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Production of cup cake containing whole wheat flour using chemical and enzymatic modification of the formulation

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ABSTRACT

The issue of separating bran from wheat has emerged as a principal challenge in the production and consumption of wheat within the country. Beyond the economic implications stemming from the exclusion of bran, which is characterized by its fibrous texture and large particle size—both of which contribute to the diminished quality of bran-containing flour products—there is also a notable reduction in the nutritional value of refined flour compared to whole flour. To enhance the quality of baked goods made with bran, various additives are employed. Therefore, the objective of this research was to produce cupcakes using flour with extraction rates of 78%, 88%, and 96%, while incorporating xylanase enzyme (0.4%), sodium stearoyl lactylate (SSL) emulsifiers, and mono- and diglyceride esters of tartaric acid (DATEM) (0.5%) as well as sorbitol (3%) as a sugar alcohol, followed by the evaluation of the quantity and quality of the final product. The results indicated that increasing the flour extraction rate and the presence of additives in the formulation led to an increase in the moisture content of the samples. Conversely, as the percentage of bran increased (resulting from a higher extraction rate), both the specific volume and porosity of the cupcakes decreased. The inclusion of the improvement agents (a mixture of enzyme, emulsifiers, and sugar alcohol) contributed to an increase in these two parameters. The cupcake sample containing flour with an extraction rate of 88%, along with the enzyme, emulsifiers, and sugar alcohol, exhibited the lowest textural firmness over a one-month storage period. Additionally, the increase in flour extraction and the presence of improvement agents corresponded to a diversification in the surface coloration of the cupcakes, resulting in darker and lighter shades, respectively. Ultimately, the sample comprising flour with an extraction rate of 88%, 0.4% xylanase enzyme, 0.5% DATEM and SSL emulsifiers, and 3% sorbitol emerged with the highest overall acceptance score, thus being recognized as the optimal sample.

1-Introduction

In contemporary baking practices, the majority of baked goods, including cakes, are produced using flour derived primarily from refined sources or a blend of refined and whole grain flours. These refined flours, characterized by low extraction rates, are notably deficient in essential nutrients, vitamins, and dietary fibers [1]. The presence of 4.5 to 4.8 percent phytic acid in wheat bran imposes limitations on the consumption of this ingredient. Additionally, the high ratio of insoluble to soluble fibers, along with the presence of insoluble arabinoxylans and glutathione, contributes to technological challenges in the production of bread enriched with wheat bran [2]. Various methods have been explored to mitigate or eliminate the anti-nutritional factors present in bran, including particle size reduction, the use of malted flour, fermentation, hydrothermal treatments, extrusion processes, and enzymatic treatments. Notably, the application of combined methods in the processing of bran has shown superior efficacy in reducing phytic acid levels while enhancing nutrient content [3, 4, 5 and 6]. To counteract the adverse effects of wheat bran on the structure of proteins and starches, common baking industry additives such as various enzymes, emulsifiers, and sugar alcohols can be employed. Xylanase, a significant member of the hemicellulase enzyme family, hydrolyzes non-starch polysaccharides into xylose and oligosaccharides [7]. Xylanase enzymes play a crucial role in the breakdown of glycosidic bonds within the xylan backbone present in arabinoxylans, leading to a reduction in polymerization degree and the release of smaller components [8]. This enzymatic activity transforms insoluble arabinoxylans into a soluble form, thereby enhancing the dough's elasticity and mitigating any adverse effects associated with their presence [9]. In the baking industry, xylanase is employed to stabilize dough structure, increase its flexibility, improve gluten strength, and reduce retrogradation [10]. Common emulsifiers used in baking include sodium stearoyl lactylate (SSL) and mono- and di-glycerides of tartaric acid (DATEM). Emulsifiers are surface-active agents that serve as additives in the bakery sector, softening the internal texture and producing a product with extended shelf life due to their ability to bond with gluten proteins and starch [11]. Furthermore, polyols, characterized by their high hygroscopic properties, can decrease water activity and enhance the internal texture of baked goods [12]. Sugar alcohols, such as sorbitol, are routinely utilized in starch-based food products to optimize production processes and improve quality through modifications in starch gelatinization and retrogradation [13]. Numerous studies have been conducted regarding the application of xylanase enzymes, emulsifiers, and the sugar alcohol sorbitol in baked products. Research conducted by Luo et al. (2020) demonstrated that the incorporation of xylanase enzyme into the liquid phase of dough made from whole wheat flour resulted in the formation of a stronger laminated structure at the air-water interface within the dough. This enhancement was attributed to the establishment of cross-links between protein-polysaccharide and protein-protein interactions, leading to a more stable foamy structure of the dough [14]. Additionally, Dudu et al. (2020) reported that the addition of the emulsifier Sodium Stearoyl Lactylate (SSL) to bread made from a mixture of wheat and cassava flour reduced the retrogradation of amylopectin (staling) during storage. Furthermore, the inclusion of this emulsifier played a significant role in increasing water absorption and stability properties of the dough, ultimately improving volume and reducing crumb firmness [15]. Furthermore, Behis and Kar (2017), in their investigation of the effects of polyols (mannitol, sorbitol, and glycerol) and various fibers (oat, psyllium, and barley) on bread quality, observed that the addition of 4% sorbitol to fiber-enriched breads led to a decrease in crumb firmness, which was influenced by the enhanced water retention capacity attributed to the polyols [16]. Thus, considering the positive roles of xylanase enzyme, Sodium Stearoyl Lactylate (SSL) emulsifiers, mono and diglycerides of tartaric acid (DATEM), and the sugar alcohol sorbitol in improving both the quantity and quality of baked products particularly those containing whole or bran-rich flours the objective of this research is to chemically and enzymatically modify whole wheat flour for the production of cupcakes enriched with bran.

2- Materials

Wheat flour, extracted at three different percentages (78%, 88%, and 96%), was procured from Reza Flour Mill and stored in a dry, cool warehouse. Additional ingredients included chemicals sourced from Merck (Germany), as well as sugar, salt, liquid vegetable oil, and baking powder obtained from a local bakery supply store. Fresh eggs were acquired one day prior to the production of the cupcake and were refrigerated at a temperature of 4 degrees Celsius. The emulsifiers sodium stearoyl lactylate (SSL) and mono- and diglyceride esters of tartaric acid (DATEM) were sourced from Pars Behbood Company (Mashhad), while the enzyme xylanase and the sugar alcohol sorbitol were obtained from Betagen (Ferdowsi University of Mashhad).

3-Methods

3.1. Preparation of cupcake

To produce the cupcake, the initial ingredients were weighed as follows: flour (100 grams) with extraction rates of 78%, 88%, and 96%; sugar (72 grams); liquid oil (57 grams); eggs (72 grams); milk powder (2 grams); table salt (1 gram); vanilla (0.5 grams); baking powder (1.34 grams); and water (as needed). In the first step of the cupcake preparation, oil and powdered sugar were combined and mixed using an electric mixer (Electra EK-230M, Japan) at a speed of 128 revolutions per minute for 6 minutes, resulting in a light cream with air bubbles. Eggs were then added to the creamy mixture in four stages. Finally, water was incorporated to achieve a uniform mixture. The resulting mixture was poured into cupcake capsules, and the baking process was conducted in a rotary laboratory oven (Zucchelli Forni, Italy) at a temperature of 180 degrees Celsius for 30 minutes. Subsequently, the baked cupcakes were cooled at room temperature and stored in polyethylene packaging for further testing. This study included six treatments as described below:

Treatment 1: Sample containing flour with an extraction rate of 78% and no improving agent.

Treatment 2: Sample containing flour with an extraction rate of 78%, 0.04% xylanase enzyme, 0.5% DATEM emulsifiers, sodium stearoyl lactylate, and 3% sorbitol.

Treatment 3: Sample containing flour with an extraction rate of 88% and no improving agent.

Treatment 4: Sample containing flour with an extraction rate of 88%, 0.04% xylanase enzyme, 0.5% DATEM emulsifiers, sodium stearoyl lactylate, and 3% sorbitol.

Treatment 5: Sample containing flour with an extraction rate of 96% and no improving agent.

Treatment 6: Sample containing flour with an extraction rate of 96%, 0.04% xylanase enzyme, 0.5% DATEM emulsifiers, sodium stearoyl lactylate, and 3% sorbitol.

3.2. Moisture Content

For this experiment, the AACC 2000 Standard, method 16-44 was utilized.

Samples were placed in an oven at a temperature range of 100-105 degrees Celsius at intervals of 2 hours, 1 week, 2 weeks, and 1-month post-baking [17].

3.3. Specific Volume

To determine the specific volume, the method of volume replacement using rapeseed seeds was employed in accordance with the AACC 2000 Standard, method 10-72, at the 2-hour mark. Initially, the volume of a whole cupcake sample was measured, followed by weighing the same sample on a balance. The specific volume was subsequently calculated by dividing the volume by the mass, with results reported in milliliters per gram [17].

3.4. Porosity

To evaluate the porosity of the internal structure of the cupcake within 2 hours post-baking, image processing techniques were applied. A 2 cm by 2 cm slice of the internal texture of the cupcake was obtained using a 120W electric serrated knife and scanned using an HP Scanjet G3010 scanner at a resolution of 300 pixels. The captured image was analyzed using Image J software. By activating the 8-bit section, grayscale images were generated. To convert the grayscale images into binary images, the binary section of the software was enabled. The analysis feature of the software was then utilized to calculate the ratio and measure the percentage of porosity in the samples [18].

3.5. Texture Assessment

The evaluation of the texture of the cupcake was conducted at intervals of 2 hours, 1 week, 2 weeks, and 1-month post-baking. This assessment utilized the QTS texture analyzer model CNS Farnell, manufactured in the UK. The maximum force required for a cylindrical probe (with a diameter of 2 centimeters and a height of 3.2 centimeters) to penetrate the center of the cupcake at a speed of 60 millimeters per minute was measured as an indicator of firmness. The starting point for this measurement was set at 0.05 Newtons, with the target point at a depth of 25 millimeters [19].

3.6. Crust Color Analysis

The color analysis of the crust was performed 2 hours after baking by determining three parameters: L*, a*, and b*. To conduct these measurements, a sample measuring 2 by 2 centimeters was cut from the crust and scanned using an HP Scanjet G3010 scanner at a resolution of 300 pixels. The subsequent images were processed using ImageJ software. By activating the LAB color space feature in the Plugins section, the aforementioned indices were calculated [20].

3.7. Sensory Attributes

For the sensory evaluation, a panel of 10 judges was selected. The sensory characteristics of the cupcake were assessed based on form and shape, surface properties, porosity, texture firmness and softness, chewability, aroma, flavor, and taste. A hedonic scale ranging from 1 (very poor) to 5 (very good) was employed for the evaluation. Recognizing that the attributes examined in the sensory assessment do not carry equal weight, a rank coefficient was assigned to each characteristic after reviewing relevant literature. The rank coefficients for the attributes were assigned as follows: 4, 2, 1, 2, 2, and 3, respectively. The final overall acceptance score, which was influenced by the other evaluated parameters and their associated coefficients, was reported [21].

3.8. Statistical Analysis

Statistical analysis of the data was conducted using a completely randomized design and was performed with Mini-Tab software, version 17, at a significance level of 5%. The Tukey method was utilized for mean comparisons. Additionally, figures were generated using MS-Office Excel, version 2010.

4- Results and Discussion

4.1. Moisture Content

Table 1 presents the moisture content of the cupcake samples over a one-month storage

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period (2 hours, 1 week, 2 weeks, and 1-month post-baking). The results indicate that increasing flour extraction rate, and the presence of xylanase enzyme, sodium stearoyl-2-lactylate (SSL) and DATEM emulsifiers, and sorbitol polyol, all contributed to increased moisture content in the cupcake samples. The lowest moisture content was observed in the sample containing 78% extraction rate flour and no improvers (Treatment 1). Conversely, the highest moisture content was observed in samples containing 88% extraction rate flour, 0.04% xylanase enzyme, 0.5% DATEM and SSL emulsifiers, and 3% sorbitol polyol; and similarly in samples containing 96% extraction rate flour, 0.04% xylanase enzyme, 0.5% DATEM and SSL emulsifiers, and 3% sorbitol polyol. It is noteworthy that all samples exhibited a decrease in moisture content over the one-month storage period, with the greatest moisture loss observed in the sample containing 78% extraction rate flour and no improvers. Teban et al. (2020) reported on the effect of xylanase enzyme on the moisture content of whole wheat bread, finding that samples containing this enzyme were more successful in retaining moisture during baking and that its presence resulted in reduced weight loss during storage in wholemeal bread [22]. Shah et al. (2006) concluded that the use of xylanase enzyme in wholemeal bread formulations resulted in an 8% higher moisture retention compared to the control (enzyme-free) sample [23]. Pourfarzad et al. (2011) utilized 1% and 5% levels of sorbitol polyol in fiber-enriched bread. Their findings indicated that the presence of polyols in baking formulations increased moisture content compared to the control [24]. The presence of hydroxyl groups in the structure of polyols creates a high capacity for binding water molecules, thereby preventing moisture loss during baking and storage [25]. Ding et al. (2019) identify the presence of polyols, such as sorbitol, as a crucial component in formulations designed to maintain moisture in baked goods. The amphiphilic nature of emulsifiers, possessing both hydrophilic and lipophilic groups, confers their functional properties. This means their molecular structure exhibits a simultaneous affinity for both oily components (due to the non-polar head) and water molecules (due to the polar head). Consequently, the addition of these compounds to food matrices results in their localization at the oil-water interface. The hydrophilic groups of the emulsifier chain, by binding to free water, enhance water retention capacity and, in turn, exhibit an inhibitory effect on moisture loss [26]. Pourfarzad et al. (2014) also found that emulsifiers, owing to their hydrophilicity, exhibit a stronger binding affinity to water molecules compared to other nano-components, thus preventing moisture migration from the crumb to the crust [27].

Table 1- The effect of treatments on the moisture of cupcakes during one month

Treatments	Moisture (%)			
	2 hours	1 week	2 weeks	1 month
1	19.2±0.7^{c}	18.0±0.4^{b}	15.6±0.7^{d}	14.1±0.8^{d}
2	20.1±0.2^{b}	19.7±0.9^{a}	18.2±0.2^{b}	17.2±0.5^{b}
3	19.9±0.1^{b}	18.4±0.2^{b}	16.8±0.5^{c}	14.9±0.2^{c}
4	21.2±0.8^{a}	20.9±0.1^{a}	20.2±0.9^{a}	18.9±0.4^{a}
5	20.3±0.2^{b}	18.3±0.5^{b}	17.1±0.2^{c}	15.2±0.9^{c}
6	21.5±0.4^{a}	21.0±0.7^{a}	19.8±0.3^{a}	19.2±0.3^{a}

Different letters in each column represent significant differences from one another ($p<0.05$).

4.2. Specific Volume

Figure 1 illustrates the specific volume of the produced samples. As the results

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demonstrate, an increase in the bran percentage in the formulation (increased extraction rate) led to a decrease in the specific volume of the cupcake samples. Furthermore, the results clearly indicate that the presence of improvers (enzyme, emulsifier, and sugar alcohol) in the cupcake formulation increased the volume of the samples. The positive effect of the improver was more pronounced on the sample containing 88% flour compared to samples containing 78% and 96% flour. Consequently, the cupcake sample containing flour with an 88% extraction rate, 0.04% xylanase enzyme, 0.5% DATEM and sodium stearoyl-2-lactylate emulsifiers, and 3% sorbitol sugar alcohol exhibited the highest specific volume, while the sample containing flour with a 96% extraction rate and lacking improvers showed the lowest specific volume compared to other produced samples. Wheat bran, possessing a higher water-holding capacity than other dough components, can result in bread with greater mass. However, a negative correlation exists between the water-holding capacity of wheat bran and volume. Differences in water binding behavior and proton distribution in bran are largely attributed to the presence of cellulose, insoluble arabinoxylans, and lipids [28]. Arabinoxylans are one of the most important dietary fibers in wheat bran and a major component of its cell wall structure, influencing the physicochemical properties of baked products. Insoluble arabinoxylans, through competition for binding sites with proteins, hinder the development of the gluten network, resulting in dough instability [29]. The weakening effect of wheat bran on volume may also be due to the inhibition of gas cell expansion to the optimum level. This effect manifests through the creation of a physical barrier by fiber particles in the bran surrounding the gas cells [28]. Several studies (Bat et al., 2020; Goushali et al., 2017; Sheikholeslami et al., 2021; Teban et al., 2020) have identified the presence of xylanase enzyme in baking formulations containing wholemeal or bran flour as a significant factor in increasing loaf volume [30, 31, 32, 22]. Multiple mechanisms contribute to this effect. Xylanase converts water-insoluble arabinoxylans into a water-extractable form, improving gas retention capacity in wholemeal dough and consequently increasing volume [10]. Furthermore, xylanase degrades non-starch polysaccharides into shorter-chain saccharides, which exhibit less interference in gluten network formation compared to their polysaccharide precursors [33]. The emulsifying effects of SSL, DATEM, and the sugar alcohol sorbitol on specific volume should also be considered. The increased volume observed with these emulsifiers can be attributed to their provision of increased water availability within the flour matrix, facilitating stronger cross-linking between protein and starch, resulting in a gluten network with enhanced gas retention capacity during baking [34]. Zou et al. (2016) reported that adding sorbitol to white flour bread formulations at levels below 8% increased specific volume, while higher concentrations (above 8%) resulted in a decrease [35]. Excessive sugar alcohols in baking formulations can reduce gluten network hydration and cohesiveness, thereby diminishing gas retention capacity and final product volume [36].

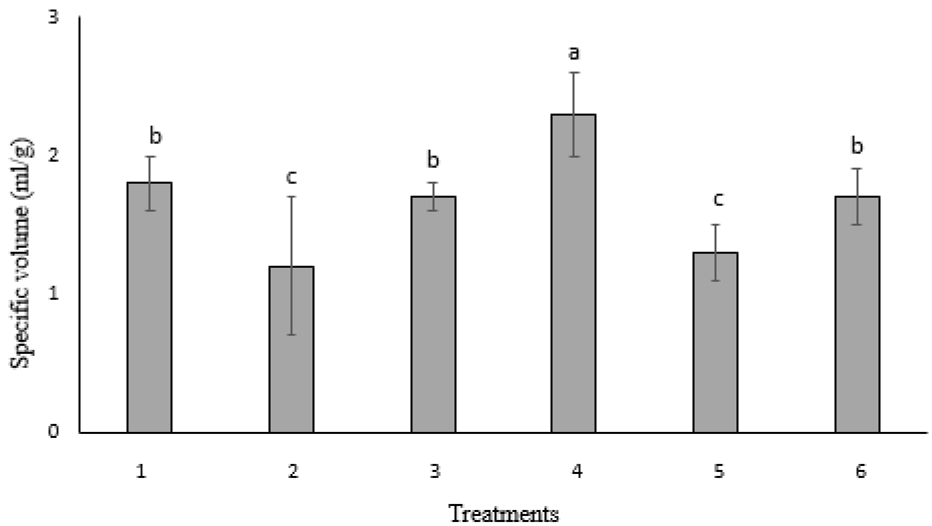

Fig 1- The effect of treatments on the specific volume of cupcakes.
Different letters represent significant differences from one another (p<0.05).

4.3. Porosity

Figure 2 illustrates the porosity levels of the produced samples. The results indicate an inverse relationship between the flour extraction percentage and the degree of porosity. This suggests that as the amount of bran in the cupcake formulation increases (corresponding to a higher flour extraction rate), the porosity of the produced samples decreases. Additionally, the findings revealed that the inclusion of additives (such as enzymes, emulsifiers, and sugar alcohols) in the formulations of bran-enriched cupcakes contributed to an increase in porosity. Notably, emulsifiers such as sodium stearoyl-2-lactylate (SSL) and mono- and diglycerides of tartaric acid (DATEM) played a significant role in enhancing the porosity of the samples. The highest porosity was observed in the sample containing flour with a 78% extraction rate without any additives (treatment 1), as well as in the sample with an 88% flour extraction rate, incorporating 0.04% xylanase enzyme, 0.5% DATEM emulsifiers, sodium stearoyl-2-lactylate, and 3% sorbitol sugar alcohol (treatment 4). Pakya-Das et al. (2019) reported that the addition of high amounts of bran to bread weakens the structure of the bread's internal cavities, resulting in reduced porosity [37]. Furthermore, Ghoshal et al. (2017) indicated that larger voids and pores were observed in bread doughs made from whole flour enriched with xylanase compared to control bread. This was attributed to a higher release of gas bubbles in the bread containing the enzyme, whereas the control bread exhibited a discontinuous structure with fewer cavities [31]. Dudo et al. (2020) demonstrated that the addition of emulsifiers to baked goods formulations increases the number and surface area of air cells, leading to enhanced porosity [15]. This effect is attributed to the emulsifiers' high water absorption capacity, improving dough stability and gas retention. Similarly, Pourfarzad et al. (2012) found that sodium stearoyl-2-lactylate (SSL) emulsifier significantly increased cell size and crumb porosity in bread. This was attributed to the interaction of SSL with flour components, increasing gas retention within the gluten network. During baking, smaller gas cells coalesce into larger bubbles; greater coalescence results in larger pores in the bread crumb [38].

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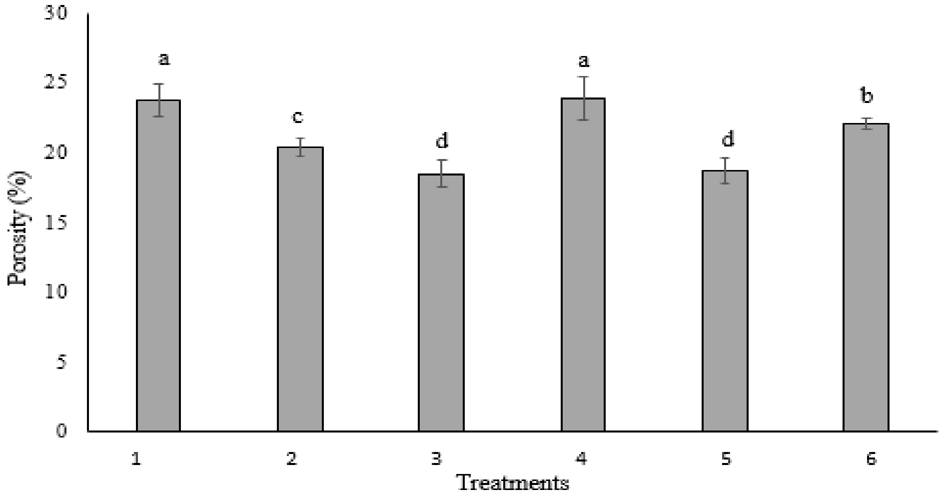

Fig 2- The effect of treatments on the porosity of cupcakes.
Different letters represent significant differences from one another ($p<0.05$)

4.4. Texture

Table 2 presents the texture firmness of the produced samples over a one-month storage period (measured at 2 hours, 1 week, and 1-month post-baking). The results indicate a positive correlation between flour extraction rate and texture firmness. Conversely, the inclusion of xylanase enzyme, sodium stearoyl-2-lactylate (SSL) emulsifiers, mono- and di-glycerides of tartaric acid esters (DATEM), and sorbitol (a sugar alcohol) resulted in decreased firmness. Furthermore, an increase in texture firmness was observed across all samples over time. It is noteworthy that on day one, the sample containing 78% extraction rate flour without any improvers (Treatment 1) and the sample containing 88% extraction rate flour, 0.04% xylanase enzyme, 0.5% DATEM and SSL emulsifiers, and 3% sorbitol (Treatment 4) exhibited the lowest firmness compared to other samples. However, after one month of storage, the sample with 88% extraction rate flour, 0.04% xylanase enzyme, 0.5% DATEM and SSL emulsifiers, and 3% sorbitol maintained the lowest firmness. Wheat bran, by disrupting cross-links between starch and gluten, reduces elasticity and increases the firmness of baked goods' interior [39]. Furthermore, dietary fibers present in bran, particularly insoluble fibers, typically weaken the texture of baked products due to competition for water absorption with the gluten network [40]. Bat et al. (2020) reported that xylanase enzyme, by increasing soluble fiber and improving water absorption in the gluten-starch network, reduces the crumb firmness of bread [30]. Emulsifiers play a crucial role in baking products by enhancing the structural integrity of dough. They facilitate the formation of a layered structure at the interface between gluten and starch, thus promoting the development of the gluten network. Moreover, by improving the rheological properties of the dough, such as stability and extensibility, emulsifiers contribute to a reduction in firmness in baked goods made with whole grain and bran-enriched flours [41]. Sorbitol, on the other hand, enhances the water retention capacity of the gluten network, leading to increased softness of the internal texture of baked products. The combination of fibers and sugar alcohols has been shown to improve textural characteristics and result in a softer crumb. This phenomenon can be attributed to the increased water retention capacity resulting from the addition of fibers as well as the water-absorbing properties of polyols [35]. Sheikh Al-Islami et al. (2021) identified the simultaneous application of emulsifiers and xylanase enzymes as a significant factor for improving the texture of bread made from flours with varying extraction rates (88% and 96%) [32].

Table 2- The effect of treatments on the firmness of cupcakes during one month.

Treatments	Firmness (N)			
	2 hours	1 week	2 weeks	1 month
1	5.2±1.3^{c}	7.9±0.4^{b}	12.1±0.2^{c}	22.1±0.4^{a}
2	7.7±1.9^{b}	8.3±1.7^{a}	14.7±0.5^{b}	19.5±0.5^{b}
3	9.0±1.2^{a}	12.8±0.2^{b}	19.2±0.2^{a}	20.2±0.2^{b}
4	4.9±0.8^{c}	6.1±0.2^{a}	8.9±0.9^{d}	9.4±0.7^{d}
5	9.2±0.2^{a}	12.2±1.4^{b}	14.5±0.6^{b}	20.2±0.3^{b}
6	7.4±0.9^{b}	6.5±0.1^{a}	9.2±0.5^{d}	12.2±0.3^{c}

Different letters in each column represent significant differences from one another ($p<0.05$).

4.5. Color Attributes of Crust (L*a*b* Components)

Table 3 illustrates the L*a*b* color components of the crust in the produced samples. The results indicate that with an increase in the flour extraction degree, there is a decrease in lightness (L*) and yellowness (b*), accompanied by an increase in redness (a*). Conversely, the presence of a combination of xylanase enzymes, sodium stearoyl lactylate (SSL) emulsifiers, tartaric acid mono- and diglyceride esters (DATEM), and the sugar alcohol sorbitol as a dough improver resulted in enhanced lightness (L*) while reducing yellowness (b*) and redness (a*) of the cupcake crust samples. The development of a yellowish-brown color in the crust of baked products is an important indicator of product quality. However, the addition of high levels of wheat bran in this category of products tends to decrease crust lightness due to the presence of reducing sugars in wheat bran, which play a significant role in non-enzymatic browning reactions, ultimately leading to a reduction in the L* color component [41, 31]. Ghoshal et al. (2013) reported that the enrichment of bread with wheat bran particles resulted in a decrease in yellow color and the emergence of a grayish-red hue in the crust. These researchers also indicated that xylanase enzymes contribute to an increase in the lightness of bread made from whole wheat flour [42]. The increase in the L* color component in baked products containing xylanase might be attributed to the enzyme's ability to convert arabinoxylans from an insoluble form to a soluble one, thereby facilitating the absorption of water released from pentosans by the gluten network. This suggests that baked products with higher water absorption exhibit higher lightness parameters [43]. Matsuhita et al. (2017) discovered that the addition of xylanase enzyme to whole wheat flour bread resulted in a reduction of crust redness (a*) compared to samples lacking the enzyme [33]. Ghoshal et al. (2016) identified the presence of the zylase enzyme in whole flour bread as a contributing factor to increased yellowness (b*) [44]. Emulsifiers, due to their high-water absorption capacity and the enhancement of water uptake in the dough, contribute to the dilution of amino acids and sugars, thereby improving the brightness parameters of bakery products' crusts [45]. Ahmed (2016) and Behis and Kar (2014) reported that sugar alcohols, including sorbitol, led to increased brightness and reduced yellowness of bread crusts. This phenomenon is attributed to the non-participation of sugar alcohols in the Maillard reaction and their interaction with amino acids [46 and 36].

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Table 3- The effect of treatments on the crust color of cupcakes

Treatments	Crust color values		
	L*	a*	b*
1	52.07±1.92^{b}	6.52±0.77^{c}	23.41±0.09^{a}
2	55.49±1.76^{a}	5.87±0.19^{d}	20.97±1.87^{b}
3	47.09±1.21^{c}	8.41±1.24^{a}	20.31±0.76^{b}
4	50.94±0.22^{b}	7.28±1.09^{b}	18.58±0.25^{c}
5	45.81±0.95^{d}	8.53±0.21^{a}	18.98±1.80^{c}
6	48.044±1.89^{c}	7.40±0.38^{b}	18.21±0.59^{c}

Different letters in each column represent significant differences from one another ($p<0.05$).

4.6. Sensory Characteristics

Table 4 and Figure 3 illustrate the sensory scores and overall acceptance ratings of the produced samples, respectively. The results indicate that among the samples without any improvers, the one made from flour with an extraction rate of 78% received the highest scores for form and appearance, porosity, chewability, and texture firmness and softness. This suggests that the bran cupcakes, in the absence of improvers such as xylanase enzyme, sodium stearoyl lactylate (SSL), and diacetyl tartaric acid esters of mono- and diglycerides (DATEM), as well as the sugar alcohol sorbitol, were unable to achieve maximum satisfaction among sensory evaluators regarding textural parameters. Furthermore, an inverse relationship was observed between the increase in flour extraction rate and the scores for these four sensory characteristics. In contrast, the highest sensory scores and ultimately the greatest acceptance rating were attributed to the sample containing flour with an extraction rate of 88%, 0.04% xylanase enzyme, 0.5% DATEM and sodium stearoyl lactylate, and 3% sorbitol. It is noteworthy that wheat bran tends to weaken textural properties and can impart undesirable flavors and odors to bread [8]. A study conducted by Ghoshal et al. (2013) demonstrated that the addition of xylanase enzyme significantly improved the sensory characteristics of bread made from whole wheat flour. According to their findings, breads containing xylanase exhibited softer textures, more uniform cellular structures (increased porosity), and superior flavor and aroma when compared to samples lacking this additive [42]. Kumar and Sathyanan (2014) reported that the addition of the enzyme xylanase to whole wheat flour resulted in an increase in sensory attribute scores, and the produced samples were well-received by consumers [47]. Furthermore, research conducted by Sheikholeslami et al. (2021) demonstrated that the highest sensory attribute scores for bread containing bran flour were attributed to breads formulated with a combination of xylanase and sodium stearoyl lactylate (SSL) emulsifiers, as well as mono- and di-glycerides of tartaric acid (DATEM). It is hypothesized that the combination of emulsifiers and xylanase facilitates the formation of a homogenous and uniform structure in the texture of baked products, where starch granules form close bonds with gluten proteins [32]. Additionally, Ding and Yang (2021) suggested that the incorporation of the sugar alcohol sorbitol into bakery products significantly enhances sensory attributes, particularly in terms of texture firmness and softness, as well as chewability, by increasing water-binding capacity within the flour components [25].

Table 3- The effect of treatments on the crust color of cupcakes

Treatments	Sensory properties

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	Form	upper surface	Texture	Porosity	Chewiness	Odor&Taste
1	3.40±0.96^{b}	4.00±0.81^{b}	4.00±0.47^{a}	3.20±0.44^{b}	3.00±0.87^{b}	4.40±0.81^{a}
2	3.30±0.48^{b}	3.30±0.67^{c}	2.80±0.78^{c}	3.30±0.51^{b}	2.80±0.56^{b}	3.30±0.67^{b}
3	3.70±0.95^{b}	2.50±0.53^{d}	2.60±0.56^{c}	4.00±0.85^{a}	3.00±0.49^{b}	3.30±0.53^{b}
4	4.20±0.92^{a}	4.80±0.42^{a}	4.00±0.81^{a}	4.20±0.82^{a}	4.10±0.78^{a}	4.20±0.42^{a}
5	2.40±0.51^{c}	2.70±0.67^{d}	1.90±0.57^{d}	2.60±0.51^{c}	2.20±0.64^{c}	3.10±0.67^{b}
6	4.10±0.60^{a}	3.90±0.87^{b}	3.40±0.52^{b}	4.10±0.58^{a}	3.90±0.55^{a}	4.20±0.87^{a}

Different letters in each column represent significant differences from one another ($p<0.05$).

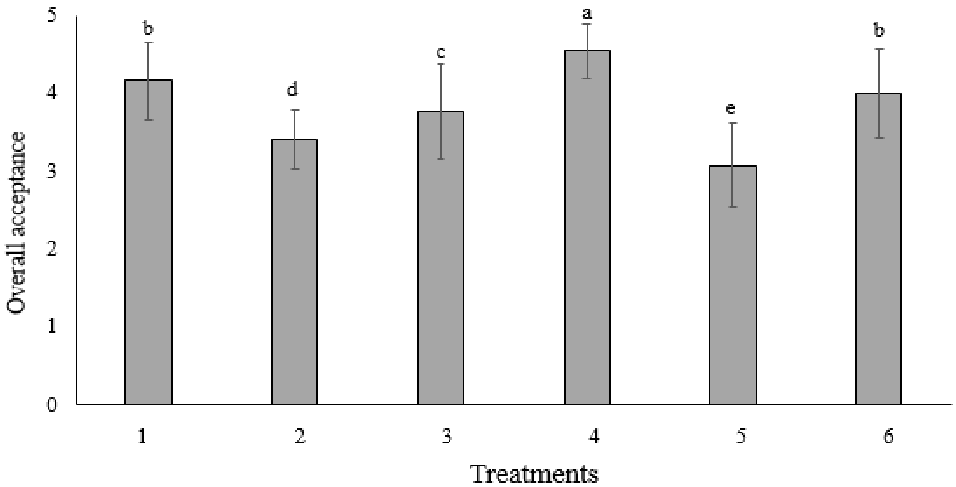

Fig 3- The effect of treatments on the overall acceptance of cupcakes.

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

5- Conclusion

Based on the results of this study, it was established that the use of bran-containing flours (with extraction rates of 88% and 96%) cannot be substituted for white flour (with an extraction rate of 78%) in the formulation of cupcakes without adversely affecting the technological and sensory properties of the resulting products. However, by employing a mixture of additives, such as enzymes, emulsifiers, and sugar alcohols in the form of a dough conditioner, it is possible to produce baked goods with satisfactory quantity and quality. The findings indicate that the sample incorporating flour with an 88% extraction rate, 0.04% xylanase enzyme, 0.5% DATEM and sodium stearoyl lactylate emulsifiers, along with 3% sorbitol sugar alcohol, exhibited superior texture firmness, specific volume, porosity, color, and sensory characteristics compared to other samples, including those made with 78% extraction flour without any dough conditioner. Furthermore, it outperformed the sample containing 88% extraction flour alongside the same proportions of xylanase, emulsifiers, and sorbitol. This formulation was identified as the best sample in this study regarding physicochemical and sensory attributes, thereby confirming the successful production of cupcakes made from bran-containing flour through both chemical (emulsifiers and sorbitol) and enzymatic (xylanase) modifications of the flour.

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6-References:

[1] Ferng, L., Liou, C., Yeh, R., & Hsin, S. (2015). Food Hydrocolloids physicochemical property and glycemic response of chiffon cakes with different rice fl ours. Food Hydrocolloids, 53: 172–179.

[2] 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.

[3] Fekri, A., Torbati, M., Yari Khosrowshahi, A., Bagherpour Shamloo, H. and Azadmard-Damirchi, S. (2020). Functional effects of phytate-degrading, probiotic lactic acid bacteria and yeast strains isolated from Iranian traditional sourdough on the technological and nutritional properties of whole wheat bread. Food Chemistry, 306: 1–11.

[4] Rezaei, S., Najafi, M. A. and Haddadi, T. (2019). Effect of fermentation process, wheat bran size and replacement level on some characteristics of wheat bran, dough, and high-fiber Tafton bread. Journal of Cereal Science, 85, 56–61.

[5] Spaggiari, M., Ricci, A., Calani, L., Bresciani, L., Neviani, E., Asta, C. D. and Galaverna, G. (2019). Solid state lactic acid fermentation: A strategy to improve wheat branfunctionality. LWT - Food Science and Technology, 108668.

[6] Ozkaya, B. and Duman, B. (2016). Dephytinization of Wheat and Rice Brans by Hydrothermal Autoclaving Process and the Evaluation of Consequences for Dietary Fiber Content, Antioxidant Activity and Phenolics. Innovative Food Science and Emerging Technologies, 39: 209–215.

[7] Jiang, Y., Zhao, Y., Zhu, Y., Qin, S., Deng, Y., & Zhao, Y. (2019). Effect of dietary fiber-rich fractions on texture, thermal, water distribution, and gluten properties of frozen dough during storage. Food Chemistry, 297: 124902.

[8] Tebben, L., Shen, Y. and Li, Y. (2018). Improvers and functional ingredients in whole wheat bread: A review of their effects on dough properties and bread quality. Trends in Food Science and Technology, 81: 10–24.

[9] Liu, W., Brennan, M. A., Serventi, L. and Brennan, C. S. (2017). Effect of cellulase, xylanase and α-amylase combinations on the rheological properties of Chinese steamed bread dough enriched in wheat bran. Food Chemistry, 234: 93–102.

[10] Altınel, B. and Ünal, S. S. (2017b). The effects of certain enzymes on the rheology of dough and the quality characteristics of bread prepared from wheat meal. Journal of Food Science and Technology, 54: 1628–1637.

[11] Colakoglu, A. S. and Ozkaya, H. (2012). Potential use of exogenous lipases for DATEM replacement to modify the rheological and thermal properties of wheat flour dough. Journal of Cereal Science, 55: 397–404.

[12] Suhendro, E. L., Waniska, R. D., Rooney, L. W. and Gomez, M. H. (1995). Effects of polyols on the processing and qualities of wheat tortillas. Cereal Chemistry, 72: 122–127.

[13] Tian, Y., Xu, X., Li, Y., Jin, Z., Chen, H. and Wang, H. (2009). Effect of β-cyclodextrin on the long-term retrogradation of rice starch. European Food Research and Technology, 228: 743–748.

[14] Liu, L., Sun, Y., Yue, Y., Yang, J., Chen, L., Ashraf, J. and Tong, L. (2020). Composition and foam properties of whole wheat dough liquor as affected by xylanase and glucose oxidase. Food Hydrocolloids, 108, 106050.

[15] 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.

[DOI: 10.22034/FSCT.22.162.171]

[16] Bhise, S. and Kaur, A. (2017). Synergistic Effect of Polyols and Fibres on Baking, Sensory and Textural Quality of Bread with Improved Shelf Life. International Journal of CurrentMicrobiology and Applied Sciences, 6: 1–12.
[17] AACC, I. (2000). Approved Methods of the AACC. Association of Cereal Chemists, St. Paul. Abdul-Hamid, A., & Luan, Y. S. (2000). Functional properties of dietary fibre prepared from defatted rice bran. Food Chemistry, 68, 15–19.
[18] Bárcenas, 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.
[19] Ronda, F. and Gomez, M. (2005). Effect of polyols and nondigestible oligosaccharids on the quality sugar free sponge cakes. Food Chemistry,90: 549-555.
[20] Sabbaghi, H., Ziaiifar, A. and Kashaninejad, M. (2018). Fractional conversion modeling of color changes in apple during simultaneous dry-blanching and dehydration process using intermittent infrared irradiation. Iranian Food Science and Technology Research Journal, 14(2): 383-397.
[21] 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 of gluten-free pan bread containing pre-gelatinization simple corn flour with microeave Carpathain Journal of Food Science and Technology.
[22] Tebben, L., Chen, G., Tilley, M. and Li, Y. (2020). Individual effects of enzymes and vital wheat gluten on whole wheat dough and bread properties. Journal of Food Science, 85: 4201–4208.
[23] Shah, A. R., Shah, R. K., & Madamwar, D. (2006). Improvement of the quality of whole wheat bread by supplementation of xylanase from Aspergillus foetidus. Bioresource Technology, 97: 2047–2053.
[24] Pourfarzad, A., Khodaparast, M. H. H., Karimi, M., Mortazavi, S. A., Davoodi, M. G., Sourki, A. H. and Razavizadegan Jahromi, S. H. (2011). Effect of polyols on shelf-life and quality of flat bread fortified with soy flour. Journal of Food Process Engineering, 34: 1435–1448.
[25] Ding, S. and Yang, J. (2021). The effects of sugar alcohols on rheological properties, functionalities, and texture in baked products – A review. Trends in Food Science and Technology, 111: 670–679.
[26] Ding, S., Peng, B., Li, Y. and Yang, J. (2019). Evaluation of specific volume, texture, thermal features, water mobility, and inhibitory effect of staling in wheat bread affected by maltitol. Food Chemistry, 283: 123–130.
[27] Pourfarzad, A., Hossein, M. and Khodaparast, H. (2014). Optimization of a novel improver gel formulation for Barbari flat bread using response surface methodology. Journal of Food Science and Technology, 51: 2344–2356.
[28] Hemdane, S., Langenaeken, N. A., Jacobs, P. J., Verspreet, J., Delcour, J. A. and Courtin, C. M. (2018). Study of the role of bran water binding and the steric hindrance by bran in straight dough bread making. Food Chemistry, 253: 262–268.
[29] Courtin, C. M. and Delcour, J. Al. (2002). Arabinoxylans and endoxylanases in wheat flour bread-making. Journal of Cereal Science, 35, 225–243.
[30] Both, J., Biduski, B., Gómez, M., Bertolin, T. E., Friedrich, M. T. and Gutkoski, L. C. (2020). Micronized whole wheat flour and xylanase application: dough properties and bread quality. Journal of Food Science and Technology, 56: 3902–3912.
[31] Ghoshal, G., Shivhare, U. S. and Banerjee, U. C. (2017). Rheological properties and microstructure of xylanase

containing whole wheat bread dough. Journal of Food Science and Technology, 54: 1928–1937.
[32] Sheikholeslami, Z., Mahfouzi, M., Karimi, M. and Ghiafehdavoodi, M. (2021). Modification of dough characteristics and baking quality based on whole wheat flour by enzymes and emulsifiers supplementation. LWT – Food Science and Technology, 139: 110794.
[33] Matsushita, K., Santiago, D. M., Noda, T., Tsuboi, K., Kawakami, S. and Yamauchi, H. (2017). The bread making qualities of bread dough supplemented with whole wheat flour and treated with enzymes. Food Science and Technology Research, 23: 403–410.
[34] Kurek, M. A., Wyrwisz, J., Piwińska, M. Wierzbicka, A. (2015). Influence of the wheat flour extraction degree in the quality of bread made with high proportions of β-glucan. Food Science and Technology, 35: 273–278.
[35] Zhou, C. F., Qian, P., Meng, J., Gao, S. M. and Lu, R. R. (2016). Effect of glycerol and sorbitol on the properties of dough and white bread. Cereal Chemistry, 93, 196–200.
[36] Bhise, S. and Kaur, A. (2014). Baking quality, sensory properties and shelf life of bread with polyols. Journal of Food Science and Technology, 51: 2054–2061.
[37] Packkia-Doss, P. P., Chevallier, S., Pare, A. and Le-Bail, A. (2019). Effect of supplementation of wheat bran on dough aeration and final bread volume. Journal of Food Engineering, 252: 28–35.
[38] Pourfarzad, A., Mohebbi, M. and Mazaheri-Tehrani, M. (2012). Interrelationship between image, dough and Barbari bread characteristics; use of image analysis to predict rheology, quality and shelf life. International Journal of Food Science and Technology, 47: 1354–1360.
[39] Penella, J. M. S., Collar, C. and Haros, M. (2008). Effect of wheat bran and enzyme addition on dough functional performance and phytic acid levels in bread. Journal of Cereal Science, 48: 715–721.
[40] Rosell, C. M. (2019). Trends in Science of Doughs and Bread Quality. In Flour and Breads and their Fortification in Health and Disease Prevention (2nd ed.). Elsevier Inc.
[41] Atalay, M. H., Bilgiçli, N., Elgün, A. and Demir, M. K. (2013). Effects of buckwheat (fagopyrum esculentum moench) milling products, transglutaminase and sodium stearoyl-2-lactylate on bread properties. Journal of Food Processing and Preservation, 37: 1–9.
[42] Ghoshal, G., Shivhare, U. S. and Banerjee, U. C. (2013). Effect of xylanase on quality attributes of whole-wheat bread. Journal of Food Quality, 36: 172–180.
[43] Niu, M., Hou, G. G., Kindelspire, J., Krishnan, P. Zhao, S. (2017). Microstructural, textural, and sensory properties of whole-wheat noodle modified by enzymes and emulsifiers. Food Chemistry, 223: 16–24.
[44] Ghoshal, G., Shivhare, U. S. and Banerjee, U. C. (2016). Thermo-mechanical and microstructural properties of xylanase containing whole wheat bread. Food Science and Human Wellness, 5: 219–229.
[45] Bilgiçli, N., Demir, M. K. and Yilmaz, C. (2014). Influence of some additives on dough and bread properties of a wheat-lupin flour blend. Quality Assurance and Safety of Crops and Foods, 6: 167–173.
[46] Ahmad, A. (2016). Optimization of Gluten Free Bread Formulation by Adding Xanthan Gum , Potato Starch and Sorbitol Using Response Surface Methodology. The National Conference for Postgraduate Research, 607–615.
[47] Kumar, Vikash, and Satyanaana, T. (2014). Production of thermo-alkali-stable xylanase by a novel polyextremophilic Bacillus halodurans TSEV1 in cane molasses medium and its applicability in making whole wheat bread. Bioprocess and Biosystems Engineering, 37: 1043–1053.

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مقاله علمی_پژوهشی

تولید کیک روغنی حاوی آرد گندم کامل با استفاده از اصلاح شیمیایی و آنزیمی فرمولاسیون

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چکیده

مسأله جداسازی سبوس از گندم به عنوان چالش اصلی برنامه تولید و مصرف گندم در کشور خودنمایی می‌کند. بجز معضلات اقتصادی ناشی از حذف سبوس به دلیل بافت سلولزی و اندازه ذرات درشت آن که از عوامل کاهش کیفیت فراورده‌های آردی سبوس‌دار است، کاهش ارزش تغذیه‌ای آرد سبوس‌گیری شده در مقایسه با آرد کامل نیز مطرح است. جهت بهبود کیفیت فراورده‌های پخت سبوس‌دار از افزودنی‌های مختلفی استفاده می‌شود. بنابراین هدف از انجام این پژوهش تولید کیک روغنی از آرد با درجه استخراج ۷۸، ۸۸ و ۹۶ درصد و استفاده از آنزیم زایلاناز (۰/۰۴ درصد)، امولسیفایرهای سدیم استاروئیل ۲-لاکتیلات (SSL) و استرهای مونو و دی گلیسرید تارتاریک اسید (داتم) (۰/۵ درصد) و قندالکلی سوربیتول (۳ درصد) و ارزیابی کمیت و کیفیت فراورده نهایی بود. نتایج نشان داد با افزایش درجه استخراج آرد و حضور افزودنی‌ها در فرمولاسیون بر رطوبت نمونه‌ها افزوده شد. با افزایش درصد سبوس (افزایش درجه استخراج) حجم مخصوص و تخلخل کیک کاهش یافت. حضور بهبوددهنده (مخلوط آنزیم، امولسیفایرها و قند الکلی) باعث افزایش این دو پارامتر شد. نمونه کیک حاوی آرد با درجه استخراج ۸۸ درصد، آنزیم، امولسیفایرها و قند الکلی دارای کمترین سفتی بافت طی یک ماه نگهداری بود. با افزایش درجه استخراج آرد و حضور بهبوددهنده در کیک به ترتیب سطح پوسته تیره‌تر و روشن‌تر شد. در نهایت نمونه حاوی آرد با درجه استخراج ۸۸ درصد، ۰/۰۴ درصد آنزیم زایلاناز، ۰/۵ درصد امولسیفایرهای داتم و SSL و ۳ درصد قند الکلی سوربیتول بیشترین امتیاز پذیرش کلی را کسب نمودند و به عنوان بهترین نمونه معرفی می‌شوند.