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Study on the use of extruded wheat bran and xanthan gum in chocolate sponge cake

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ABSTRACT

The properties of wheat bran affect its performance in food formulations. The technological and nutritional properties of bran can be improved by using the extrusion cooking process. In this study, extruded wheat bran at levels of 0, 1, 2, and 3 % and xanthan gum at levels of 0, 0.05, and 0.1 % were used in the formulation of chocolate sponge cake, and the moisture, specific volume, porosity, texture firmness, crust color, and sensory properties of the cake were evaluated. The results showed that the sample containing 3 % bran and 0.1 % xanthan gum had the highest moisture content. The results of the surface color (crust) evaluation indicated that all three crust color components (L*a*b*) were similar in all produced samples. The sample containing 2 % bran and 0.05 % xanthan gum and the sample containing 3 % bran and 0.1 % xanthan gum had the highest specific volume and porosity, and the lowest texture firmness. Sensory evaluation also showed that with increasing bran consumption in the formulation, the amount of xanthan gum increased. So that in samples containing 2 and 3 % bran, the presence of 0.05 and 0.1 % xanthan gum in the sponge cake formulation was required to achieve the best sensory properties, respectively. Therefore, considering all the findings from the physical, chemical, textural and sensory evaluation of the produced samples, the sample containing 2 % extruded wheat bran and 0.05 % xanthan gum and the sample containing 3 % extruded wheat bran and 0.1 % xanthan gum are introduced as the superior samples of this study.

1- Introduction

In the diet of individuals, cereal-based bakery products occupy a highly prominent position. These foods not only play a key role in supplying energy, vitamins, and minerals needed by the body, but also, owing to the low cost of raw materials, offer considerable added value [1]. Consequently, given the importance of baked goods as staple foods in the population, their enrichment warrants particular attention. The production of bran-enriched bakery products, including bran-rich cakes, can have substantial health-promoting effects. Dietary fibers, with beneficial nutritional and health effects, can contribute to the reduction of obesity, the management of diabetes mellitus, and the decreased risk of cardiovascular diseases and colorectal cancer, while supplying a large portion of B vitamins and minerals required for metabolic processes [2]. The use of bran flour is limited by the presence of phytic acid, which in wheat bran typically ranges from about 4.5 to 4.8%. Additionally, the relatively high ratio of insoluble to soluble fibers, insoluble arabinoxylans, and glutathione are among the factors that cause technological challenges in bran-enriched bakery products [3]. Extrusion cooking represents an effective strategy for reducing anti-nutritional compounds and processing-related degradations in baked products. During extrusion, materials are subjected to a combination of moisture, pressure, temperature, and mechanical shear, which induce a range of physicochemical transformations. The process offers notable advantages, including reductions in microbial load and inactivation of certain anti-nutritional factors, such as phytates present in bran. Additionally, extrusion alters the structure of dietary fiber, increasing the fraction of soluble fiber [4]. Moreover, to mitigate the adverse effects of bran on the protein and starch matrices, hydrocolloids can be employed in the formulation of baked products. Xanthan gum, in particular, exhibits high solubility in both cold and hot water and possesses strong emulsifying, suspending, and stabilizing capabilities [5]. In food systems, xanthan gum displays pseudoplastic behavior, whereby viscosity decreases with increasing shear rate. This rheological property can influence processing performance and sensory outcomes, including enhanced release of volatile compounds and flavors and an improved mouthfeel [6].

Xanthan gum exhibits high tolerance to pH values ranging from 2 to 12, making it suitable for use across a wide spectrum of food systems. It demonstrates good stability under acidic conditions and has been utilized in fruit-based bakery products [7]. The gum can maintain moisture in doughs and contribute to the shelf-life stability of baked goods. Additionally, xanthan gum is effective at increasing loaf volume and crumb porosity, particularly in weaker flours such as bran-containing flours [8]. Accordingly, the objective of this study is to evaluate the use of extruded wheat bran at levels of 0, 1, 2, and 3% in conjunction with xanthan gum at 0, 0.5, and 1% in the production of bran-enriched sponge cake, with the aim of leveraging the nutritional benefits of bran and improving product quality through the application of xanthan gum.

2- Materials and Methods

2.1. Materials

Wheat flour (extraction rate 78%) and wheat bran prior to extrusion were obtained with moisture contents of 12.50%, ash 5.45%, protein 15.00%, fat 5.30%, and phytic acid 2200 mg per 100 g, from the Al-Quds Razavi Flour Company. Oils, sugar, sodium pyrophosphate, eggs, vanilla, cocoa, and other chemicals were procured from reputable suppliers and brands, including Sigma-Aldrich, Merck, and others.

2.2. Preparation of Extruded Bran

Extruded bran was prepared using a co-rotating twin-screw extruder operated at a barrel temperature of 140°C. The feed moisture was 20%, the feed rate was 40 kg/h, the screw speed was 120 rpm, and the die diameter was 3 mm. post-extrusion, the bran was milled to obtain a uniform particle size using a 120-mesh sieve [9]. The extruded bran contained 9.50% moisture, 5.55% ash, 16.40% protein, 4.90% fat, and 850 mg per 100 g of phytic acid.

2.3. Chocolate Sponge Cake Preparation

Formulation of the chocolate sponge cake comprises the following ingredients by weight: 250 g wheat flour, 214 g granulated sugar, 0.8 g vanilla, 5.15 g milk powder, 0.70 g cocoa powder, 4 g sodium pyrophosphate, 110 g oil, 210 g eggs, and 225 g water. For the preparation of the control sponge cake, the eggs are first beaten in a mixer at high speed for 1 minute. The oil is then added to the eggs and the mixture is beaten for an additional 20 seconds. Water is subsequently incorporated and the mixture is beaten at high speed for 1 minute until a foamy, aerated consistency is achieved. In a separate vessel, all dry ingredients are thoroughly blended and, in three successive additions, are incorporated into the foamy wet mixture (eggs, oil, and water), with continuous mixing of 1 minute per addition to yield a smooth, homogeneous batter. The batter is then portioned into appropriate pans and baked in a convection oven (a unit manufactured by Mashhad Baking Industries) at 180°C for 40 minutes. For the bran-containing variants, bran is added at 0, 1, 2, and 3% by weight of the flour. In addition, xanthan gum (and/or both xanthan gum and bran) is incorporated into the aqueous phase at 0, 0.25%, and 0.50% by weight of the flour. All other steps follow the same protocol as described for the control sample. The preparation protocol thus remains consistent across samples, with modifications limited to bran and hydrocolloid (xanthan gum) inclusion levels and corresponding adjustments in the liquid–solid balance to accommodate the added components.

2.4. Moisture content

The moisture content of the manufactured samples was measured by oven-drying at three time points—2 hours, 1 week, and 2 weeks after baking—in accordance with the AACC standard method 01-15-45 (2000) [10].

2.5. Specific volume

Specific volume was determined from volume measurements of the samples using volume displacement with canola seed as the filling medium, following AACC (2000) method 10-72 [10]. The sample volume (ml) was divided by the sample weight (g) to compute bulk density (g/ml).

2.6. Porosity

Porosity (internal crumb porosity) of the sponge cake was evaluated using image processing with ImageJ in three steps: (a) preparation of a 4 cm by 4 cm cut using a 120 W electric saw, model 41600, to obtain a precise slice with minimal waste; (b) imaging of the cut samples with a HP ScanJet G3010 scanner at a resolution of 300 dpi; (c) analysis of the images using ImageJ [11].

2.7. Texture hardness

TA Plus texture analyzer (Stable Micro Systems, UK) employed to evaluate the texture of the cake crumb at three post-baking intervals: 2 hours, 1 week, and 2 weeks. The texture hardness was defined as the maximum force required to penetrate the sample with a cylindrical probe (diameter 2 cm, height 1.5 cm) moving at a speed of 60 mm per minute [12].

2.8. Crust color values ($L^*a^*b^*$)

For color evaluation, crust color was measured using a HunterLab instrument by placing samples in a standard white chamber for digital photography, after which images were processed with the instrument's software. The color space was described by CIELAB coordinates (L^*, a^*, b^*): L^* ranges from 0 to 100 (black to white), a* from −120 to +120 (red to green), and b* from −120 to +120 (yellow to blue) [13].

2.9. Sensory properties

Ten panelists were selected for sensory evaluation. The sensory evaluation employed a five-point hedonic scale (very good = 5, good = 4, average = 3, poor = 2, very poor = 1). The attributes assessed included form and shape (weighting factor 4), surface characteristics of the upper and lower surfaces (weights 2 and 1, respectively), porosity and crumb structure (weight 2), hardness and softness of the crumb (weight 2), chewability (weight 3), and aroma and flavor (weight 3) [14-15]. The overall acceptability score for each cake sample was computed as a weighted composite of these attribute scores, i.e., the mean scores of the sensory attributes multiplied by their respective weighting coefficients.

2.10. Statistical analysis

Statistical analysis was conducted using a completely randomized factorial design. The first factor was extruded wheat bran at levels of 0, 1, 2, and 3 percent, and the second factor was xanthan gum at levels 0, 0.5, and 1.0 percent. Data were analyzed with MiniTab software (Version 17), and mean comparisons were performed using Duncan's post hoc test at a significance level of $P < 0.05$.

3- Results and Discussion

3.1. Moisture content

Table 1 presents the moisture evaluation results of cake samples stored for one month under varying levels of extruded wheat bran and xanthan gum. The results indicate that sponge cakes containing bran exhibited higher moisture content than the control (without extruded wheat bran) both immediately after baking and after two weeks of storage. This is most likely due to greater water retention in the cake formulation or to weaker interactions within the internal texture matrix caused by the presence of bran [16]. In this context, Yawen et al. (2021) used extruded wheat bran in the formulation of a steamed brown rice-based cake and reported higher moisture in bran-containing samples compared with bran-free samples. The authors attributed this to the presence of pentosan in cereal brans, particularly wheat bran, as a key factor in maintaining the moisture of baked and stored bakery products [17]. In addition, the results suggest moisture retention in samples containing xanthan gum during baking and thereafter, relative to the control lacking gum. Barsenas and Rosell (2006) and McCarthy et al. (2005) reported that the hydrophilic nature of gums enhances water interactions and absorption in flour, thereby increasing dough water retention during baking and contributing to the maintenance of cake moisture throughout shelf life [11 and 18]. Taramsari and Ghiyasi Tarzi (2024), based on their findings, concluded that the presence and increased use of xanthan gum in sponge cake formulations leads to higher cake moisture, a phenomenon attributed to the hydrophilic properties of gums and to a greater number of hydroxyl groups in xanthan gum compared with other formulation components such as flour (protein and starch) [19].

Table 1: The effects of extruded wheat bran and xanthan gum on the moisture of cake during 3 times

Treatments	Extruded wheat bran (%)	Xanthan gum (%)	Moisture (%)		
			2 hours	1 week	2weeks
1	-	-	$20.80±0.99^{b}$	$18.60±2.26^{c}$	$15.80±0.42^{d}$
2	-	0.05	$24.15±1.06^{ab}$	$20.60±0.49^{abc}$	$18.10±1.27^{bcd}$
3	-	0.10	$24.35±1.06^{ab}$	$21.50±1.27^{abc}$	$19.55±1.34^{abc}$
4	1	-	$23.35±0.78^{ab}$	$19.05±0.77^{bc}$	$17.50±0.42^{cd}$
5	1	0.05	$24.25±1.06^{ab}$	$20.65±0.14^{abc}$	$18.65±0.49^{bcd}$
6	1	0.10	$24.65±0.92^{ab}$	$22.15±0.49^{ab}$	$19.55±0.92^{abc}$
7	2	-	$23.97±0.98^{ab}$	$20.60±0.99^{abc}$	$18.73±0.28^{bc}$
8	2	0.05	$24.45±0.77^{ab}$	$20.10±1.27^{abc}$	$18.99±0.07^{abc}$
9	2	0.10	$24.75±0.35^{ab}$	$22.30±0.57^{ab}$	$19.45±0.35^{abc}$
10	3	-	$23.50±1.27^{ab}$	$19.50±0.49^{abc}$	$19.00±0.28^{abc}$
11	3	0.05	$25.10±1.27^{a}$	$22.35±0.35^{ab}$	$20.45±0.07^{ab}$
12	3	0.10	$26.60±0.85^{a}$	$23.20±0.28^{a}$	$21.65±0.91^{a}$

Different letters represent a significant difference from one another ($p<0.05$).

3.2. Specific volume

Table 2 reports the findings from the assessment of the specific volume of sponge cake as influenced by different levels of extruded bran and xanthan gum. The results indicate that the presence of high levels of extruded wheat bran and xanthan gum in the cake formulation exerts a negative effect on the specific volume of the produced samples, whereas an intermediate level of extruded bran (2%) combined with xanthan gum (0.5%) demonstrated a positive effect on the specific volume of the produced samples. Majzoobi et al. (2013) reported that the reduction in specific volume observed in bakery products containing high levels of wheat bran can be attributed to interactions between the gluten network and bran. It has been established that hydroxyl groups in the wheat bran fiber participate in water absorption by the protein and gluten network in dough. In other words, these components engage in hydrogen bonding with water, thereby increasing the water-holding capacity of the product. Conversely, the presence of arabinoxylans within the gluten network derived from bran-containing flour reduces water availability for the gluten network, resulting in decreased elasticity and gas retention in the dough and, consequently, lower final product volume [20]. Coda et al. (2014) advocated the use of bran with intermediate particle size in bread formulations to improve volume without the negative effects of bran on crumb structure, attributing this to a dilution of gluten. They also noted that the reduction in loaf volume observed in fiber-containing bread with fine particle size could be driven by either a weakened gas-retaining network or interference with carbon dioxide generation [21]. Ozkaya et al. (2018), the addition of bran and the excessive reduction of its particle size are factors that diminish the number and area of gas bubbles, promote a weak crumb structure, and consequently reduce loaf volume. Overall, the count and volume of bubbles are reliable indicators of the sufficiency and quality of the bread crumb architecture, with bran exerting a negative effect on this structure. The deleterious impact is attributed to a combination of physical effects of bran particles on the gluten network and chemical effects involving glutathione and other reducing agents. Moreover, a reduction in dough stability is more closely related to the destabilizing influence of bran particles on the gas-escape film surrounding the bubbles. A further observation is that increasing gum concentration in the formulation is likely to decrease specific volume, probably due to a marked rise in viscosity that hinders dough extensibility and gas retention [22]. Sahraiyan et al. (2013) investigated xanthan gum in a semi-leavened bread formulation and reported reductions in loaf volume, particularly at higher usage levels (above 0.3%). They note that xanthan gum can generate high viscosity even at very low usage levels. Consequently, when the level of this gum is selected to suit the formulation and the flour type, the viscosity can strengthen the walls of the gas bubbles within the dough and help preserve them during baking, thereby increasing the specific volume of the bread. "However, if the level of formulation ingredients exceeds the required amount, the gluten network becomes stronger than expected, which disrupts the distribution of air bubbles within the dough matrix. In addition, an excess of gum in the formulation, by increasing the apparent viscosity, leads to thicker walls of the gas cells, which hinders the expansion of these bubbles during baking and results in a substantial reduction in volume [23]. Ghaemi et al. (2024) reported similar findings regarding the addition of xanthan gum to cake formulations. Their results showed that the presence of more than 0.15% xanthan gum in the formulation caused a decrease in specific volume, attributed to increased apparent dough viscosity and the gel resistance of xanthan [24]. The findings of Khoshdouni Farahani (2021) likewise indicate a reduction in the specific volume of sponge cake as a result of xanthan gum levels exceeding 0.10% in the formulation, an effect attributed to the reinforcement of the gluten network by the gum and the inhibition of airbubble expansion within the dough, along with the appropriate evaporation of water present in the dough (water absorption by xanthan gum) [25].

Table 2: The effects of extruded wheat bran and xanthan gum on the specific volume of cake

Treatments	Extruded wheat bran (%)	Xanthan gum (%)	Specific volume (ml/g)	Porosity (%)
1	-	-	2.60±0.14[a]	38.30±0.42[a]
2	-	0.05	1.95±0.07[bcd]	35.95±1.34[ab]
3	-	0.10	1.25±0.07[f]	34.35±0.92[ab]
4	1	-	1.95±0.07[bcd]	32.65±0.49[bc]
5	1	0.05	2.45±0.21[ab]	36.00±1.41[ab]
6	1	0.10	1.80±0.14[cdef]	35.60±0.85[ab]
7	2	-	1.57±0.07[def]	29.47±0.78[cd]
8	2	0.05	2.30±0.14[abc]	37.60±0.57[a]
9	2	0.10	1.90±0.14[bcd]	36.15±1.20[ab]
10	3	-	1.20±0.14[f]	26.00±0.92[d]
11	3	0.05	1.85±0.21[cde]	37.10±1.27[ab]
12	3	0.10	2.35±0.07[abc]	38.55±0.78[a]

Different letters represent a significant difference from one another ($p<0.05$).

3.3. Porosity

Table 2 presents the findings on the porosity of cake samples measured under the influence of different levels of extruded wheat bran and xanthan gum. Porosity is defined as the fraction of void spaces within the product that are filled with air, calculated as the pore volume divided by the total sample volume [26]. The results indicate that incorporating extruded wheat bran into the sponge cake formulation acts as a negative factor for porosity. However, the simultaneous addition of extruded bran with xanthan gum mitigates these adverse effects, such that the sample containing 3% extruded wheat bran and 1.0% xanthan gum exhibits porosity comparable to the control sample (which contained neither extruded bran nor xanthan gum). In this context, Sahraiyan et al. (2013) reported that very small levels of xanthan gum in baked products containing weak flours (such as bran-containing flours) enhance dough viscosity and strengthen the gluten network, which improves the distribution and stabilization of air bubbles during baking, thereby increasing loaf volume and porosity [23]. The literature further indicates that the addition of dietary fiber sources to flour can reduce gluten development, compromising the dough's elastic properties, enabling air bubbles to escape during processing, and leading to reduced crumb porosity and increased firmness of the crumb [27]. Dudu et al. (2020) found that hydrocolloids contribute to increasing the number of voids, their surface area, and the overall porosity of the internal crumb by promoting high water absorption and improving dough stability and gas retention [28]. Anvarinejad and Javadi (2017) reported that the addition of agar gum to sponge cake increases porosity; during baking, small gas cells coalesce with larger bubbles, enlarging internal voids and thereby enhancing porosity. Moreover, the use of various gums and emulsifiers can form a protective coating around small emulsion droplets, preventing coalescence and thereby increasing the porosity [29].

3.4. Texture hardness

Table 1 presents the results of an assessment of crumb hardness in cake, conducted after one month of storage, as a function of varying levels of extruded bran and xanthan gum. The findings indicate that the presence of wheat bran increases crumb hardness, whereas the inclusion of xanthan gum reduces it. In line with Rieder et al. (2012), the increase in hardness for this class of bran-containing baked products is attributed to the dilution of the gluten network resulting from water uptake by bran fibers (both soluble and insoluble) [30]. Noort et al. (2010) likewise reported that bran in baked products can hinder gluten protein aggregation during mixing, contributing to greater crumb hardness [31]. Ozkaya et al. (2018) further demonstrated that bran addition decreases the number of bubbles and bubbly regions, leading to a weaker crumb and, consequently, increased hardness. Overall, the number and volume of gas cells are considered indicators of the sufficiency of the internal crumb structure in baked goods; bran exerts a negative influence on this structure. The deleterious effect of bran is proposed to arise from a combination of physical interactions whereby bran particles disrupt the gluten network and chemical interactions, such as those involving glutathione and other reducing agents. Moreover, reductions in dough stability are more closely linked to the destabilizing effects of bran particles on gas-bubble films, and collectively these changes account for the observed increase in crumb hardness of bakery products [22]. Ortiz et al. (2020) reported analogous findings, noting that the addition of wheat bran to flour increased the textural hardness of bread. In this context, hydrocolloids such as xanthan gum can influence starch structure and, hence, the distribution and retention of water within doughs and bakery products [32]. The greater water affinity of gum-containing systems in the dough reduces moisture migration from starch and gluten proteins, which helps explain the softer crumb observed in samples containing gum compared with those lacking it [32]. Consequently, the starch constituents—amylose and amylopectin—tend to crystallize later, and the polymerization of their chains is delayed, leading to a reduction in crumb hardness [23]. Noshad et al. (2022) examined the use of xanthan and guar gums (xanthan/guar oligo-gels) as fat replacers in sponge cake formulations. Their results showed that substituting 75% of fat with xanthan/guar oligo-gels decreased the cake's hardness, adhesiveness, and chewiness [33]. Busarawan et al. (2015) employed xanthan gum at levels ranging from 0.3% to 1.0% in sponge cake formulations. Their findings indicated that the sample containing approximately 0.10–0.11% xanthan gum exhibited the highest specific volume and the lowest hardness, gumminess, and chewiness, with the gum's beta-glucan content contributing to the reduction in crumb hardness [34].

Table 3: The effects of extruded wheat bran and xanthan gum on the texture of cake during 3 times

Treatments	Extruded wheat bran (%)	Xanthan gum (%)	Hardness (N)		
			2 hours	1 week	2weeks
1	-	-	4.20 ± 0.28^{c}	8.85 ± 0.21^{de}	16.30 ± 0.98^{bcd}
2	-	0.05	4.70 ± 0.24^{bc}	8.50 ± 0.57^{de}	10.15 ± 0.21^{fg}
3	-	0.10	5.80 ± 0.28^{ab}	7.50 ± 0.71^{e}	9.55 ± 0.77^{g}
4	1	-	5.10 ± 0.14^{bc}	11.30 ± 0.42^{cd}	15.45 ± 0.77^{cde}
5	1	0.05	5.00 ± 0.28^{bc}	10.30 ± 0.35^{cde}	13.55 ± 0.63^{cdef}
6	1	0.10	4.60 ± 0.14^{bc}	9.50 ± 0.84^{de}	11.90 ± 0.99^{efg}
7	2	-	5.80 ± 0.21^{ab}	14.67 ± 1.06^{ab}	19.73 ± 0.92^{ab}
8	2	0.05	4.10 ± 0.14^{c}	13.05 ± 0.07^{bc}	16.50 ± 0.70^{bcd}
9	2	0.10	5.40 ± 0.28^{bc}	12.80 ± 1.20^{bc}	15.90 ± 0.70^{cd}

10	3	-	7.20±0.49[a]	17.20±0.92[a]	22.00±0.91[a]
11	3	0.05	5.40±0.56[bc]	15.20±0.98[ab]	18.65±0.92[abc]
12	3	0.10	4.15±0.21[c]	14.30±0.99[ab]	16.55±1.91[bcd]

Different letters represent a significant difference from one another ($p<0.05$)

3.5. Crust color values ($L^*a^*b^*$)

Table 4 presents the colorimetric parameters of cake crusts subjected to varying levels of extruded bran and xanthan gum over a storage period of one month. The colorimetric assessment indicated that the surface color of sponge cakes containing extruded wheat bran and xanthan gum was similar across the samples, with no statistically significant differences observed at the 95% confidence level. It appears that the presence of cocoa powder in all formulations, which imparted a dark coloration due to chocolate, masked any pronounced differences attributable to the extruded bran and xanthan gum. One rationale for adding cocoa powder to bran-containing sponge cake formulations is the availability of information on the negative effects of various brans on the color of baked products (tendency to darken) and the potential to obscure color defects associated with this nutrient. Nevertheless, the inclusion of bran in bakery formulations tends to darken the crust color, whereas the addition of xanthan gum tends to lighten the crust color. An important consideration is that the presence of bran in baked products more markedly influences crumb coloration, while the crust color of these products is largely governed by browning reactions. In this context, Marston et al (2015) reported that the crust coloration of bakery products containing various fiber sources is affected by Maillard reaction and caramelization; specifically, the protein content and the release of reducing sugars modulate the intensity of these reactions, and crust color is not directly dependent on the amount of fiber added. However, some studies have documented darkening of baked goods when bran is incorporated into bread formulations [35]. Coda et al. (2014) and Tonsel et al. (2014) reported crust darkening (decreases in L* and b*, increases in a*) with the addition of wheat bran and rice bran, respectively. In contrast, multiple studies have investigated the use of gums to brighten baked products [21 and 36]. For instance, Mohammadi et al. (2014) observed lighter crust coloration when xanthan gum and other hydrocolloids were added to bread formulations, attributing this to increased dough viscosity, which reduces the intensity of Maillard and caramelization reactions [37]. Conversely, Nooshad et al. (2022) demonstrated that xanthan and guar gums used as fat replacers in sponge cake formulations increased the surface darkness of the samples [33].

Table 4: The effects of extruded wheat bran and xanthan gum on the crust color of cake

Treatments	Extruded wheat bran (%)	Xanthan gum (%)	Crust color		
			L*	a*	b*
1	-	-	58.15±1.20[a]	19.50±0.71[a]	15.10±2.26[a]
2	-	0.05	59.00±1.41[a]	19.95±0.92[a]	24.85±3.46[a]
3	-	0.10	60.65±0.21[a]	18.60±0.57[a]	24.45±1.62[a]
4	1	-	32.65±1.06[a]	20.00±1.41[a]	24.42±2.76[a]
5	1	0.05	58.70±0.42[a]	20.35±0.07[a]	24.05±2.19[a]
6	1	0.10	60.30±0.98[a]	19.45±2.05[a]	24.70±4.10[a]

7	2	-	57.03±0.07^{a}	20.40±1.41^{a}	24.80±1.97^{a}
8	2	0.05	50.58±0.05^{a}	20.10±2.69^{a}	25.05±0.64^{a}
9	2	0.10	60.10±1.27^{a}	19.80±1.13^{a}	24.90±2.96^{a}
10	3	-	56.90±0.63^{a}	18.00±2.26^{a}	26.00±1.27^{a}
11	3	0.05	59.20±1.13^{a}	20.15±2.61^{a}	24.05±3.75^{a}
12	3	0.10	59.95±1.48^{a}	19.45±2.19^{a}	25.35±3.46^{a}

Different letters represent a significant difference from one another ($p<0.05$).

3.6. Sensory properties

Table 5 presents the findings from the sensory evaluation of a cake with varying levels of extruded wheat bran and xanthan gum. The overall acceptance score is described as the mean of all sensory parameters, weighted to reflect their relative importance, including form and shape; upper and lower surface properties; porosity and texture; softness and firmness; chewability; and aroma and taste. The results indicate that both extruded bran and xanthan gum influenced the evaluated sensory attributes. Specifically, the formulations containing 2% extruded wheat bran with 0.5% xanthan gum (rank 1) and 3% extruded wheat bran with 1.0% xanthan gum (rank 2) achieved the highest overall acceptance compared with other samples. Notably, the use of extruded bran in the absence of xanthan gum led to a markedly diminished sensory profile and overall acceptance. These findings align with prior work exploring bran inclusion in sponge cakes. Zolghadri et al. (2023) reported that rice bran can be incorporated up to 2% in sponge cake, with higher bran levels necessitating hydrocolloids in the formulation [38]. Sitong et al. (2022) observed declines in sensory attributes such as softness, taste, appearance, and color with bran incorporation, proposing a reduction in particle size as a strategy to mitigate these effects [2]. Haghighi-Manesh and Azizi (2018) demonstrated that raw (unprocessed) bran reduces sensory attributes, whereas extrusion of bran and increased soluble fiber improved texture and color relative to the bran-raw control [39]. Bosarvan et al. (2015) reported that the inclusion of xanthan gum in cake formulations enhances sensory scores, particularly for texture, color, aroma, and taste [34].

Table 5: The effects of extruded wheat bran and xanthan gum on the sensory properties of cake

Treatments	Extruded wheat bran (%)	Xanthan gum (%)	Sensory properties			
			Form & Shape	Upper surface	Lower surface	Porosity
1	-	-	2.90±0.32^{a}	2.60±0.42^{abc}	2.70±0.48^{abc}	3.60±0.51^{a}
2	-	0.05	3.10±0.31^{a}	3.30±0.48^{a}	2.30±0.48^{bc}	3.00±0.32^{ab}
3	-	0.10	3.30±0.48^{a}	3.10±0.51^{ab}	2.00±0.66^{c}	2.20±0.42^{c}
4	1	-	2.80±0.42^{a}	2.60±0.52^{abc}	2.20±0.63^{bc}	2.80±0.52^{bc}
5	1	0.05	3.20±0.42^{a}	3.20±0.56^{a}	2.50±0.52^{abc}	3.00±0.31^{ab}
6	1	0.10	3.30±0.48^{a}	3.40±0.48^{a}	2.20±0.63^{bc}	2.60±0.52^{bc}
7	2	-	1.60±0.52^{b}	2.30±0.82^{bc}	2.00±0.47^{c}	2.60±0.48^{bc}
8	2	0.05	3.40±0.51^{a}	2.80±0.48^{abc}	3.00±0.67^{ab}	3.00±0.66^{ab}
9	2	0.10	3.40±0.69^{a}	3.10±0.57^{ab}	2.30±0.82^{bc}	2.50±0.53^{bc}
10	3	-	1.60±0.52^{b}	2.10±0.74^{c}	1.90±0.56^{c}	2.10±0.47^{c}
11	3	0.05	2.90±0.32^{a}	3.30±0.52^{a}	2.40±0.51^{abc}	2.60±0.52^{bc}

12	3	0.10	3.10 ± 0.32^{a}	3.10 ± 0.48^{a}	3.20 ± 0.42^{a}	3.00 ± 0.47^{ab}

Treatments	Extruded wheat bran (%)	Xanthan gum (%)	Sensory properties			
			Texture	chewiness	Odor &Taste	Acceptance
1	-	-	3.10 ± 0.31^{a}	3.20 ± 0.42^{a}	2.50 ± 0.53^{ab}	3.01 ± 0.21^{abc}
2	-	0.05	2.50 ± 0.53^{abcde}	2.70 ± 0.48^{abc}	2.80 ± 0.51^{ab}	2.76 ± 0.19^{bcd}
3	-	0.10	2.20 ± 0.42^{c}	2.30 ± 0.48^{cd}	3.10 ± 0.48^{a}	2.53 ± 0.15^{de}
4	1	-	2.00 ± 0.47^{def}	2.20 ± 0.42^{cd}	2.70 ± 0.63^{ab}	2.51 ± 0.18^{de}
5	1	0.05	2.80 ± 0.42^{abc}	2.90 ± 0.31^{abc}	3.10 ± 0.56^{a}	2.97 ± 0.16^{abc}
6	1	0.10	2.10 ± 0.32^{bc}	2.40 ± 0.52^{bcd}	3.10 ± 0.52^{a}	2.71 ± 0.21^{cd}
7	2	-	1.70 ± 0.67^{f}	2.30 ± 0.67^{cd}	2.50 ± 0.67^{ab}	2.23 ± 0.11^{ef}
8	2	0.05	2.90 ± 0.31^{ab}	3.20 ± 0.42^{a}	3.10 ± 0.63^{a}	3.24 ± 0.34^{a}
9	2	0.10	1.80 ± 0.42^{ef}	2.30 ± 0.48^{cd}	3.10 ± 0.42^{a}	2.78 ± 0.16^{bcd}
10	3	-	1.70 ± 0.82^{f}	1.70 ± 0.67^{d}	2.00 ± 0.42^{b}	1.94 ± 0.29^{f}
11	3	0.05	2.10 ± 0.31^{cdef}	2.30 ± 0.67^{cd}	2.60 ± 0.52^{ab}	2.53 ± 0.23^{de}
12	3	0.10	2.70 ± 0.48^{abcd}	3.10 ± 0.32^{ab}	3.10 ± 0.42^{a}	3.06 ± 0.18^{ab}

Different letters represent a significant difference from one another ($p<0.05$).

4-Conclusions

This study sought to produce a nutritionally enhanced sponge cake using extruded wheat bran and to evaluate the effect of xanthan gum as a permitted additive on the physical, chemical, textural, and sensory properties of bran-containing cakes. The results indicated that the formulations containing 2% extruded wheat bran with 0.5% xanthan gum and 3% extruded wheat bran with 1.0% xanthan gum exhibited the highest specific volume and porosity and the lowest textural firmness among the tested samples. The surface color was similar across all produced samples. Sensory evaluation revealed that increasing the level of extruded bran in the formulation was associated with a higher required content of xanthan gum to achieve optimal sensory properties. Specifically, among the formulations containing 2% and 3% bran, the best sensory attributes were achieved with 0.5% xanthan gum for the 2% bran formulation and with 1.0% xanthan gum for the 3% bran formulation. Taking into account the physical, chemical, textural, and sensory outcomes, the formulations of 2% extruded bran with 0.5% xanthan gum and 3% extruded bran with 1.0% xanthan gum are identified as the superior samples in this study.

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Author Contributions

All activities were carried out by the author.

Competing Interests

The author confirms that he / she has no financial conflicts of interest or competing interests in this study.

5- References

[1] Zolghadri, R., Zarringhalami, S. and Haghnazari, S. (2023). Effect of Rice Bran Protein Isolate (RBPI) Addition on the Sponge Cake Qualitative and Bioactive Properties. Journal of Food Processing and Preservation, 3053852: 1-8.

[2] Sitong, L., Jinlong, L., Yanqing, Z., Yuanmeng, W., Guang, L. and Qingliang, C. (2022). Effects of wheat bran micronization on the quality of reconstituted whole-wheat flour and its cooked noodles. Processes, 10:1001.

[3] Javed, M. M., Zahoor, S., Shafaat, S., Mehmooda, I., Gul, A., Rasheed, H. and Aftab, M. N. (2012). Wheat bran as a brown gold: Nutritious value and its biotechnological applications. 6: 724–733.

[4] Goli Movahed, G., Millani, E. and Jafari, M. (2018). Utilization of extruded wheat bran in Barbary bread: Evaluation of sensory, color and texture properties of bread and rheological properties of dough. Journal of Food Science and Technology, 82(15): 129-137.

[5] Gowthaman, M. K., Prasad, M. S. and Karanth, N. G. (2000). Production of xanthan gum. Encyclopedia of Food Microbiology, 1: 699-705.

[6] Robinson, R. K. (2014). Encyclopedia of food microbiology. Academic press.
[7] Chaturvedi, S., Kulshrestha, S., Bhardwaj, K. and Jangir, R. (2021). A review on properties and applications of xanthan gum. Microbial Polymers: Applications and Ecological Perspectives, 87-107.
[8] Murad, H. A., Abo-Elkhair, A. G. and Azzaz, H. H. (2019). Production of xanthan gum from nontraditional substrates with perspective of the unique properties and wide industrial applications. JSMC Microbiol, 1(6).
[9] Kaur, S., Sharma, S., Singh, B. and Dar, B. N. (2015). Effect of extrusion variables (temperature, moisture) on the antinutrient components of cereal brans. Journal of food science and technology. 52(3): 1670-1676.
[10] AACC. (2000). Alam, M.S., Kaur, J., Khaira, H., Gupta, K. (2016). Extrusion and extruded products: changes in quality attributes as affected by extrusion process parameters: A review. Critical Reviews in Food Science and Nutrition, 56: 445-473.
[11] Barcenas, M. E. and Rosell, C. M. (2006). Different approaches for improving the quality and extending the shelf life of the partially baked bread: low temperatures and HPMC addition. Journal of Food Engineering. 72: 92-99.
[12] Zolfaghari, N., Ataye Salehi, E. and Sheikholeslami, Z. (2022). Production of functional low-sugar muffin containing maltodextrin and ghavoot. Iranian Journal of Food Science and Technology, 18(121): 275-288.
[13] Saricoban, C. and Yilmaz, M. T. (2010). Modelling the effects of processing factors on the changes on color parameters of cooked meatballs using response surface methodology. World Applied Science Journal, 9(1): 14-22.
[14] Yassen, A. A., Shouk, A. H. and Ramadan, M. T. (2010). Corn-Wheat pan bread quality as affected by hydrocolloids, Journal of American Science, 6(10): 684-690.
[15] Jalali, M., Sheikholeslami, Z., Elhamirad, A. H., Haddad Khodaparast, M. H. and Karimi, M. (2019). The effect of Balangu Shirazi (Lallemantia Royleana) gum on the quality if gluten-free pan bread containing pre-gelatinization simple corn flour with microweave Crapathain, Journal of Food Science and Technology, 11(2): 68.
[16] Curti, E. Carini, E. Tribuzio, G. and Vittadini, E. (2015). Effect of bran on bread staling: Physico-chemical characterization and molecular mobility. Journal of Cereal Science. 65:25-30.
[17] Yawen, C., Jianwei, Z., Zhengyu, J., Yaoqi, T., Xing, Z. and Jie, L. (2021). Improvement of rice bran modified by extrusion combined with ball milling on the quality of steamed brown rice cake. Journal of Cereal Science, 99: 103229.
[18] McCarthy, D. F., Gallagher, E., Gormley, T. R., Schober, T. J and Arendt, E. K. (2005). Application of response surface methodology in the development of gluten free bread. Cereal Chemistry. 82: 609-615.
[19] Taromsari, A. and Ghiassi Tarzi, B. (2024). Optimization of Functional Gluten-Free Cake Formulation Using Rice Flour, Coconut Flour, and Xanthan Gum via D-Optimal Mixture Design. Food Science & Nutrition, 12: 10734-10755.
[20] Majzoobi, M., Farahnaky, A., Nematolahi, Z., Mohammadi Hashemi, M. and M. Taghipour Ardakani, J. (2013). Effect of Different Levels and Particle Sizes of Wheat Bran on the Quality of Flat Bread. Journal of Agricultural Science and Technology. 15:115-123.
[21] Coda, R., Rizzello, C. G., Curiel, J. A., Poutanen, K. and Katina, K. (2014). Effect of bioprocessing and particle size on the nutritional properties of wheat bran fractions. Innovative Food Science and Emerging Technologies. 25:19-27.
[22] Ozkaya, B., Baumgartner, B. and Ozkaya, H. (2018). Effects of concentrated and dephytinized wheat bran and rice bran addition on bread properties. Journal of texture studies. 49:84-93.
[23] Sahraiyan, B., Naghipour, F., Karimi, M. and Ghiafe Davoodi, M. (2013). Evaluation of Lepidium sativum seed and guar gum to improve dough rheology and quality parameters in composite rice-wheat bread. Food Hydrocolloid. 30: 698-703.
[24] Ghaemi, P., Arabshahi-Delouee, S., Aalami. M. and Hosseini Ghaboos, S. H. (2024). The Effect of Whey Protein Concentrate, Soy Protein Isolate, and Xanthan Gum on Textural and Rheological Characteristics of Gluten-Free Batter and Cake. Journal of Food Processing and Preservation, 5571107:1-11.
[25] Khoshdouni Farahani, Z. (2021). Physicochemical, textural and sensorial properties of cocoa sponge cake formulated with xanthan gum during shelf-life. Journal of Food and Bioprocess Engineering, 4(1): 94-98.
[26] Turabi, E., Sumnu, G., and Sahin, S. (2008). Rheological properties and quality of rice cake formulated with different gums and an emulsifier blend. Food Hydrocolloids. 22:305-312.

[27] Sahraiyan, B., Pourhaji, F. and Alizadeh Behbahani, B. (2021). Evaluation of the effect of cheese powder and ultrasonic wave on physicochemical and sensory properties of gluten-free oil cake, 17(4): 423-435.
[28] Dudu, O. E., Ma, Y., Adelekan, A., Oyedeji, A. B., Oyeyinka, S. A. and Ogungbemi, J. W. (2020). Bread-making potential of heat-moisture treated cassava flour-additive complexes. Lwt, 130: 109477.
[29] Anvarinejad, M. and Javadi, A. (2017). The Impact of Addition of Agar Gum and Propylene Glycolmono-stearate Emulsifier on The Qualiative and Physico chemical Properties of Sponge Cake, Specialty journal of Engineering and Applied Science, 3(1): 20-31.
[30] Rieder, A., Holtekjølen, A. K., Sahlstrøm, S. and Moldestad, A. (2012). Effect of barley and oat flour types and sourdoughs on dough rheology and bread quality of composite wheat bread. Journal of Cereal Science, 55(1): 44-52.
[31] Noort, M. W., van Haaster, D., Hemery, Y., Schols, H. A., and Hamer, R. J. (2010). The effect of particle size of wheat bran fractions on bread quality–Evidence for fibre–protein interactions. Journal of Cereal Science, 52(1): 59-64.
[32] Ortiz de Erive, M., Wang, T., He, F. and Chen, G. (2020). Development of high-fiber wheat bread using micro fluidized corn bran. Food Chemistry, 310.
[33] Nooshad, M., Hojjati, M., Hassanzadeh, M., Zadeh-Dabbagh, R. and Hossen Khani, M. (2022). Edible Utilization of Xanthan- guar Oleogels as a Shortening Replacement in Sponge Cake: Physicochemical Properties. Journal of Chemical Health Risks, 12(2): 255-264.
[34] Busarawan, C., Rungnaphar, P. and Witoon, P. (2015). Optimization of wheat flour-based sponge cake formulation containing tapioca starch and xanthan gum. International Journal of Food Science and Technology, 50: 532-540.
[35] Marston, K., Khouryieh, H. and Aramouni, F. (2016). Effect of heat treatment of sorghum flour on the functional properties of gluten-free bread and cake. LWT-Food Science and Technology, 65: 637-644.
[36] Tuncel, N. B., Yılmaza, N. Kocabıyıkb,H. and Uygura. A. (2014). The effect of infrared stabilized rice bran substitution on physicochemical and sensory properties of pan breads: Part 1. Journal of Cereal Science. 59:55–161.
[37] Mohammadi, M., Sadeghnia, N., Azizi, M.-H., Neyestani, T.-R. and Mortazavian, A. M. (2014). Development of gluten-free flat bread using hydrocolloids: Xanthan and CMC. Journal of Industrial and Engineering Chemistry, 20(4): 1812-1818.
[38] Zolghadri, R., Zarringhalami, S. and Haghnazari, S. 2023. Effect of Rice Bran Protein Isolate (RBPI) Addition on the Sponge Cake Qualitative and Bioactive Properties. Journal of Food Processing and Preservation, 3053852: 1-8.
[39] Haghighi-Manesh, S. and Azizi, M. H. (2018). Integrated extrusion-enzymatic treatment of corn bran for production of functional cake. Food Science & Nutrition. 6: 1870-1878.

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بررسی کاربرد سبوس گندم اکسترود شده و صمغ زانتان بر ویژگی‌های کمی و کیفی کیک اسفنجی شکلاتی

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چکیده

ویژگی‌های سبوس گندم بر عملکرد آن در فرمولاسیون مواد غذایی مؤثر است. با استفاده از فرایند پخت اکستروژن می‌توان ویژگی‌های تکنولوژیکی و تغذیه‌ای سبوس را بهبود بخشید. در این پژوهش از سبوس گندم اکسترود شده در سطوح صفر، ۱، ۲ و ۳ درصد و صمغ زانتان در سطوح صفر، ۰/۰۵ و ۰/۱ درصد در فرمولاسیون کیک اسفنجی شکلاتی استفاده شد و رطوبت، حجم مخصوص، تخلخل، سختی بافت، رنگ پوسته و ویژگی‌های حسی کیک ارزیابی گردید. نتایج نشان داد نمونه حاوی ۳ درصد سبوس و ۰/۱ درصد صمغ زانتان از بیشترین رطوبت برخوردار بود. نتایج ارزیابی رنگ پوسته حاکی از آن بود که هر سه مولفه رنگی پوسته ($L^*a^*b^*$) در تمام نمونه‌های تولیدی مشابه بود. نمونه حاوی ۲ درصد سبوس و ۰/۰۵ درصد صمغ زانتان و نمونه حاوی ۳ درصد سبوس و ۰/۱ درصد صمغ زانتان دارای بیشترین حجم مخصوص و تخلخل و کمترین سختی بافت بودند. ارزیابی حسی نیز نشان داد که با افزایش مصرف سبوس در فرمولاسیون، میزان صمغ زانتان افزایش یافت. به طوری که در نمونه‌های حاوی ۲ و ۳ درصد سبوس برای دستیابی به بهترین ویژگی‌های حسی به ترتیب به حضور ۰/۰۵ و ۰/۱ درصد صمغ زانتان در فرمولاسیون کیک اسفنجی نیاز بود. بنابراین با توجه به تمام یافته‌های حاصل از ارزیابی فیزیکی، شیمیایی، بافتی و حسی نمونه‌های تولیدی، نمونه حاوی ۲ درصد سبوس گندم اکسترود شده و ۰/۰۵ درصد صمغ زانتان و نمونه حاوی ۳ درصد سبوس گندم اکسترود شده و ۰/۱ درصد صمغ زانتان به عنوان نمونه‌های برتر این پژوهش معرفی می‌گردند.