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Research Article

Impact of Herbal Mix Incorporation on Biscuit Attributes

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Abstract

The increasing popularity of foods possessing additional health benefits has set new demands for snack foods including biscuits. These novel snacks while maintaining basic nutritional benefits, should also exhibit additional health benefits. Along these lines, the biscuit was utilized as a carrier for herbal-mix consisting of tulsi, ginger, and black pepper. The baking combination of 190°C for 10 min and herbal blend having ginger, tulsi and black pepper in the ratio of 5:2:1 was standardized after preliminary experimentation. Herbal mix and honey concentration in biscuits were optimized employing a two-factor response surface methodology experiment based on central composite rotatable design. The optimal formulation of biscuits could be prepared using 6.38 parts herbal-mix and 55 parts honey. In comparison to control biscuits, functional biscuits had significantly ($p<0.05$) higher phenolic content (100.66±10.81 mg/ml) and DPPH inhibition activity (22.01±0.84 %). The incorporation led to a slight decrease in the thickness, diameter, and spread ratio along with a modest increase in the textural hardness of the developed biscuits. The addition of herbal mix caused a decrease in the lightness value of the product. Functional biscuits developed possessed a good acceptance score (7.00±0.15) on the nine-point hedonic scale. The study justified the positive nutritional effect of herbal mix incorporation in biscuits.

Keywords: Functional biscuits, herbal mix, antioxidative capacity, response surface methodology

1. Introduction

The rise in the burden of non-communicable diseases (NCDs) presumably hinders socio-economic development and threatens the health security of the nations. These diseases contribute to ill health, poverty, and inequity and consequently slow down the progress of the nation (FAO, 2020). Dietary interventions based on research and innovation in the functional and health food segment have the potential to manage these NCDs. Functional foods are thought to promote well-being, and general health and reduce the risk of disease. The food industry is putting in constant efforts to produce foods having enhanced health benefits. These foods offer a practical and new approach to achieve optimal health status by promoting the state of well-being and reducing the risk of diseases. Natural herbs are known for their effectiveness in boosting immune system and renewing the body's vitality. Tulsi leaves, ginger, and black pepper are common herbs well known for their health-beneficial properties. The presence of phytochemical and bioactive constituents endows them with various bioactivities. The major phytochemicals present are: gingerol, shogaols, and paradols in ginger (Mao *et al.,* 2019), eugenol, ursolic acid, carvacrol, caryophyllene, nerol, apigenin and camphene in tulsi leaves (Hasan *et al.,* 2023; Dubey and Pandey, 2018) and piperine, piperic acid, piperlonguminine, pellitorine, piperolein B, piperamide, piperettine, and kusunokinin in black pepper (Takooree *et al.,* 2019). Various investigations have displayed that *Ocimum* possesses various important bioactivities e.g., antifungal, antistress, antidiuretic, antioxidant, hepatoprotective, immunomodulating, anti-inflammatory, antibacterial, antiviral, antipyretic, antidiabetic, antimalarial, and hypolipidemic properties (Dubey and Pandey, 2018). Ginger also exhibits antioxidant activity, anti-inflammatory activity, anti-microbial activity, cytotoxicity, neuroprotective activity, cardioprotective activity, anti-obesity activity, antinausea, antiemetic activity, protection against respiratory syndrome and anticancer activity (Mao *et al.,* 2019) while the black pepper possesses the following activities- antimicrobial, antioxidant, anticancer, neuroprotective, hypo-glycaemic, anticonvulsant, analgesic, hypolipidemic and anti-inflammatory. Ayurvedic Pharmacopoeia of India (2007) has described the importance and therapeutic usage of these foods in many health conditions (Table 1).

Table 1. Properties and therapeutic uses of herbs

Properties	Ginger	Tulsi leaves	Black pepper
Rasa	*Katu*	*Katu, Tikta, Kasaya*	*Katu, tikta,*
Guna	*Laghu, Snigdha*	*Laghu, Ruksa, Tiksna*	*Laghu, Ruksa, Tiksna*
Virya	*Usna*	*Usna*	*Usna*
Vipaka	*Madhura*	*Katu*	*Katu*
Karma	*Dipana, pacana, anulomana, amadosahara, vatakaphapaha, hrdya*	*Vatahara, kaphara, pittahara, dipani, hrdya, krmighna*	*Slesmahara, pittakara, kaphavatajit, vatahara, chedana, dipana, rucya, jantusana, medhora, chedi, hrdroga, vataroga*
Therapeutic use	*Agnimandya, adhmana, pandu, svasa, udararoga, amavata*	*Svasa, kasa, pratisyaya, parsvasula, aruci, hikka, krmiroga, kustha*	*Svasa, sula, krmiroga, tvagroga*

Biscuits are liked by a large segment of the population and are available in various formulations having an array of flavours. They are cherished around the globe due to their ready-to-eat nature, convenience, shelf life, and affordability. The prioritization of healthy snacks over conventional ones by consumers has created new demands for healthy snacks which should also possess health/functional benefits apart from traditional nutritional properties (Islam et al., 2024). 'Healthy snacking' and 'food-on-the-go' go well with today's swift lifestyle (Kumar *et al.,* 2023). Accordingly, food scientists and technologists have tailored their strategies to enhance the diversification (Yang *et al.,* 2020) and functional benefits of snack food products like biscuits (Kumar et al., 2023). The addition of newer functional ingredients enhances the value of the already existing products and thus might help avoid neophobia. The product formulation of such a product needs to be optimized considering processing, nutritional, and sensory aspects. Biscuits can be used as a vehicle to incorporate functional ingredients to fulfil the demands of consumers looking for healthy ingredients in convenience foods. Herbal mix consisting of tulsi, ginger, and black pepper powder can be consumed in a much more palatable way in the form of biscuits for deriving their functional benefits. Following the leads, the present study was focused on analysing the impact of incorporating herbal mix into biscuits, on its physicochemical, functional, and sensorial properties. The incorporation of herbal mix with potential functional properties is expected to open up a wide commercial market for herb/herbs-based biscuits for targeted needs.

2. Materials and Methods

2.1. Ingredients

Commercially available quality ingredients utilized during biscuit manufacturing were purchased from the local market. Herbal mix was prepared after homogenously mixing ginger, and black pepper powder along with tulsi powder. Ginger, black pepper, and tulsi powder were mixed in a ratio of 5:1:2 respectively. All the chemicals used were of analytical grade and procured from standard companies.

2.2. Experimental Design

A Response Surface Methodology (RSM) experiment was designed incorporating the herbal mix (M) and honey (H) ranging from 7-9 parts and 50-60 parts, respectively as the process variables (factors). A total of 13 different combinations were worked out using Central Composite Rotatable Design (CCRD) to investigate the effect of aforementioned factors on the response variables viz. various sensorial parameters (color, flavor, texture, and overall acceptability). The design matrix consisted of 5 centre points, 4 axial points, and 4 factorial points (Tables 2 and 3). The response variables were related to the coded factors using either a response surface quadratic/ linear model:

$$Y = b_0 + b_1A + b_2B + b_{11}A^2 + b_{22}B^2 + b_{12}AB + \varepsilon$$

$$Y = b_0 + b_1A + b_2B + \varepsilon$$

2.3. Biscuit preparation

Each batch of biscuits was produced utilizing 200 g of refined wheat flour. The required amount of honey and biscuit fat (50 g) were weighed and creamed for 5 min in a Hobart mixer along with lecithin. Then sodium bicarbonate (2g), salt (2g), and water (16 ml) were added and the creaming was continued for 10 min. Further, the required amount of flour-herbal mix (as per RSM) (Table 2) was added and the content was kneaded for 3-4 min to obtain a homogeneous dough. The dough was rolled out, sheeted, cut using a die, and baked at 190°C for 10.5 min. The baked biscuits were cooled at ambient temperature and stored in an airtight container until further analysis.

Table 2. Coded and actual values of the process variables in the RSM experiment

Independent variable	Levels				
	Axial point	Factorial point	Centre coordinate	Factorial point	Axial point
	-1.413	-1	0	+1	+1.413
A: Herbal mix (parts)	6.38	7	8.5	10	10.62
B: Honey (parts)	47.93	50	55	60	62.07

2.4. Analyses

2.4.1. Functional properties

The water absorption index (WAI) was determined according to the method of Anderson *et al.,* (1970). Distilled water (5 ml) was added to the sample (0.2 g), vortexed for 2 min, and then centrifuged for 20 min at 700 g. WAI was calculated as:

$$WAI = \frac{m_g}{m_s}$$

where m_g is the weight of the hydrated gel (g) and m_s is the weight of the sample (g). The water solubility index (WSI) was determined from the dry solids recovered by evaporating the supernatant from the water absorption test as:

$$WSI = \frac{m_{ds}}{m_s} \times 100$$

where m_{ds} is the weight of dry solids from the supernatant (g) after evaporation and m_s is the weight of the sample (g).

The pasting properties of herbal biscuits and mix were measured on a Rapid Visco Analyser (RVA-4), using the general pasting method (Newport Scientific Pvt. Ltd., Warriewood, Australia) described by the manufacturer. Approximately, 3.5 g of flour sample was mixed with 25 ml water (corrected to compensate for 14% moisture basis), mixed, and kept for amylography. The heating/ cooling ramping program is described elsewhere (Kumar *et al.,* 2016).

2.4.2. Proximate Composition

The proximate composition (moisture, fat, protein, ash, and carbohydrate) of biscuit samples was evaluated as described in AOAC (2000). Moisture content was determined by gravimetric method using oven dry method at 105°C. The nitrogen content was determined by following the Kjeldahl procedure. Crude fat content was determined by extraction of fat using petroleum ether in a Soxhlet extractor. The ash content was determined gravimetrically by incinerating the charred samples in a muffle furnace at 550 °C. The carbohydrate content of the samples was determinedby difference. The analyses were carried out in triplicate.

2.4.3. Hunter color parameters

The color characteristics of samples were estimated in terms of Hunter color parameters as L, a, b values utilizing a spectro-colorimeter (ColorflexEZ 45/0, Hunter lab, Reston, USA) using D65 illuminant and 10° standard observer. The measurement was performed on ten biscuits.

2.4.4. Dimensional parameters and weight

Thickness and diameter were determined using a digital Vernier Caliper (CD-6" CSX, Mitutoyo Corporation, Japan) and spread ratio was obtained as their quotient. Samples were weighed using an electronic weighing balance (ME204, Mettler Toledo, US) for gravimetric analysis.

2.4.5. Antioxidant Activity

The total phenolic content and DPPH radical scavenging activity of the methanolic extract (1:50- sample: methanol) of the flour and biscuit sample were determined according to Tambe and Bhambhar (2014) and Brand-Williams *et al.,* 1995. The sample was extracted in methanol for two hours using a wrist shaker.

2.4.7. Hardness

The textural hardness of the biscuit was determined as break strength employing a texture analyzer (TA-HD plus (M/s Stable Micro Systems, UK) utilizing a 3-point bend rig with probe testing speed of 10 mm/s.

2.4.8. Sensory analysis

The sensory evaluation of different samples of the biscuit was carried out using a 9-point Hedonic rating test (Stone *et al.,* 2008). The panel consisted of 10 judges having adequate knowledge about the sensory evaluation methods and product characteristics and were chosen from the Cereal and Pulses Technology Division. The following sensory descriptors were utilized for the evaluation: color, flavor, texture, and overall acceptability on the 9-point Hedonic scale.

3. Results and Discussion

3.1. Selection of herbal mix

During the preliminary trials, various blends of tulsi leaf powder, ginger powder, and black pepper were tried for incorporation in biscuits and sensorially evaluated by the panel of judges. Out of various trials, an herbal mix consisting five parts ginger powder, two parts *tulsi* powder and one-part black pepper powder (5:2:1) scored maximum on sensory analysis and was utilized in further trials.

3.2. Influence of herbal mix and honey on sensory properties of biscuits

The effect of the herbal mix (7-9 parts) and honey (50-60 parts) on sensory attributes was studied employing a two-factor RSM experiment based on central composite rotatable design (Table 3). This study investigated the influence of variations in the herbal mix and honey levels on sensory responses viz., color, flavor, texture, and overall liking for developed herbal biscuits. The research offers an intricate analysis of how the optimal levels of herbal mix and honey can be determined to achieve a biscuit product that is highly favoured based on sensory assessments. The effects have been presented as response surface diagrams for better visualization (Fig. 1) and the coefficients for suited models are presented in Table 4. The colour score ranged from 6.98 to 7.35. The statistical analysis revealed the model's F-value to have significance with a 99% confidence level, indicating its effectiveness in explaining changes in the sensory color score due to alterations in the herbal mix and honey proportions. The coefficient of determination was observed to be 0.6945, and the adequate precision value stood at 9.423, significantly surpassing the minimum requirement of 4 for robust prediction capability. Overall, the sensory colour score plays a vital role in the sensory evaluation of developed biscuits and serves as a guide for refining the concentrations of herbal mix and honey to produce the most well-received product. As depicted in Fig. 1, both process variables exerted a significant negative($p>0.05$) linear effect on the color score, indicating that enhanced levels of herbal mix and honey decreased the sensory perception of color.

The sensory flavor score of biscuits as determined sensorially ranged from 6.62 to 7.21. The lowest sensory flavor score was for a biscuit prepared from the combination of 10.62 parts herbal mix and 55 parts honey, while the highest sensory flavor score was recorded in a biscuit prepared from 6.38 parts herbal mix and 55 parts honey. The incorporation of herbal mix influenced the sensory flavor score adversely. Further, the negative interaction of the process variable indicated a decreased combined effect rather than the sum of individual effects.

Table 3. Design matrix for herbal mix and honey levels as process variables along with the sensory responses for the RSM experiment

Run	Process Variables		Response variables			
	Herbal Mix (Parts per 100 g RWF#)	Honey (Parts per 100 g RWF#)	Colour score	Flavour score	Texture score	Overall acceptability score
1	8.5	55	7.17	7.19	7.17	7.18
2	8.5	55	7.19	7.19	7.23	7.19
3	8.5	55	7.19	7.17	7.13	7.14
4	10	50	7.08	7.21	7.33	7.00
5	7	60	7.13	7.08	7.13	7.08
6	8.5	55	7.22	7.00	7.19	7.12
7	10.62	55	6.98	6.85	6.44	6.95
8	7	50	7.19	6.91	6.78	7.17
9	8.5	62.07	7.17	6.89	6.81	7.12
10	10	60	7.00	6.62	6.63	7.00
11	6.38	55	7.35	7.21	7.16	7.21
12	8.5	47.93	7.25	7.04	7.01	7.04
13	8.5	55	7.14	7.19	7.19	7.21

#RWF: Refined wheat flour

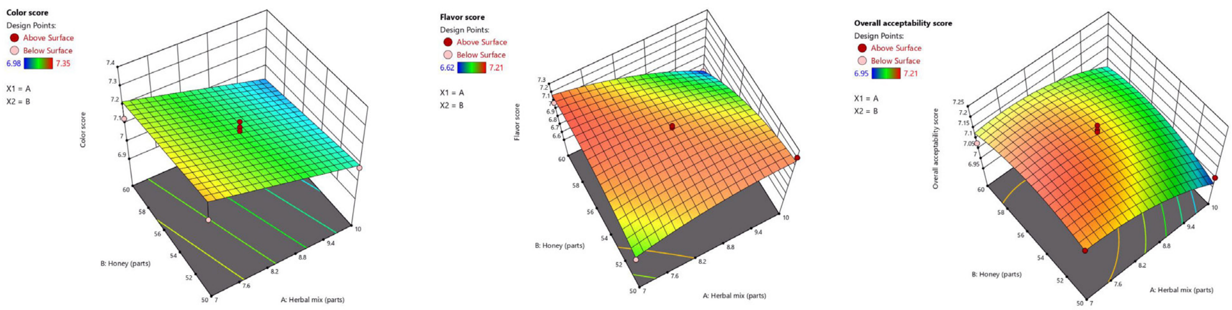

***Fig. 1.** Response surface curve showing the effect of process variables on sensory color, flavor and overall acceptability score of biscuits*

The quadratic effect was noticed to be non-significant ($p>0.05$). The sensory texture score varied from 6.44 to 7.33. The minimum appearance score (6.44) was obtained with10.62 parts herbal mix and 55 parts honey while the maximum texture score (7.33) was obtained with 10 parts herbal mix and 50 parts honey. Although the model F value was significant, but significant lack of fit, indicated that the model could not adequately describe the functional relationship between process variables (honey, herbal mix) and response variable (texture score). Thus, it can be concluded that process variables studied did not have any definite impact on texture score of herbal biscuits in the experimental range studied. Overall acceptability (OA) score, which could be thought of as a cumulative score assigned for consumer liking towards food products by subsuming all sensory characteristics, for the herbal biscuits ranged from 6.95-7.21 on hedonic rating i.e., vicinity of the 'like moderately'. The model F value, lack of fit, and adequate precision were in agreement for effective regression of the model for the determination of the acceptability score by sensory means. The coefficient of quadratic terms of the regression model for herbal mix and honey suggested that the response plot was convex upwards i.e., initial increase in OA score was followed by plateauing at higher levels of the independent variables. Further, at linear levels, increasing the herbal mix significantly ($p<0.01$) placated the acceptance of the herbal biscuits.

Table 4. Coefficients of quadratic/ linear models for the sensory properties of biscuit as a function of process variables

Partial coefficients	Responses			
	Color score	Flavor score	Texture score	Overall acceptability score
Intercept	7.16	7.15	7.17	7.18
Herbal mix A	-0.095**	-0.084*	-0.121	-0.077**
Honey B	-0.032	0.080*	-0.079	0.0029
A^2	-	-0.069	-0.16*	-0.048*
B^2	-	-0.10	-0.11	-0.048*
A*B	-	-0.19*	-0.26*	0.023
R^2	0.6946	0.8747	0.7966	0.8582
Model F value	11.37**	9.77**	5.48*	8.47**
Adequate precision	9.423	9.605	7.166	7.465
Lack of fit	NS	NS	S	NS

* ($p<0.05$); ** ($p<0.01$)

The sensory scores for color, flavor, and overall acceptability could be predicted using the following regression model:

Color score = 8.0471 – 0.0636 x M – 0.0063 x H

Flavor score = – 17.7532 + 1.8623 x M + 0.6422 x H – 0.0253 x M x H – 0.0308 x M^2 – 0.0041 x H^2

OA score = 1.5694 + 0.1490 x M + 0.1879 x H + 0.0030 x M x H – 0.0215 x M^2 – 0.0019 x H^2

To arrive at the optimal formulation, the independent factor settings were realized by assigning the criteria for optimization i.e., the herbal mix and honey levels were defined as ‘in range’ along with sensory color and flavour response. The overall acceptability score was set at ‘maximum’ to obtain the most acceptable product. The optimized solution derived consisted of 7.24 parts herbal mix and 54.18 parts honey.

3.3. Characteristics of the flour

The control as well as herb blended flour were analyzed for its compositional, biochemical, and techno-functional attributes and presented in Table 5 and 6. As expected, the nutritional properties in terms of protein, mineral, and fat content for herbal mix blended flour were higher than refined wheat flour. Further, the total phenolic content and DPPH radical scavenging activity of optimal flour were 6.2 times and 6.5 times higher in comparison to refined wheat flour. Ginger, black pepper, and tulsi leaves are known to be important sources of dietary antioxidants (Mao *et al.,* 2019; Takooree *et al.,* 2019; Hasan *et al.,* 2023). This implied that the addition of herbs on a replacement basis accentuated the nutritional profile of the flour. Further, moisture levels of both flour samples lay in the range of 13.65-14.05%. Low moisture content in the flour is essential for its shelf life (Altemimi et al., 2023). Moisture uptake leads to changes in biochemical and organoleptic changes- changes in pH and alcoholic acidity (Vashishth *et al.,* 2018) in flour which degrades the quality of flour and makes it unsuitable for consumption.

Water absorption describes the hydration characteristics of the flour and dictates the amount of water that flour can absorb until the desired consistency. The water absorption characteristics are related to the product quality. During the hydration of the flour, the protein and starch molecules interact with water via hydrogen bonding and hydrophilic interactions. The water absorption index of refined flour (2.09) increased upon the addition of herbal mix (2.29). This could be attributed to the presence of more hydrophilic components especially polysaccharides, in the herbs incorporated in the flour. It must be noted that apart from starch (native and damaged) and protein, the presence of fiber components also influences the absorption behavior of flour. The ginger and tulsi powders are stated to be good sources of fibre i.e.,10.11% and 12.10%, respectively (Kaushal *et al.,* 2019; Agrawal *et al.,* 2021). The WSI values for refined and herbal mix flour were found to be 0.05 and 0.06, respectively.

Table 5. Compositional and bioactive properties of the flour and biscuits

Constituents	Flour		Biscuits	
	Control	Optimized	Control	Optimized
Moisture (%)	14.05±0.16	13.65±0.28	3.46±0.04	3.51±0.50
Fat (%)	1.23±0.31	1.62±0.19	13.37±0.46	16.67±0.89
Protein (%)	8.86±0.12	9.10±0.14	7.58±0.09	7.62±0.08
Ash (%)	0.43±0.02	0.75±0.07	0.63±0.05	0.97±0.12
Carbohydrate (%)	75.43	74.88	74.96	71.23
Phenolic content (µg/mL extract)	12.26±0.53	76.04±4.00	49.81±0.53	100.66±10.81
DPPH inhibition (%)	2.94±0.45	19.12±0.10	10.15±0.79	22.01±0.84

Rapid visco-amylography helps in continuous monitoring of viscosity as governed by temperature and shear effects. The pasting parameters obtained could be utilized to predict the gelatinization behavior of starch and the degree of cooking. Further, the viscosity changes give information about phase transitions in food systems viz., gelatinization, retrogradation, etc. An increase was seen in pasting parameters viz., peak viscosity, breakdown viscosity, final viscosity, and setback viscosity upon incorporation of herbal mix in refined wheat flour (Table 6). The peak viscosity governs the water-binding ability and indicates the viscous load during gelatinization. The high peak viscosity of 296.67 cP for optimized flour in comparison with control flour 284.83 cP dictates the higher potential of flour to lock the water during cooking. On the other hand, the biscuits prepared using optimized flour had lower peak viscosity in comparison with the biscuits produced from control sample. This can be attributed to the lower water-holding capacity of the control sample (Altemimi et al., 2023). Although the presence of a limited amount of water and sugar in the biscuit formula hampers the gelatinization process, the partial gelatinization of starch during baking may affect the textural characteristics (Kumar *et al.,* 2019; Arepally *et al.,* 2020). Peak viscosity and breakdown are positively associated with the density of the biscuit (Ma and Baik, 2018) whereas final viscosity and setback are associated with products tending to form a gel upon cooling.

Table 6. Pasting characteristics of the flour

Flour characteristics	Control flour	Optimized flour
Water absorption index	2.09	2.29
Peak viscosity (cP)	284.83	296.67
Breakdown viscosity (cP)	60.25	67.00
Final viscosity (cP)	324.83	333.58
Setback viscosity (cP)	88.42	115.75
Pasting temperature (°C)	70.25	70.95

3.4. Proximate composition and antioxidant activity of biscuits

The composition attributes of biscuits are presented in Table 5. The proximate composition of the biscuits depicted a pattern similar to the flour. The moisture level in the biscuits ranged from 3.46-3.51%. The biscuits are different from other bakery items like cakes and bread since the moisture levels are too low. The low moisture levels attained due to the baking process ensure their higher shelf life. The packaging requirement needs to be met strictly to compensate for the hygroscopic nature of biscuits. The careful control of moisture in the product is desirable because the moisture uptake influences its stability and shelf life (Faridi, 1994; Mahloko *et al.,* 2019). The lipids level of the optimized biscuit was significantly higher compared to the control biscuit ($p<0.05$). Similarly, an increase was also observed in the protein and ash content of the herbal biscuits, compared with normal biscuits. This presumably came from the herbal mix utilized for supplementation. Further attributed to the propositional changes during baking and flour replacement. The higher lipid and protein content enhances the energy value of the product and its lubricating role improves the flavor and textural properties of the biscuits (Ikuomola *et al.,* 2017). The ash content of a food product indicates its mineral content, thus herbal biscuits having higher mineral density will greatly benefit the consuming population. Biscuits are considered high-density baked foods and the inclusion of the herbal mix further elevated the nutrient density of the food product.

The health-beneficial properties were measured in terms of total phenolic content and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity. The increase in radical scavenging ability might be due to the increased hydrogen-donating ability of the polyphenols and other antioxidants present in the herbal mix (Ajila *et al.,* 2008). The total phenolic content and DPPH activity of both the biscuit samples were significantly different ($p<0.05$). The increase in polyphenol content correlated well with the increase in radical scavenging activity. The inclusion of herbal mix appears to be justified because of the increase noticed in the phenolic level and antioxidant capacity of the biscuits upon supplementation. The biscuits with enhanced polyphenols increase total dietary intake and may assist in preventive nutrition (Filipcev *et al.,* 2011). Phenolic compounds are good electron donors because their hydroxyl groups can directly contribute to antioxidant action and they may further stimulate the synthesis of endogenous antioxidant molecules in cells. The phenolic compounds exhibit free radical inhibition, peroxide decomposition, metal inactivation, or oxygen scavenging and prevent oxidative stress (Aryal et al., 2019). The addition of mango peel powder, amla, drumstick leaves, raisins, and grape marc extract in biscuits showed improved antioxidant activity (Ajila *et al.,* 2008; Reddy *et al.,* 2005; Pasqualone *et al.,* 2014).

3.5. Physical properties of biscuits

The physical attributes viz., dimensional parameters, hunter color values, break strength, and overall acceptability score are mentioned in Table 7. The dimensional parameters give basic information about the biscuits and are helpful in the development of the package. Further, these attributes are linked to the cumulative assessment of biscuit appearance (Ma and Baik, 2018), affect the sensory perception (Mieszkowska and Marzec, 2015), and also control the textural attributes and eating quality of biscuits. These are also important for quality control of the end product (Mamat *et al.,* 2010). Large variations in weight and dimensions may lead to production breakdown (Cronin and Preis, 2000). No significant difference ($p>0.05$) was noticed for the thickness, weight and spread ratio of both the biscuit samples; although the diameter of the control biscuits (56.55 mm) was slightly larger than the optimized herbal biscuit (55.21). A small and non-significant ($p>0.05$) reduction was observed in the spread ratio of herbal biscuits. A higher spread ratio of biscuits is preferred (Kumar *et al.,* 2019) because it provides better texture properties but it also becomes essential to control the cookie spread during the production. The cookies which are over-spread/ under-spread cause problems in filling and metering, and create manufacturing drudgery (Matz, 1992). The minor decrease in spread could be attributed to gluten dilution and higher water absorption (Bolek, 2021) for herbal mix blended flour. No considerable ($p>0.05$) difference was noticed between the weights of the biscuits.

Table 7. Physical attributes of the biscuit

Physical attribute		Control	Optimized
Diameter (mm)		56.55 ± 0.67^a	55.21 ± 0.57^b
Thickness (mm)		6.63 ± 0.52^a	6.52 ± 0.48^a
Weight (g)		8.56 ± 0.50^a	8.59 ± 0.50^a
Spread ratio		8.58 ± 0.72^a	8.50 ± 1.20^a
Hunter color values	L	61.95 ± 0.15^a	54.70 ± 0.06^b
	a	11.10 ± 0.03^a	7.84 ± 0.08^b
	b	33.45 ± 0.28^a	33.09 ± 0.46^a
Break strength (N)		21.67 ± 3.44^a	24.06 ± 6.53^a
Overall acceptability score		7.65 ± 0.50^a	7.00 ± 0.15^b

*Values in different column with different superscript are significantly ($p<0.05$) different

The color of a food product has a major role to play in its acceptance, commercial value, and flavor expectation (Bolek, 2021), and thus, the quantitation of color becomes important. The color of biscuits is expressed in terms of Hunter color values- L (lightness/ darkness), a (redness/ greenness), and b (yellowness/ blueness). As expected, the blending of herbal mix in the flour resulted in a darker color, thereby decreasing the lightness (L) value from 61.95 to 54.70. The addition also led to a decline in the redness part of the color, wherein the value decreased from 11.10 to 7.84. The effect on yellowness/ blueness was non-significant ($p>0.05$). The color of biscuits is governed by the browning-Maillard reaction, caramelization, chlorophyll destruction and dextrinization (Arepally *et al.,* 2020). The addition of herbal mix changed the final color of the biscuits and presumably, herbal mix imparted its color to the flour which was altered during baking. This could also be noticed from the color of the herbal mix blended flour. The difference in hunter color parameters (L, a, and b) of refined flour and herb blended flour was- 8.14, -2.94 and 6.71. Ingredient's composition and baking time-temperature combination are important factors that alter the color of any product. The textural hardness determined as the break strength of biscuits varied from 21.67-24.06 N and differed significantly ($p<0.05$) for both biscuits. The addition of herbal mix made biscuits harder in texture than the control sample. This might be attributed to lower gas retention capacity as a result of interaction between herbal polysaccharides, fat, and gluten protein (Bolek, 2021), which may have yielded a denser structure. Further, the water distribution pattern also alters the textural properties of the biscuits. the reduction in moisture content also played in modifying the final texture of the herbal biscuits. The overall acceptability score quantified on the hedonic scale, was significantly higher ($p<0.05$) for the control biscuit. Although the control biscuits (7.65) were preferred more readily by the sensory panel, the score (7.00) of herbal biscuits lay in the 'like-moderately range'.

Conclusion

Biscuits are popular snack food consumed all over the world and a healthy snack loaded with additional nutrients may support in meeting the functional requirements. The current study was concerned with the utilization of biscuits as a delivery vehicle for an herbal mixture consisting tulsi, ginger and black pepper in formulized concentration. Herbal mix and honey concentration in biscuits were optimized employing two-factor response surface methodology (RSM) experiment-based on a central composite rotatable design. The sensorial optimized level for herbal mix and honey, for the preparation of functional biscuits, were found to be 6.38 g and 55g per 100 g of refined wheat flour. The standardized biscuit though had lower overall acceptability but it was still had very good consumer acceptability score. The optimized product is nutritionally dense than the control biscuit sample justifying the minor reduction in consumer acceptability with enhanced functional value. The biscuit developed could help in delivering the targeted nutrition to the body.

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Author contributions

AK: Conceptualisation, methodology, data curation, formal analysis, validation, writing the original draft. GKS: Conceptualisation, visualization, validation, supervision, reviewing and editing; RV: conceptualization, methodology, data curation, reviewing and editing; ADS: Conceptualisation, reviewing and editing, supervision.; HMD: formal analysis, reviewing and editing; MAK: Methodology, analysis, supervision.

Conflict of Interest

Authors declare no conflict of interest.

Ethical Approval

The article doesn't contain any study involving ethical approval.

Generative AI or AI/Assisted Technologies use in Manuscript Preparation

No

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