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Investigating the effect of adding date seed powder and wheat bran on the physicochemical, mechanical and sensory characteristics of Brotchen bread

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ABSTRACT

This study investigated the effect of adding Mozafati date seed powder and wheat bran on the quality parameters of Brotchen bread and dough. For this purpose, the values of physical and chemical characteristics (volume, specific volume, weight, moisture, ash, protein, dietary fiber, water activity, particle size, percentage of biota, Falling number, gluten, gluten index, zelenic sedimentation, delayed sedimentation) and examining the color of the crust and the central part of the bread), farinograph and extensograph characteristics of the prepared doughs, mechanical characteristics (texture profile analysis) and sensory characteristics (appearance, color, flavor, texture) of the bread produced with additional date kernel powder (0, 5, and 10 %) and wheat bran (0, 2.5, and 5%) were investigated in two resting periods of 90 and 180 minutes during 7 days of storage. The results showed that the amount of water absorption, development time, stability, tensile strength and maximum dough strength increased with the increase in the amount of added date kernel powder and wheat bran. It also decreased in softening degree, extensibility and energy levels. The values of L* and a* color of the crust and the Crumb part of the bread decreased with the addition of PKP ($p<0.05$). The change in softening degree and stability values was statistically significant ($p<0.05$). The addition of the two mentioned substances caused a firmer structure in the bread samples and reduced the staleness of the bread. It was observed that resting time of 180 minutes compared to 90 minutes had better results in texture and physical characteristics of bread ($p<0.05$). Although the sensory acceptance by the descriptors decreased ($p<0.05$), it was placed in a good grade. The result of this study showed that the presence of wheat bran and date kernel powder provides good quality bread and helps to increase fiber in the diet.

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1- Introduction

Globally, grains and starch-based products surpass other food items as the primary sources of dietary energy. Bread is one of the essential staple foods of humanity, dating back to the Neolithic era, and is prepared by baking in ovens or various types of furnaces. The first bread was baked around 10,000 BCE and may have been produced through deliberate experimentation with water and wheat flour [1]. Since bread is the most relevant source of carbohydrates in the diet, yeast, particularly *Saccharomyces cerevisiae*, has been used for over 5,000 years to improve its quality. The inclusion of salt, oil, milk, oilseeds, and spices such as turmeric gradually spread across the Mediterranean regions. While the primary purpose of consuming bread is to provide the body with necessary energy, advancements in nutritional science in the 20th century have introduced new objectives, such as obtaining various vitamins (especially B vitamins), essential micronutrients like folic acid, and increasing dietary fiber intake, leading to changes in bread formulations [2].

Dietary fiber is now considered a vital component in food products. The growing popularity of dietary fiber in food products stems from the increasing interest in developing healthier foods, with popular food items, especially bread, being widely accepted as suitable carriers for dietary fiber. Dietary fibers can be classified into the following categories: (1) edible carbohydrate polymers that naturally occur in consumed foods; (2) carbohydrate polymers derived from food raw materials through physical, enzymatic, or chemical processes, which have been shown to have beneficial physiological effects on health, as demonstrated by generally accepted scientific evidence presented to competent authorities; and (3) synthetic carbohydrate polymers that have been shown to have physiological health benefits, as supported by scientific evidence recognized by competent authorities [3].

Dietary fiber is a type of edible fiber that consists of a mixture of plant carbohydrate polymers, including polysaccharides and oligosaccharides, as well as hemicellulose, cellulose, resistant starch, pectic substances, inulin, gums, and more [2]. In addition to being indigestible, non-absorbable, and resistant to hydrolysis, dietary fiber plays a role in increasing stool bulk, stimulating fermentation in the small intestine, and reducing preprandial cholesterol levels and postprandial blood glucose levels in the body [4]. Moreover, the technological properties of dietary fiber make it a valuable ingredient in bread production. For instance, its water-holding capacity helps prevent staling, which can extend the product's shelf life. Additionally, research has demonstrated the antibacterial properties of dietary fiber [5]. Other beneficial effects of increased dietary fiber consumption on human health and bodily functions have also been reported [6].

On the other hand, the presence of dietary fiber has a positive impact on the glycemic index. Previous research has clearly shown that the starch in white bread is rapidly digested and absorbed, leading to high glucose and insulin responses [7]. This characteristic classifies bread as a high-glycemic-index (GI) food (<70) [8].

The date fruit is an important agricultural product in the arid and semi-arid regions of the world, including Iran. Most of Iran's date palm orchards are located in southern provinces such as Khuzestan, Bushehr, Kerman, and Hormozgan. Date cultivation has always played a significant role in the economic and social life of the people in these regions. The date fruit is considered a staple food and consists of a fleshy pericarp and a seed or pit with a firm texture and an oval shape.

In 2023, Iran's date production amounted to more than 1,300,000 tons, accounting for approximately 15% of the global production. Among the high-yield and popular varieties, the "Mazafati" date is one of the most common and widely consumed types in Iran, making up nearly 40% of the country's total date production [9].

Today, the consumption and export of pitted dates are increasing, leading to the generation

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of large amounts of date pits, which are usually discarded, used as a component of organic fertilizers, or, at best, processed into powder for animal feed. The pit of the Mazafati date accounts for about 10 to 14% of the fruit's total weight. In recent research, date pits have been utilized as by-products in the food industry [10].

Typically, the moisture content of date pits is around 10%, with approximately 7% protein, 10% oil, 10–25% fiber, 50% carbohydrates, 0.5–2% ash, and around 50 mg/g of polyphenolic compounds. The fiber in date pits is usually soluble, containing dietary fiber in the range of 78–80 g/100 g. Another key component of date pits is oil, which contains both saturated and unsaturated fatty acids, with lauric and oleic acids being the predominant ones.

Additionally, date pit oil contains significant amounts of phytochemicals such as tocopherols, tocotrienols, phytosterols, and phenolic compounds. These bioactive components enhance the value of date pit oil, making it suitable for various applications, including food formulations, cosmetics, and pharmaceutical products [10].

The antioxidant compounds present in date pits have been demonstrated in previous studies. Dietary fiber and antioxidants can be metabolized together in the colon and utilized by gut microbiota to provide health benefits for humans. In addition to improving gut health, these compounds can inhibit lipid oxidation and help prevent cardiovascular diseases under laboratory conditions [11].

Furthermore, research has shown that these compounds can suppress colorectal cancer and intestinal tumorigenesis in mouse models. Beyond their health benefits for humans, antioxidant compounds are also incorporated into food systems to enhance product shelf life. Examples include increasing the shelf life of yogurt and salad dressings, preventing spoilage in bread, and inhibiting lipid oxidation in fish products [12–14].

Nowadays, bread products are made from refined flours, which lack essential nutrients such as dietary fiber, vitamins, minerals, and antioxidants due to the removal of wheat bran and germ [15]. As a result, bread made from refined wheat flour fails to meet consumers' growing nutritional and health needs. Recently, there has been an increasing trend toward incorporating vegetable or fruit by-products into bread to enhance its nutritional value and health benefits [16]. Over the past two decades, bread production has been enriched with dietary fiber and antioxidant polyphenols [17].

Wheat bran is the outer layer or husk of the wheat grain, consisting of the pericarp, testa, hyaline layers, and aleurone layer. By weight, the wheat caryopsis consists of an outer bran shell, making up 14–16% of the wheat grain [18]. Wheat bran is rich in fiber, minerals, vitamin B6, thiamine, folate, vitamin E, and certain phytochemicals, particularly antioxidants such as phenolic compounds. Bran is used in whole-wheat and brown flour production, preserving valuable nutrients, whereas refining white flour removes most of these beneficial components, reducing the quality of white bread [19].

The physiological effects of wheat bran can be categorized into nutritional effects (due to its nutrient content), mechanical effects (mainly on the digestive system due to its fiber content), and antioxidant effects (stemming from phytochemicals such as phenolic acids and alkylresorcinols) [20].

This study examines the physicochemical, mechanical, sensory, and microbial properties of enriched Brötchen bread with date seed powder and wheat bran. It evaluates dough and bread characteristics in terms of rheological properties (e.g., dough development time, stability, resistance to extension, elasticity), interactions between date seed powder, bran, and bread components, and their impact on mechanical properties (e.g., hardness, bread volume, crust and crumb color, texture, and sensory properties). Additionally, the study investigates the microbial properties, including

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the effect of date seed powder on mold and yeast growth.

2.Materials and Methods

2.1 Materials

2.1.1 Preparation of Date Seed Powder

In this study, date seeds of the Mazafati variety were used. Five-kilogram samples were randomly collected from fully ripened date bunches at the end of the season, without any preference for size, color, appearance, or firmness. The seeds were first separated from the dates, soaked in water, and washed to remove the remaining fruit flesh. They were then dried at room temperature using an air stream. Initially, the seeds were coarsely ground using a hammer mill and then further ground into fine powder using a laboratory mill (IKA M 20 Universal Mill; IKA Werke GmbH Co. KG, Staufen, Germany). The fine powder was separated using laboratory sieves (mesh 40, size 150 microns, Azman Company, Iran). The resulting powder was stored at room temperature for bread preparation.

2.1.2 Other Ingredients

Wheat bran (Savahi Company, Tehran, Iran), wheat flour (Morshedi Flour Factory, Tehran, Iran), table salt (Hediyeh Salt Company, Semnan, Iran), sugar (Haft-Tappeh Sugar Company, Khuzestan, Iran), *Saccharomyces cerevisiae* yeast (Haft-Tappeh Sugar Company, Khuzestan, Iran), and oil (Ladan Oil, Iran) were used. All laboratory chemicals were purchased from Sigma (Germany).

2.1.3 Preparation of Brotchen Bread Containing Date Seed Flour and Wheat Bran

The bread dough formulation consisted of flour (100 parts), sugar (2.4 parts), salt (1 part), yeast (0.8 part), and distilled/deionized water (50 parts). Date seed powder was incorporated at three levels: 0%, 5%, and 10% (w/w) of the dry matter in the formulation, while wheat bran was added at 0%, 2.5%, and 5% (w/w) of the dry matter. The ingredients were mixed in a dough kneader equipped with a mixer (Kitchen Aid Kenwood, Great Britain) at low speed for 30 minutes in three stages until a uniform dough was obtained. The dough was left to rest and ferment at 40°C for two durations: 90 and 180 minutes. It was then divided into four equal parts and allowed to rest at room temperature for 20 minutes before shaping. The dough balls were baked in a preheated oven at 250°C with 15% humidity for 20 minutes. The baked bread was cooled on a wire rack at room temperature, packed in polyethylene bags, and stored until further analysis.

2.2 Tests

2.2.1 Date Seed Powder Analysis

The chemical and physical properties of date seed powder were analyzed based on standard AACC methods (2000). Moisture content (A 44-16), protein content using the Kjeldahl method (13-46), ash content (07-08), fat content (10-30), wet gluten (11-38), and crude fiber (10-01-32) were determined [21].

2.2.2 Physical and Chemical Analysis of Brotchen Bread Containing Date Seed Powder and Wheat Bran

The weight of the bread samples was measured at room temperature after cooling completely using a digital analytical balance with four decimal places (Sartorius, Germany) in three replications, based on the method of Yüksel et al. (2023) with slight modifications. The specific volume of the samples was determined according to Monteiro et al. (2021) with slight modifications [22]. Samples were sliced to a volume of more than 3.5 cm^3/g. Some analyses, such as the falling number test (81-56), were performed according to AACC (2000) standards [20].

Moisture analysis was conducted using AACC method 19-44, crude ash analysis using method 01-08, and fat content using method 10-30. Wet gluten and gluten index were determined following method 12-38 using Glutomatic-2200 and Glutork 2020 devices (Perten Instruments AB, Huddinge, Sweden). The falling number was measured using method b56-81. The Zeleny sedimentation test was performed based on the method of Yüksel et al. (2023). The delayed sedimentation test, different from the Zeleny test, was determined

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by measuring after the addition of bromophenol blue and allowing it to settle for 2 hours [21].

Bread staling was evaluated after 7 days of storage using formula (1):

$$BS_d = \frac{H_{7d} - H_{1d}}{H_{1d}} \times 100 \quad (1)$$

Where **H_1d** represents the firmness measurement on the first day, **H_7d** represents the firmness measurement on the seventh day, and **BSd** is the percentage of staling [23].

Colorimetric analysis of both the crust and the crumb of the bread was performed using a HunterLab colorimeter (HUNTERLAB-D25-9000, USA). The L* value (0 = black, 100 = white), a* value (positive = red, negative = green), and b* value (positive = yellow, negative = blue) were measured.

Particle size was determined using a digital micrometer (Mitutoyo, Japan) based on the method of Lapčíková et al. (2019) with slight modifications. A **1×1 mm²** section was cut from the center of each sample. After calibrating the device, the sample was placed in the designated section, and the screw was tightened as much as possible. The digital display reading was recorded as the particle size. This test was performed in three replications [24].

Water activity analysis was conducted using an **aw meter** (Novasina, Germany) according to the method of Zhao et al. (2021) with slight modifications. A **5×5 mm²** piece was cut from the center of the bread sample and placed in the device. After selecting the appropriate program and closing the lid, the stabilized value displayed on the digital screen was recorded as the water activity of the sample [25].

2.2.3 Farinograph and Extensograph Parameters

Water absorption capacity (as a percentage), dough development time (in minutes), dough stability (in minutes), and dough softening degree (12 minutes after the peak value on the curve) were determined using a farinograph (Brabender, Germany) following AACC method 21-54 [20].

Dough resistance to extension, maximum dough resistance, extensibility, and energy values were also measured using the same device and method. All analyses were performed using 300 grams of flour [20].

2.2.4 Mechanical Properties of Bread

The texture profile analysis of the bread was performed at room temperature using a HOUNSFIELD/H5KS device (UK). Sampling and measurements were carried out by cutting and removing the top third of the bread, and the measurements were taken from the middle section of the bread. The probe was placed in the center of the bread slices, avoiding the area close to the crust. The thickness of each bread slice was approximately 100 millimeters. The applied settings included a 35 mm diameter acrylic cylindrical probe, 50% strain, 5 mm/s speed, and a 5-second waiting time between two measurements. The main texture parameters evaluated were hardness, cohesiveness, springiness, resilience, chewiness, and adhesiveness. These tests were performed on the first, third, and seventh days of storage of the samples [26].

2.2.5 Sensory Test

The sensory evaluation panel, using the hedonic method, consisted of 15 people (10 women and 5 men, aged between 25 and 46 years, who were untrained in this field). The panelists were presented with a full slice of the bread samples in a blind manner, with no prior knowledge of the samples. They were asked to evaluate the intensity of four main sensory attributes [27]. For the appearance attribute, they assessed the color of the crust and the crumb, as well as the porosity of the bread. For taste, they evaluated the sweetness and saltiness. For aroma and flavor, they assessed the acceptability of date seed powder and wheat bran. For texture, the adhesiveness, gumminess, and tenderness of the samples were evaluated. The samples were served with three-digit codes on white plastic plates under white light at room temperature.

2.3 Statistical Analysis

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The obtained data were analyzed using IBM SPSS Statistics software (Version 2.2.0.25, USA). Significant differences between the measured groups were determined using one-way analysis of variance (ANOVA) with a confidence level of 95%. After testing for normality and homogeneity of variances, Tukey's HSD test was applied. Linear Discriminant Analysis (LDA) was used to assess the separability of each bread type. Sensory test data were analyzed using ANOVA. If significant differences were found, Tukey's test with a significance level of 5% was employed. All tests were performed in triplicate.

3. Results and Discussion

3.1 Properties of Date Seed Powder

The properties of dry matter, moisture, ash, protein, total carbohydrates, fiber content, fat, and fat characteristics of date seed powder from the Maktabi variety are presented in Table 1. The moisture content was very low, approximately 2%, indicating that it is unlikely to provide a suitable environment for microbial contamination or chemical spoilage. The protein content in the date seed powder was 8.9%, which was about 4% higher than the results of Morabet et al. (2015) who tested three other varieties. The fiber content in the Maktabi date seed powder was found to be 28% [9]. Soleimani et al. (2016) reported a significant difference in protein content between two varieties of Maktabi dates from Jiroft and Bam. In the Bam date seed, this value was over 28%, while in the Jiroft variety, it was less than 26%. In other varieties, Savia et al. (1984) reported the dietary fiber content in the date seeds of Roziz and Sifri to be about 22%, while Dushnoni et al. (1992) reported the fiber content in Zahidi and Majoul dates to be around 16%. This factor could be influenced not only by the date variety but also by the ripeness stages, geographical location, and climatic conditions. The high dietary fiber content in Maktabi date seed powder can be very beneficial for diabetic patients and those with gastrointestinal problems, especially those suffering from colon issues. It can help in preventing future complications or the progression of their diseases. The dietary fiber content in Maktabi date seed powder is higher than in other varieties, making it an important component for formulating dietary food products [28-30]. The fat content in Maktabi date seed powder was 7.09%, and in terms of its key characteristics, the peroxide value was 0.2, similar to the results of Soleimani et al. (2016) [30]. The antioxidant activity was 239,745 millimolar ascorbic acid per 100 grams of date seed powder. In the results of Soleimani et al. (2016), it was 194,488 millimolar and 248,166 millimolar ascorbic acid per 100 grams for the Bam and Jiroft varieties of date seed powder. Although the Maktabi variety used in our study was from Bam, the data show a significant difference, suggesting higher levels of polyphenolic compounds and antioxidant activity [30]. However, the peroxide value of 18.476 milliequivalents per gram in 1000 grams of oil from phenolic compounds, compared to the value of 19.448 milliequivalents per gram in 1000 grams of oil, indicates a lower content of phenolic compounds. Therefore, it is likely that there is a significant difference in the polyphenolic compounds [31].

3.2 Physical and Chemical Properties of Bread

The physicochemical properties of bread containing date seed powder and wheat bran are shown in Table 2. Based on the results, the volume of bread significantly increased with the addition of date seed powder ($p < 0.05$). For example, in the control sample with 90 minutes of fermentation, the volume increased from 411.21 cc to 485.57 cc. This is attributed to the effect of the presence of date seed powder in the treatments DKP10%-B0% and DKP5%-B5% at both 90 and 180 minutes of resting time, which enhanced the fermentation and yeast activity, similar to the results obtained by Onwar et al. (2013) [32]. Regarding dough weight, due to the high bulk density and water absorption capacity of wheat bran and date seed powder, an increase in dough weight was observed from 129.54 grams in the control sample to 137.89 grams in the DKP10%-B5% sample, showing a 6% increase at both fermentation times of 90 and 180 minutes.

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The moisture content of the baked bread, after cooling, did not show a significant increase with higher levels of both variables and only showed a 1% increase with the addition of date seed powder and wheat bran. Since resting time did not affect moisture content, the moisture test was only conducted at the 90-minute resting time. If the moisture content of bread is less than 15%, the likelihood of chemical spoilage, such as fat oxidation and mold or bacterial growth, is minimized [33]. The increase in ash content with the rising ratio of bran and date seed powder is attributed to the fiber content in the samples. Fermentation time did not have a significant effect on this, and the DKP10%-B5% sample showed the highest ash content. However, this increase should not exceed 5% of the total bread, as it could lead to very firm texture and reduced flexibility.

On the other hand, changing the ratio of flour to date seed powder and bran resulted in a decrease in protein content, due to the lower protein levels in both variables. By increasing the date seed powder from 0% to 10% in the DKP10%-B0% sample, a greater increase in total fiber content (around 2%) was observed, while increasing the wheat bran from 0% to 5% in the DKP0%-B5% sample only resulted in a 0.5% increase ($p < 0.05$) [27]. This increase corresponds to the presence of 28% fiber in date seed powder and only 8% in wheat bran.

No significant differences were observed in water activity or changes in the levels of the mentioned variables ($p < 0.05$). Yuksel et al. (2023) observed similar conditions when adding date seed powder to their flour formulation. Fermentation time did not have a significant impact on this either, and the results remained nearly constant. The particle size in the baked bread increased by 100 micrometers and showed a significant difference compared to the control sample. This change is attributed to the wheat bran. Corti et al. (2013) showed that increasing the particle size from wheat bran also increases the bread's moisture content. However, given the small increase in bran (5% of the total dry matter), the moisture only increased slightly [27].

The increased levels of date seed powder, which has higher fat content compared to wheat flour, led to a decrease in staling after 7 days. The staling rate increased from 82.5% in the DKP0%-B0% sample with 90 minutes of resting time to 85.5% in the DKP10%-B0% sample. One reason for this could be the imbalance in the amount of date seed powder and water in the dough, leading to a reduction in water content to less than 85% of dry matter [24]. Wheat bran initially increased the staling to 92.41% in the DKP0%-B2.5% sample, but in the DKP0%-B5% sample with 5% bran, it decreased to 80.72%. This initial increase was due to the same cause mentioned earlier. This suggests that increasing the bran level can help prevent staling in bread, but according to Corti et al. (2013), increasing the bran level beyond 5% in leavened bread can cause changes in texture and more staling [27].

Increasing the levels of date seed powder and wheat bran resulted in a reduction in staling from 62.99% to approximately 60%. Fermentation time had a significant effect on this. The percentage decrease in staling was more significant with both variables at 180 minutes of fermentation compared to 90 minutes (from about 60% to around 55%). Increasing fermentation time created more initial porosity and more hydrogen bonds in the bread dough, leading to reduced staling due to the improved firmness characteristics of the bread at both early and late storage stages [23].

The color characteristics of the raw materials used in the final product are reflected in the bread's appearance, and the visual appeal of the product is one of the most important factors influencing consumer choice. The presence of pigments such as carotenoids in the flour caused the bread to have a dark orange-brown color, which also led to a darker crust in the control sample (Table 3). Additionally, the presence of flavonoid and phenolic pigments caused the color to shift from dark orange to dark brown [32]. In the evaluation of the crust and inner section color of the samples, a significant difference was found between the control sample and the samples with date seed powder and wheat bran ($p < 0.05$). It was found

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that the lightness (L*) of both the crust and inner section decreased with the increase in date seed powder and wheat bran levels. The most commonly used and reported color parameter for crust analysis in bread is L*, as it correlates with the crust's brightness [32].

Furthermore, the *a* value increased in the crust with the rising ratio of date seed powder ($p < 0.05$), and this increase was more prominent in the presence of wheat bran. A similar trend was observed in the inner section, consistent with the results of Yuksel et al. (2023) (Table 3). This change may be due to the Maillard reaction occurring on the bread surface during baking. The *b* index generally decreased, indicating a shift in the color of the crust and inner sections towards yellow and brown due to the Maillard reaction [21, 34].

The Falling Number, gluten, gluten index, Zeleny sedimentation, and delayed sedimentation tests could not be conducted with the addition of date seed powder. Date seed powder differs in composition from wheat or other cereal flours, so the gluten content and potential for gluten network formation in flours added with date seed powder did not allow for the desired outcomes in these tests. However, the presence of wheat bran significantly increased the gluten index ($p < 0.05$), and Zeleny and delayed sedimentation tests also showed a significant increase ($p < 0.05$) [21, 34].

3.3 Farinograph and Extensograph Parameters

Farinograph analysis provides valuable information for assessing gluten structure and flour strength, as well as dough processing properties and quality. The farinograph test results were used to evaluate factors such as dough resistance, extensibility, expansion capacity, water absorption capacity, and overall efficiency. Some of the parameters (water absorption, development time, stability, and softening degree) from the farinograph analysis are shown in Table 4.

Stability time is related to flour strength and other solid materials. Longer stability times are generally more suitable for producing various types of bread and often require longer mixing times. It was observed that as the amount of date seed powder and wheat bran increased in the flour mixture, the development time and dough stability also increased ($p < 0.05$). This increase was more pronounced when the resting time was doubled, which, according to Ferrara et al. (2020), shows the impact of resting time on dough stability. Resting times greater than 120 minutes lead to a very regular structure formed by Saccharomyces cerevisiae yeast [35]. However, in none of the treatments did this time reach 16 minutes, which is related to the particle size of the date seed powder and wheat bran [36]. A significant correlation was also found between dough stability and bread volume ($p < 0.05$).

On the other hand, the softening index of the samples decreased with the addition of wheat bran and date seed powder, which contributes to improved bread shelf life [37]. In the presence of wheat bran, the reduction in softening was smaller, but with the addition of date seed powder, this reduction increased. The fermentation time of 180 minutes and the maximum presence of both variables led to the lowest recorded softening values. Iqbal et al. (2015) stated that dough development time is affected by the concentration and quantity of wheat protein. A longer dough development time is a desirable property for bread [38]. The results obtained show that the addition of date seed powder, bran, and an increase in fermentation time to 180 minutes have a positive impact on dough development time.

Water absorption capacity and high stability are important traits for bakers as they facilitate dough processing [39]. Furthermore, Aydogan et al. (2012) found significant relationships between water retention capacity above 60% and rheological and mechanical properties [40]. The higher this index, the longer the shelf life, reduced staling, and the optimal firmness of bread [41]. Increasing the ratio of both variables did not have a significant effect on water retention capacity, but extending fermentation time resulted in a significant increase in this index. Additionally, with the increase in date

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seed powder (PKP) ratio, stability also increased, indicating that dough rheology has a positive impact. High-quality flour is characterized by high water retention capacity and low softening degree [42]. The findings in this study also confirm the data from previous studies.

The differing effects of increasing date seed powder and wheat bran were particularly evident in the dough's resistance to further stretching. With the increase in date seed powder amount, dough resistance to stretching, maximum resistance values increased, while energy and stretch values decreased (Table 4). However, it was found that this change was not statistically significant ($p > 0.05$). Fermentation time had no effect on any of these factors. Excess fiber (over 22%) in date seed powder caused a reduction in dough extensibility and energy values (Table 4). Therefore, increasing the percentage of this powder increased resistance to stretching, and in this context, the energy required also decreased [29].

3.4 Mechanical Properties of Bread

The results of measuring the texture profile parameters of bread during the shelf-life study on days 1, 3, and 7 are presented in Table 5. Overall, it can be observed that the DKP10%-B5%-FT3 sample had significantly ($p < 0.05$) higher hardness but lower cohesiveness throughout the entire study. The DKP0%-B0%-FT1.5 sample, which lacked date seed powder and wheat bran, was significantly softer on day 1 with 90 minutes of resting time. However, it had no significant difference compared to the DKP0%-B0%-FT3 sample with 180 minutes of resting time on the next day, where the softest bread on day 1 was the control sample with 180 minutes of fermentation. On day 7, the DKP0%-B5%-FT3 sample had the softest bread containing date seed powder, but the bread with a 90-minute fermentation had higher firmness.

High cohesiveness leads to less disintegration during chewing, while low cohesiveness causes the bread to crumble. Moor et al. (2004) observed a reduction in cohesiveness ($p < 0.01$) in gluten-free bread samples after two days of storage [43, 44]. In this study, all the brotchen bread samples with date seed powder and wheat bran at both 90 and 180 minutes of resting time during the 7-day storage test showed lower cohesiveness compared to the wheat-based bread samples. In the case of the 180-minute resting time samples with wheat bran and date seed powder, the DKP10%-B5%-FT3 sample had the lowest cohesiveness. Compared to the DKP10%-B2.5%-FT3 (with half the amount of wheat bran) and DKP10%-B0%-FT1.5 (without wheat bran), the cohesiveness decreased significantly. However, as mentioned, adding date seed powder and wheat bran, due to their large particle size, reduced cohesiveness from 0.31 in the control sample to 0.21 in the final sample [45].

Elasticity is associated with freshness in bread, and low-value products are related to brittleness and crumb formation. Therefore, a high elasticity value is desired for the product's shelf life. In this study, the DKP10%-B5%-FT1.5 sample showed significantly ($p < 0.05$) lower elasticity during the 7-day storage period compared to other bread samples. The elasticity decreased day by day, but by day 7, all samples except the DKP10%-B5%-FT1.5 sample (84%) were able to maintain elasticity above 85%. This result, when compared to the study by Tooth et al. (2022), where they achieved 80% at best, indicates good texture for the bread after 7 days (Table 5).

The elasticity property indicates the start of the sample's stretch and is calculated as the ratio of the area under the second half of the first cycle curve to the first half of the cycle [27]. The reduction in elasticity reflects texture changes and the formation of crumbs [46]. The control brotchen breads (DKP0%-B0%-FT1.5 and DKP0%-B0%-FT3) had the highest elasticity on days 1 to 7 (40 and 41 on day 1, 31 and 37 on day 7). In comparison to other treatments, the samples with wheat bran and date seed powder had the lowest elasticity values (17 on day 7) at their highest values. Resting time did not cause a significant difference in all samples, as both treatments showed the same value for the higher elasticity, but the difference was significant ($p < 0.05$) in the lower values.

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Regarding chewability and stickiness, the samples without date seed powder and wheat bran showed better results. In terms of chewability, less force was required with the increase of date seed powder and wheat bran due to the reduction in cohesiveness, and the values in this test decreased significantly over the one-week period, as well as with the increase in the amounts of both variables. On the other hand, the stickiness of the product increased significantly over the week due to the greater firmness of the bread samples with date seed powder and wheat bran.

3.5 Sensory Evaluation

The average ranking scores of the evaluators for 15 sensory descriptors across 18 bread samples are presented in Table 6. All the samples showed significant differences from the control samples. Overall, the lowest score was for the DKP10%-B5%-FT1.5 sample, which had the highest level of date seed powder and wheat bran with 90 minutes of resting time, followed by DKP10%-B5%-FT3 with a score of 4.2. However, no sample had a total score lower than a "good" level (4).

Changes in the appearance characteristics such as the crust color, crumb, and porosity of the bread samples with increasing levels of date seed powder and wheat bran led to a reduction in the ranking scores for these descriptors, but they still remained at a "good" (4) level. The flavor, however, showed a decrease to an "acceptable" level (3) for saltiness and a "good" level (4) for sweetness, with the lowest score being attributed to the DKP10%-B5%-FT3 sample. As the levels of both variables increased, the acceptance of the aroma and the texture of the samples also decreased.

4. Conclusion

Date seed powder is still considered a waste product globally, or at best, used as animal feed, despite its high fiber content and potential for utilization in various sectors of the food industry. Brotchen bread is a type of leavened bread, and like other leavened breads, changing its formulation can lead to a decrease in visual quality, texture, aroma, and taste. However, the addition of date seed powder and wheat bran at the levels used in this study showed that the physicochemical, mechanical, and sensory properties of the bread, as well as the dough characteristics, remained largely preserved despite some minor declines.

In the treatment DKP1%-B5%-FT3, the physical properties of the bread showed no significant decline in protein content, an increase in ash and moisture, and no significant change in particle size. Although the particle size increased, which was a result of the addition of date seed powder and wheat bran, the sensory evaluation tests were positive. The profile analysis test also showed that the addition did not have a significant negative impact on the texture of the bread, which remained fairly preserved. One of the most important benefits of adding these two variables to Brotchen bread was the reduction in staling over the 7-day storage period, which reflects an improvement in shelf life and increased commercial value, especially in the DKP5%-B5%-FT3 treatment.

In the analysis of the dough, we observed an increase in parameters such as development time and stability in the DKP5%-B5%-FT3 sample, which helped improve the texture and structure of the bread. In terms of physical characteristics, the results showed that after 7 days, a 180-minute fermentation time performed better than the control sample. Sensory acceptance regarding the color and taste of the product also showed changes compared to the control, but the bread with higher levels of wheat bran and date seed powder still maintained a good rating.

In general, considering all the results, the DKP5%-B5%-FT3 sample showed the most promising outcomes and could be developed as a viable industrial product for the market.

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Table 1. Date Seed Powder characteristics ‡ [a]

PHENOLIC CONTANT[**] [*]	DPPH[**]	PEROXIDE[*]	OIL (%)	FIBER (%)	CHO (%)	Protein Contant (%)	Ash (%)	Moisture Contant	DRY MATTER (%)
18476.9±0.34 [f]	239745.9±0.18[c]	0.2±0.44[g]	7.09±0.14[b]	28±0.13[b]	80±0.1[a]	8.9±0.33[f]	1.2±0.3 [e]	2.1±0.29[d]	**90.01±0.29 [d]**

[*] Milliequivalent grams of peroxide per 1000 grams of oil

[**] Millimolar ascorbic acid per 100 grams

[***] mg of gallic acid per 100 grams of dry matter

‡ Means within each column with the same letters are not significantly different ($P < 0.05$).

[a] Data are means ± SD.

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Table 2. Physicochemical properties of Brotchen bread fortified by date seed powder and wheat bran[‡*]

Sample Name[a]	Volume (cc)	Specific volume (CC/g)	Weight (g)	Moisture (%)	Ash (%)	Protein (%)	Total Dietary Fiber (TDF) (%)
DKP0%-B0%-FT1.5	411.21 ± 0.19^{c}	3.27 ± 0.1^{b}	129.54 ± 0.01^{a}	9.76 ± 0.54^{d}	0.44 ± 0.14^{b}	10.97 ± 0.27^{d}	2.79 ± 0.3^{f}
DKP5%-B0%-FT1.5	435.41 ± 0.21^{c}	3.45 ± 0.02^{a}	131.21 ± 0.04^{a}	9.79 ± 0.69^{f}	0.51 ± 0.24^{c}	10.25 ± 0.33^{e}	3.01 ± 0.24^{e}
DKP10%-B0%-FT1.5	485.57 ± 0.1^{b}	3.74 ± 0.12^{c}	133.78 ± 0.1^{b}	9.81 ± 0.47^{c}	0.59 ± 0.13^{b}	10.16 ± 014^{c}	3.51 ± 0.19^{d}
DKP0%-B0%-FT3	415.35 ± 0.14^{a}	3.30 ± 0.09^{b}	-	-	-	-	-
DKP5%-B0%-FT3	439.78 ± 0.07^{a}	3.48 ± 0.1^{b}	-	-	-	-	-
DKP10%-B0%-FT3	501.89 ± 0.1^{b}	3.78 ± 0.12^{b}	-	-	-	-	-
DKP0%-B2.5%-FT1.5	415.22 ± 0.17^{c}	3.21 ± 0.2^{f}	131.75 ± 0.19^{d}	9.58 ± 0.74^{g}	0.61 ± 0.07^{a}	11.06 ± 0.26^{d}	3.49 ± 0.13^{b}
DKP5%-B2.5%-FT1.5	440.87 ± 0.14^{b}	3.35 ± 0.14^{c}	132.02 ± 0.24^{f}	9.88 ± 0.51^{e}	0.66 ± 0.15^{b}	10.40 ± 0.47^{f}	3.11 ± 0.06^{a}
DKP10%-B2.5%-FT1.5	489.37 ± 0.27^{e}	3.59 ± 0.2^{f}	135.99 ± 0.21^{e}	9.94 ± 0.41^{b}	0.71 ± 0.29^{d}	10.16 ± 0.57^{g}	3.60 ± 0.07^{a}
DKP0%-B2.5%-FT3	421.01 ± 0.15^{b}	3.28 ± .17^{e}	-	-	-	-	-
DKP5%-B2.5%-FT3	454.75 ± 0.29^{e}	3.38 ± 0.15^{c}	-	-	-	-	-
DKP10%-B2.5%-FT3	492.22 ± 0.3^{f}	3.63 ± 0.21^{g}	-	-	-	-	-
DKP0%-B5%-FT1.5	414.63 ± 0.08^{a}	3.19 ± 0.13^{c}	131.28 ± 0.14^{c}	9.68 ± 0.81^{i}	0.73 ± 0.29^{d}	11.7 ± 0.33^{e}	3.64 ± 0.16^{c}
DKP5%-B5%-FT1.5	461.28 ± 0.14^{b}	3.35 ± 0.15^{d}	134.39 ± 0.12^{c}	10.09 ± 0.78^{h}	0.79 ± 0.09^{a}	10.59 ± 0.08^{a}	3.84 ± 0.06^{a}
DKP10%-B5%-FT1.5	492.54 ± 0.24^{d}	3.48 ± 0.16^{d}	137.89 ± 0.2^{e}	10.24 ± 0.37^{a}	0.87 ± 0.33^{e}	10.21 ± 0.11^{b}	4.07 ±0.14^{b}
DKP0%-B5%-FT3	440.77 ± 0.39^{g}	3.24 ± 0.16^{d}	-	-	-	-	-
DKP5%-B5%-FT3	472.29 ± 0.14^{b}	3.45 ± 0.24^{g}	-	-	-	-	-
DKP10%-B5%-FT3	509.55 ± 0.13^{b}	3.53 ± 0.2^{f}	-	-	-	-	-

[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT 1.5 & 3h)

[‡] Means within each column with the same letters are not significantly different ($P < 0.05$).

[*] Data are means ± SD.

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Table 2. (continued) Physicochemical properties of Brotchen bread fortified by date seed powder and wheat bran[‡*]

Sample Name	aw	Particle Size (µm)	Degree of Staling Bread-BSd(%)	Falling number (s)	Gluten (%)	Gluten index (%)
DKP0%-B0%-FT1.5	0.968 ± 0.41[i]	529.54 ± 0.01[a]	82.5 ± 1.2[b]	350.11 ± 0.1[b]	27.67 ± 0.04[a]	99.12 ± 0.08[a]
DKP5%-B0%-FT1.5	0.963 ± 0.37[h]	631.21 ± 0.02[b]	60.4 ± 1.5[c]	0	0	0
DKP10%-B0%-FT1.5	0.951 ± 0.51[k]	633.78 ± 0.02[b]	85.5 ± 1.64[d]	0	0	0
DKP0%-B0%-FT3	0.965 ± 0.29[f]	-	75.16 ± 2.34[e]	0	0	0
DKP5%-B0%-FT3	0.954 ± 0.21[d]	-	72.69 ±1.1[a]	0	0	0
DKP10%-B0%-FT3	0.948 ± 0.21[d]	-	60.09 ± 3.54[k]	0	0	0
DKP0%-B2.5%-FT1.5	0.971 ± 0.11[a]	643.75 ± 0.01[a]	92.41 ±2.41[f]	345.1 ± 0.12[c]	23.5 ± 0.12[a]	0
DKP5%-B2.5%-FT1.5	0.971 ± 0.36[h]	644.02 ± 0.02[b]	62.99 ± 2.39[f]	0	0	0
DKP10%-B2.5%-FT1.5	0.967 ± 0.14[b]	644.99 ± 0.02[a]	54.88 ± 3.31[j]	0	0	0
DKP0%-B2.5%-FT3	0.977 ± 0.12[a]	-	79.68 ± 1.13[a]	0	0	0
DKP5%-B2.5%-FT3	0.972 ± 0.16[c]	-	60.63 ± 2.75[g]	0	0	0
DKP10%-B2.5%-FT3	0.966 ± 0.17[c]	-	47.85 ± 3.67[l]	0	0	0
DKP0%-B5%-FT1.5	0.979 ± 0.46[j]	644.28 ± 0.01[a]	80.72 ± 3.21[i]	342.65 ± 0.07[a]	20.64 ±0.08[b]	0
DKP5%-B5%-FT1.5	0.974 ± 0.35[h]	644.39 ± 0.02[b]	68.78 ± 3.14[h]	0	0	0
DKP10%-B5%-FT1.5	0.967 ± 0.22[d]	643.89 ± 0.3[c]	60.4 ± 1.24[b]	0	0	0
DKP0%-B5%-FT3	0.978 ± 0.37[h]	-	66.35 ± 2.33[e]	0	0	0
DKP5%-B5%-FT3	0.975 ± 0.31[e]	-	65.45 ± 2.37[e]	0	0	0
DKP10%-B5%-FT3	0.970 ± 0.33[g]	-	55.57 ± 1.09[a]	0	0	0

[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT 1.5 & 3h)

[‡] Means within each column with the same letters are not significantly different ($P < 0.05$).

[*] Data are means ± SD.

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Table 2. (continued) Physicochemical properties of Brotchen bread fortified by date seed powder and wheat bran[‡*]

Sample Name[a]	Sedimentation (cc)	Delayed sedimentation (cc)
DKP0%-B0%-FT1.5	40.05 ± 0.1[b]	50.05 ± 0.41[c]
DKP5%-B0%-FT1.5	0	0
DKP10%-B0%-FT1.5	0	0
DKP0%-B0%-FT3	0	0
DKP5%-B0%-FT3	0	0
DKP10%-B0%-FT3	0	0
DKP0%-B2.5%-FT1.5	45.78 ± 0.14[c]	54.78 ± 0.37[b]
DKP5%-B2.5%-FT1.5	0	0
DKP10%-B2.5%-FT1.5	0	0
DKP0%-B2.5%-FT3	0	0
DKP5%-B2.5%-FT3	0	0
DKP10%-B2.5%-FT3	0	0
DKP0%-B5%-FT1.5	51.28 ± 0.09[a]	61.28 ± 0.29[a]
DKP5%-B5%-FT1.5	0	0
DKP10%-B5%-FT1.5	0	0
DKP0%-B5%-FT3	0	0
DKP5%-B5%-FT3	0	0
DKP10%-B5%-FT3	0	0

[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT 1.5 & 3h)
[‡] Means within each column with the same letters are not significantly different ($P < 0.05$).
[*] Data are means ± SD.

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Table 3. CIE analysis parameters of Brotchen bread fortified by date seed powder and wheat bran[‡*]

		Samples[a]																
		DKP0%-B0%-FT1.5	DKP5%-B0%-FT1.5	DKP10%-B0%-FT1.5	DKP0%-B0%-FT3	DKP5%-B0%-FT3	DKP10%-B0%-FT3	DKP0%-B2.5%-FT1.5	DKP5%-B2.5%-FT1.5	DKP10%-B2.5%-FT1.5	DKP0%-B2.5%-FT3	DKP5%-B2.5%-FT3	DKP10%-B2.5%-FT3	DKP0%-B5%-FT1.5	DKP5%-B5%-FT1.5	DKP10%-B5%-FT1.5	DKP0%-B5%-FT3	DKP5%-B5%-FT3	DKP10%-B5%-FT3
Crust	L*	72.54 ±0.21[e]	59.67 ±0.08[b]	50.18 ±0.11[a]	73.07 ±0.1[a]	59.69 ±0.16[b]	50.24 ±0.26[d]	65.23 ±0.11[d]	54.9 ±0.23[d]	45.45 ±0.27[c]	65.27 ±0.1[a]	54.89 ±0.16[c]	45.71 ±0.25[d]	63.21 ±0.2[b]	51.62 ±0.19[a]	41.77 ±0.16[b]	64.18 ±0.37[d]	51.78 ±0.16[d]	41.45 ±0.2[b]
	a*	9.23 ±0.14[c]	11.14±0.09[c]	15.18 ±0.18[b]	9.45 ±0.21[f]	11.08 ±0.13[a]	15.45 ± 0.16[a]	11.14 ±0.09[b]	10.53 ±0.28[e]	9.35 ±0.22[b]	12.25 ±0.33[e]	11.41 ±0.17[d]	9.99 ±0.19[a]	13.1 ±0.3[d]	10.18 ±0.23[b]	9.15 ±0.39[f]	14.54 ±0.16[a]	12.47 ±0.14[d]	11.68±0.24[d]
	b*	29.8 ±0.2[d]	26.5 ±0.8[b]	22.41 ±0.24[c]	30.63 ±0.15[e]	27.73 ±0.41[e]	24.98 ±0.25[c]	28.41 ±0.13[e]	22.88 ±0.39[f]	19.76 ±36[e]	29.55 ±0.14[b]	25.13 ±0.22[e]	23.91 ±0.24[c]	27.65 ±0.22[c]	21.16 ±0.37[d]	18.58 ±0.27[c]	28.41 ±0.33[e]	23.95 ±0.19[e]	20.93 ±0.25[e]
Crumb	L*	73.54 ±0.11[a]	62.45 ±0.13[e]	56.14 ±0.26[d]	75.45 ±0.14[d]	65.65 ±0.33[c]	58.11 ±0.27[e]	69.41 ±0.08[a]	61.57 ±0.18[b]	53.88 ±0.16[a]	70.99 ±0.29[d]	64.16 ±0.14[b]	59.97 ±0.2[b]	66.58 ±0.14[a]	60.1 ±0.39[e]	50.17 ±0.14[a]	68.14 ±0.21[b]	61.18 ±0.1[a]	51.29 ±0.22[c]
	a*	-0.88 ±0.11[a]	2.54 ±0.1[d]	4.54 ±0.35[e]	-1.41 ±0.11[b]	3.57 ±0.37[d]	5.91 ±0.23[b]	0.14 ±0.1[c]	3.97 ±0.23[c]	6.01 ±0.28[d]	0.54 ±0.26[c]	4.58 ±0.31[f]	6.87 ±0.34[e]	1.09 ±0.22[c]	5 ±0.44[f]	7.1 ±0.33[e]	1.94 ±0.4[e]	5.87 ±0.13[b]	8.88 ±0.16[a]
	b*	14.14 ±0.12[b]	12.51 ±0.07[a]	10.87 ±0.11[a]	14.69 ±0.13[c]	13.02±0.42[e]	11.47 ±0.3[f]	14.97 ±0.11[d]	13.56 ±0.16[a]	12.41 ±0.44[f]	15.31 ±0.44[f]	14.06 ±0.13[a]	13.08 ±0.34[e]	14.68 ±0.31[e]	12.99 ±0.36[c]	10.78 ±31[d]	14.84 ±0.33[e]	13.14 ±0.14[d]	11.12 0.3[f]

[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT 1.5 & 3h)

[‡] Means within each column with the same letters are not significantly different ($P < 0.05$).

[*] Data are means ± SD.

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Table 4. Farinograph and Extensograph analysis parameters of Brotchen bread fortified by date seed powder and wheat bran[‡*]

Sample Name[a]	Farinograph Values						Extensograph Values			
	Dough Development time (DDT) (min.)	Stability (min.)	Degree of Softening (DOS) (BU)	Water absorption (%)	Arrival Time (AT) (min)	gelatination temperature (GT)(°C)	Energy (cm2)	Resistance to Extension (BU)	Extensibility (mm)	Maximum Resistance (BU)
DKP0%-B0%-FT1.5	1.8±0.43^{i}	9.67±0.24^{g}	52.12±0.41^{j}	60.05±0.29^{e}	1.4±0.31	92.05±0.08^{f}	100.21±0.12^{b}	767.4±0.25^{c}	102.42±0.24^{d}	845±0.28^{f}
DKP5%-B0%-FT1.5	1.9±0.19^{a}	13.01±0.15^{d}	42.87±0.35^{f}	61.01±0.3^{f}	1.1±0.35^{h}	91.08±0.09^{g}	89.5±0.19^{d}	799.14±0.21^{a}	90.41±0.25^{e}	865.77±0.16^{b}
DKP10%-B0%-FT1.5	2±0.34^{e}	13.51±0.16^{d}	39.95±0.29^{d}	61.18±0.24^{a}	1.1±0.31^{f}	91.02±0.04^{b}	82.41±0.09^{a}	801.2±0.41^{g}	88.91±0.29^{g}	885.34±0.34^{i}
DKP0%-B0%-FT3	1.9±0.24^{b}	9.89±0.19^{e}	52.14±0.28^{d}	61.21±0.25^{a}	1.3±0.3^{e}	92.01±0.05^{c}	-	-	-	-
DKP5%-B0%-FT3	2.07±0.18^{a}	14.57±0.1^{a}	43.01±0.29^{c}	62.78±0.27^{c}	0.9±0.29^{d}	91±0.02^{a}	-	-	-	-
DKP10%-B0%-FT3	2.11±0.41	14.98±0.11^{a}	39.94±0.43^{k}	62.97±0.26^{b}	0.8±0.29^{d}	90.8±0.06^{d}	-	-	-	-
DKP0%-B2.5%-FT1.5	2.05±0.35^{f}	9.55±0.16^{d}	41.62±0.49^{l}	60.78±0.29^{e}	1.5±0.36^{h}	91.78±0.07^{e}	94.63±0.15^{c}	789.56±0.35^{f}	95.41±0.23^{c}	859±0.33^{h}
DKP5%-B2.5%-FT1.5	2.15±0.39^{h}	14.1±0.13^{b}	39.51±0.36^{g}	61.29±0.28^{d}	1±.034^{g}	90.2±0.06^{d}	81.39±.15^{e}	809.91±0.34^{e}	89.88±0.15^{a}	877.45±0.15^{s}
DKP10%-B2.5%-FT1.5	2.3±0.37^{g}	14.15±0.24^{g}	37±0.33^{e}	61.34±0.26^{b}	0.87±0.19^{b}	90.1±0.1^{h}	80.01±0.11^{b}	854.87±0.24^{b}	84.35±0.25^{e}	890.14±0.29^{g}
DKP0%-B2.5%-FT3	2.1±0.33^{e}	9.71±0.26^{i}	41.67±0.37^{h}	60.97±.034^{g}	1.3±0.16^{a}	91±0.11^{i}	-	-	-	-
DKP5%-B2.5%-FT3	2.19±0.27^{c}	14.28±0.22^{f}	39.5±0.38^{i}	62.05±0.34^{g}	0.9±0.34^{g}	90.5±0.09^{g}	-	-	-	-
DKP10%-B2.5%-FT3	2.41±0.22^{b}	14.76±0.26^{i}	37.54±0.39	62.49±0.36^{h}	0.8±0.33^{g}	90.4±0.04^{b}	-	-	-	-
DKP0%-B5%-FT1.5	2.64±0.26^{c}	9.44±0.25^{h}	39.71±0.34^{e}	61.28±0.34^{g}	1.6±0.28^{d}	90.9±0.05^{c}	90.43±0.23^{e}	796.45±0.23^{b}	89.58±0.16^{b}	867±0.25^{c}
DKP5%-B5%-FT1.5	2.85±0.29^{d}	14.84±0.26^{i}	34.51±0.33^{e}	61.31±0.33^{g}	0.9±0.35^{h}	90±0.01^{h}	80.75±0.15^{c}	863.71±0.29^{d}	74.54±0.15^{a}	881.31±0.26^{d}
DKP10%-B5%-FT1.5	3.07±0.31^{e}	15.07±0.29^{j}	31.81±0.26^{b}	61.35±0.38^{i}	0.8±0.36^{h}	89.8±0.1^{h}	79.24±0.19^{d}	910.54±0.34^{e}	67.34±0.28^{f}	897±0.27^{e}
DKP0%-B5%-FT3	2.73±0.23^{b}	9.5±0.25^{h}	39.8±0.26^{b}	62.09±0.34^{g}	1.3±0.22^{c}	89.9±0.08^{f}	-	-	-	-
DKP5%-B5%-FT3	3.12±0.33^{e}	15±0.22^{f}	34.51±0.22^{a}	63.75±0.29^{e}	0.7±0.31^{f}	89.80.05^{c}	-	-	-	-
DKP10%-B5%-FT3	3.28±0.26^{c}	15.25±0.34^{k}	31.87±0.29	64.99±0.26^{b}	0.6±0.41^{i}	89.8±0.05^{c}	-	-	-	-

[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT 1.5 & 3h)

[‡] Means within each column with the same letters are not significantly different ($P < 0.05$).

[*] Data are means ± SD.

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Table 5. TPA analysis parameters of Brotchen bread fortified by date seed powder and wheat bran[‡*]

	Hardness (N)			Cohesiveness (−)			Springiness (%)			Resilience (−)			Chewiness (J)			Gumminess (N)		
Sample Name[a]	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7
DKP0%-B0%-FT1.5	5.41 ± 0.1[a]	7.94 ± 0.4[d]	9.25 ±0.1[a]	0.84 ±0.2[b]	0.52 ±0.1[b]	0.31 ±0.1[a]	92 ±0.1[a]	91 ±0.2[b]	90 ±0.1[a]	40 ±0.1[a]	37 ±0.4[d]	31 ±0.2[b]	0.75 ±0.1[a]	0.84 ±0.2[b]	0.94 ±0.4[d]	1.25 ±0.1[a]	3.51 ±0.1[a]	5.1 ±0.4[d]
DKP5%-B0%-FT1.5	5.91 ±.01[a]	8.9 ±0.1[a]	9.48 ±0.2[b]	0.77 ±0.1[a]	0.45 ±0.2[c]	0.22 ±0.2[b]	91 ±0.2[b]	90 ±0.3[c]	90 ±0.2[b]	35 ±0.1[a]	30 ±0.1[a]	24 ±0.1[a]	0.1 ±0.1[a]	0.13 ±01[a]	0.12 ±0.1[a]	2.01 ±0.2[b]	3.99 ±0.1[a]	6.97 ±0.1[a]
DKP10%-B0%-FT1.5	7.01 ±0.4[d]	9.11 ±0.1[a]	9.55 ±0.5[e]	0.7 ±0.3[c]	0.42 ±0.09[a]	0.22 ±0.1[a]	91 ±0.4[d]	88 ±0.3[c]	87 ±0.1[a]	34 ±0.2[b]	29 ±0.2[b]	24 ±0.3[c]	0.11 ±0.1[a]	0.14 ±0.1[a]	0.15 ±0.2[b]	2.1 ±0.2[b]	4.59 ±0.1[a]	7.8 ±0.2[b]
DKP0%-B0%-FT3	4.98 ±0.5[e]	6.24 ±0.2[b]	9.47 ±0.6[f]	0.9 ±0.1[a]	0.69 ±0.1[b]	0.33 ±0.3[c]	94 ±0.3[c]	93 ±0.1[a]	90 ±0.3[c]	41 ±0.7[g]	37 ±0.3[c]	34 ±0.1[a]	0.79 ±.01[a]	0.82 ±0.3c	0.9 ±0.5[e]	1.01 ±0.1[a]	2.97 ±0.2[b]	3.81 ±0.1[a]
DKP5%-B0%-FT3	5.53 ±0.2[b]	6.77 ±0.3[c]	9.55 ±0.4[d]	0.8 ±0.1[a]	0.6 ±0.2[c]	0.23 ±0.3[c]	92 ±0.1[a]	90 ±0.6[f]	90 ±0.4[d]	39 ±0.4[d]	35 ±0.1[a]	29 ±0.2[b]	0.91 ± 0.2[b]	0.12 ±0.1[a]	0.1 ±0.4[d]	1.54 ±0.3[c]	3.7 ±0.1[a]	50.3 ±0.1a
DKP10%-B0%-FT3	6.59 ±0.3[c]	6.87 ±0.2[b]	10.55 ±0.6[f]	0.74 ±0.2[b]	0.51 ±0.1[b]	0.22 ±0.2[b]	93 ±0.2[b]	91 ±0.5[e]	90 ±0.1[a]	35 ±0.6[f]	30 ±0.2[b]	26 ±0.1[a]	0.11 ±0.3c	0.12 ±0.3[c]	0.14 ±0.6[f]	1.9 ±0.2[b]	4.1 ±0.4[d]	6.7 ±0.2[b]
DKP0%-B2.5%-FT1.5	5.14 ±0.2[b]	8.99 ±0.2[b]	9.89 ±0.1[a]	0.79 ±0.4[d]	0.49 ±0.2[c]	0.21 ±0.3[c]	90 ±0.1[a]	88 ±0.7[g]	87 ±0.3[c]	39 ±0.5[e]	34 ±0.4[d]	30 ±0.3[c]	0.08 ±0.1[a]	0.88 ±04[d]	0.95 ±0.1[a]	1.57 ±0.4[d]	4.11 ±0.3[c]	7.5 ±0.3[c]
DKP5%-B2.5%-FT1.5	6.08 ±0.2[b]	9.14 ±0.1[a]	9.91 ±0.3[c]	0.71 ±0.3c	0.4 ±0.1[b]	0.21 ±0.2[b]	90 ±0.2[b]	89 ±0.4[d]	87 ±0.2[b]	34 ±0.3[c]	29 ±0.1[a]	22 ±0.4[d]	0.11 ±0.3[a]	0.14 ±05[e]	0.17 ±0.2b	2.27 ±0.1[a]	5 ±0.1[a]	8.1 ±0.3[c]
DKP10%-B2.5%-FT1.5	6.45 ±.03[c]	9.01 ±0.4[d]	9.99 ±0.2[b]	0.64 ±0.1[a]	0.37 ±0.3[d]	0.18 ±0.1[a]	89 ±0.1[a]	88 ±0.5[e]	86 ±0.4[d]	32 ±0.1[a]	24 ±0.3[c]	19 ±0.1[a]	0.12 ±0.5[e]	0.15 ±05[e]	0.18 ±0.1[a]	2.35 ±0.5[e]	5.4 ±0.2[b]	11.36 ±0.5e
DKP0%-B2.5%-FT3	5.07 ±.01[a]	6.88 ±0.3[c]	9.11 ±0.1[a]	0.8 ±0.1[a]	0.54 ±0.4[e]	0.22 ±0.2[b]	91 ±0.1[a]	89 ±0.2[b]	89 ±0.1[a]	40 ±0.4[d]	37 ±0.1[a]	35 ±0.1[a]	0.8 ±0.4[d]	0.84 ±0.1[a]	0.88 ±0.1[a]	1.4 ±0.6[f]	3.45 ±0.1[a]	7.5 ±0.4[d]
DKP5%-B2.5%-FT3	5.97 ±.04[d]	7.11 ±0.3[c]	9.59 ±0.1[a]	0.75 ±0.2[b]	0.41 ±0.1[a]	0.24 ±0.1[a]	90 ±0.1[a]	90 ±0.1[a]	89 ±0.1[a]	36 ±0.4[d]	30 ±0.2[b]	27 ±0.3[c]	0.95 ±0.2[b]	0.11 ±03[c]	0.15 ±0.2[b]	2.01 ±0.1[a]	4.7 ±0.1[a]	7.9 ±0.1[a]
DKP10%-B2.5%-FT3	6.77 ±.01[a]	7.41 ±0.4[d]	10.01 ±0.3[c]	0.7 ±0.2[b]	0.4 ±0.3[d]	0.3 ±0.3[c]	89 ±0.1[a]	89 ±0.3[c]	87 ±0.2[b]	34 ±0.1[a]	27 ±0.1[a]	23 ±0.3[c]	0.1 ±0.1[a]	0.14 ±0.4[d]	0.18 ±0.2[b]	2.2 ±0.2[b]	5.5 ±0.1[a]	11.1 ±0.5[e]
DKP0%-B5%-FT1.5	5.5 ±0.3[c]	7.41 ±0.3[c]	9.94 ±0.2[b]	0.73 ±0.3[c]	0.51 ±0.1[b]	0.34 ±0.1[a]	89 ±0.2[b]	88 ±0.4[d]	87 ±0.2[b]	36 ±0.1[a]	31 ±0.4[d]	25 ±0.1[a]	0.1 ±0.2[b]	0.14 ±0.1[a]	0.17 ±0.4[d]	1.6 ±0.3[c]	5.7 ±0.2[b]	8 ±0.6[f]
DKP5%-B5%-FT1.5	5.99 ±0.1[a]	8.25 ±0.3[c]	10.11 ±0.1[a]	0.62 ±0.3[c]	0.35 ±0.3[d]	0.25 ±0.2[b]	88 ±0.1[a]	86 ±0.1[a]	86 ±0.3[c]	33 ±0.2[b]	25 ±0.2[b]	20 ±0.4[d]	0.14 ±0.1[a]	0.17 ±0.1[a]	0.19 ±0.3[c]	2.31 ±0.1[a]	5.5 ±0.1[a]	9.7 ±0.2[b]
DKP10%-B5%-FT1.5	6.49 ±0.2[b]	8.54 ±0.1a	10.41 ±0.4[d]	0.51 ±01[a]	0.3 ±0.1[a]	0.14 ±0.1[a]	87 ±0.2[b]	85 ±0.1[a]	84 ±0.3[c]	31 ±0.5[e]	24 ±0.3[c]	17 ±0.1[a]	0.14 ±0.1[a]	0.18 ±.3[c]	0.21 ±0.1[a]	2.35 ±0.1[a]	5.7 ±0.1[a]	12.4 ±0.3[c]
DKP0%-B5%-FT3	5.35 ±0.1[a]	7.64 ±0.3[c]	8.9 ±0.5[e]	0.76 ±0.4[d]	0.55 ±0.2[c]	0.41 ±0.3[c]	90 ±0.4[d]	89 ±0.2[b]	89 ±0.1[a]	38 ±0.5[e]	34 ±0.2[b]	29 ±0.5[e]	0.1 ±0.3[c]	0.14 ±02[b]	0.17 ±0.2[b]	1.5 ±0.4[d]	5.4 ±0.2[b]	7.9 ±0.2[b]
DKP5%-B5%-FT3	5.5 ±0.1[a]	8.11 ±0.2[b]	9.1 ±0.3[c]	0.71 ±0.5[e]	0.44 ±0.1[b]	0.22 ±0.1[a]	88 ±0.5[e]	87 ±0.4[d]	87 ±0.2[b]	35 ±.05[e]	29 ±0.4[d]	21 ±0.3[c]	0.13 ±0.4[d]	0.15 ±0.4[d]	0.17 ±0.4[d]	2.3 ±0.3[c]	5.5 ±0.1[a]	9.5 ±0.4[d]
DKP10%-B5%-FT3	6.01 ±0.1[a]	8.81 ±0.1[a]	9.35 ±0.1[a]	0.69 ±0.1[a]	0.41 ±0.1[b]	0.21 ±0.1[a]	87 ±0.3[c]	86 ±0.1[a]	85 ±0.1[a]	32 ±0.1[a]	24 ±0.1[a]	17 ±0.1[a]	0.13 ±0.2[b]	0.15 ±0.2[b]	0.21 ±0.3[c]	2.3 ±0.1[a]	5.5 ±0.2[b]	11.7 ±.01[a]

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[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT 1.5 & 3h)
[‡] Means within each column with the same letters are not significantly different ($P < 0.05$).
[*] Data are means ± SD.

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Table 6. Sensory evaluation of Brotchen bread fortified by date seed powder and wheat bran‡

Sensory descriptor	Samples[a]																	
	DKP0 %- B0%- FT1.5	DKP5 %- B0%- FT1.5	DKP10 %- B0%- FT1.5	DKP0 %- B0%- FT3	DKP5 %- B0%- FT3	DKP10 %- B0%- FT3	DKP0 %- B2.5% -FT1.5	DKP5 %- B2.5% -FT1.5	DKP10 %- B2.5%- FT1.5	DKP0 %- B2.5% -FT3	DKP5 %- B2.5% -FT3	DKP10 %- B2.5%- FT3	DKP0 %- B5%- FT1.5	DKP5 %- B5%- FT1.5	DKP10 %- B5%- FT1.5	DKP0 %- B5%- FT3	DKP5 %- B5%- FT3	DKP10 %- B5%- FT3
Appearance																		
Porosity	4.8	4.8^{b}	4.6^{b}	4.8^{b}	4.6^{b}	4.4^{b}	4.8^{c}	4.6^{c}	4.8c	4.8^{d}	4.8^{c}	4.8^{e}	4.4^{a}	4.6^{d}	4.4^{e}	4.6^{b}	4.4^{e}	4.6^{f}
Crumb color	5^{b}	4.8^{b}	4.8^{c}	5^{c}	4.8^{c}	4.8^{e}	4.6^{b}	4.6^{c}	4.8^{c}	4.6^{b}	4.8^{c}	4.8^{e}	4.8^{d}	4.6^{d}	4.6^{f}	4.8^{d}	4.8	4.8^{g}
Crust color	5^{b}	4.8^{b}	4.6^{b}	5^{c}	5^{d}	4.8^{e}	4.6^{b}	4.4^{b}	4.6^{d}	4.6^{b}	4.6^{b}	4.6^{d}	4.4^{a}	4.4^{c}	4.6^{f}	4.6^{b}	4^{c}	4.4^{e}
Taste																		
Sweet	5^{b}	4.6^{a}	4.4^{a}	4.4^{a}	4^{a}	4.4^{b}	4^{a}	3.6^{a}	3.8^{a}	4.6^{b}	4.4^{a}	4^{a}	4.6^{b}	4^{b}	3.6^{a}	4.6^{b}	3.4^{a}	3.4^{a}
Salty	5^{b}	4.8^{b}	4.4^{a}	4.4^{a}	4.6^{b}	4.6^{c}	4.8^{c}	4.4^{b}	4.6^{d}	4.8^{d}	4.6^{b}	4.6^{d}	5^{e}	4.8^{d}	4.8^{g}	5^{e}	4.4^{e}	4.4^{e}
Flavor & Smell (by gustation)																		
DPK	5^{b}	5^{c}	4.4^{a}	5^{c}	5^{d}	4^{a}	5^{d}	4.6^{c}	4.6^{d}	5^{e}	4.8^{c}	4.8^{e}	5^{e}	4.6^{c}	4.6^{f}	5^{e}	4.8^{f}	4.6^{f}
BRAN	5^{b}	5^{c}	4.8^{c}	4.8^{b}	5^{d}	4.6^{d}	4.8^{c}	4.6^{c}	4.6^{d}	5^{e}	4.8^{c}	4.6^{d}	4.4^{a}	4^{b}	3.8^{c}	4.4^{a}	3.8^{b}	3.4^{a}
Texture (by gustation)																		
Adhesive	4.8^{a}	4.8^{b}	4.8^{c}	5^{c}	5^{d}	5^{f}	4.8^{c}	4.6^{c}	4.6^{d}	4.6^{b}	4.4^{a}	4.4^{a}	4.6^{b}	4^{b}	4^{d}	4.8^{d}	4.8^{f}	4.6^{f}
Rubbery	4.8^{a}	4.6^{a}	4.6^{b}	4.8^{b}	4.6^{b}	4.6^{d}	4.8^{c}	4.4^{b}	4^{b}	4.8^{d}	4.6^{a}	4.6^{d}	4.6^{b}	3.8^{a}	3.4^{b}	4.6^{b}	4^{c}	4^{c}
Soft	5^{b}	4.8^{c}	4.6^{b}	5^{c}	4.6^{b}	4.6^{d}	4.8^{d}	4.6^{c}	4.6^{d}	4.8^{d}	4.6^{a}	4.4^{b}	4.6^{b}	4^{b}	3.4^{b}	4.6^{b}	4^{c}	3.8^{b}
Overall	$4.94^{a,b}$	4.8^{c}	4.6^{b}	$4.82^{b,c}$	$4.72^{b,c}$	$4.58^{c,d}$	4.7^{c}	$4.44^{b,c}$	4.5^{c}	$4.76^{c,d}$	$4.64^{b,c}$	$4.56^{c,d}$	$4.64^{b,c}$	$4.28^{b,c}$	$4.12^{d,e}$	4.7^{c}	4.24^{d}	4.2^{d}

[a] Brutchen bread with date kernel powder (DKP, 0, 5 & 10%), wheat bran (B, 0, 2.5 & 5%) in two times of fermentation (FT, 1.5 & 3h)

‡ Means with the same letters in the same row do not statistically differ ($p > 0.05$) by Tukey's test

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بررسی تاثیر افزودن پودر هسته خرمای مضافتی و سبوس گندم بر ویژگی‌های فیزیکوشیمیایی، مکانیکی و حسی نان بروتچن

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چکیده

در این مطالعه، تأثیر افزودن پودر هسته خرمای مضافتی و سبوس گندم به عنوان منابع فیبر را بر پارامترهای کیفی نان بروتچن و خمیر مورد بررسی قرار گرفت و مقادیر ویژگی‌های فیزیکی و شیمیایی (حجم، حجم مخصوص، وزن، رطوبت، خاکستر، پروتئین، فیبر رژیمی، فعالیت آبی، اندازه ذرات، درصد بیاتی، فالینگ نامبر، گلوتن، شاخص گلوتن، ته نشینی زلنی، ته نشینی تاخیری و بررسی رنگ پوسته و بخش مرکزی نان)، ویژگی‌های فارینوگراف و اکستنسوگراف خمیرهای تهیه شده، ویژگی‌های مکانیکی (پروفایل بافت نان) و ویژگی‌های حسی (ظاهر، رنگ، عطر و طعم،بافت) از نان تولید شده به همراه پودر هسته خرمای مضافتی (۰، ۵ و ۱۰ درصد) و سبوس گندم (۰، ۲/۵ و ۵درصد) در دو زمان استراحت ۹۰ و ۱۸۰ دقیقه در طی مدت ۷ روز نگهداری مورد بررسی قرار گرفت. نتایج نشان داد که میزان جذب آب، زمان توسعه، پایداری، مقاومت در برابر کشش و حداکثر مقاومت خمیر با افزایش مقادیر پودر هسته خرمای مضافتی و سبوس گندم افزایش یافت. همچنین در درجه نرم شدن، انبساط پذیری، سطوح انرژی، مقادیر L^* و a^* رنگ پوسته و بخش داخلی نان با افزودن پودر هسته خرما کاهش یافت($p>۰/۰۵$). تغییر در درجه نرم شدن و مقادیر پایداری از نظر آماری معنی‌دار بود ($p>۰/۰۵$). افزودنی دو ماده یاد شده باعث ایجاد ساختار سفت‌تری در نمونه های نان شد و بیاتی نان را کاهش داد. مشاهده شد زمان استراحت ۱۸۰ دقیقه نسبت به ۹۰ نتایج بهتری در بافت و ویژگی‌های فیزیکی نان داشت ($p>۰/۰۵$). پذیرش حسی توسط توصیفگران اگرچه کاهش یافت ($p>۰/۰۵$) اما در درجه خوب قرار گرفت. نمونه DKP5%-B5%-FT3 بهترین عملکرد را در مجموع آزمون‌های مورد اشاره داشت. نتیجه این مطالعه نشان داد که حضور سبوس گندم و پودر هسته خرمای مضافتی نانی با کیفتی مناسب ارائه و به افزایش فیبر در رژیم غذایی کمک می‌کند.

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