



Development and Quality Analysis of Wheat Bran Enriched Herbal Cookies

V. K. Jadhav^{a*}, S. V. Ghodke^a, P. D. Shere^a and R. S. Agrawal^a

^a MIT School of Food Technology, MIT Art, Design and Technology University, Loni Kalbhor, Pune, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Wheat bran, byproduct of the wheat milling has extensive applications in the food industry attributing to its high dietary fiber (polysaccharides), protein and minerals content. Dietary fiber assist in gastrointestinal health maintenance and diseases risk reduction (Diverticular disease, heart disease, cancer and diabetes). Tulsi (*Ocimum sanctum*) contains numerous bioactive compounds (Caryophyllin, ursolic acid, rosmarinic acid, thymol, methyl chavicol, citral, carvacrol, and caryophyllene) imparting health benefits. Tulsi being rich in antioxidants advised for fighting free radicals and excess oxidative damage. In developing countries like India, with growing urbanization healthy bakery products demand is progressively rising in both urban and rural area. Hence, sincere efforts were undertaken to develop functionally and nutritionally enhanced cookies by incorporating wheat bran and tulsi powder. The cookies were developed by replacing refined wheat flour with varying level of wheat bran (20-35%). Cookies formulated with 30% wheat bran was observed to be sensorially best sample against other levels. Hence this sample was further selected for incorporation of tulsi powder (1-3%) and subjected to physical, chemical and sensory analysis. Sensory score indicated 1% tulsi powder incorporated cookie sample was highly acceptable against rest of the samples. The wheat bran (30%) and tulsi powder (1%) incorporation increased the dietary fiber (42.43%) and protein content (27.69%) without affecting on sensory

*Corresponding author: E-mail: vinayakjadhav707@gmail.com;

parameters. The enhanced total phenol content (63.66%) and antioxidant activity (16.30%) was emerged out as one of the achievements of present investigation.

Keywords: *Dietary fiber; wheat bran; tulsi (Ocimum sanctum); herbal; cookies; antioxidant.*

1. INTRODUCTION

The wheat bran, dietary fiber containing fraction is a nutritional milling by-product finds application in variety of food product. Wheat bran utilization and consumption has gradually enhanced owing to health beneficial component such as fiber (36.5–52.4 per 100gm), protein (14.5%), carbohydrate (27%), minerals (5%), fat (6%), B vitamins and bioactive compounds [1,2]. The dietary fiber exist in wheat bran are xylans, lignin, cellulose, galactan and fructans. Additionally, wheat bran consists of bioactive compounds such as phytic acid (2180-5220mg), ferulic acid (500-1500mg), alkylresorcinols (220-400mg) and lutein (97-140µg/100gm) [3].

The wheat bran containing phytochemicals (Phenolic acid and alkylresorcinols) are antioxidants modifying cellular oxidative status, protecting biologically important components (DNA, proteins and lipids) from oxidative damage and potentially lowering chronic diseases risk [1]. Constipation can be relieved by eating a high-fiber diet. In the digestive tract, both forms of fiber (Soluble and insoluble) play a vital function. Insoluble fiber can help to promote bowel health and regularity. Soluble fiber appears to affect the functioning of digestive enzymes and hormones, delaying digestion and absorption of nutrients. [4]. The intake of inulin and certain soluble fibers enhances immune function in humans. The recommended dietary fiber intake for adult women and men are 28 g/day and 36 g/day respectively [5].

Tulsi (*Ocimum sanctum L*), an aromatic plant belongs to the genus *Ocimum* and *Lamiaceae* family. Tulsi contains numerous bioactive compounds (Caryophyllin, ursolic acid, rosmarinic acid, thymol, methyl chavicol, citral, carvacrol, and -caryophyllene). Additionally, it is source of eugenol (7%), carvacrol (3%), and eugenol-methyl ether (20%) responsible for therapeutic benefit. The nutraceutical potential of tulsi is synergistically coiling around antioxidant, antiviral, antibacterial, adaptogenic, and immune-enhancing capabilities that help the body's natural defence against stress and disease [6,7]. Tulsi is good source of antioxidants (Eugenol,

ursolic acid and rosmarinic acid) leading to scavenge free radicals and reduces excessive oxidative damage. Excess oxidation is result of free radicals' attack on cells, leading to cell damage and eventually death. This cellular damage caused by free radicals can be responsible for initiating or accelerating non communicable diseases [8]. Tulsi review base epidemiological study indicates tulsi as an effective therapeutic agent against numerous diseases (Colds, coughs, malaria, dengue fever, bronchitis, asthma, sore throats, influenza, heart problems, eye ailments, mouth infections, insect bites, stress and kidney stone) [9].

Presently, consumers food habits, food product use and purchase behaviour are changing on large extent. Convenience, low price, ready-to-eat nature, easy transport and diversified flavour availability are the key drivers for ready to eat convenient bakery products. [10,11]. Bakery products such as cookies are extensively popular among all age group. Cookies are not only suitable bioactive and nutritional compounds delivering food products into human diet but also ideal for nutrient availability, palatability, compactness and convenience. Taking into consideration the need and demand of nutritionally enriched food products the studies have been carried out to formulate the fiber enriched herbal cookies with incorporation of wheat bran and herb (Tulsi powder).

2. MATERIALS AND METHODOLOGY

2.1 Raw Material

Refined wheat flour, wheat bran, margarine, sugar, baking powder, milk powder, salt and packaging material (LDPE) were procured from the local market of Hadpsar, Pune. For the formulation of cookies Tulsi powder (*Ocimum Sanctum*) was procured from the local market Hadpsar, Pune. It is manufactured by the Isha Agro Developers Pvt. Ltd. Nangargaon, Lonavla, Pune and marketed by Indian Herbal Velly.

2.2 Methodology

2.2.1 Process technology of tulsi powder incorporated wheat bran cookies

Cookies sample were formulated by replacing refined wheat flour with wheat bran at different proportion as shown in table no.1. Refined wheat flour (Maida) and sugar powder were sieved. All other ingredients such as margarine (70 g), sugar (60 g), milk powder (5 g), baking powder (1.4 g) and salts (0.8 g) were weighed accurately. All dry ingredients mixed into maida. Margarine is creamed with the sugar to form a uniform fluffy texture. The dry ingredients were

incorporated into the cream to form a uniform smooth firm dough. The dough rolled into a sheet followed by cutting in the desired size and shape. Subsequently the pieces were baked at 130^o C for 10-15 min. The cookies were cooled at room temperature and packed in LDPE [12].

The sensory analysis of formulated wheat bran cookies indicated best overall acceptability score for 30% wheat bran (S₃) sample. Hence S₃ sample was further selected for tulsi powder incorporation. Tulsi powder incorporated wheat bran cookies were developed by varying the proportion of tulsi powder as shown in Table 2.

Table 1. Proportion of the wheat bran

Ingrideints	S ₀	S ₁	S ₂	S ₃	S ₄
Maida%	100	80	75	70	65
Wheat bran%	0	20	25	30	35

Table 2. Proportion of tulsi powder and wheat bran

Ingredients	S ₀	S ₁	S ₂	S ₃
Maida%	100	70	70	70
Wheat bran%	0	30	30	30
Tulsi powder%	0	1	2	3

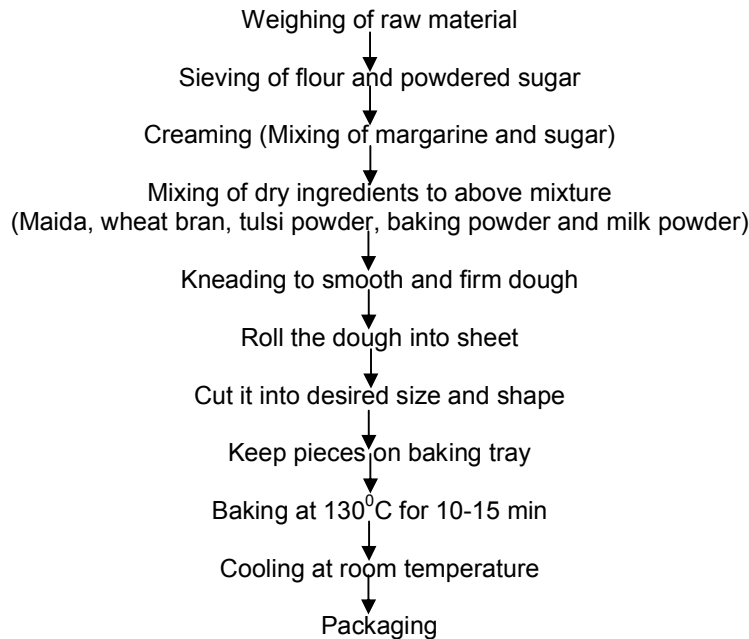


Fig. 1. Processing technology of tulsi powder incorporated wheat bran cookies

2.2.2 Physical analysis of raw material

Particle size analyzed by using sieve shaker, the bulk density was determined by using measuring cylinder and colour of flour were determined by visual observations [13,14].

2.2.3 Physical analysis of cookies

The cookies were analysed for weight, diameter, thickness, volume, density and spread ratio according to method given by Suma and Nandini [2] and Gupta and Tiwari [10].

Weight: Weight of cookies was determined as the average weight of six individual cookies using digital weighing balance.

Diameter: Arranging six cookies edge to edge and measuring the total diameter of cookies.

Thickness: Six cookies were stacked one on top of the other. With the use of a ruler, the total height of six cookies was measured in millimetres. This was repeated twice to get an average value of thickness.

Volume: Volume of cookies was determined by using formula.

$$V (\text{cm}^2) = d^2 \pi t / 4$$

t= average thickness

d= diameter.

Spread ratio: The spread ratio was determined by the formula

$$\text{Spread ratio} = \frac{\text{diameter}}{\text{thickness}}$$

2.2.4 Density

Density of cookies measured by mass (weight) per unit volume.

2.2.5 Chemical analysis

The moisture content was determined by using the hot air oven method, fat content was estimated by using the Soxhlet apparatus, protein content measured by using the Kjeldahl method and ash content determined by using muffle furnace methods given by the Rangana [15]. The carbohydrate calculated by the difference method. The dietary fiber determined using phosphate buffer systems given by AOAC 985.29. [16].

2.2.6 Total polyphenol content and antioxidant activity of cookies

Phenolic extracts were prepared by refluxing 2 g of sample with 20 ml of methanol containing 1%

HCl for 2 h at 60^o +5^oC. The mixtures were centrifuged for 25 min at 4000 rpm centrifuge. Supernatants were separated and used for analysis of total phenolic and antioxidant activity. Total phenolic contents determined by using Folin-Ciocalteu colorimetric method and antioxidant activity was measured by using DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging assay described by Mahloko et al., [17].

2.2.7 Sensory evaluation

The sensory analysis of formulated cookies was carried by using semi trained panel members on 9-point hedonic scale (9-like extremely to 1-dislike extremely) as per the method suggested by Upadhyay et al. [18].

2.2.8 Texture analysis

The texture profile analysis of prepared cookies samples was performed by using Texture Pro CT V1.7 Build 28 texture Analyzer.

2.2.9 Statistical analysis

The collected data statistically analysed using the complete randomised design (CRD) to determine level of significance as per the method proposed by Panse and Sukhatme [19]. The analysis of variance revealed at significance of P<0.05 level, S.E and C.D at 5% is mentioned wherever required.

3. RESULTS AND DISCUSSION

3.1 Physical Parameter of Raw Material

The selective physical parameters (Colour, particle size and bulk density) of raw material (Wheat bran and refined wheat flour) were assessed and the results obtained are presented in the table no.3.

The colour of flour and particle size contributes in deciding the finished product quality. Refined wheat flour colour observed to be white compare to wheat bran which appeared yellow in colour. Particle size affects flour purity and water absorption capacity of wheat flours during kneading. The particle size of refined wheat flour and wheat bran was observed to be 141.80 and 213.21 µm respectively indicating larger particle size of wheat bran assist in enhancing water absorption capacity. These results are in good agreement with Kamal-Eldin et al. [20] and

Navrotskyi et al., [21]. Bulk density represents the weight per unit volume. The bulk density of materials affects the processing economics, such as handling and transporting costs. The bulk density of refined wheat flour was 0.64 g/ml and found to be greater than the wheat bran (0.49 g/ml) similar results observed to David et al., [22] and Shenoy and Prakash [23].

3.2 Proximate Composition of Raw Material

The finished product quality is dependent on raw material quality. The data on proximate analysis of refined wheat flour, wheat bran and tulsii powder is depicted in table no. 4. which reflects its suitability in cookies formulations.

Moisture content emphasizes on shelf life and stability. The highest value for moisture content was found in maida (12.3%) against wheat bran (9.1%) and tulsii powder (4.2%). Fat is major source of energy in food and plays significant role in cookies texture enhancement. The highest fat content observed in wheat bran (3.5%) followed by maida (1.3%) and tulsii powder (1.2%). Protein is core component of food product which has major role in body building. Wheat bran had the highest protein content (17.1%), followed by maida (10.3%) and tulsii powder (7.8%) justifying raw ingredient as protein enhancing component. Fiber is essential to maintain intestinal health. Constipation can be managed or relieved by eating sufficient fiber, which aids waste movement through the body. Wheat bran, tulsii powder, and maida contained 21.9 %, 12.20 % and 2.5 % crude fiber respectively reflecting the wheat bran as rich source of crude fiber. Carbohydrates are one of our diet's macronutrients, and their primary role is to supply energy to the body. Maida contains more carbohydrates than wheat bran and tulsii powder. Maida, wheat bran, and tulsii powder contained 76.3 %, 68.5 %, and 47.3 % carbohydrate respectively. Ash content helps to determine the amount and type of minerals in food. Maida has the lowest ash content of 0.4 %. Wheat bran contains the highest ash (4.48 %) content. The ash content of tulsii powder was 3.1 %.

The results recorded regarding proximate parameters (Moisture, fat, protein, crude fiber, ash and carbohydrate) are in close agreement with the findings of Sudha et al., [24], Stevensons et al., (2012), Onipe et al., [25], Shenoy and Prakash [23] for wheat bran, Hend

et al., [26] for refined wheat flour and Kaur et al., [27], Wisdom et al., [28], Mansoori et al., [29] Akbar et al., [30] for tulsii powder.

3.3 Effects of Wheat Bran Incorporation on Sensory Characteristics of Cookies

The organoleptic characteristics of wheat bran cookies samples were evaluated by semi trained panelists using 9-point hedonic scale and the results are shown in fig 2.

The colour, being an important parameter emphasizes on the overall appearance and consumer acceptability of food product. The progressive increase in colour score was observed up to 30 % wheat bran incorporation. The colour score of S₃ (7.5) sample was comparable to control sample score (7.6) and highest among all the incorporation level of wheat bran. The data indicates lowest colour score in S₄ (7.2) sample. This may be due to highest wheat bran level (35%) affected on colour score. Texture plays a crucial role in judging food quality. Perceived texture is intimately tied to the structure and composition of the food. Among the various wheat bran addition levels, 30% incorporated cookies sample (S₃) had highest score (7.5) in texture followed by S₂ (7.4), S₁ (7.4) and S₄ (7.0). The taste is a good predictor of food product consumption. The taste score was highest in the S₃ (7.6) sample as compare to other wheat bran incorporated samples reflecting on acceptability of wheat bran and bakery ingredient. Beyond the 30% bran inclusion, cookies were slightly gritty and had residual branny mouthfeel, hence the taste score was low in S₄ (6.8). Flavour influences product acceptance by inducing hedonic response. The flavour score ranges from 6.9 (S₄) to 7.6 (S₃). It is observed from the sensory profile evaluation, overall acceptability of 30 % bran incorporated cookies is more (7.6) than the other wheat bran incorporated cookies sample. The organoleptic characteristics score was found to be highest in S₃ (30%) sample against rest of the sample. Hence the 30% wheat bran inclusion is further selected for the incorporation of herb (Tulsii powder).

3.4 Effect of Tulsii Powder Incorporation on Sensory Characteristics of Wheat Bran Cookies

The sensory attributes of wheat bran (30%) and tulsii powder (1, 2 and 3%) incorporated cookies

were analysed and the results are presented in Fig 3.

The colour of a product has direct influence on consumer acceptability. The colour score was observed to be decreasing (7.8 to 7.1) from 1 to 3 % tulsii powder incorporation in selected (30% wheat bran) cookies sample. Reduction in colour score with increasing level of tulsii powder attributed to the inherent green colour of tulsii powder. The cookies become slightly darker in colour as the herb (Tulsii powder) inclusion level increased. Crispiness is major textural characteristics of cookies which has impact on mouthfeel. Highest texture score observed in S₁ (7.5) as compared to the other herb added

cookies sample. The slight decrease in texture score was observed due to the increased fiber content in the cookies sample after addition of wheat bran and herb (Tulsii powder). Taste is deciding factor in repurchase behavior of consumer. The sensory evaluation indicated taste and flavour score ranges from 6.7 to 7.7 and 6.6 to 7.5 in S₃ to S₀ sample respectively. Tulsii powder has a strong aroma and a bitter flavour, so the taste and flavour score reduced with inclusion of rising level of tulsii powder. The overall acceptability score observed to be highest in S₁ (7.6) against another sample. Hence 30% wheat bran and 1% tulsii powder proportion was sensorially acceptable for enriching cookies with high fiber content.

Table 3. Physical parameters of raw material

Raw material	Parameters		
	Colour	Particle size (µm)	Bulk density (g/ml)
Wheat bran	Yellow	213.21	0.49
Refined wheat flour	White	141.80	0.64
SE ±	-	0.065	0.019
CD @ 5%	-	0.225	0.037

**Each value is average of three observations*

Table 4. Proximate of composition of raw material

Raw material	Parameters (%)					
	Moisture	Fat	Protein	crude Fiber	Carbohydrate	Ash
Maida	12.3	1.3	10.3	2.5	76.3	0.4
Wheat bran	9.1	3.5	17.1	21.9	68.5	4.4
Tulsii powder	4.2	1.2	7.8	12.2	71.5	3.1
SE ±	0.081	0.045	0.025	0.022	0.058	0.019
CD @5%	0.282	0.156	0.089	0.079	0.202	0.067

**Each value is average of three observations*

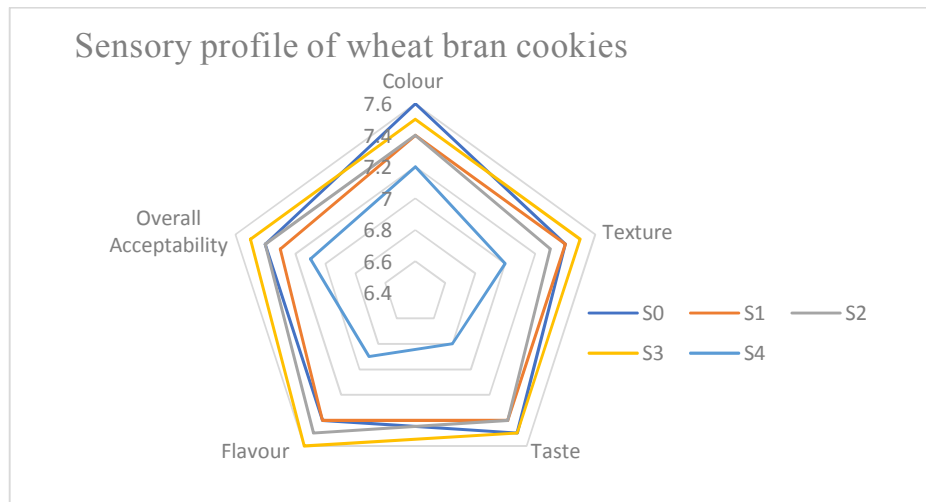


Fig. 2. Sensory profile of wheat bran cookies

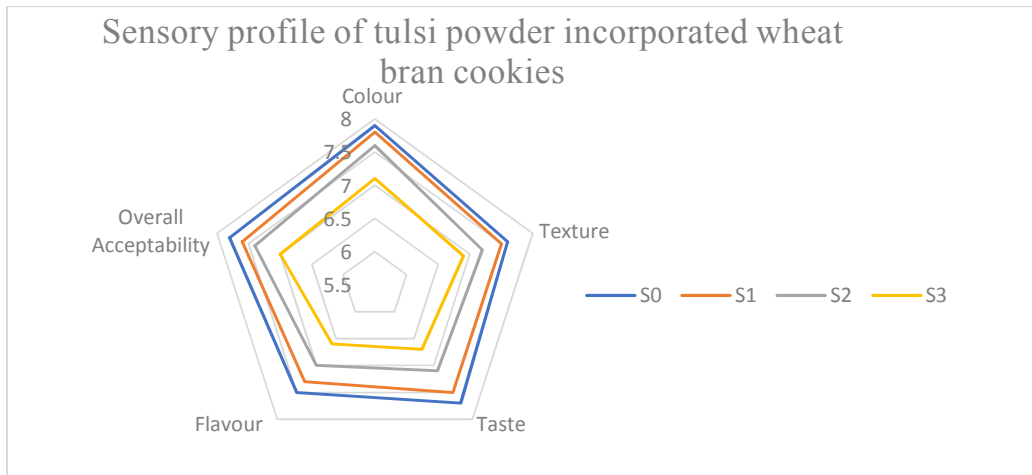


Fig. 3. Sensory profile tulsii powder incorporated wheat bran cookies

3.5 Physical Properties of Tulsii Powder Incorporated Wheat Bran cookies

S₀ – 0 % wheat bran, **S₁**-30% bran and 1% tulsii powder, **S₂** -30% wheat bran and 2% tulsii powder, **S₃** -30% wheat bran and 3% tulsii powder.

The physical parameter of tulsii powder incorporated wheat bran cookies is analyzed and the results obtained were shown in the table no. 5. The weight of the cookies is slightly increased by the addition of tulsii powder in wheat bran cookies. The highest weight shown by the sample **S₃** (10.81g). The diameter and spread ratio of cookies was slightly decreased as increase in the tulsii powder addition. The higher diameter shown by the control sample (5.61cm) and lower diameter observed in the sample **S₃** (5.41cm). The volume of cookies decreased from 17.78cm³ to 17.23cm³ with increase in tulsii powder. Thickness slightly increased in sample **S₃** (0.75cm). There are no significant changes in thickness of **S₁** and **S₂** (0.74cm). Lowest thickness observed in control sample (0.72 cm). Highest density was observed in the sample **S₃** (0.63 gm/cm³) followed by **S₁** and **S₂** (0.62 gm/cm³). The physical analysis of cookies is in good agreement with result of Filipcev et al., [31].

3.6 Proximate Composition of Tulsii Powder Incorporated Wheat Bran Cookies sample

S₀-0% wheat bran and 0% tulsii powder, **S₁**-30% bran and 1% tulsii powder, **S₂** -30% wheat bran and 2% tulsii powder, **S₃** -30% wheat bran and 3% tulsii powder.

Proximate composition (Moisture, fat, protein, dietary fiber, ash and carbohydrate) of tulsii powder incorporated wheat bran cookies was analysed and results are reported in table no 6.

Moisture and temperature regulation during cookies production and baking operation ensures the end product quality and shelf life. Low moisture content controls enzymatic activity and microbial growth. The moisture content of formulated cookies slightly increased due to wheat bran and tulsii powder incorporation from sample **S₀** to **S₃** (1.54 to 2.12 %). Enhanced water retention resulted in significant rise of moisture level in cookies sample due to presence of more polysaccharides in bran and tulsii powder. Fat controls the texture of finished product, its spread and its appearance. With the inclusion of wheat bran and tulsii powder, the fat level slightly decreased from 24.84% to 23.19%. Protein has immense importance as body building component. Wheat Protein performs various function as dough conditioner, structuring agent and moisture controller influencing functional properties of flour and dough. Data from table no. 6 indicated the rise in protein content from sample **S₀** (8.12 %) to **S₃** (12.04 %). Fiber is composed of indigestible plant parts. The primary function of fiber is to keep the digestive system healthy. Due to the inclusion of wheat bran and tulsii powder, the dietary fiber content increased from 3.54 % to 6.98 %. Reflecting high fiber content of finished product. The sensorially accepted wheat bran herbal cookies (**S₁**) found to contain 6.15% dietary fiber suffice high fiber requirement as per FSSAI (6g /100g). The ash content of foods is simply the result of organic content being burned away, leaving inorganic

minerals. Cookies had ash content ranging from 1.08% (S₀) to 1.82% (S₃). Carbohydrates provide energy for daily tasks and they are the primary source of fuel for our brain's high energy demands. Carbohydrate was observed to be reduced from 60.56 % (S₀) to 53.76 % (S₃).

The proximate analysis values of cookies were in close agreement with result obtained by Filipcev B. et al., [31], Karthiga and Kiruthika [32]. Alam et al., [6], Alam et al., [33] for wheat bran herbal and Gupta et al., [10], Ertas N. [34], Sudha et al., [24] wheat bran cookies.

3.7 Effect of Wheat Bran and Tulsi Powder Incorporation on Antioxidant Activity and Total Phenol Content (TPC) of Cookies Sample

S₀-0% wheat bran and 0% tulsi powder, S₁-30% bran and 1% tulsi powder, S₂-30% wheat bran and 2% tulsi powder, S₃-30% wheat bran and 3% tulsi powder.

Table 5. Physical parameters of tulsi powder incorporated wheat bran cookies

Sample	Physical parameter					
	Weight (cm)	Diameter (cm)	Thickness (cm)	Volume (cm ³)	Spread ratio	Density (gm/cm ³)
S ₀	9.39	5.61	0.72	17.78	7.79	0.52
S ₁	10.78	5.47	0.74	17.38	7.39	0.62
S ₂	10.79	5.45	0.74	17.25	7.36	0.62
S ₃	10.81	5.41	0.75	17.23	7.21	0.63
SE±	0.013	0.031	0.012	0.041	0.030	0.036
CD @ 5%	0.045	0.102	0.042	0.136	0.098	0.118

**Each observation is average of 3 determinations*

Table 6. Proximate composition of tulsi powder incorporated wheat bran cookies

Sample	Parameter (%)					
	Moisture	Fat	Protein	Dietary fiber	Ash	Carbohydrate
S ₀	1.54	24.84	8.12	3.54	1.08	60.88
S ₁	1.84	23.67	11.23	6.15	1.58	55.53
S ₂	1.99	23.32	11.75	6.66	1.75	54.54
S ₃	2.12	23.19	12.04	6.98	1.82	53.85
SE	0.030	0.170	0.020	0.019	0.033	0.018
CD @5%	0.100	0.554	0.066	0.064	0.110	0.059

**Each observation is average of three determinations*

Table 7. Antioxidant activity and Total Phenol Content profile of wheat bran tulsi powder and cookies

Sample	% Inhibition	Total phenol content (mg GAE /100gm)
Wheat bran	21.20	108.56
Tulsi powder	77.20	73.56
S ₀	22.79	5.98
S ₁	27.23	16.46
S ₂	28.43	20.66
S ₃	29.38	23.56
SE	0.011	0.008
CD @ 5%	0.034	0.028

**Each observation is average of 3 determinations*

Table 8. Texture profile of standardized cookies

Sample	Hardness (g)	Fracturability (g)	Adhesiveness (mJ)	Cohesiveness	Chewiness (mJ)
S ₀	2450.0	2212.0	1.70	0.42	89.30
S ₁	3229.0	3152.0	1.10	0.75	83.70
SE	0.091	0.062	0.057	0.013	0.078
CD @ 5%	0.358	0.244	0.226	0.051	0.308

*Each observation is average of three determinations

Total phenol content and antioxidant activity of wheat bran and tulsi powder were analyzed and results presented in the Table no.7. The total phenolic content and antioxidant activity observed to be 108.56 mg GAE/100g, 21.20% inhibition in wheat bran and 77.2 mg GAE/100g and 73.56 % inhibition in tulsi powder. Similar results were observed by Pathak and Niraula [35] for tulsi and Lopez-Perea et al., [36] and Zhou and Yu [37] for wheat bran.

The antioxidant activity profile of formulated of cookies containing wheat bran and tulsi powder presented in the Table no.7. The antioxidant activity increased 16.3% in S₁(27.23 % inhibition) as compare to control (22.79 % inhibition) due to incorporation of wheat bran and tulsi powder. These results are in good agreement with Sharma, and Gujral [38], Lee et al., [39] and Bilgicli et al., [40]. Increase in antioxidant activity because of processing such as baking and microwave roasting. This may be attributed due to the formation of brown pigments melanoidins, which are the products of Maillard reaction (a non-enzymatic browning reaction), which takes place during baking [41]. The total phenol content of formulated cookies sample is depicted in Table no.7. The total phenol content was progressively increased with rising level of wheat bran and tulsi powder from S₀ (5.98 mg GAE/100gm) to S₃ (23.56 mg GAE/100gm) sample. This is attributed to higher level total phenol content in wheat bran and tulsi powder. These results are in close agreement with the findings of Sharma, and Gujral [38], Lee et al., [39] and Bilgicli et al., [40].

3.8 Texture Profile of Tulsi Powder Incorporated Wheat Bran Cookies

S₀-0% wheat bran and 0% tulsi powder, S₁-30% bran and 1% tulsi powder.

The texture profile analysis of standardized cookies (30% bran and 1% tulsi powder) presented in the table no. 8.

One of the most important texture characteristics is hardness (firmness), which is frequently used to identify the freshness of food. Hardness is the force require to compress a food between molars. It is defined as force necessary to attain given deformation. Hardness and fraturability of cookies were increased from 2450.0 g to 3229.0 g and 2212.0g to 3152.0 g in sample S₀ and S₁ respectively. This is due to the water holding capacity of fibers. Cohesiveness is a dimension less unit measured by dividing the energy consumed during the second compression by the energy consumed during the first compression. Cohesiveness of sample S₁ has increased which signifies that the strength of the internal bonds making the product's body which is high for sample S₁ (0.75) against S₀ (0.50). Adhesiveness describes the ability required to resist the attraction forces that exist between the surfaces of food and the surfaces of other materials with which food interacts such as the tongue, teeth and palate. It means the capability necessary to remove food from a surface. The adhesiveness was observed to reduce with the incorporation of wheat bran and tulsi powder in finished product (1.10 mJ). Chewiness is the energy required to chew a solid food product to swallowing ready state. The chewiness is more in S₀ (89.30 mJ) sample than the S₁(83.70 mJ) indicating improved textural attributes of wheat bran (30%) and tulsi powder (1%) incorporate. These results are in good agreements with the Filipcev et al., [31],Erinc et al., [42].

4. CONCLUSION

Wheat bran and tulsi powder incorporated cookies provides a healthy option for the health-conscious consumers in bakery sector with enhanced dietary fiber, protein, and antioxidant activity. Cookies at 30% wheat bran and 1% tulsi powder incorporation recorded higher acceptability as compared to control (100% refined wheat flour) cookies. Wheat bran and tulsi powder incorporated cookies have the potential to satisfy the consumer demands for nutritionally rich food product.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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