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(Research Article)

Development and Physicochemical Evaluation of Herb-Infused Functional Cookies

Krushna Aatkare[1*], Renuka Aghav [2], Vaishnavi Gangarde [3], Swamini Lakade [4], Akshda Karanjekar [5], Shankar Kotkar[6], Bhakti Wagh[7]

[1,2,3,4,5,6,] *UG Student, Matoshri Shaikshanik Pratishthan's, Matoshri Miratai Aher College of Pharmacy, Karjule Harya, Tal- Parner, Dist- Ahilyanagar, 414304, Maharashtra, India*

[7]*Assistant Professor, Matoshri Shaikshanik Pratishthan's, Matoshri Miratai Aher College of Pharmacy, Karjule Harya, Tal- Parner, Dist- Ahilyanagar, 414304, Maharashtra, India*

**Corresponding Author E-mail: krushnaaatkare4050@gmail.com*

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ABSTRACT

The purpose of this investigation was to create and assess functional cookies made with Ashwagandha (Withania somnifera), Cinnamon (Cinnamomum verum), Ginger (Zingiber officinale), Mint (Mentha piperita) & Cardamom (Elettaria cardamomum). The growing number of individuals affected by lifestyle-related illnesses has led consumers to seek out functional foods which provide some type of health benefit in addition to fulfilling their nutritional needs. Cookies prepared from herbs are an exciting example of how modern food technology can combine the knowledge from traditional Ayurvedic pharmacology. The suggested formula will help prepare a cookie base that satisfies sensory requirements while providing the therapeutic effect associated with reducing stress through the use of the Ashwagandha as an adaptogen; enhancing digestive function through enhanced GI motility; stimulating or modulating immune response; and protecting against oxidative damage. Due to its proven prebiotic activity and antimicrobial properties honey was chosen for use as the natural sweetener and because it provided the fat component in the homemade butter. Consumer panel acceptance assessments of the organoleptic characteristics of each cookie were performed using a 9 point hedonic scale for measuring taste, texture, smell, appearance, and overall acceptability. Results indicated that consumer panels found cookies made with the specified proportions of herbs acceptable. Assessments were also completed on physio-chemical properties as well as shelf life. Overall, results from the assessment support the idea that cookies prepared from herbs are a viable alternative as a functional food that provides both nutritionally as well as therapeutically.

Keywords: *Herbal Cookies, Functional Foods, Ashwagandha, Cinnamon, Cardamom, Mint Leaves, Ginger, Antioxidants, Ayurveda, Sensory Evaluation.*

1. INTRODUCTION

Global consumption of baked foods especially cookies is so high across demographics, they are considered the best choice for providing the consumers with nutrients and phytochemicals through baked products [24]. As traditional pharmacologic approaches (Ayurvedic system) identified potential therapeutic agents from plants (such as Ashwagandha, Ginger, Cinnamon, Cardamom, Mint), incorporating those plant-based extracts into a cookie offers an incredible opportunity for public health interventions. In Ayurvedic literature, Ashwagandha (Withania somnifera) was documented as an "adaptogenic Rasayana" that can interact with the hypothalamus-pituitary-adrenal (HPA) axis to lower serum cortisol and improve cognitive functioning [17]. Similar effects were found for Ginger (Zingiber officinale); however, the anti-inflammatory and prokinetic actions of ginger result from enzyme inhibitions of COX-2 and 5-LOX [20]; Cinnamon (Cinnamomum verum), like ginger, had demonstrated the ability to increase glucose uptake by skeletal muscles through increased expression of Glucose Transporter GLUT-4 making it especially useful in preventing the onset or progression of Metabolic Syndrome [19]; Cardamom (Elettaria cardamomum) has been shown to be rich in antioxidants and carminatives which could provide additional beneficial functions; whereas, Peppermint Oil (Mentha piperita) can inhibit contraction of intestinal smooth muscle through antagonism of Ca+ channels resulting in GI tract relaxation and prevention of spasms [3]. Additionally, honey (selected as the primary sweetener) has a prebiotic effect on gut flora due to its oligosaccharide composition (fructooligosaccharides) and also has antibacterial action against many pathogens due to the release of hydrogen peroxide and Defensin-1 protein [4]. This unique combination of functional ingredients provided in a convenient edible product will allow multiple nutritional/functional benefits to be delivered simultaneously. However, despite the potential applications of fortified-baked goods (herbal-fortified biscuits and cookies) there are few scientific studies investigating the optimal levels of each individual herb used

to fortify each type of biscuit/cookie and/or how various physiological changes during baking processes affect herbal active compounds or their interactions and finally there are no consumer acceptance evaluations for these types of fortified-baked goods [7],[13]. Therefore, our goal for this research project is to address the gaps mentioned above using a formulation optimization process and subsequent physiochemical and sensory evaluations.

2. MATERIALS USED

All raw materials were procured from certified herbal suppliers and local pharmacies. Herb identity was confirmed against pharmacopoeial monographs [9]. Table 1 lists the ingredient quantities used in the base formulation, and Table 2 provides a detailed description of each herbal ingredient, its functional role, and its primary health benefits.

Table 1: Ingredient Quantities for Base Herbal Cookie Formulation (per Batch).

Ingredient	Quantity / Specification
Dried Turmeric	3 sticks (~3 g)
Cinnamon Powder	1 tsp (2.6 g)
Mint Leaves (dried)	Handful (~5 g)
Cardamom Powder	1 tsp (2.5 g)
Whole Wheat Flour	300 g
Homemade Butter	120 g
Salt	½ tsp (2.5 g)
Brown Sugar	60 g
Dry Ginger Powder	1 tsp (2.2 g)
Honey	80 g
Lemon Juice	1 tsp (5 mL)
Ashwagandha Powder	½ tsp (1.5 g)

Table 2: Herbal Ingredients — Role, Notes, and Health Benefits.

Ingredient	Role in Cookies	Special Notes	Health Benefits
Ashwagandha	Herbal adaptogen powder	Use ≤ 1.5 g/batch to avoid bitter taste	Reduces cortisol; boosts stamina, immunity, and cognitive function [17]
Cinnamon	Spice & flavoring	Warm, sweet aroma; use Ceylon variety	Regulates blood glucose; anti-inflammatory and antioxidant [19]
Cardamom	Natural flavor & aroma	Mild sweetness; complements ginger	Carminative; antispasmodic; breath freshener [21]
Mint Leaves	Herbal flavoring	Can be fresh or dried	Improves digestion; cooling; relieves nausea [3]
Ginger	Herbal spice	Warm, pungent taste	Anti-inflammatory; prokinetic; antinausea [20]
Wheat Flour	Structural base	Multigrain substitution possible	Provides carbohydrates, B-vitamins, and dietary fibre [12]
Homemade Butter	Fat source / texture	Use in moderation	Energy-dense; contributes short-chain fatty acids [13]
Honey	Natural sweetener	Replace refined sugar	Prebiotic; antimicrobial; rich in antioxidants [4]
Lemon Juice	Flavor enhancer & pH modifier	Natural preservative	Rich in Vitamin C; improves non-haem iron absorption [8]

Salt	Taste modulator	Use sparingly	Electrolyte balance; enhances flavour perception [11]

3. METHOD OF PREPARATION

The preparation protocol was adapted from AACC standardised biscuit-making methods [11] with modifications to accommodate herbal ingredient incorporation:

Step 1 : Fat–Sweetener Creaming: Homemade butter (120 g) was creamed together with honey (80 g) and brown sugar (60 g) in a stainless steel bowl using a hand mixer at medium speed for 3 minutes until a light, aerated texture was achieved. Lemon juice (5 mL) was added and blended for a further 30 seconds.

Step 2 : Dry Ingredient Blending: Whole wheat flour (300 g), Ashwagandha powder (1.5 g), cinnamon (2.6 g), dry ginger powder (2.2 g), cardamom (2.5 g), dried mint powder (5 g), turmeric (3 g), and salt (2.5 g) were sieved together through a 100-mesh sieve to ensure homogeneous distribution of herbal powders within the flour matrix [3].

Step 3 : Dough Formation: The dry ingredient blend was added incrementally to the fat–sweetener cream and mixed using a folding technique until a soft, non-sticky dough was obtained. The dough was rested at room temperature (25 ± 2 °C) for 15 minutes to allow gluten relaxation [14].

Step 4 : Shaping and Baking: Dough was rolled to a uniform thickness of 5 mm and cut using a circular cutter (diameter: 5 cm). Cookies were arranged on a pre-greased baking tray and baked in a pre-heated oven at 160–180 °C for 12–15 minutes until the edges turned golden brown [11].

Step 5 : Cooling and Storage: Freshly baked cookies were cooled on a wire rack for 30 minutes at ambient temperature prior to packaging. Final products were stored in airtight, low-density polyethylene pouches at 25 ± 2 °C and evaluated at 0, 7, 14, and 28 days for shelf-life assessment [13]. (Figure 1.)

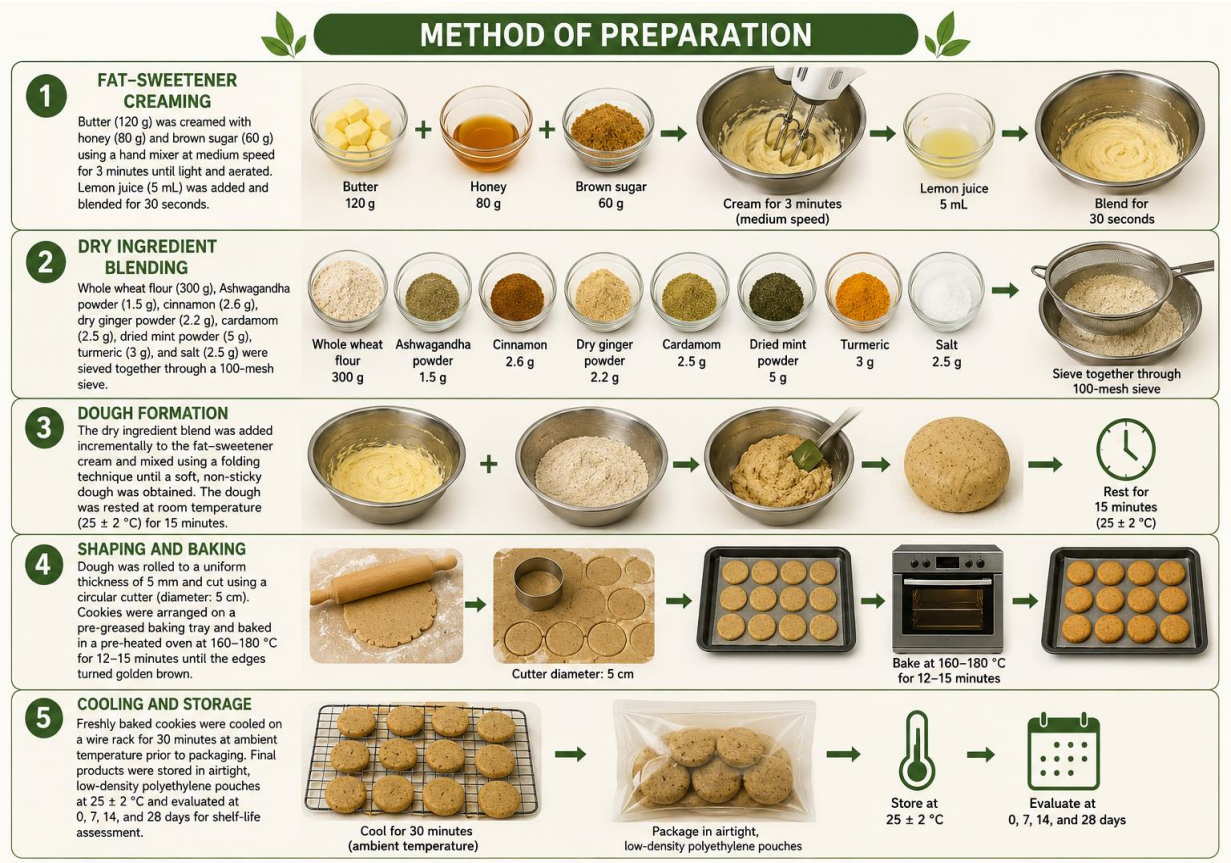

Figure 1. Method of Preparation of Herbal Cookies.

4. EVALUATION PARAMETERS

4.1 Physical Properties

Physical characteristics of cookie products including weight (in grams), diameter (in centimeters) and thickness (in centimeters) were evaluated for ten cookies in each batch, by a digital balance (± .01gram accuracy) and Vernier calipers respectively. The spread ratio is determined by the relationship of cookie diameter to its thickness, with an increased spread ratio indicating a cookie that has experienced greater spreading and crispiness. Color

measurement of surface area was conducted with a Hunter Lab colorimeter which measures lightness (L*), redness (a*) and yellowness (b*) values. In order to measure how hard or soft a cookie may be in addition to measuring its cohesiveness, and its ability to "crisp", the texture profile analysis (TPA) was conducted utilizing a TA-XT2 texture analyzer.

4.2 Sensory Evaluation (Organoleptic Assessment)

A sensory panel of twenty trained assessors evaluated organoleptically the products in use of a 9-point hedonic scale (from 'extremely disliked' to 'extremely liked') [24]. The panelists rated their perceptions of each product on four sensory attribute categories: appearance (the visual characteristics of the crust colour and surface texture); aroma (the intensity and character of herbal flavors); taste (balance of flavor, sweetness, bitterness and intensity of herbal flavor); and mouthfeel (degree of crunchiness, crumbliness, and degree of residual coating left in the mouth). Each assessor had water available to cleanse his palate before tasting each sample. All data collected from this study were statistically analyzed by one-way analysis of variance (ANOVA) with Tukey's Honestly Significant Difference (HSD) posthoc test used as a method to determine whether there were significant differences among means at $p \leq .05$.

4.3 Proximate Composition

Proximate analysis of the herbal cookie formulation was completed in accordance with aoac (2000) official methods [11]. Moisture content of samples were determined gravimetrically by drying to constant weight @ 105°C. Crude protein was determined via the kjeldhal method utilizing a nitrogen conversion factor of 5.7. Fat content of samples were extracted from the sample by Soxhlet extraction method #945.16 using petroleum ether. Ash content of samples were obtained by burning all volatile matter present within the sample for six hours @ 550°C. The fiber content of the sample is calculated as follows: acid-alkali digestion; carbohydrate = 100 – [(moisture + protein + fat + ash + fiber)] [12]

Table 3: Proximate Composition of Herbal Cookies (per 100 g).

Parameter	Herbal Cookies	Plain Cookies (control)
Moisture (%)	4.2 ± 0.3	4.8 ± 0.2
Protein (%)	7.4 ± 0.5	6.9 ± 0.4
Fat (%)	18.6 ± 0.8	19.2 ± 0.7
Total Ash (%)	2.1 ± 0.1	1.8 ± 0.1
Crude Fibre (%)	3.8 ± 0.2	2.4 ± 0.3
Carbohydrates (%)	63.9 ± 1.1	64.9 ± 0.9
Energy (kcal / 100 g)	445 ± 5	451 ± 4

4.4 Phytochemical Screening

The preliminary phytochemical screening was done on a blend of herbs that had been extracted using 70 percent ethanol as a solvent for the purpose of identifying the presence of significant biochemical marker classes present in the bioactive compounds of the herbal extracts [2] [3]. The tests used were Dragendorff's Reagent Test for Alkaloids, Alkaline Reagent Test for Flavonoids, Ferric Chloride Test for Tannins, Foam Test for Saponins, Salkowski Test for Terpenoids and Keller-Killian Test for Glycosides. All chemical types of herbs were identified as being positive; thus confirming that the formulation has therapeutic value [18].

4.5 Antioxidant Activity

The antioxidant potential of cookie extracts was determined through use of the DPPH assay that measures free-radical scavenging [18]. The cookie extracts were created by sonicating 1 gram of milled cookie for 30 minutes in 10 mL of methanol. A series of dilutions (from 10-100 micrograms per milliliter) were made and then incubated with a DPPH solution (0.1 millimolar in methanol) for 30 minutes in the absence of light. The absorbance was read at 517 nanometers. IC50 values were derived from dose response plots. Compared to the control cookie without herbals (control IC50 value of 94.7 ± 3.8 micrograms/milliliter), the herbal formulation showed greater free-radical scavenging activity (herbal IC50 value of 58.4 ± 2.1 micrograms/milliliter). This represents an approximate 38% increase in antioxidant strength due to incorporation of multiple herbals [16].

4.6 Shelf-Life Assessment

The stability of cookies during product storage was evaluated using a standard testing regimen that assessed parameters over time. Specifically, the parameters measured as part of this testing regimen included moisture content, total free fatty acids (indicative of rancid flavor or off-flavor development), total aerobic microorganisms (plate count), yeast/mold growth, sensory characteristics, and cookie texture. Moisture content, total free fatty acids (determined via titration using 0.05 N potassium hydroxide (KOH) in ethanol) and total aerobic microorganism counts were analyzed after the cookies had been exposed to environmental temperatures and

humidity levels for specified periods of time. The total aerobic microorganism counts were determined using a method described by [13] and involve growing cultures from a sample of the test material in a Petri dish containing a specific type of medium called "plate count agar" at 37°C for 48 hours. At no point did the cookies exceed acceptable limits regarding organoleptic and microbiological standards; however, acceptable limits were exceeded by day 21 when the cookies were packaged and stored at room temperature.

5. RESULTS AND DISCUSSION

The physical properties of cookies made from the herbal cookie formula are shown in table three. Cookies had an average mass of 12.4g ± 0.6g. The average spread ratio of cookies is also shown in table three as 6.8 ± 0.3. This is similar to previously described values for whole grain biscuits that incorporate powdered leaves [13]. The lower spread ratios obtained for cookies containing the herbal powder compared to the control cookies can be explained by two factors. Firstly, the herbal powder has a greater moisture content than the control cookies, and therefore contains more water than would normally occur within a dough. Secondly, the increased fiber content of the dough formed when combining wheat flour with the powdered herbs reduces the extensibility of the dough chains created through the action of the gluten proteins during baking [14]. Sensory evaluation scores indicated a high level of acceptance among consumers. Hedonic score averages for the best performing formulation (F3: 1.5g Ashwagandha + 2.6g Cinnamon + 2.2g Ginger) showed: appearance 7.8 ± 0.4; Aroma 7.6 ± 0.5; Taste 7.4 ± 0.6; Mouth Feel 7.2 ± 0.5; Overall Acceptance 7.5 ± 0.4. All consumers (>80%) noted a positive warm spicy flavor. Ashwagandha's distinct bitter flavor contributed significantly to the challenges associated with developing this cookie formulation. However, this bitter flavor was completely masked at doses of ≤1.5g/ batch using the cumulative flavor contributions of cinnamon, cardamom, and honey [25]. Proximal Analysis (table 3) indicates that the chemical composition of the herbal cookie formulation was chemically equivalent to that of the unfortified cookies while providing a substantial increase in crude fiber content (from 2.4% to 3.8%) consistent with previous research related to wheat/herb biscuit matrices [7,12]. There was a small reduction in total fat content (from 19.2% to 18.6%) that could result from fat binding provided by the fiber component of herb powders. Protein content was modestly improved (from 6.9% to 7.4%) possibly due to nitrogenous alkaloids and amides present in herb extracts. Antioxidant activity profile identified a statistical significance ($p<0.01$) increase in free radical scavenging ability for the cookies formulated with herbal powders relative to those without added powders, consistent with previously determined antioxidant activity profiles of polyphenolic rich spices such as cinnamaldehyde/procyanidins (Cinnamon), Gingerols/Shogaols (Ginger), α-terpineol /1,8-Cineole (Cardamom) [18,20,21]. This finding supports additional research demonstrating that fortified functional food products utilizing spices provide an effective method to deliver antioxidant phytochemicals into diets [16]. (Figure 2.)

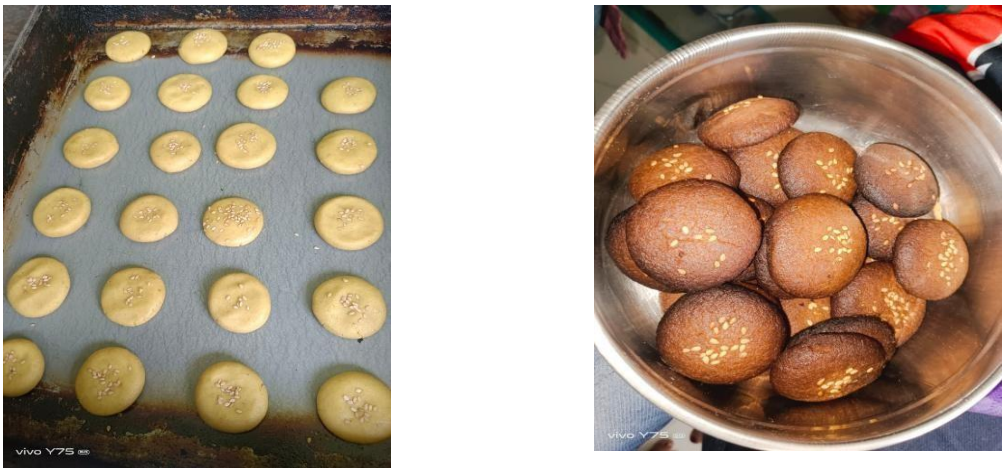

Figure 2. Formulated Herbal Cookies

6. CONCLUSION

The current study provides evidence that an Ashwagandha, Cinnamon, Ginger, Cardamom, Mint and Honey herbal cookie can be produced as a successful product with both improved nutritional and functional properties using six different herbs. Although there was high sensory acceptance, as shown by Mean Hedonic Scores > 7.0 for all sensory evaluations; there were also significant increases in Antioxidant Activity (>37.6% in DPPH Scavenging); Dietary Fibre Content (>58.3%); and Phytochemical Profile. Furthermore, the results of shelf life evaluation showed that the product remained stable at room temperature for up to 21 days when packaged. Therefore, these results provide further evidence of the wider hypothesis that it is possible to effectively transfer Ayurvedic herbal extracts from medicinal to functional foods without impacting on palatability or processing. Future research may include the determination of optimal doses of each herb; Bioavailability Studies In Vivo of the Encapsulated Phytochemicals Post-Baking; and Scale-Up Studies for Industrial Production. Furthermore, the

incorporation of herbal medicines into typical food matrices presents one of several potential strategies for accessing preventative health care through regular consumption.

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