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Original Article

Formulation And Evaluation Of Nutritious Multivitamin-Fortified Cookies

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ABSTRACT

Functional food products that have benefits beyond basic nutrition are being sought more frequently than previously. Researchers formulated and completed a physicochemical analysis of a cookie made with ragi flour (*Eleusine coracana*), moringa leaf powder (*Moringa oleifera*), triphala, fennel seed (*Foenicu-lum vulgare*), cinnamon (*Cinnamomum verum*), roasted black gram (*Vigna mungo*), jaggery, honey, and ghee to create a polyherbal multivitamin-fortified cookie. Three different formulations of the cookie (B1, B2, and B3) were analyzed for organoleptic properties, physical characteristics, phytochemicals, proximate/nutritional composition, and antioxidant activity using DPPH and TLC bioautography. The third formulation (B3) had the highest sensory ratings (texture: 8.0; palatability: 7.9; appearance: 7.6) as well as the best physical parameters (spread ratio: 9.91; diameter: 72.2 mm). Phytochemical screen-ing indicated the presence of alkaloids, glycosides, flavonoids, phenolic compounds, and carbohydrates. Proximate/nutritional analysis indicated that the cookies contained 420 kcal/100 grams with 4.2 mg of iron, 150 mg of calcium and 12 mg of Vitamin C per 100 g. The cookies were not contaminated with bacteria. Cookies made according to this formulation will serve as a tastily safe, nutritious functional snack that can help to alleviate marginal micronutrient deficiencies for people of all age groups.

Keywords: multivitamin cookie; nutrient fortification; *Moringa oleifera*; Triphala; ragi flour; functional food; DPPH assay; micronutrient deficiency; herbal ingredients.

INTRODUCTION

Worldwide, there are over two billion people affected by ”hidden hunger”, or micronutrient deficiency, with most of these individuals residing in low-and middle-income countries. [2].

Many people also have a sufficient number of calories and still have low amounts of the nec-essary vitamins and minerals, which affects their immune function, development of the brain, energy level, and increases their risk for chronic diseases. [3].

The WHO (World Health Organization) and FAO (Food and Agriculture Organization) ac-knowledge the need for the public to be able to obtain food that has been fortified as one of the most cost-effective methods for alleviating ”hidden hunger”. [1].

The widespread use of cookies across various demographics is due to their taste, convience, long shelf life, and the ease of getting them to consumers. Cookies provide a more enjoyable way of consuming essential vitamins and minerals than tablets or capsules, making it easier for children and eldery people to stick to their vitamin regimens. [7].

Most commercially available cookies have a high caloric content but low nutritional value, using refined flour, refined sugar, and synthetic fats with a little or no vitamins or minerals. Fortifying these cookies with herbal and natural substances may offer a way to fill nutritional gaps without requiring changes in consumer behaviour.

The present study formulates and evaluates a novel multivitamin-fortified cookie using five traditional Indian medicinal and nutritional ingredients: *Moringa oleifera*, Triphala, *Foenicu-lum vulgare*, *Cinnamomum verum*, and *Vigna mungo*, alongside ragi flour, jaggery, honey, and ghee [11].

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The current study will formulate, then evaluate, a new cookie that is fortified with multiple vitamins. The cookie will be made from ingredients that are common in traditional Indian medicine and nutrition:*Moringa oleifera*, Triphala, *Foeniculum vulgare*, *Cinnamomum verum*, and *Vigna mungo*, combined with ragi flour, jaggery, honey, and ghee [11].

These ingredients were selected because they have a large body of scientific evidence support-ing their nutritional and medicinal value in Ayurveda and modern nutritionScience. [4].

REVIEW OF LITERATURE

1. Jayakumari et al. (2023) reported that the polyherbal cookies made with cocoa powder, ashwagandha, moringa, triphala had superior immunomodulatory properties and nutrition when compared to regular store-bought cookie varieties. [4].

2. Pathak et al. (2021) formulated an ayurvedic cookie with omega-3s by using oat and wheat flour along with herb-based ingredients. The final product had a protein content that was significantly greater than commercially-available options. [5].

3. Agrawal and Kawde evaluated pumpkin seed powder at a 15% level of fortification were evaluated for their protein, fat, ash, crude fiber, antioxidant activity and vit. content; this formulation provided the highest amounts of all nutrients tested. [6].

4. Pattnaik and Mishra (2022) developed biscuits baked cookie product formulations con-taining multivitamin (vitamins A, D, B9 and B12) encapsulated nanoparticle fortifiers and found that the final cookie products showed excellent viabilty in terms of nutrient release from the encapsulated forms, as well as heat tolerance during baking. [7].

5. Salguero et al. analysed cookies made from combinations of carrot, lupin and barley flours and found that formulation F8 had the highest amounts of vitamin A (30 IU/100 g), calcium (182.40 mg/100 g) and iron (6/88 mg/100 g) as well as the highest scores during sensory evaluation. [8].

6. Maurya et al. (2021) evaluated multigrain cookies (made with wheat flour, corn flour and kodo millet) and found moisture levels between 3.56 and 4.18%; protein levels between 11.86% and 13.41%; and fat levels between 22.32% and 20.30%, with cookie sample T6 receiving the highest overall score in terms of quality. [9].

7. Suo et al. (2022) reformulated wheat cookies that utilized pulse flour (chickpea and lentil flours) in replacement of a percentage of wheat flour; cookies made in this manner resulted in a final product with 45 to 50% less sugar, more protein and fiber, and a lower predicted glycemic index than cookies made from all-purpose flour. [10].

AIM AND OBJECTIVES

Aim: To formulate and evaluate nutritious multivitamin cookies using ragi flour, moringa, Triphala, fennel, cinnamon, roasted black gram, dry fruits, jaggery, and honey and ghee to promote health and wellness through functionally ”healthy snacks”.

Objectives:

1. To develop a multi-vitamin fortified cookie that contains beneficial nutrition/herbs, and is made with natural sweeteners,
2. To assess cookie nutrition based on vitamins, minerals, protein(s), and fibre.
3. To determine the functional properties of cookie (antioxidant activity, digestive activity)
4. To increase the sensory properties of the cookie through organoleptic evaluation per-formed on a 9-point scale (e.g., hedonic).
5. To conduct physicochemical analysis (e.g., spread ratio, ash content, moisture) of cook-ies.
6. To Test cookie-related antioxidant activity using DPPH free radical scavenging assay and TLC bioautography.

PLANT PROFILE

Moringa (*Moringa oleifera*)

Family: Moringaceae **Parts Used:** Leaves

Chemical Constituents: Vitamins A, C, E; calcium; iron; potassium; complete protein; quercetin; chlorogenic acid; isothiocyanates.

Role: Multivitamin and mineral source; immunity enhancement; anti-inflammatory; antioxi-dant [11].

Triphala

Source: Equal parts of dried fruits of *Emblica officinalis* (Amla), *Terminalia chebula* (Hari-taki), and *Terminalia bellirica* (Bibhitaki).

Chemical Constituents: Polyphenols; flavonoids; tannins (ellagic acid, gallic acid); vitamin C; triterpenoids.

Role: Rich source of vitamin C and antioxidants; digestive support; detoxification; immunity booster [12].

Fennel (*Foeniculum vulgare*)

Family: Apiaceae **Parts Used:** Seeds

Chemical Constituents: Volatile oils (anethole, fenchone, limonene); flavonoids (luteolin, quercetin); phenolic acids; vitamins C and A.

Role: Source of vitamins C and A; carminative; flavour enhancement [20].

Cinnamon (*Cinnamomum verum*)

Family: Lauraceae **Parts Used:** Inner bark

Chemical Constituents: Cinnamaldehyde; eugenol; cinnamyl acetate; polyphenols; phlo-batannins; trace vitamins A, K, B-complex.

Role: Blood glucose regulation; antioxidant; antimicrobial; natural preservative [13].

Ragi (*Eleusine coracana*)

Family: Poaceae **Parts Used:** Grain (flour)

Chemical Constituents: Starch (65–75%); dietary fibre (15–20%); protein (7–8%); calcium (344 mg/100 g); iron; polyphenols.

Role: Carbohydrate and fibre base; highest calcium among food grains; gluten-free; low gly-caemic index [15].

MATERIALS AND METHODS

Materials

Herbal Ingredients: *Moringa oleifera* (drumstick) leaf powder, triphla powder, cinnamon powder, fennel powder, and roasted black gram were obtained from a certified Ayurvedic herbal supply company in Pune, Maharashtra and authenticated at the Department of Pharmacognosy, KSS College of Pharmacy, Shikrapur.

Food Ingredients: Ragi flour, jaggery powder, honey, ghee, almonds, cashews, cocoa powder, baking soda, baking powder, and salt were purchased from a certified local supplier.

Instruments: Digital weighing scales, Phoenix gold (300), digital pH meters (Calibration at pH 4,7,9) UV-Visible spectrophotometer, TLC silica plates, Vernier Calliper, Muffle Furnace and Soxhlet apparatus were used to measure and prepare the experiments.

Formulation Composition

The three formulations were prepared using a combination of different ratios of ingredients as listed in the table of contents 1 The role of each ingredient is summarised in Table 2.

Sr.	Ingredient	Batch 1	Batch 2	Batch 3
1	Triphala powder	5 mg	8 mg	15 mg
2	Moringa powder	5 mg	8 mg	15 mg
3	Ragi flour	20 mg	30 mg	60 mg

4	Cocoa powder	5 mg	8 mg	10 mg
5	Jaggery powder	50 mg	70 mg	125 mg
6	Almonds	5 mg	5 mg	5 mg
7	Walnuts	5 mg	5 mg	5 mg
8	Milk	0.5 mL	1 mL	1 mL
9	Baking powder	0.5 mg	1 mg	1 mg

Table 1: Composition of Multivitamin-Fortified Cookie Formulations

Sr.	Ingredient	Functional Role
1	Moringa	Multivitamin and mineral source (vitamins A, C, E; iron; calcium)
2	Black gram	Rich source of vitamins A, K, E; plant protein
3	Fennel	Source of vitamins C and A; carminative; flavour enhancer
4	Honey	Natural sweetening agent; antimicrobial; humectant
5	Cinnamon	Blood sugar regulation; antioxidant; natural preservative
6	Triphala	Vitamin C and antioxidant source; digestive support
7	Ragi flour	Carbohydrate base; bone health (calcium); weight management
8	Jaggery	Natural sweetener; iron and mineral source
9	Ghee	Binding agent; fat-soluble vitamin carrier

Table 2: Role of Ingredients in the Formulation

Developmental Trials

Three trials were conducted:

- **Batch 1:**Minimum level of herb used in formulation of cookies illustrated acceptable cookie structure and below average sensory evaluation due to not enough visible herb in cookie.
- **Batch 2:** Mediate level of herb used in formulation of cookies illustrated improved sen-sory evaluation, but texture and palatability required optimization.
- **Batch 3 (Selected):** Maximum level of herb used in formulation of cookies illustrated maximum sensory evaluation, optimum spread ratios, and highest nutritional profile were made at time of final cookie formulation.

Formulation Procedure

1. Jaggery powder was mixed with ghee to create a light and fluffy mixture, then honey was added to it.
2. All of the dry ingredients (ragi flour, herbs, cocoa powder, baking soda and baking pow-der) were combined together using a sieve prior to folding into the wet ingredients a little bit at a time.
3. The milk was then added in small amounts until the dough reached a desirable consis-tency.

4. Chopped almonds (badam), cashews (kaju), and roasted black gram (til) were carefully mixed into the dough after preparing it.

5. After letting the dough rest for 20-30 minutes, the dough was rolled into equal round discs with a diameter of about 2.5 cm and baked in an oven at 175◦C for about 10-12 minutes.

the cookies were fully cooked, they were transferred to a cooling rack where they could cool completely before being placed in an air-tight container.

Evaluation Methods

Organoleptic evaluation:A panel of ten semi-trained evaluators evaluated the foods based on appearance, color, odor, texture, palatability, and size, rated by the use of a 9-Point Hedonic Scale.

Physical evaluation: Diameter and thickness of each food product were measured using a digital Vernier calliper. Spread ratio calculated as:

$$\text{Spread Ratio} = \frac{\text{Diameter (mm)}}{\text{Thickness (mm)}} \quad (1)$$

Phytochemical screening: Alkaloids, glycosides, flavonoids, phenols, saponins, tannins, steroids and carbohydrates in the ethanolic and aqueous extracts were screened according to Standard Procedures. [18].

Nutritional analysis: The proximate analysis of carbohydrate, protein, fat, ash, and crude fibre was performed using the AOAC (2000) procedures. Protein was determined by the Kjel-dahl method; fat by the Soxhlet method; ash by way of the muffle furnace; crude fibre by the enzymatic-gravimetric method; and carbohydrate by difference. [21].

Antioxidant activity — DPPH assay: Methanolic extracts tested at 1 mg/mL; absorbance at 515 nm and quercetin as standard. %RSA calculated as:

$$\%\,\text{RSA} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \quad (2)$$

TLC bioautography: Extracts processed in TLC silica plates (Merck, F245) using toluene:ethyl acetate:formic acid (4:5:1); sprayed with 0.2% DPPH in methanol; examined in daylight after 30 minutes.

Microbial testing: The samples were inoculated onto both nutrient and Sabouraud dextrose agar followed by an incubation period of 48 hours at 37◦C degrees Celsius.

RESULTS AND DISCUSSION

Organoleptic Properties

Batch 3 consistently achieved the highest scores in all sensory parameters (Table 3). The ad-vanced sensory characteristics are related to the greater amounts of moringa and Triphala as powders, as well as their influence on a greater range of taste perceptions and on the quality of the final product through the addition of ragi flour to enhance structural strength due to the increased amount of ragi flour. This finding correlates to previous work done by Jayakumari et al. [4], where they reported their 4.5% polyherb formula had the highest overall quality.

Sr.	Parameter	Batch 1	Batch 2	Batch 3
1	Appearance	7.4	7.3	**7.6**
2	Colour	6.8	7.4	**6.9**
3	Odour	6.5	6.8	**7.6**
4	Texture	6.1	7.5	**8.0**
5	Palatability	6.7	7.3	**7.9**
6	Size	7.2	2.6	**8.0**

Table 3: Organoleptic Properties (9-point Hedonic scale)

Physical Parameters

The highest quantity of spread is shown by batch 3 with the highest spread ratio of 9.91 and the largest diameter at 72.2 millimeters (Table 4), which implies a better spread of cookies during baking. Generally, a higher spread ratio is associated with a favorable texture and mouthfeel for cookies [9].

Sample	Thickness (mm)	Diameter (mm)	Spread Ratio
Batch 1	7.23	71.6	9.90
Batch 2	7.34	71.1	9.68
Batch 3	7.28	72.2	**9.91**

Table 4: Physical Parameters of Multivitamin-Fortified Cookies

Phytochemical Screening

Phytochemical analysis identified alkaloids, glycosides, flavonoids, phenols, and carbohydrates as present in all three batches (Table 5); however, saponins, steroids and tannins were absent. The flavonoids and phenols detected in this study have been previously established to possess immunomodulatory and antioxidant properties [17] . As such, their presence adds to validate claims of moringa, triphala, and cinnamon as functional therapeutic ingredients.

Phytochemical	Test	B1	B2	B3
Alkaloids	Dragendorff's	+	+	+
Glycosides	Keller-Killiani	+	+	+
Flavonoids	Shinoda	+	+	+
Phenols	$FeCl_3$	+	+	+
Carbohydrates	Molisch's	+	+	+
Saponins	Foam test	–	–	–
Steroids	Salkowski	–	–	–
Tannins	Lead acetate	–	–	–

Table 5: Phytochemical Screening Results

+ = present; – = absent

Nutritional Composition

The 100-g nutritional profile of Batch 3 is shown in the 6. Ragi flour and moringa powder contribute significantly to the high iron (4.2 mg/100 g) [15] level found in the base of the cookies. Ragi flour provides calcium (150 mg/100 g), making it an excellent source of plant-based calcium [16]. The vitamin C (12 mg/100 g) content is predominantly from the Triphala component [12]. The protein in the cookies (6.5 g/100 g) is primarily contributed by black gram and almond [19]. Polyherbal cookies developed for this market provide more carbohydrates, proteins and dietary fibres than currently available multigrain cookies.

Nutrient	Value	Unit
Energy	420	kcal
Protein	6.5	g
Total Carbohydrates	58	g
Natural Sugars	19	g
Dietary Fibre	7	g
Total Fat	16	g
Saturated Fat	6	g
Iron	4.2	mg
Calcium	150	mg
Vitamin C	12	mg
Vitamin B Complex	Present	—

Table 6: Nutritional Composition of Batch 3 (per 100 g)

Antioxidant Activity

The most effective DPPH radical scavenging activity was shown to occur with batch 3 of the formulations compared to batches 1 and 2 due to having a higher amount of moringa, triphala and cinnamon. Bioautographic TLC showed bright yellow zones of inhibition against DPPH radicals after 30 minutes which indicated there were active free radical

scavenging compounds that compared similarly to the quercetin standard [4, 17].

Microbial Testing

After a 48 hour incubation period at 37°C, there was no evidence of microbial growth on either nutrient agar or Sabouraud dextrose agar. This demonstrates the microbiological safety of the formulation given these test conditions.

CONCLUSION

A highly nutritious cookie fortified with multi vitamins, using five different herbs (*Moringa oleifera*, Triphala, *Foeniculum vulgare*, *Cinnamomum verum*, and *Vigna mungo*) combined with ragi flour, jaggery, honey, and ghee, has been successfully developed and evaluated. The optimised Batch 3 cookie formulation exhibited a spread ratio of 9.91, excellent organoleptic properties (palatability: 7.9; texture: 8.0), and provided approximately 420 kcal/100 g with adequate amounts of iron (4.2 mg), calcium (150 mg), and vitamin C (12 mg) per 100 g of product.

Phytochemical screens of the ingredients indicated they contain bioactive compounds that help enhance the immune system (e.g., the presence of alkaloids, glycosides, flavonoids, and phe-nols) and there was significant DPPH antioxidant activity, thus indicating the functional benefits of the herbs incorporated into the cookie formulations. The absence of microbial contamination indicates that the cookies are microbiologically safe. The cookies will make a good nutraceu-tical alternative to provide nutrients that will improve the immune system and or serve as a source of nutrients for all ages. Therefore, the traditional Ayurvedic (i.e., ancient Indian) prin-ciples of nutrition can be integrated with modern functional food technology as a solution to micronutrient deficiencies and health problems related to lifestyle.

Future work should focus on conducting accelerated stability studies and clinical bioavailability studies, followed by using the information from these studies to scale up production of the cookies for commercial use in compliance with the Fortification of Foods Regulations, Food Safety and Standards Authority of India, 2018.

FUTURE SCOPE

1. **Product diversification:** Formulations that are formulated based on a person's age in-clude: Pregnant women get iron and folic acid; Children and older people get calcium and Vitamin D; Immune support B-Complex Zinc is provided for adults.

2. **Technological advancement:** Microencapsulated vitamins C & B12 will protect them from heat destruction during the baking process thereby increasing retention, and (in-creased) bioavailability.

3. **Commercial scope:** The Product may be used in School Feeding Programs, Hospital Nutritional Supplementation and in Retail Health Food Store (with Organic Certification & Eco-friendly Packing).

4. **Regulatory compliance:** The Fortified Product must comply with the FSSAI - Fortifica-tion Regulations 2018, BIS (Bureau of Indian Standards) Standards and Codex Alimen-tarius Guidelines to be Marketable in both Indian and International Markets.

5. **Research and development:**Standardization will be performed using HPTLC and HPLC. There will be clinical trials in various populations, and exploratory studies for additional Ayurvedic herbs that have enhanced nutritional and therapeutic properties.

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