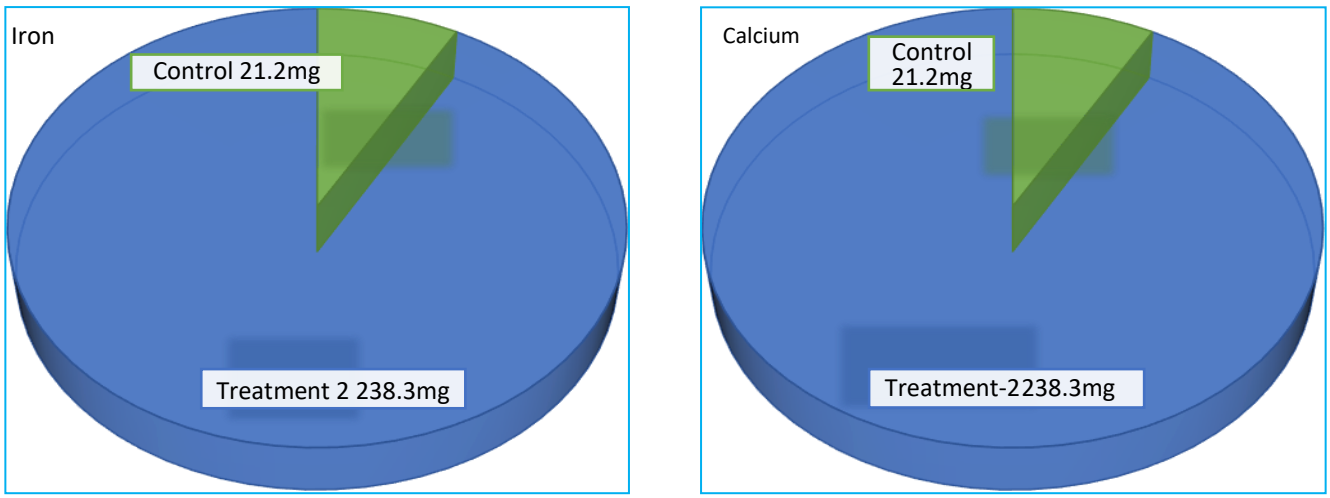

Fig 7 Iron and calcium content of control and treatment 2 crackers

Mineral content analysis

The mineral content of the control and Treatment-2 crackers were analyzed and the results showed the following (Fig 7). The tabulation of the results is seen in (Table 5).

Table 5 Tabulation of the mineral content of control group and treatment 2 crackers

Nutrients /100g	Control	Treatment -2
Iron (mg)	2.1	99.2
Calcium (mg)	21.2	238.3

Antioxidant analysis

The antioxidant analysis of the control and Treatment-2 cracker were recorded. Properties such as DPPH Assay, total phenol content, and total flavonoid content were analyzed and the results were tabulated as shown in (Table 6). The DPPH assay measures the ability of antioxidants to neutralize free radicals. A higher percentage indicates a stronger antioxidant activity. Treatment-2 has a significantly higher DPPH value compared to the control, suggesting that Treatment-2 crackers possess greater free radical scavenging activity.

Table 6 Tabulation of the antioxidant content analyzed by the HPLC method

Parameters	Control	Treatment - 2
DPPH Assay (%)	67.3%	74.92%
Total phenol (mg/g GAE)	0.89mg/g GAE	0.055mg/g GAE
Total flavonoid (mg/g QE)	0.22mg/g QE	0.039mg/g QE

Microbial analysis

In this research study, the microbial analysis on the total bacterial count and, the total yeast and mold count of the control and Treatment-2 were analyzed and given in (Table 7).

Table 7 Microbial content analysis of the product

Parameters	Control	Treatment - 2
Total bacterial count (CFU/g)	1.6x104	1x104
Total yeast and mold count (CFU/g)	1.2 x103	Nil

- The total viable count of the Treatment-2 (25g of moringa leaves powder) and control cracker was calculated by use the pour plate method to inoculate 0.1 ml of 103 dilutions on agar, followed by a 24-hour incubation period at 37 °C. After 24 hours, bacterial colonies were counted and the total bacterial count was expressed in CFU/g.

- The total viable count was calculated by inoculating 0.1ml of from 103 dilutions on a Rose Bengal agar plate and incubating at 37◦C for 72 hours. After 72 hours, fungal colonies were counted and expressed in CFU/g.

Shelf-life analysis

The shelf life of the control and Treatment-2 crackers was analyzed by calculating the presence of colony-forming bacterial and fungal strains by spread plate technique for 60 days with an interval of 15 days. The summarized results of the shelf-life analysis are tabulated in (Table 8).

Table 8 Shelf-life analysis of the product

Days	Control bacterial Count × 10^4Cfu/G	Treatment-2 bacterial Count × 10^4Cfu/G	Control yeast or mold count × 10^4Cfu/G	Treatment- 2 yeast or mold count × 10^4Cfu/G
0^{th}	1.4	1	1	0
15^{th}	2.5	0	1	0
30^{th}	3.8	1	1.4	0
45^{th}	4.1	1	1.5	0
60^{th}	6	0	1.4	0

CONCLUSION

The present study concluded that the developed wheat-based crackers incorporated with Moringa leaf powder is a wholesome ready-to-eat food product rich in protein, fiber, iron, and calcium, and low in calories and fat. It is considered microbially safe for consumption. These crackers can be recommended for patients with diabetes and heart disease and are an ideal snack for children who are suffering from malnutrition. The antioxidant content is also found to be high when compared to the other crackers. Hence, these crackers provide a flavorful taste and are proven to be nutritionally dense. The incorporation of Moringa leaf powder into wheat-based crackers offers a promising approach to developing nutritious, safe, and appealing food products that cater to the needs of health-conscious consumers.

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