WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.63
Volume 15, Issue 6, 987-1000. Research Article ISSN 2277–7105

DEVELOPMENT OF MORINGA-FORTIFIED BISCUIT WITH ENHANCED NUTRITIONAL AND IMMUNOLOGICAL PROPERTIES

Mr. Bishesar Sahu*[1], Mr. Hariom Rajput[2]

[1]Assistant Professor, Disha College of Pharmacy, Raipur (C.G.) 492101.

[2]Assistant Professor, UIPER, University of Kota, (Rajasthan) 324005.

Article Received on 11 Feb. 2026,
Article Revised on 03 March 2026,
Article Published on 16 March 2026,

https://doi.org/10.5281/zenodo.19046268

***Corresponding Author**

Mr. Bishesar Sahu

Assistant Professor, Disha College of Pharmacy, Raipur (C.G.) 492101.

How to cite this Article: Mr. Bishesar Sahu*[1], Mr. Hariom Rajput[2]. (2026). Development of Moringa-Fortified Biscuit with Enhanced Nutritional and Immunological Properties. World Journal of Pharmaceutical Research, 15(6), 987–1000.

ABSTRACT

The worldwide outbreak of COVID-19 highlighted the critical importance of nutritional status in maintaining immune competence and reducing susceptibility to infectious diseases. Post-pandemic observations indicate that a significant proportion of the population experienced weakened immunity due to infection, stress, poor dietary habits, and micronutrient deficiencies, emphasizing the need for accessible functional foods that support immune health. The present study aimed to develop a nutritionally enriched immune-boosting biscuit fortified with Moringa oleifera leaf powder and to evaluate its physicochemical, nutritional, antioxidant, and sensory characteristics. Moringa oleifera is well recognized for its rich content of proteins, vitamins, essential minerals, and bioactive phytoconstituents possessing antioxidant and immunomodulatory properties. Biscuits were formulated by incorporating moringa leaf powder at different concentrations (0%, 5%, 10%, and 15%) into a standard wheat-based formulation. The prepared biscuits were evaluated for physicochemical parameters (moisture, ash, spread ratio, hardness), nutritional composition (protein, fiber, and mineral content), and antioxidant activity using established in-vitro methods. Sensory evaluation was conducted by a semi-trained panel to assess color, taste, aroma, texture, and overall acceptability. Results demonstrated that moringa fortification significantly improved protein, dietary fiber, iron content, and antioxidant activity compared with control biscuits. The study suggests that moringa-fortified biscuits can serve as a convenient, affordable, and nutritionally dense functional food to support immune health, particularly in populations vulnerable to post-

COVID-19 immune decline and micronutrient deficiencies.

KEYWORDS: Nutri Gold Biscuit; Moringa oleifera; Immune-boosting biscuit; Functional food; Nutritional fortification; Herbal nutraceutical; post-pandemic nutrition.

INTRODUCTION

The COVID-19 pandemic has highlighted the important role of nutrition in immune competence and disease resistance. Adequate intake of micronutrients such as vitamins A, C, E, iron, and zinc is essential for maintaining immune function and reducing susceptibility to infections.[1,2] Post-COVID conditions and dietary disruptions have increased the prevalence of nutritional deficiencies and weakened immunity in many populations, particularly in developing countries.[3] Moringa oleifera is widely recognized as a nutrient-dense plant with exceptional nutritional and medicinal value. Its leaves contain high-quality protein, essential amino acids, vitamins, minerals, and bioactive phytochemicals such as flavonoids and phenolic compounds with antioxidant and immunomodulatory properties.[4,5] Regular dietary inclusion of moringa has been associated with improved nutritional status and antioxidant defence.[6]

Bakery products such as biscuits are widely consumed across age groups due to convenience, affordability, and long shelf life. Fortification of biscuits with plant-based functional ingredients is an effective strategy to improve nutrient intake and deliver health benefits through commonly consumed foods.[7] Health-promoting foods, especially cookies, have recently garnered significant attention from consumers, dietitians, specialists, and producers. Cookies are classed as widely marketed bakery items globally due to their ready-to eat nature, affordability, nutritional richness, diverse flavours, and extended shelf life.[8,9]

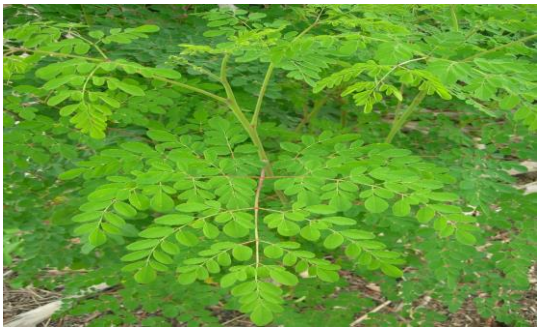


Fig. 1: Moringa oleifera plant.

In addition to moringa, several traditional medicinal and nutrient-rich ingredients have

demonstrated immune-supportive potential and suitability for functional bakery products. Withania somnifera (Ashwagandha) is an adaptogenic herb extensively used in Ayurveda for improving vitality, reducing stress, and modulating immune responses. Its bioactive withanolides possess anti-inflammatory, antioxidant, and immunomodulatory activities, which may contribute to enhanced resistance against infections and fatigue.[10,11]

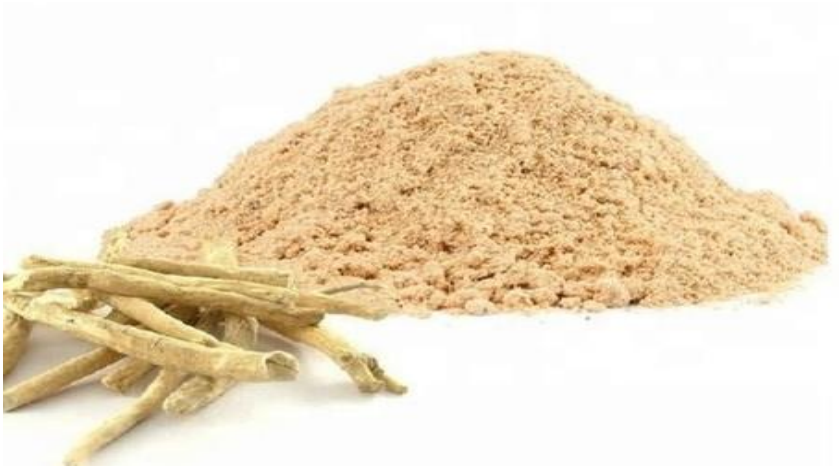


Fig. 2: Ashwagandha Powder for Biscuit preparation.

Similarly, Ocimum sanctum (Tulsi or holy basil) is known for its antimicrobial, antioxidant, and immunomodulatory effects. Tulsi contains eugenol, ursolic acid, and flavonoids that support respiratory health and immune function, making it particularly relevant in post-viral recovery nutrition.[12,13]

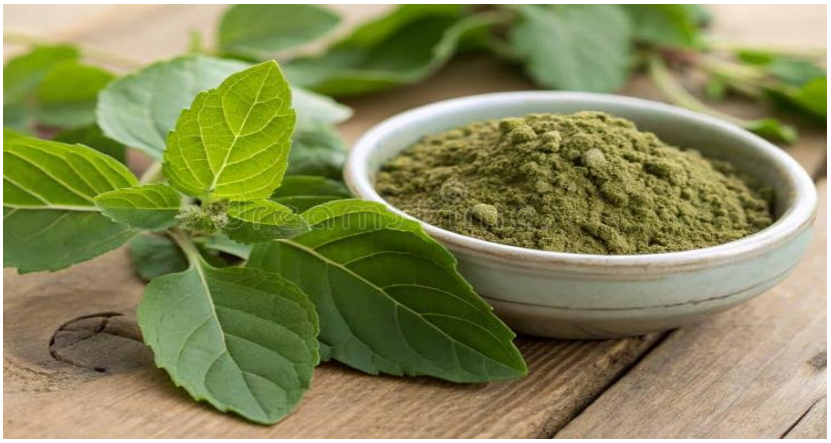


Fig. 3: Tulsi powder for Biscuit preparation.

Jaggery (unrefined cane sugar) is a traditional sweetener rich in iron, minerals, and phenolic antioxidants compared with refined sugar. It has been reported to improve hemoglobin status and provide sustained energy release, which may support recovery and immunity in

nutritionally vulnerable populations.[14] Oats (*Avena sativa*) are a valuable cereal source of β-glucan soluble fiber, known to enhance immune responses, improve gut microbiota, and reduce inflammation. β-glucans act as biological response modifiers that stimulate macrophage and natural killer cell activity.[15,16]

Fig. 4: Jaggery powder for Biscuit preparation.

Dry fruits such as almonds, cashews, and raisins are concentrated sources of healthy fats, proteins, vitamins (especially vitamin E), and trace minerals including zinc and selenium, which are essential for immune cell function and antioxidant defence.[17]

Fig. 5: Dry fruits powder for Biscuit preparation.

MATERIALS AND METHOD

Procurement of Material

All ingredient, Moringa Powder, including sugar, multigrain flour, Ashwagandha Powder, Tulsi powder, Jaggery, Milk, Dry fruits, Ghee and other components, were sourced from local markets in Bhilai Chhattisgarh. This local sourcing reflected the ingredients typically available to consumers while ensuring freshness and accessibility. All analytical reagents used were of laboratory grade.

Formulation of Moringa Biscuit

Refined wheat flour, jaggery powder, rolled oats, butter, baking powder, milk powder, and mixed dry fruits (almonds, cashews, raisins) were procured from the local market. Fresh moringa (*Moringa oleifera*) leaves and tulsi (*Ocimum sanctum*) leaves were collected from authenticated herbal gardens. Ashwagandha (*Withania somnifera*) root powder was obtained from a certified Ayurvedic supplier. All analytical reagents used were of analytical grade (Dharma tech Pharma, India).

The selection of ingredients was based on their reported nutritional and immunomodulatory properties. Moringa leaves provide proteins, vitamins, and minerals; ashwagandha and tulsi contribute adaptogenic and immunomodulatory phytochemicals; oats supply β-glucan soluble fiber; jaggery provides iron and antioxidants; and dry fruits contribute essential fatty acids, micronutrients, and vitamin E.[4,7,13,17]

Rolled oats were lightly roasted at 80–90 °C for 5 min to improve flavour and reduce moisture, then ground into coarse flour. Dry fruits (almonds, cashews, raisins) were chopped and incorporated directly into the dough to enhance nutrient density and sensory attributes.[17]

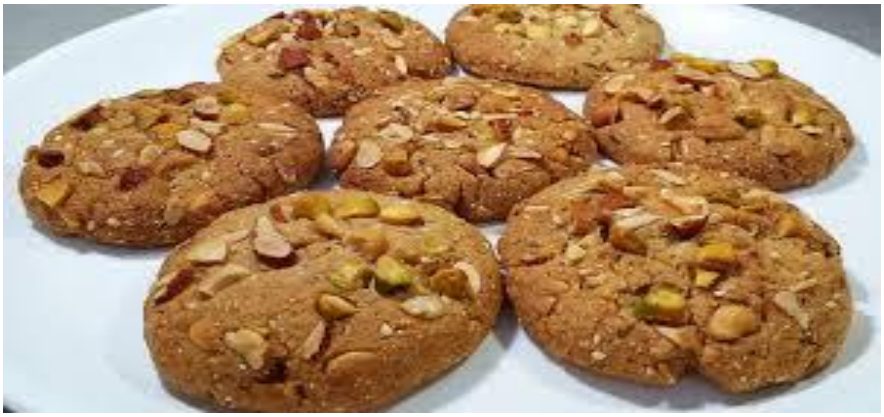


Fig. 6: Moringa Containing Biscuit.

Formulation of Functional Moringa Biscuit

Biscuits were formulated by replacing wheat flour with moringa powder at 0%, 5%, 10%, and 15% levels. Complementary functional ingredients were added at fixed levels based on preliminary trials and literature reports on acceptable sensory limits in bakery products.[7,9]

Table 1: Composition of Functional Moringa Biscuit Formulations.

Ingredient	F0 (%)	F1 (%)	F2 (%)	F3 (%)
Wheat flour	100	95	90	85
Moringa powder	0	5	10	15
Oat flour	10	10	10	10
Jaggery powder	30	30	30	30
Butter	20	20	20	20
Milk powder	5	5	5	5
Ashwagandha powder	1	1	1	1
Tulsi powder	1	1	1	1
Baking powder	1	1	1	1
Dry fruits	8	8	8	8
Water	q.s.	q.s.	q.s.	q.s.

Preparation of biscuit

Biscuits were prepared using the standard creaming method (9). Butter and jaggery were creamed until light and fluffy. Dry ingredients (wheat flour, moringa powder, oat flour, milk powder, ashwagandha powder, Tulsi powder, baking powder) were sieved and mixed. The dry mix was incorporated into the cream along with chopped dry fruits and sufficient water to obtain uniform dough. Dough was sheeted to 4 mm thickness, cut into circular shapes (50 mm diameter), and baked at 180 °C for 12–15 min in a preheated oven. Baked biscuits were cooled to room temperature and stored in airtight polyethylene pouches for analysis.

Raw Materials

Butter, Jaggery, Wheat flour, Moringa powder, Oat flour, Milk powder, Ashwagandha powder, Tulsi powder, baking powder, Dry fruits, Water

Creaming

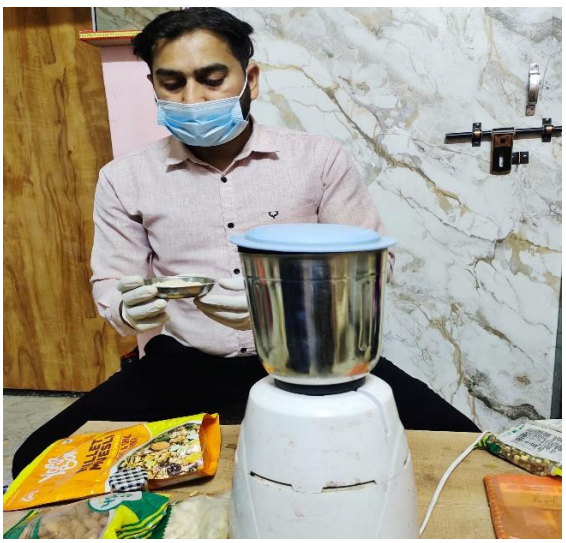
Butter + Jaggery creamed until light and fluffy

Fig. 7: Creaming of Jaggery and Butter.

Preparation of Dry Mix

Wheat flour + Moringa powder + Oat flour + Milk powder + Ashwagandha powder + Tulsi powder + Baking powder

→ Sieving → Uniform dry mixture



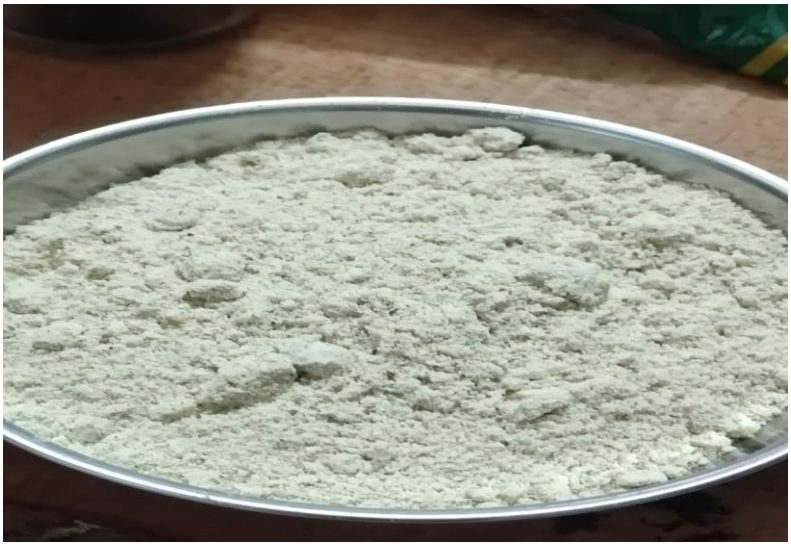


Fig 8. Preparation of Dry Mixture

Dough Formation

Dry mix incorporated into cream

Chopped dry fruits

Sufficient water

→ Uniform dough

Fig. 9: Dough Formation.

Sheeting

Dough rolled to **4 mm thickness**

Cutting

Circular biscuits (≈ 50 mm diameter)

Fig. 10: Shape formation.

Baking

180 °C, **12–15 min** (preheated oven)

Fig. 11: Heating in Oven and Drying.

Physical Evaluation

Moisture and ash content were determined using AOAC standard methods (10). Biscuit diameter and thickness were measured using digital vernier calipers, and spread ratio was calculated as diameter/thickness. Texture (hardness) was evaluated using a texture analyser with a three-point bending test.[10]

Sensory Evaluation

Sensory quality was evaluated by a semi-trained panel (n = 12–15) using a 9-point hedonic scale for colour, aroma, taste, texture, and overall acceptability. Samples were coded and presented randomly under controlled conditions with potable water for palate cleansing.[12]

Marketed Product

Table 2: Comparison of Commercial Moringa-Fortified Biscuits.

S. No.	Brand / Product	Key Ingredients	Flour Base	Claimed Uses / Benefits	Unique Features	Reference
1	Farmerette Zero-Maida Millet-Moringa Cookies	Millet flour, moringa leaf powder, jaggery	Millet	Mineral-rich nutritious snack	No refined flour	Farmerette Foods Pvt. Ltd., 2024
2	Nutriwala Moringa Biscuits with Jaggery	Wheat flour, moringa powder, jaggery	Wheat	Immunity & energy support	Traditional sweetener	Nutriwala Agro Products, 2023
3	Doctor Moringa Healthy	Wheat flour, moringa,	Wheat	Digestive & herbal nutrition	Ayurvedic positioning	Doctor Moringa

	Cookies	herbs				India, 2024
4	Vriksha Moringa Cookies	Whole-wheat flour, moringa leaves	Whole wheat	Daily nutritional supplementation	Whole-grain base	Vriksha Organics, 2023
5	Healthy Binge Moringa Jowar Snack	Jowar flour, moringa, spices	Millet (jowar)	Low-fat healthy snack	Savory moringa snack	Healthy Binge Foods, 2024
6	Moringa Miracle Millet-Moringa Cookies	Millet flour, moringa powder	Millet	Antioxidant & micronutrient source	Functional blend	Moringa Miracle, 2023

CONCLUSION

Moringa-fortified functional biscuits enriched with oat flour, milk powder, ashwagandha, tulsi, jaggery, and dry fruits were successfully developed using the standard creaming method. Incorporation of moringa leaf powder significantly enhanced the nutritional and phytochemical profile of the biscuits, particularly protein, fiber, minerals, and antioxidant constituents.

The formulated biscuits exhibited acceptable physicochemical characteristics, desirable texture, and good sensory scores comparable to control biscuits. Functional ingredients such as moringa, tulsi, and ashwagandha contributed to elevated phenolic and flavonoid content, supporting potential immunomodulatory benefits. Shelf-life evaluation indicated stability and microbiological safety for at least 60 days under ambient storage.

Future Prospects

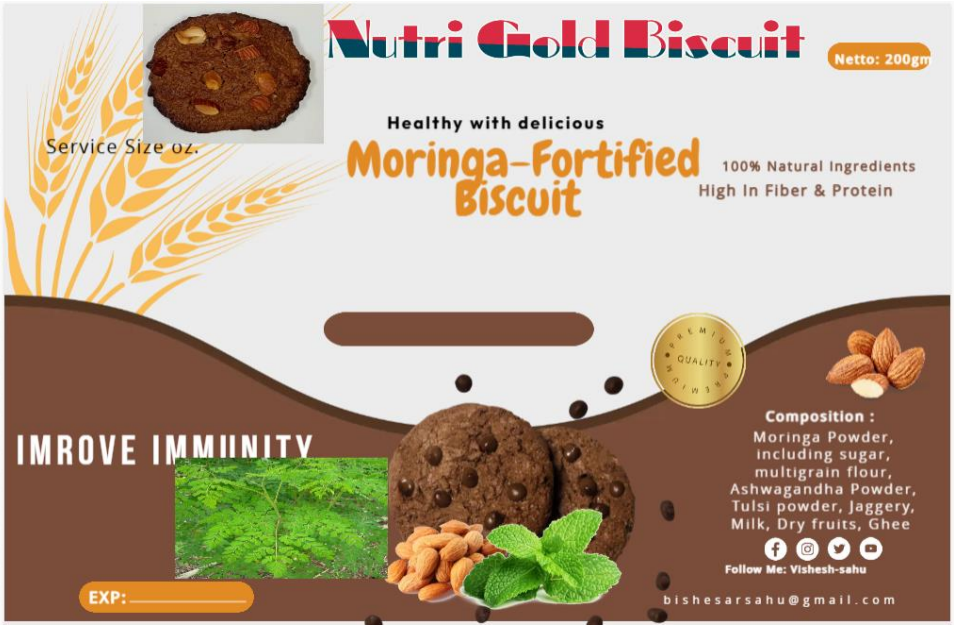
The development of moringa-fortified biscuits enriched with functional herbal ingredients such as ashwagandha, tulsi, and jaggery demonstrates significant potential in the growing sector of functional and immunity-supporting foods. Future research and product development may focus on several important directions.

Firstly, optimization of formulation through response surface methodology (RSM) or mixture design can be undertaken to achieve the best balance between nutritional enhancement, sensory acceptability, and bioactive retention. Standardization of moringa and herbal powder particle size and pre-treatments (blanching, drying conditions) may further improve texture and color stability.

Secondly, advanced nutritional and clinical validation studies are required to substantiate the immunomodulatory claims of the developed biscuits. In vivo or human intervention studies evaluating antioxidant biomarkers, immune response markers, and micronutrient bioavailability would strengthen evidence for nutraceutical positioning.

Product Branding and Label Design

Finally, the developed moringa-fortified biscuit has already been supported by preliminary **product branding and label design**, demonstrating its readiness for future commercialization and market positioning. Establishing a distinct brand identity highlighting the product's functional, herbal, and immunity-supporting attributes can enhance consumer recognition and acceptance. The designed label incorporating nutritional claims, herbal ingredients, and health-focused messaging may facilitate regulatory approval, packaging standardization, and promotional activities. Future work may involve consumer perception studies on branding effectiveness, package communication, and purchase intent to support successful product launch in functional food and nutraceutical markets.



REFERENCES

1. Calder PC. Nutrition, immunity and COVID-19. BMJ Nutr Prev Health, 2020; 3: 74-92.
2. Gombart AF, Pierre A, Maggini S. Micronutrients and immune system function. Nutrients, 2020; 12: 236.
3. Richardson DP, Lovegrove JA. Nutritional status and immune function during COVID-19. **Nutrients,** 2021; 13: 1562.

4. Leone A, Spada A, Battezzati A, et al. Cultivation, genetic, and nutritional properties of *Moringa oleifera*. **Int J Mol Sci.,** 2015; 16: 12791-835.
5. Gopalakrishnan L, Doriya K, Kumar DS. *Moringa oleifera*: A review on nutritive importance. **Food Sci Hum Wellness,** 2016; 5: 49-56.
6. Saini RK, Sivanesan I, Keum YS. Phytochemicals of *Moringa oleifera* and health benefits. **Antioxidants,** 2016; 5: 49.
7. Gupta S, Prakash J. Nutritional and sensory quality of moringa-supplemented foods. **Food Sci Nutr.,** 2012; 3: 1-8.
8. Jha R, Berrocoso JFD. Dietary fiber and protein fermentation in the intestine of swine and their interactive effects on gut health and on the environment: A review. Anim Feed Sci Technol, Feb. 1, 2016; 212: 18–26.
9. Cosme F, Inês A, Vilela A. Consumer's acceptability and health consciousness of probiotic and prebiotic of non-dairy products. Food Research International, Jan. 1, 2022; 151.
10. Mirjalili MH, Moyano E, Bonfill M, et al. Steroidal lactones from *Withania somnifera*. **Phytochemistry,** 2009; 70: 1241-9.
11. Chandrasekhar K, Kapoor J, Anishetty S. Clinical evaluation of Ashwagandha for stress and immunity. **Indian J Psychol Med.,** 2012; 34: 255-62.
12. Cohen MM. Tulsi (*Ocimum sanctum*): A herb for all reasons. **J Ayurveda Integr Med.,** 2014; 5: 251-9.
13. Pattanayak P, Behera P, Das D, Panda SK. Ocimum sanctum: Pharmacological review. **Pharmacogn Rev.,** 2010; 4: 95-105.
14. Singh J, Singh N. Jaggery: A traditional sweetener with health benefits. **J Food Sci Technol,** 2013; 50: 623-31.
15. Wood PJ. Oat β-glucan and immune function. **Cereal Chem.,** 2010; 87: 315-30.
16. Vetvicka V, Vetvickova J. β-Glucans and immune modulation. **J Nutr Biochem,** 2014; 25: 1-10.
17. Alasalvar C, Bolling BW. Nutritional and health benefits of tree nuts. **Br J Nutr.,** 2015; 113: S68-78.
18. Farmerette Foods Pvt. Ltd. *Zero-maida millet moringa cookies – product description and nutrition claims*. Retrieved from official product catalogue/retailer listing, 2024.
19. Nutriwala Agro Products. (2023). *Moringa biscuits with jaggery – ingredients and health benefits*. Company product information sheet.

20. Doctor Moringa India. (2024). *Moringa healthy cookies – herbal nutrition snack*. Product label and marketing description.
21. Vriksha Organics. (2023). *Whole-wheat moringa cookies – nutritional product profile*. Brand product literature.
22. Healthy Binge Foods. (2024). *Moringa jowar baked snack – functional millet snack.* Product specification sheet.
23. Moringa Miracle. (2023). *Millet-moringa cookies – antioxidant functional cookies*. Manufacturer product details.