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Evaluation of the technical-functional, antifungal and sensory properties of semi-bulk bread with rice husk flour sourdough in the presence of commercial starter *L. acidophilus* (LA5) during shelf-life

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ABSTRACT

With increasing consumer knowledge, the production of healthy foods without unnatural preservatives has had a significant impact on the development of functional and strategic foods. In this study, by using a commercial DVS starter (LA5) and determining the optimal fermentation control point with a potential capability appropriate to the fitted models, with an accuracy and reliability coefficient of 78%, the technical-functional, antifungal and sensory properties of semi-loaf bread produced during a 7-day shelf life were evaluated. ANOVA and comparison of the means of all qualitative and technical-functional tests of bread samples containing rice husk flour sourdough (RHFS) showed a significant difference in shelf life compared to the control sample at the 5% level ($P<0.05$). The decrease in water activity and cross-linking in the RHFS bread sample compared to the control sample during shelf-life resulted in a decrease in moisture loss (4% and 10% respectively) and a slower release of moisture content in the core and crust compared to the control. Two quality indicators, specific volume and porosity showed a decreasing trend over the shelf life and the TCD color indices, BI index, YI and WI and anti-fungal properties were significantly different from the control sample. Compared to the control sample, the texture characteristics as the staling index during shelf life showed a more favorable trend. Finally, the effect of controlling RHFS fermentation during shelf-life improved the gelatinization and spreadability, sensory and anti-fungal properties of the bread sample.

1- Introduction

Social and economic development has made bakery products gradually become an important part of the daily diet of people around the world. By 2021, bread and other bakery products had a global turnover of about $1 billion, and the global bakery products market is expected to reach about $458 billion by 2027 [1]. According to the nutritional and cultural value of bread as a strategic food product and the amount of waste it generates in the country (more than thirty percent), the desire to consume bakery products with minimal amounts of preservatives, free of chemical additives, and with desirable quality and shelf life has been one of the concerns of bakery industry leaders [2]. The interest in optimizing production and increasing shelf-life by improving characteristics such as taste, texture and nutritional properties, delaying staleness and microbial spoilage, as well as providing energy and meeting the body's structural needs, has shifted to the precise evaluation of food compounds that are biologically active, in accordance with the habits and diets of each climate and region, and with food-pharmaceutical properties [3 & 4]. Fermented products owe their aroma and flavor characteristics mainly to the microbial consortium. Accordingly, the preservation of beneficial microbial species in the production and quality improvement of organic foods, especially sourdough as a strategic food precursor (bread), will be of paramount importance in any country [5]. Sourdough is actually a very complex biological system, consisting of a mixture of cereal products, water and active microorganisms, used in the bread fermentation process for specific reasons such as improving flavor, shelf life, nutritional value or even health benefits [6]. Acid production as an important metabolite during the random and directed fermentation process of sourdough affects the starch and protein components of wheat flour and, while reducing the pH and protease activity of wheat flour, affects the staleness of bread and increases the porosity and softness of the texture of sourdough bread. Sourdough also reduces the rate of starch hydrolysis by inhibiting the activity of the flour alpha-amylase enzyme, which limits the release of low molecular weight dextrin's and reduces gelatinization and reversion [7].

The use of cereals, especially rice bran, which is rich in nutrients, minerals and dietary fiber, improves important qualitative and organoleptic properties in the bakery industry and increases the water-binding capacity of the dough structure compared to other commercial fiber sources. As the ability to retain air in the fermented structures of rice bran is much higher than that of other fiber compounds, it accelerates volume increase in baked goods [8]. The "freshness" of bakery products, which is closely related to the type of bread, additives and its structural quality, is severely affected by relative quality loss and microbial spoilage during shelf-life. Therefore, preservation of flavor and aroma, improvement of qualitative-microscopic and organoleptic properties of bread can be considered as the first and most important aspects related to the quality of produced bread [9]. Accordingly, several studies have been carried out in the country and around the world to evaluate the factors that influence the controlled fermentation of sourdough on the quality characteristics of sourdough bread. For example, in a study by Abedfar [10], the antimicrobial activity and the effect of rice husk flour sourdough under the influence of two lactic acid strains on the amount of phytic acid in semi-solid bread were investigated; the results showed that there was no significant difference between the antimicrobial activity of logarithmic phase and stationary phase active culture suspensions of both lactic acid isolates in the well method, and the highest zone of non-growth associated with Escherichia coli was observed with values of (13. 22±1.13) mm. The phytic acid content in controlled fermentation with each of the starters had a decreasing trend, and the effect of the Pediococcus pentosaceus starter in reducing the amount of phytic acid was much greater than that of the Lactobacillus plantarum species, which in fact the effect of increasing acidity in its directed fermentation caused a decrease in the phytic acid content with the highest antimicrobial properties and zone of non-growth. Abedfar et al [11] studied the optimization of controlled fermentation with L. acidophilus in rice bran sourdough and evaluated the quality characteristics of bulk bread using the (RSM) method; the results of the fit assessment of the fitted models showed that with increasing temperature and fermentation time for a fixed sugar content, titratable acidity, microbial population monitoring, specific volume, porosity, total difference index of bread crust colour showed an increasing trend and its continuity also showed a significant decreasing trend. Similarly, the firmness of the overall acceptance assessment of bread texture also showed a decreasing trend ($P<0.05$). Sadeghi et al [12] studied the use of dominant lactic acid bacteria with antifungal ability as a protective initial culture in bulk sourdough bread. The results of PCR product sequencing led to the identification of L. reuteri as the selected isolate. The isolate had good anti-Aflatoxin activity and, based on HPLC analysis, reduced the levels of Aflatoxin B1, B2, G1 and G2. In addition, the presence of sourdough fermented with the selected isolate had a significant effect ($P<0.05$) on the quality of the bread produced in terms of hardness, specific volume and phytic acid content. Manini et al [13] (2014) studied the chemical changes and microbial evaluation of wheat bran sourdough, and also investigated the amount of

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bioactive compounds in the fermentation process of wheat bran sourdough. The results of the study showed that after the first day of wheat bran fermentation process, the number of lactic acid bacteria and yeast also increased slowly, and after 8 times of inoculation process, the microbial count reached a constant level. Also, the chemical changes resulting from wheat bran fermentation showed that the amount of ferulic acid and phytic acid in the sourdough obtained from fermented wheat bran increased and decreased, respectively, compared to normal bran, and the bioactive compounds obtained from wheat bran fermentation caused greater solubility of soluble fibers such as arabinoxylan. Ilofa et al [14] studied the fermentation of brown rice flour as a functional ingredient in foods. The results of this study showed that fermentation reduced the negative effects of bran on cereal products. Therefore, brown rice flour is recommended as a functional food ingredient and increases the sensory properties and improves the viscoelastic properties of the final product. Katina et al [15] investigated the effect of bran addition on the rheological properties of dough and the texture of voluminous bread. In this study, bran was added at three levels of 10, 15 and 20%. The results showed that the addition of bran reduced the elasticity and tensile strength of the dough, reduced the volume of the bread and increased the density of the bread by 0-40% depending on the amount of bran added. A two-dimensional study of bread crumb morphology also showed that fineness, uniformity and uniform distribution of pores decreased with increasing bran content.

Although there have been many studies on sourdoughs and their performance in the world and in this country, the main objective of this research was to evaluate the technical-functional, antifungal and sensory properties of a semi-leavened bread containing rice flour sourdough with commercial starter DVS culture during shelf-life.

2. Materials and Methods

The raw materials used for the preparation of the final product included; wheat star flour and rice husk flour (RHF) of Tarom Hashemi variety for the preparation of rice husk flour sourdough were obtained from Shad Flour Factory (Rasht, Iran) and Giltaz (Lengroud, Iran), respectively, in accordance with the international standard AACC [16], with the values of moisture percentage (13. 80±0.68; 3.70±0.28), protein percentage (10.90±0.32; 3.67±0.02), fat content (4.25±0.26; 0.82±0.01), ash percentage (0.75±0.01; 15.55±0.05) and acidity (3.51±0.1; 3.28±0.3). The food spoilage mould Aspergillus niger (PTCC 5319) was obtained from the Microbial Collection Center of the Scientific and Industrial Research Organization of Iran, and the commercial lactic acid strain Lactobacillus acidophilus pure culture (LA5) used in this study was DVS culture. The culture media used included MRS (agar and broth), Nutrient (agar and broth) and Potato Dextrose Agar (PDA) and chemicals were obtained from Iberesco (Iranian Biosciences) and Merck, Germany.

2-1. Purified activation of the active culture of the commercial strain (LA5)

Although the DVS culture of the commercial lactic acid strain (LA5) was pre-active, the dominant strain was revived under short-term conditions to ensure proper performance. First, the stock culture was inoculated into 10 ml of MRS broth after removal from the -20°C freezer and then incubated at 37°C for 48 hours.

2-2. Evaluation of the antifungal properties of the commercial strain (LA5)

The spotting method was used to evaluate the antifungal properties of the commercial DVS culture. In general, 2 cm of each was cultured on MRS agar and then incubated at 37 °C for 48 hours. To prepare the mould suspension, it was cultured in PDA medium and incubated at 25 °C for 72 hours. The mould suspension at 10^4 Cfu/ml PDA medium was then poured onto the lactic acid isolate cultured lines as a two-layer culture, and after coagulation of the second layer, the plates were incubated at 30 °C for 48 hours [17].

2-3. Directed fermentation of rice husk flour sourdough (RHFS)

Directed conditions RHFS with a yield factor of 280 was cultivated with the commercial strain LA5 at 37°C for 48 hours until 10^8 Cfu/gr (compared to 0.5 McFarland tube) was obtained in MRS broth culture medium. Then 0.9% of the produced biomass (without supernatant), centrifuged at 6000 g for 15 minutes at 4°C (Sigma 3-30KS, Germany), was added to the RHFS submerged fermentation bed at a stirring speed of 300 rpm until pH = 33.4 was reached to determine the optimum point [18].

2-4. Evaluation of the qualitative characteristics of the optimum semi-bulk bread sample (RHFS) compared to the control during shelf life

After determining the optimum point (the best treatment of the RHFS semi-loose bread sample on the first day of baking), the optimum semi-loose bread sample containing the controlled RHFS and the control sample were prepared according to the method of Magnin et al [19] with slight modifications. The qualitative, technical-functional, antifungal and sensory properties were then evaluated at intervals of one week (day one, day three and day seven).

2-5. Evaluation of moisture content of crust and crumb of semi- bulk bread

To measure the moisture content of semi-loose bread containing RHFS, a piece of crust and a piece of crumb were weighed. An equal weight of each piece was then dried at 105°C to constant weight, and after cooling in a desiccator, the weight of each

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piece was calculated separately, and the moisture content of each piece was calculated from the difference in weight before and after drying based on equation (1) [20].

Equation (1)

%MCwb = [((Wib-Wfdb))/Wib] × 100

Wib weight of bread sample, Wfdb weight of dried bread sample.

2-6. Study of the textural properties of semi- bulk bread containing RHFS during shelf life

The study of changes in firmness was carried out using a texturometric test. For this purpose, a texture analyzer (Brookfield CT3 model, USA) with a cylindrical aluminium probe (TA25/1000) was used on a sample of semi-loose bread containing RHFS at a probe speed of 30 mm/min and up to 50% compression from the initial height during shelf-life (one week after baking) to estimate the textural properties of the bread by evaluating only two of several properties (hardness and cohesion) [21].

2-7. Study of the specific volume and porosity of semi- bulk bread containing RHFS during shelf life

The specific volume of semi-loose bread containing RHFS, produced separately and under certain conditions, in hygienic polyethylene packages with lids and at ambient temperature, was evaluated by replacing rapeseed with the control sample. Using image processing techniques, the porosity values of a 2 x 2 cm section of the semi-loose bread containing RHFS was investigated and photographed using a high-pixel camera. The processed image was then made available to Image J software (version 1.45). The images in this software were a set of dark and light spots that were estimated by calculating the ratio of light to dark spots as an indicator of porosity during shelf life compared to the control sample [22 & 23].

2-8. Result of colour characteristics, browning index, yellowness index and whiteness of RHFS semi- bulk bread crust

The analysis of the colour yield (Delta E*) of the RHFS semi-bulky bread crust compared to the control sample during the shelf life was carried out by determining the three indices L*, a* and b* related to the treated sample and the colour dimensions $*L_0$, $*a_0$ and b_0* related to the control bread according to equation (2). In order to measure these indices, a slice of bread crust with specific dimensions was first prepared, then the images were taken and made available to the Image J software. By activating the Lab space in the Plugins section, the above indices are calculated. Next, to measure the Browning Index (BI), which is obtained from non-enzymatic browning reactions, equation (2) and the Yellowness Index (YI) were calculated using equation (3) and the Whiteness Index (WI) of RHFS semi-bulky bread crust was calculated using equation (4) [24].

Equation (2& 3 and 4)

$$\text{Delta E}^* = \sqrt{(L_0^* - L^*)^2 + (a_0^* - a^*)^2 + (b_0^* - b^*)^2}$$

$$BI = \frac{100(x - 0.31)}{0.172}$$

$$x = \frac{(a^* + 1.75L^*)}{(5.645L^* + a^* - 3.012b^*)}$$

$$YI = \frac{142.86 * b}{L}$$

$$WI = \frac{100 - [(100 - L)^2 + a^2 + b^2]}{2}$$

2-9. Evaluation of the overall acceptance of semi- bulk bread samples containing RHFS during shelf-life compared to the control

For the sensory evaluation, a number of male and female panelists (students and university employees) aged 25 to 45 years were randomly selected to evaluate the characteristics of the breads produced, in order to determine the overall acceptability, crust colour, chewiness, texture firmness, flavour, porosity and elasticity on a scale of 1 to 5 (1 being the lowest and 5 the highest). Finally, an evaluation coefficient was applied to each attribute to assess the overall acceptability of the quality of RHFS-containing loaves during the shelf-life [25].

2-10. Statistical analysis

The results of this study were statistically analyzed using SAS (version 9.1) and Microsoft Office Excel (2013) software, based on a completely randomised basic statistical design with factorial method in three replications. The comparison of means was also performed using the least significant difference (LSD) test at the 95% level.

3. Results and Discussion

3-1. Evaluation of the antifungal properties of a commercial lactic acid strain (LA5) after activation

After purified activation of the active culture of the commercial strain, the inhibition of fungal growth and spread was assessed. The results showed that on the first and third day of incubation, the growth of mycelium of the fungus (*Aspergillus niger*) was not observed on the plates as an indicator of the spread of contamination in food, but after seven days, the growth *of A. niger* and the density of its hyphae were observed on the plates. In fact, the commercial DVS strain of L. acidophilus in question prevented the growth of A. niger, which had sufficient resistance compared to a native lactic acid strain (RHFS) to prevent the growth of *A. niger* (Figure 1-A). In fact, the antifungal properties of lactic acid strains are not

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only related to the production of organic acids (acetic acid and lactic acid), but also to cyclic dipeptides and active compounds such as 4-hydroxyphenylpropanoic acid, phenylpropanoic acid and phenyllactic acid [20 & 26]. The results of the study of the antifungal properties of the semi-bulk bread sample produced with sourdough containing DVS starter obtained in this study were clearly evident when compared with the control sample (without sourdough) as shown in Figure (1-B) over a period of one week. In fact, the antifungal effect can be attributed to the production of a number of antifungal compounds such as organic acids and extracellular secondary metabolites produced by this strain.

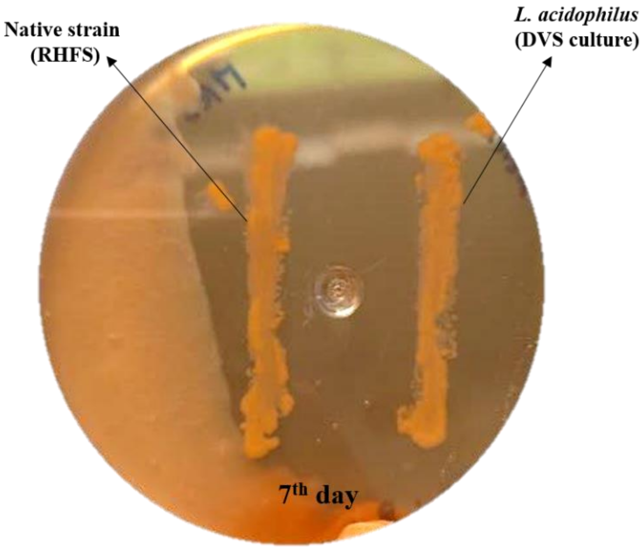

Fig 1 (A). Comparison of the antifungal properties of the DVS culture (LA5) with those of the native strain (after 7 days).

Fig 1 (B). Antifungal properties of RHFS semi-bulk bread sample compared to the control sample.

3-2. Evaluation of crust and core moisture loss of RHFS-containing bread samples during shelf-life

Heat transfer is the main factor in water evaporation, generally moisture transfer is by evaporation to the outer surface of the bread under the function of mass transfer [27]. The results of the analysis of variance showed changes in the moisture content of the crust and crumb of the semi-loose bread containing RHFS during a period (one week) in the vicinity of the DVS starter compared to the control sample (without sourdough) at the level of 5% in Table (1). Accordingly, during the shelf life (7 days after baking), the moisture content of the bread crumb decreased and the moisture content of the bread crust increased. Meanwhile, the rate of moisture loss in the semi-loose bread sample containing RHFS was much slower than that of the control bread sample, which was significant at the 5% level. The semi-loose bread sample containing RHFS is able to increase the moisture content of the final product in food model systems due to its high content of fiber, protein and free hydroxyl groups in its structure and its ability to bind with water molecules in the dough formulation [28].

Table 1. Evaluation of the moisture content* of crust and crust of SBB containing DVS culture during shelf life

Shelf Life	SBB with RHFS	SBB without RHFS (Control)

Moisture content* (Crust bread) %		
1 day	21.113 ± 0.178 ^{bA}	20.018 ± 1.101 ^{cA}
3 day	22.001 ± 0.052 ^{bA}	21.256 ± 0.114 ^{bB}
7 day	25.068 ± 0.128 ^{aB}	29.089 ± 0.304 ^{aA}
Moisture content* (Crumb bread) %		
1 day	38.235 ± 0.205 ^{aA}	37.590 ± 0.213 ^{aA}
3 day	36.174 ± 0.226 ^{bA}	32.110 ± 0.840 ^{bB}
7 day	32.006 ± 0.301 ^{cA}	29.816 ± 0.087 ^{cB}

Results expressed as mean values of triplicates ± standard deviation

a-d Different superscript letters in the same column between samples denote signifcant differences (P< 0.05)

A-B-C Different superscript letters in the same row between samples denote signifcant differences (P< 0.05)

3-3. Evaluation of textural properties of semi-bulk bread samples containing RHFS during shelf life

The phenomenon of bread texture hardening (Hardness) can be influenced mainly by two parameters: firstly, the hardness resulting from the transfer of moisture from the core to the crust and, secondly, the intrinsic hardening of the cell material resulting from starch recrystallization [29]. The results of measuring the hardness of the core of semi-loose bread containing RHFS during a seven-day storage period are shown in Table (2). The results showed that the force required to compress the semi-loose bread in the bread samples increased over time. The lowest level of bread texture hardness was observed in the semi-bulk bread sample treated with RHFS on the first day compared to the control sample. The highest level of texture hardness was also observed in the processed sample obtained on the seventh day after baking in the control sample. The analysis of variance and comparison of the mean changes in bread texture hardness at the 5% level also showed that, under the conditions applied in this study, storage time had a significant effect on the changes in texture hardness of semi-bulk bread, especially in bread containing RHFS, because the presence of fibrous compounds and elements with free hydroxyl groups strengthens the gluten network, which prevents moisture loss during baking by absorbing water. It also has the ability to react with starch molecules, delaying the retro-gradation process in the final product and preventing staleness [30].

Table 2. Evaluation of Hardness of SBB samples during shelf-life in comparison to the control sample.

Shelf Life	SBB with RHFS	SBB without RHFS (Control)
Hardness* (Crust bread) %		
1 day	6.624 ± 0.233 ^{Bc}	9.156 ± 0.081 ^{Ac}
3 day	11.490 ± 0.342 ^{Bb}	13.801 ± 1.069 ^{Ab}
7 day	17.006 ± 0.482 ^{Ba}	21.055 ± 0.371 ^{Aa}

Results expressed as mean values of triplicates ± standard deviation

The cohesion and disintegration of the bread structure are closely related to the staleness of the bread. The results of the comparison of means showed that the cohesion of the semi-bulk bread sample processed with RHFS content decreased over time, the results of this study were in accordance with the research objectives of Fitzgerald et al [31]. Accordingly, the highest amount of cohesion was observed in the (RHFS) processed bread sample on day one compared to the control sample. The lowest amount of cohesion was also observed in the processed sample obtained from 7 days after baking in the control sample (Figure 2). In addition, during the shelf life, there will be slight changes in the decrease of cohesion due to the breakdown of the internal structure and the lack of retention of free water in the structure of the bread cells [32].

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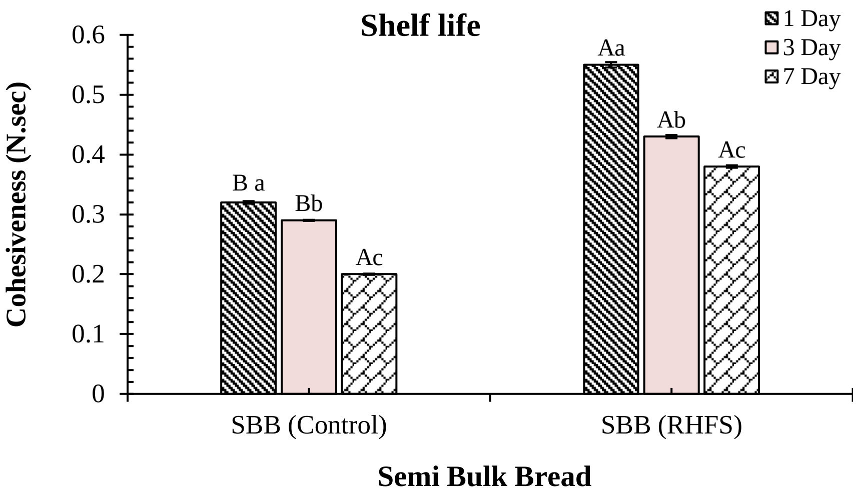

Fig 2. Evaluation of cohesiveness of SBB samples during shelf-life in comparison to the control sample.

Results expressed as mean values of triplicates ± standard deviation.

3-4. Evaluation of specific volume and porosity of semi-bulk bread containing RHFS during shelf life

One of the items controlling the staleness index is the specific volume. The results of this study showed that the presence of RHFS-containing sourdough in the structure of semi-bulk bread caused a slight improvement and also a noticeable increase in specific volume in semi-bulk bread. In fact, with increasing storage time over a week, the specific volume of the produced breads decreased significantly (P≤0.05), while it was always higher than the control sample (Table 3). In fact, the reason for this parameter is probably that due to starch gelatinization, the viscosity of the dough increases and its extensibility decreases. As a result, the gas pressure in the cells increases and the cell walls are destroyed. In addition, the high water absorption power of siliceous compounds in the rice husk and the reduction of free water activity ultimately lead to the improvement and increase in specific volume of bread [33]. With increasing storage time and the development of physicochemical changes in the protein network structure of cereal products with high amounts of silica and fiber, porosity will decrease because it causes the starch-gluten network to be disrupted [34]. Analysis of variance and comparison of the mean changes in the porosity of semi-bulk bread crumb at the 5% level showed that increasing storage time had a significant effect (P≤0.05) on the porosity of the semi-bulk bread texture containing RHFS sourdough with commercial starter during one week of storage after baking compared to the control sample. Among them, the lowest porosity values were related to the control sample after 7 days of storage (Table 2). In fact, the bread texture becomes compact and brittle over time due to moisture loss, and the porosity in the bread texture does not have sufficient resistance to retain carbon dioxide gas in the gluten network and the gas is not distributed properly in the bread, and this inconsistency will be effective in reducing the size of the pores in the bread texture.

Table 3. Evaluation of the specific volume and porosity sourdough SBB containing DVS culture during shelf life

Shelf Life	SBB with RHFS	SBB without RHFS (Control)
Specific volume (cm^3/gr)		
1 day	2.553 ± 0.171 ^{aA}	2.424 ± 0.153 ^{aA}
3 day	2.167 ± 0.021 ^{bA}	1.829 ± 0.014 ^{bB}
7 day	1.880 ± 0.066 ^{cA}	1.361 ± 0.030 ^{cB}
Porosity (%)		
1 day	21.836 ± 1.052 ^{aA}	19.959 ± 1.290 ^{aA}
3 day	18.921 ± 1.138 ^{bA}	16.143 ± 0.803 ^{bB}
7 day	15.134 ± 0.042 ^{cA}	13.225 ± 0.609 ^{cB}

Results expressed as mean values of triplicates ± standard deviation

a-d Different superscript letters in the same column between samples denote signifcant differences (P< 0.05)

A-B Different superscript letters in the same row between samples denote signifcant differences (P< 0.05).

3-5. Evaluation of derived colour indices of semi-bulk bread crusts containing RHFS during shelf life

The differences in the colour indices of the crusts of the semi-soft bread samples were undoubtedly influenced by the fermentation of microorganisms,

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the use of different flours and the fermentation processes in the presence of some additives, which could lead to the production of different active compounds in the non-enzymatic browning process during baking. In fact, changes in the colour of the bread crust occur as a result of bread baking, which are related to the Maillard reactions and the interactions between reducing sugars and the amino groups of proteins (caramelisation reaction) and the interactions between sugars, resulting in a golden brown colour of the bread crust [35]. Analysis of variance and comparison of the mean of the colorimetric characteristics of the crust of the semi-leavened sourdough breads with the control sample showed a significant difference (P≤0.05) during the shelf life. In addition, the effect of storage time had a decreasing trend in the values of the browning index, while for the yellowness index this trend was completely reversed and a significant difference compared to the control sample was observed (Table 3). The whiteness index of the bread crust showed much lower values compared to the control sample, which can be attributed to the absence of sourdough and the lack of complete fermentation in it. Scanlon and Zghal [36] studied the presence of the protease enzyme and the relative increase in amino acids resulting from proteolysis in bread dough, which, in fact, increased the non-enzymatic browning reaction on the surface of the bread crust.

Table 3. Evaluation of the Delta E*, BI, YI and WI of crust SBB containing DVS culture during shelf life

Shelf Life	Semi-bulk bread (RHFS)	Semi-bulk bread (Control)
Delta E* index		
1 day	5.828 ± 0.762 ^{c}	-
3 day	10.996 ± 0.931 ^{b}	-
7 day	13.415 ± 1.018 ^{a}	-
Browning index (BI)		
1 day	37.203 ± 1.184 ^{aA}	35.640 ± 1.081 ^{aA}
3 day	24.308 ± 1.160 ^{bA}	21.201 ± 2.066 ^{bA}
7 day	19.802 ± 1.259 ^{cA}	15.377 ± 1.102 ^{cB}
Yellow index (YI)		
1 day	58.060 ± 2.189 ^{cA}	36.020 ± 1.134 ^{cB}
3 day	68.355 ± 1.052 ^{bA}	52.616 ± 2.542 ^{bB}
7 day	78.825 ± 3.214 ^{aA}	72.978 ± 1.083 ^{aA}
White index (WI)		
1 day	10.070 ± 1.231 ^{cA}	7.133 ± 2.018 ^{cA}
3 day	26.169 ± 2.642 ^{bB}	42.608 ± 3.021 ^{bA}
7 day	36.300 ± 1.515 ^{aB}	59.410 ± 1.033 ^{aA}

Results expressed as mean values of triplicates ± standard deviation

a-d Different superscript letters in the same column between samples denote signifcant differences (P< 0.05)

A-B-C Different superscript letters in the same row between samples denote signifcant differences (P< 0.05).

3-6. Overall acceptance of RHFS semi-bulk bread sample during shelf life

Overall acceptance indicates the acceptance of the overall sensory characteristics of the bread. Accordingly, the final acceptance process of the sensory properties of semi-leavened breads made from rice husk flour sourdough as a function of the presence of sourdough during shelf life and controlled fermentation conditions is shown in Figure (3). Based on the results of statistical analysis, different levels of shelf life had a significant difference (P≤0.05) on the final acceptance of semi-loose bread. The final acceptance of the produced samples decreased with increasing shelf life. A significantly higher overall acceptance was observed in the treated bread sample compared to the control sample. Katina et al [37] reported that the intensity of freshness and pungency, overall taste and aftertaste were significant between the treatments containing sourdough and the control bread, and also the degree of toastiness of the bread crust increased more with sourdoughs containing only one starter. The use of sourdough in bread making reduces proteolysis to a limited extent, prevents further gluten degradation and provides adequate and sufficient release of amino acids for flavor precursors [38].

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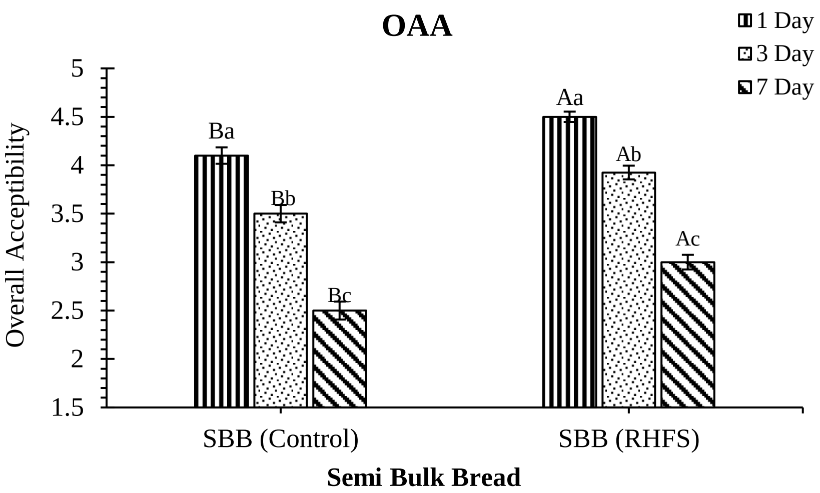

Fig 3. Evaluation of OAA of sourdough SBB samples during shelf-life in comparison to the control sample.

Results expressed as mean values of triplicates ± standard deviation

4. Conclusion

Optimum point control with the aim of producing and increasing the shelf life of fermented products by improving characteristics such as taste, textural and nutritional properties and delaying staleness and microbial spoilage for functional products and products rich in dietary compounds and rich in mineral salts such as bread as the country's strength during shelf life is considered necessary and a new approach for food industry researchers. Accordingly, the results of this study showed that the effect of sourdough fermentation guidance during shelf life improved sensory and antifungal properties, and also analysis of variance and comparison of the means of all qualitative and technical-functional tests of bread samples containing rice bran sourdough during shelf life compared to the control sample showed a significant difference at the 5% level. Finally, in examining the rate of staleness, gelatinization, and reversion of the semi-loose bread sample treated with sourdough, there was a more favorable trend compared to the control sample, which can be used for semi-industrial and industrial production of the product.

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ارزیابی خصوصیات تکنیکی-عملکردی، ضدقارچی و حسّی نان نیمه حجیم حاوی خمیرترش آرد شلتوک برنج در مجاورت با استارتر تجاری *لاکتوباسیلوس اسیدوفیلوس* (LA5) در طول مدت ماندگاری

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چکیده

با پیشرفت دانش مصرف‌کنندگان برای تولید محصولات غذایی سالم بدون نگهدارنده‌های غیرطبیعی در توسعه غذاهای کاربردی و استراتژیک اثرات چشمگیری داشته است. در این پژوهش با بکارگیری استارتر DVS تجاری (LA5) و تعیین نقطه بهینه هدایت تخمیر با قابلیت بالقوه متناسب با مدل‌های برازش شده با ضریب صحت و اطمینان ۷۸ درصد، به ارزیابی خصوصیات تکنیکی-عملکردی، ضدقارچی و حسّی نان نیمه حجیم تولیدی در طول مدت ماندگاری ۷ روز پرداخته شد. آنالیز واریانس و مقایسه میانگین تمام آزمون‌های کیفی و تکنیکی-عملکردی نمونه‌های نان محتوی خمیرترش آرد شلتوک برنج (RHFS) در طول مدت ماندگاری در مقایسه با نمونه شاهد در سطح ۵ درصد اختلاف معنی‌داری را نشان دادند ($P<0.05$). کاهش فعالیت آبی و اتصالات عرضی در نمونه نان خمیرترشی در مقایسه با نمونه شاهد در طول مدت ماندگاری سبب کاهش افت رطوبت (بترتیب ٤ و ١٠ درصد) و رهایش آهسته‌تر محتوی رطوبت مغز و پوسته در مقایسه با آن شد. دو شاخص کیفی حجم مخصوص و تخلخل، در طول مدت ماندگاری روند نزولی داشت، همچنین شاخص‌های رنگی، برایند رنگ کل، شاخص قهوه‌ای شدن، زردی و سفیدی و خصوصیات ضد قارچی در مقایسه با نمونه شاهد اختلاف مشهودی داشت. خصوصیات بافتی بعنوان شاخصی از بیاتی در طول مدت ماندگاری در مقایسه با نمونه کنترل روند مطلوب‌تری را نشان داد. در نهایت تاثیر هدایت تخمیر خمیرترش در طول مدت ماندگاری سبب بهبود ژلاتینه شدن و واگشتگی، خصوصیات حسّی و ضد قارچی نمونه نان نیمه حجیم گردید.