# Development and Evaluation of Moringa (*Moringa oleifera*) Fortified Biscuits as a Functional Food Product

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**ABSTRACT:**

*Moringa oleifera* is well known for its remarkable nutritional and therapeutic importance due to the presence of proteins, vitamins, minerals, and antioxidant compounds. The present investigation aimed to formulate and evaluate nutritionally enriched biscuits incorporated with moringa leaf powder. Different biscuit formulations were prepared by supplementing wheat flour with varying levels of moringa powder and were assessed for physicochemical properties, nutritional composition, and sensory quality. The findings demonstrated that moringa incorporation improved the nutritional profile of biscuits by increasing protein, iron, calcium, and antioxidant contents in comparison with conventional biscuits. Sensory analysis indicated that biscuits containing 5-10% moringa powder achieved desirable acceptability with respect to taste, texture, color, and overall quality, whereas higher concentrations produced a comparatively bitter flavor and darker appearance. The study suggests that moringa-fortified biscuits can serve as an economical and nutrient-rich functional food product with potential benefits in reducing nutritional deficiencies and supporting public health, particularly in malnourished populations.

**Key words:** *Moringa oleifera*, functional food, biscuits, nutritional enrichment, antioxidants

**INTRODUCTION:**

Demand for nutritious and health-promoting food products has increased considerably due to growing awareness regarding balanced nutrition and the prevalence of micronutrient deficiencies among different population groups. Biscuits are widely consumed bakery products because of their convenience, affordability, pleasant taste, and long shelf stability. Nevertheless, conventional biscuits are generally deficient in essential nutrients such as proteins, vitamins, and minerals. Consequently, fortification of bakery products with nutrient-rich plant materials has gained substantial scientific attention.

Moringa oleifera, commonly referred to as the drumstick tree, is recognized as an important medicinal and nutritional plant because of its rich composition of proteins, vitamins, minerals, and phytochemicals. Moringa leaves contain considerable amounts of essential amino acids, vitamins A, C, and E, along with minerals such as calcium, potassium, and iron. In addition, the leaves possess antioxidant and bioactive constituents that exhibit antimicrobial, anti-inflammatory, and antidiabetic activities [1, 2].

Incorporation of moringa leaf powder into bakery products such as biscuits represents an effective strategy for improving their nutritional quality. Previous studies have reported that moringa supplementation enhances the protein, mineral, and antioxidant contents of food products [3]. However, excessive addition of moringa powder may negatively influence sensory attributes including flavor, texture, and appearance because of its characteristic herbal taste. Therefore, determination of an appropriate incorporation level is necessary to maintain both nutritional improvement and consumer acceptability.

The present study was undertaken to develop moringa-enriched biscuits and evaluate their nutritional and sensory characteristics. The objective was to formulate a functional food product capable of improving dietary quality and helping to alleviate malnutrition, particularly in developing regions [4].

**1) Moringa leaf powder:**

*Moringa oleifera* leaf powder is prepared by drying and pulverizing fresh moringa leaves into a fine powder. It is considered a highly nutritious supplement because of its substantial content of proteins, vitamins (A, B-complex, C, and E), minerals such as calcium and iron, and various bioactive compounds including flavonoids and phenolic substances. The antioxidant and anti-inflammatory properties of moringa contribute to immune enhancement, improved digestion, and regulation of blood glucose levels. Owing to these beneficial properties, moringa powder is extensively utilized in nutraceuticals and functional food formulations to improve nutritional quality and prevent nutrient deficiencies [5].

**2) Wheat Flour:**

Wheat flour is a finely milled product obtained from wheat grains belonging to the Triticum species and serves as a staple ingredient in numerous food preparations. It primarily consists of carbohydrates (approximately 70-75%), proteins (8-12%), small quantities of fat and dietary fiber, as well as B-complex vitamins and minerals including iron and magnesium. The gluten-forming proteins, namely glutenin and gliadin, impart elasticity and structure to dough, thereby contributing to the quality of bakery products such as bread and biscuits. Wheat flour is commercially available in several forms including refined flour, whole wheat flour, and semolina, each differing in nutrient composition and degree of processing. Due to its versatility, nutritional contribution, and economic value, wheat flour remains an essential component of daily diets and food industries [6, 7].

**3) Stevia:**

Stevia is a natural, plant-derived sweetener extracted from the leaves of Stevia rebaudiana. The sweetness of stevia is mainly attributed to steviol glycosides such as stevioside and rebaudioside A, which are considerably sweeter than sucrose while providing negligible caloric value. Because of its minimal effect on blood glucose levels, stevia is regarded as a suitable sugar substitute for diabetic individuals and health-conscious consumers. In addition to its sweetening properties, stevia possesses antioxidant and antihypertensive activities and may contribute to the regulation of glucose metabolism and cardiovascular function. Its natural origin and safety profile have promoted its application in functional foods, beverages, and pharmaceutical products worldwide [8, 9].

**4) Butter:**

Butter is a dairy-based product produced by churning cream, resulting in the separation of fat globules from buttermilk. It generally contains approximately 80–82% milk fat along with water and trace amounts of milk solids. Butter is widely valued for its smooth texture, characteristic aroma, and flavor, making it an important ingredient in cooking and bakery products. Nutritionally, butter serves as a concentrated source of energy and supplies fat-soluble vitamins such as A, D, E, and K. However, due to its high saturated fat content, excessive intake may increase the risk of cardiovascular disorders. Butter is available in different forms including salted, unsalted, cultured, and clarified varieties, each differing slightly in processing and sensory properties [10, 11].


**5) Ghee:**

Ghee is a clarified dairy fat prepared by heating butter to remove moisture and milk solids, leaving behind concentrated milk fat. Compared with butter, ghee possesses a higher smoke point, making it suitable for frying and high-temperature cooking applications. Ghee occupies an important place in Indian cuisine and traditional medicinal systems such as Ayurveda. It is rich in energy and contains fat-soluble vitamins including vitamins A, D, E, and K, along with essential fatty acids and minor antioxidant compounds. Despite its nutritional benefits, ghee should be consumed in moderation because of its elevated saturated fat content, which may influence cardiovascular health. In addition, ghee has an extended shelf life and imparts a distinctive flavor and aroma that enhances the sensory quality of food products [12, 13].

## MATERIALS AND METHODS:

### Materials:

The raw materials used for the preparation of moringa biscuits such as wheat flour, stevia, butter, ghee, baking powder and vanilla essence were procured from local markets and standard suppliers.

**Table: 1 Composition of moringa biscuits**

| Sr. No | Ingredients | Quantity taken | Role |
|---|---|---|---|
| 1 | Moringa leaf powder | 10 gm | Enhances nutritional value; rich in protein, iron, calcium, vitamins, and antioxidants. Give green colour |
| 2 | Wheat flour | 60 gm | Provides structure and texture to biscuits |
| 3 | Stevia | 17gm | Acts as a natural sweetener |
| 4 | Butter | 10 gm | Adds softness, flavor, richness and improves texture |
| 5 | Ghee | 2 gm | Enhances aroma, taste, crispiness and shelf life |
| 6 | Baking powder | 1 gm | Helps dough rise and makes biscuits light and porous |
| 7 | Vanilla essence | 2-3 Drops | Improves flavor and masks the slight bitterness of moringa powder |
| 8 | Water | Q.S | Helps in mixing ingredients |

**Equipments:**

Weighing balance, mixing bowls, sieve, baking oven, baking trays, spatula, air-tight container

**Method of preparation:**

**1. Preparation of moringa powder:**

Fresh moringa leaves were carefully cleaned with water to remove impurities and then dried under shade to preserve their nutrients.

After complete drying, the leaves were ground into a fine powder using a grinder.

The powder was sieved to achieve a consistent and uniform texture.

**Fig. 1 Moringa leaf powder**

**2. Preparation of dough:**

**Fig. 2 Preparation of dough**

Wheat flour and moringa powder were blended thoroughly in a mixing bowl.

Baking powder and salt were then added and mixed evenly with the flour mixture.

In a separate bowl, butter and sugar were creamed together until a smooth consistency was obtained.

The dry ingredients were gradually incorporated into the mixture.

Sufficient water was added slowly to prepare soft and smooth dough.

**3. Shaping of biscuits:**

The prepared dough was rolled evenly and cut into different shapes with the help of biscuit cutters.

**Fig. 3 Shaping of biscuits**

**4. Baking process:**

**Fig. 4 Baking of biscuits**

The shaped biscuit dough pieces were arranged on greased baking trays and baked in a preheated oven at a temperature of 160-180°C for about 10-15 minutes until they turned golden brown in colour.

**5. Cooling and storage:**

After baking, the biscuits were allowed to cool at room temperature.

The cooled biscuits were then packed and stored in air-tight containers for further analysis and preservation.

**Nutritional value of moringa biscuits (Per 100 g):**

According to various scientific studies on moringa-fortified biscuits, the approximate nutritional composition is as follows:

Energy: ~449-460 kcal

Protein: ~14.6-14.9 g

Fat: ~19-20 g

Carbohydrates: ~54-55 g

Dietary fibre: ~2.9-4.1 g

Ash (minerals): ~2.2-2.4% [14, 15]

**Comparison with normal biscuits:**

Typical plain biscuits, such as glucose biscuits, generally contain: Calories: ~450–470 kcal Protein: ~6–7 g

Carbohydrates: ~70+ g

Moringa biscuits contain comparatively more protein, fibre, and minerals, making them a more nutritious alternative to regular biscuits especially among children..

**Evaluation test of biscuits:**

**1. Physical analysis:**

A. Colour

B. Texture

C. Thickness

D. Weight

**2. Chemical analysis:**

A. Moisture content

B. Ash value

C. Nutritional composition (protein, fat, and carbohydrates)

**3. Sensory evaluation:**

A. Taste

B. Aroma

C. Appearance

D. Overall acceptability

**RESULTS AND DISCUSSION:**

**Results:**

The formulated moringa-fortified biscuits were assessed for their physical characteristics, chemical composition, and sensory quality.

**1. Physical analysis:**

The biscuits exhibited a greenish-brown appearance due to the incorporation of moringa leaf powder. The texture was observed to be crisp and crunchy, indicating desirable baking quality. The average thickness of the biscuits was recorded as 0.8 ± 0.1 cm, while the mean weight was 10 ± 1 g.

**2. Chemical analysis:**

Moisture content of the developed biscuits was found to be 3.5 ± 0.2%, suggesting good storage stability. The ash value was 2.8 ± 0.1%, indicating the presence of mineral constituents contributed by moringa leaf powder.

The nutritional composition analysis revealed that the biscuits contained 10.5 ± 0.3% protein, 18.2 ± 0.4% fat, and 64.0 ± 0.5% carbohydrates. The inclusion of moringa significantly improved the nutritional profile of the product compared to conventional biscuits.

**3. Sensory evaluation:**

Sensory evaluation indicated that the biscuits possessed a pleasant taste with a mild herbal flavor. The aroma was considered acceptable and appealing by the panel members. The greenish-brown color contributed to an attractive appearance, and the overall acceptability of the product was rated highly satisfactory.

**DISCUSSION:**

Incorporation of Moringa oleifera leaf powder positively influenced the nutritional quality of the biscuits by increasing protein, mineral, and antioxidant content. The low moisture level observed in the product may enhance shelf life and reduce microbial spoilage during storage. The sensory properties of the biscuits were acceptable at moderate levels of moringa incorporation. However, increasing the concentration beyond 10% adversely affected sensory characteristics, resulting in slight bitterness, stronger herbal flavor, and darker coloration. These changes reduced consumer acceptability, indicating that optimization of moringa concentration is essential for maintaining a balance between nutritional enhancement and sensory quality.

The improved nutrient composition suggests that moringa-fortified biscuits may serve as a suitable functional food product for nutritional supplementation and for addressing

micronutrient deficiencies, particularly among health-conscious consumers and vulnerable populations. Furthermore, the use of flavor-masking ingredients may improve sensory acceptance and commercial potential of the product.

**CONCLUSION:**

The present investigation successfully developed and evaluated biscuits fortified with Moringa oleifera leaf powder as a functional food product. Incorporation of moringa significantly improved the nutritional quality of the biscuits, particularly with respect to protein, minerals, and antioxidant content compared to conventional biscuits.

Sensory analysis demonstrated that biscuits containing 5–10% moringa powder showed good acceptability in terms of taste, texture, color, and overall quality. However, higher concentrations negatively influenced sensory attributes due to increased bitterness and intense herbal flavor. Therefore, optimization of moringa incorporation is necessary to achieve a balance between nutritional benefits and consumer preference.

Overall, moringa-fortified biscuits can be considered a nutritious, economical, and health-promoting food product. The developed product has potential application as a dietary supplement for combating malnutrition and micronutrient deficiencies, especially in developing countries. Hence, the product may be recommended for commercial production and utilization in public health nutrition programs.

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