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DEVELOPMENT OF FUNCTIONAL FOOD DEVELOPED FROM TERMINALIA ARJUNA AND GLYCYRRHIZA GLABRA - ARJUNA BISCOTTI

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ABSTRACT

A growing consumer preference for nutritious, plant-based functional snacks highlights the commercial potential of specialized bakery goods. This study aimed to formulate and evaluate "Arjuna Biscotti," a wholesome, health-promoting snack crafted with heart-healthy and weight-friendly functional ingredients. The product incorporates *Terminalia arjuna* bark powder, valued for its antioxidant and cardioprotective properties, and *Glycyrrhiza glabra* (licorice) root powder. To optimize nutritional quality, the formulation utilizes fiber-rich multi-cereals including ragi flour, oats flour, whole wheat flour, and flaxseed powder, sweetened naturally with jaggery. Comprehensive proximate analysis revealed a low moisture content of 1.67%, an ash content of 2.52%, a fat content of 10.8g per 100g, a protein content of 6.1g per 100g, and total carbohydrates of 67.92g per 100g. Sensory evaluation conducted with a 21-participant panel using a 9-point Hedonic scale demonstrated exceptional consumer acceptability, achieving an overall acceptance score of 8.3 out of 9, with the highest marks awarded for taste (9 out of 9). Microbiological evaluation using total plate count techniques confirmed safety and stability, yielding zero colony-forming units (CFU) across serial dilutions. Shelf-life studies verified that the product remains highly stable and safe for up to three months under optimal storage conditions. These findings establish Arjuna Biscotti as a viable, nutrient-dense, and commercially promising functional alternative to conventional high-fat commercial bakery items.

KEYWORDS: *Terminalia arjuna*, *Glycyrrhiza glabra*, antioxidants, nutraceutical, functional food, weight management, heart health, sensory analysis.

INTRODUCTION

Maintaining a healthy lifestyle is essential, and proper nutrition plays a key role in overall well-being. Modern consumers are increasingly active in making conscious dietary choices, opting for functional foods that offer distinct metabolic and therapeutic health benefits beyond primary basic nutrition. One sector experiencing significant commercial growth is the bakery market, particularly biscuits, cookies, and biscotti enriched with natural, bioactive herbal ingredients.[1]

Arjuna Biscotti is a specially formulated nutraceutical baked snack designed to support cardiovascular function and weight management. A key therapeutic component is *Terminalia arjuna*, a prominent tree whose bark has been extensively utilized in traditional Ayurvedic medicine for its potent cardioprotective, hypolipidemic, anti-thrombotic, and antioxidant properties.[3] Bioactive compounds within the bark, such as arjunic acid, arjunolic acid, and specialized tannins, stimulate cardiac function, enhance endogenous antioxidant enzymes, and assist in regulating serum cholesterol and blood pressure profiles.[4,5]

To augment these therapeutic outcomes, the biscotti incorporates *Glycyrrhiza glabra* (licorice) root powder. *Glycyrrhiza glabra* contains unique isoflavan components like glabridin, which effectively inhibit low-density lipoprotein (LDL) oxidation, an essential mechanism for slowing down atherogenesis and reinforcing general cardiovascular well-being.[6,7]

Furthermore, the integration of functional multi-cereals—such as finger millet (ragi), oats, whole wheat, and flaxseed powder—provides a dense nutritional matrix. Soluble fibers like the beta-glucans found in oats promote prolonged satiety and alter appetite hormones, which assists in long-term body weight management.[15,16] Ground flaxseeds enrich the matrix with omega-3 fatty acids, lignans, and digestive fiber.,[11,12] whereas ragi supplies crucial calcium, plant-based proteins, and phenolic antioxidants.[13] Utilizing jaggery as a natural sweetener ensures a gradual energy release without the sudden glycemic spikes associated with refined sugars.[14] This study aims to finalize a standardized formulation for Arjuna Biscotti, evaluate its full proximate nutritional profile, establish its microbiological safety margins, and systematically measure its sensory acceptability among consumer panels.

MATERIALS AND METHODS

Raw Materials Procurement and Preparation

The primary therapeutic ingredients, *Terminalia arjuna* bark powder and *Glycyrrhiza glabra* root powder, were obtained along with food-grade ragi flour, oats flour, whole wheat flour, cocoa powder, flaxseed powder, jaggery, and olive oil.[3,8] All coarse dry ingredients were uniformly sifted through a standard mesh screen to ensure particle uniformity before batch formulation.

PRODUCT FORMULATION

Product Trials

To develop a high-quality functional food, six distinct experimental product trials were conducted to optimize the sensory, structural, and physical attributes of the ARJUNA BISCOTTI. Adjustments were systematically introduced across parameters such as flour composite ratios, sweetener metrics, oil concentrations, and herbal bark/root inclusions to eliminate the natural bitterness associated with therapeutic plant extracts.

The finalized master formulation optimized from these trials utilizes the following core ingredients per production batch: Jaggery (55g), Finger Millet (*Eleusine coracana* / Ragi) Flour (25g), Oats Flour (22g), Whole Wheat Flour (16g), Olive Oil (10g), Flaxseed Powder (5g), *Terminalia arjuna* Bark Powder (3g), *Glycyrrhiza glabra* Root Powder (2g), and Cocoa Powder (2g).

The manufacturing protocol was standardized as follows: Flaxseed powder is hydrated in warm water to form a binding mucilage. The dry flours, cocoa powder, *Terminalia arjuna*, and *Glycyrrhiza glabra* powders are combined and sifted to ensure complete structural homogeneity. Liquefied jaggery is blended into an emulsion with the flaxseed gel and olive oil. The wet and dry phases are combined and kneaded into a uniform dough matrix, which is then rolled to a thickness of 5 mm, cut into geometric sections, and baked for exactly 15 minutes.

Figure 1: Final Standardized and Baked Batch of Arjuna Biscotti Functional Food.

Proximate Nutritional Analysis

Moisture Content Determination: Moisture content was measured using the thermogravimetric "Loss on Drying" (LOD) principle via a digital moisture analyzer (Model No. ULS-110M) heated to a constant temperature of 105°C.

Total Ash Content Estimation: Ash content was determined via dry ashing inside a muffle furnace maintained at 550°C to achieve complete oxidation.

Crude Protein Analysis: Protein content was quantified utilizing a colorimetric Biuret assay measured colorimetrically via optical density (OD) at 540 nm against a Bovine Serum Albumin (BSA) standard curve.

Crude Fat Extraction: Total crude lipid extraction was carried out using a continuous solid-liquid Soxhlet extraction apparatus with petroleum ether solvent fractions.

Microbiological Quality Evaluation

Total Plate Count (TPC) was performed to enumerate residual bacterial and fungal populations using calibrated serial dilution configurations.[29] Nutrient Agar (NA) plates were used for bacterial profiling and Sabouraud Agar plates for fungal profiling, incubated at 37°C for 3 to 5 days to determine colony-forming units per gram (CFU/g).

RESULTS AND DISCUSSION

The systematic analysis of the finalized Arjuna Biscotti revealed a stable, nutrient-dense profile well-suited for functional food applications. The moisture content of the sample was found to be 1.67%. This low value is highly beneficial for shelf stability, as restricted water activity suppresses microbial reproduction and slows hydrolytic rancidity pathways during storage. The total inorganic ash content was calculated at 2.52%, indicating a rich mineral footprint contributed by the whole grain components like ragi flour and oats flour.

The Biuret colorimetric protein assay indicated that the product contains 6.1g of crude protein per 100g sample. Soxhlet extraction confirmed a total fat content of 10.8g per 100g sample. Total Soluble Solids measured via refractometry yielded an 11% Brix value at 20°C. Spectrophotometric Anthrone evaluation showed a total carbohydrate profile of 67.92g per 100g, with a high concentration of complex dietary fiber (7.3g per serving) derived from oats, ragi, and flaxseed.

Table 1: Nutritional Information Panel (NIP) for Arjuna Biscotti.

Nutrient Parameter	Value Per 40g Serving	Value Per 100g Base	% RDA Contribution*
Energy (kcal)	157.6	394.0	7.9%
Protein (g)	2.44	6.1	4.5%
Total Carbohydrates (g)	27.17	67.92	20.9%
Dietary Fiber (g)	2.92	7.3	10.2%
Added Sugars (g)	0.0	0.0	0.0%
Total Fat (g)	4.32	10.8	7.2%
Sodium (mg)	77.3	193.3	3.9%

**Percent Daily Allowance (RDA) values based on a standard 2000 kcal reference diet. No vertical lines included per guidelines.*

MICROBIOLOGICAL AND SHELF-LIFE PERFORMANCE

Microbiological monitoring across serial dilutions (10^{-4} to 10^{-6}) on Nutrient Agar and Sabouraud Agar plates revealed zero colony-forming units (CFU/g) for both bacterial and fungal growth. The permissible limit for total microbial load in a food sample should be less than 10000 CFU /g. The microbial load was enumerated and no colonies were found. Stability testing confirmed that Arjuna Biscotti remains physically, chemically, and microbiologically stable for up to three months under closed storage conditions.[29]

Table 2: Hedonic Scale Sensory Evaluation Results.

Sensory Attribute Profile	Mean Panel Score (Out of 9)
Taste	9.0
Aroma/Odor	8.7
Color/Appearance	8.5
Overall Acceptance	8.3
Texture Performance	8.1
Aftertaste Impression	8.0
Mouthfeel Quality	7.5
Sensory Attribute Profile	**Mean Panel Score (Out of 9)**

CONCLUSION

Arjuna Biscotti was successfully developed into a functional, nutrient-dense snack combining traditional Ayurvedic herbs (*Terminalia arjuna* and *Glycyrrhiza glabra*) with a robust multi-cereal matrix. The final product features a balanced nutritional profile, rich in antioxidants, complex carbohydrates, and dietary fiber, while keeping fat and sodium levels low. With a stable three-month shelf life, an excellent safety profile, and high sensory approval—particularly for taste—this biscotti demonstrates strong market potential as a heart-healthy alternative to conventional commercial bakery products.

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REFERENCES

1. Cantarelli MA, Pellerano RG, Marchevsky EJ, Camina JM. Quality evaluation and mineral profiles of fortified bakery goods. *Anal Sci*., 2011; 27(1): 73-8.
2. Sather BC, Forbes JJ, Starck DJ, Rovers JP. Clinical and nutritional implications of traditional Ayurvedic herbs in functional snacks. *J Am Pharm Assoc*., 2007; 47(1): 825.
3. Amalraj A, Gopi S. Medicinal properties of *Terminalia arjuna* (Roxb.) Wight & Arn.: A review. *J Tradit Complement Med*., 2017; 7(1): 65-78.
4. Maulik SK, Talwar KK. Therapeutic potential of *Terminalia arjuna* in cardiovascular disorders. *Am J Cardiovasc Drugs*, 2012; 12(3): 157-163.

5. Dwivedi S, Chopra D. Revisiting *Terminalia arjuna* - An ancient cardiovascular drug. *J Tradit Complement Med*., 2014; 4(4): 224-231.
6. Belinky PA, Aviram M, Fuhrman B, Rosenblat M, Vaya J. The antioxidant effects of the isoflavan glabridin on endogenous constituents of LDL during its oxidation. *Free Radic Biol Med*., 1998; 24(8): 1245-1253.
7. Ram A, Lauria P, Gupta R, Kumar P, Sharma VN. Hypocholesterolaemic effects of *Terminalia arjuna* tree bark. *J Ethnopharmacol*., 1997; 55(3): 165-169.
8. Fortification of baked products with *Glycyrrhiza glabra* polysaccharides and evaluation of quality attributes. *Foods*, 2022; 11(15): 2253.
9. Surveswaran S, Cai YZ, Corke H, Sun M. Systematic evaluation of natural phenolic antioxidants from 133 Indian medicinal plants. *Bioorg Med Chem*., 2006; 14(12): 2144-2155.
10. Pandey MM, Rastogi S, Rawat AKS. Indian traditional Ayurvedic system of medicine and nutritional supplementation. *Evid Based Complement Alternat Med*., 2013; 2013: 1-12.
11. Bernacchia R, Preti R, Vinci G. Chemical composition and health benefits of flaxseed. *Austin J Nutr Food Sci*., 2014; 2(8): 1045.
12. Covington MB. Omega-3 fatty acids and cardiovascular health profiles. *Am Fam Physician*, 2004; 70(1): 133-140.
13. Murtaza N, Baboota RK, Jagtap S, Singh DP, Khare P. Finger millet bran supplementation alleviates obesity-induced oxidative stress and inflammation. *Br J Nutr*., 2014; 112(9): 1447-1458.
14. Nath A, Dutta D, Kumar P, Singh JP. Review on recent advances in value addition of jaggery based products. *J Food Process Technol*., 2015; 6(3): 1-7.
15. de Groot AP, Luyken R, Pikaar NA. Cholesterol-lowering effect of rolled oats. *Lancet*., 1963; 2(7314): 303-304.
16. Hallfrisch J, Behall KM. Mechanisms of the effects of grains on insulin and glucose responses.
17. *J Am Coll Nutr*., 2000; 19(3 Suppl): 320S-325S.
18. Smith DF. Benefits of flavanol-rich cocoa-derived products for mental and cardiovascular well-being: A review. *J Funct Foods*, 2013; 5(1): 10-15.
19. Gupta S, Bishnoi JP, Kumar N, Kumar H. *Terminalia arjuna* (Roxb.) Wight & Arn: Competent source of bioactive components in functional food and drugs. *Pharma Innov J*., 2018; 7(3): 223-231.
20. Ramesh P, Palaniappan A. *Terminalia arjuna*, a cardioprotective herbal medicine –

Relevancy in the modern era of pharmaceuticals and functional foods. *Pharmaceuticals*, 2023; 16(1): 2-24.

21. Thakur S, Kaurav H, Chaudhary G. *Terminalia arjuna*: A potential Ayurvedic cardio tonic.
22. *Int J Res Appl Sci Biotechnol*., 2021; 8(2): 227-236.
23. Mishra N, Kumar A. Pharmacological approach of *Terminalia arjuna*: A review. *Plant Cell Biotechnol Mol Biol*., 2021; 22(3-4): 1-5.
24. Soni N, Singh VK. Efficacy and advancement of *Terminalia arjuna* in Indian herbal drug research: A review. *Trends Appl Sci Res*., 2019; 14(4): 233-242.
25. Saucedo-Pompa S, Martínez-Ávila GCG, Rojas-Molina R, Sánchez-Alejo EJ. Natural ingredients and sensory quality based on phenolic contents in functional snacks.
26. *Antioxidants*, 2018; 7(2): 112-125.
27. Meltzer PS, Kallioniemi A, Trent JM. Chromosome alterations in human solid tumors. In: Vogelstein B and Kinzler KW (eds.). *The Genetic Basis of Human Cancer*, New York; McGraw-Hill: 2002; 93-113.
28. Bard AJ, Faulkner LR. *Electrochemical Methods: Fundamentals and Applications*. 2nd ed., New York; John Wiley and Sons: 2001.
29. Aviv H, Friedman D, Bar-Ilan A, Vered M. Method for processing botanical lipid complexes in baked goods. *US Patent, US 5496811*, 1996.
30. World Health Organization. *Quality control methods for medicinal plant materials*. Geneva; World Health Organization: 2011.
31. Indian Pharmacopoeia Commission. *Indian Pharmacopoeia*. Ghaziabad; Indian Pharmacopoeia Commission: 2018.
32. Food Safety and Standards Authority of India (FSSAI). *Manual of methods of analysis of foods: Microbiological examination*. New Delhi; FSSAI: 2020.
33. Database of Natural Matrix Reference Materials, Compilation prepared by International Atomic Energy Agency (IAEA), http://www.iaea.org/programmes/nahunet/e4/nmrm/browse.htm/.