

Evaluating the Effects of Sourdough, Bakery Yeast and Sodium Bicarbonate on Texture, Volatile Compounds and Staling of Barbari Bread

Barbari Ekmeğinin Bayatlama ve Uçucu Bileşik Özelliklerine Maya, Fırıncılık Mayası ve Sodyum Bikarbonat Etkisinin Değerlendirilmesi

Research Article

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ABSTRACT

There are various methods to process dough for bread production. In this study, sourdough, bakery yeast, sodium bicarbonate and a combination of bakery yeast and sodium bicarbonate were used to produce dough of Barbari bread. The structure of the texture of bread, bread staling and volatile compounds of bread samples were analyzed. The results showed that the texture of treated bread samples with a combination of bakery yeast and sodium bicarbonate had less hardness and were stale later. Generally, 33 volatile compounds were observed in this type of bread. Most of these compounds were aldehyde, alcohol, and ketones compounds.

Key Words

Bread, sourdough, bakery yeast, volatile compounds.

ÖZET

Ekmeğin üretimi için hamur hazırlamanın çeşitli teknikleri vardır. Bu çalışmada Barbari ekmeğinin hamurunu üretmek için maya, fırın mayası, sodyum bikarbonat ve fırın mayasıyla sodyum bikarbonatın bir birleşimi kullanılmıştır. Ekmeğin dokusu, bayat ekmeğin ve ekmeğindeki uçucu bileşiklerin yapısı analiz edilmiştir. Sonuçlar, ekmeğin örneğinin yapısının fırın mayası ve sodyum bikarbonat birleşimiyle daha az sert olduğu ve daha geç bayatladığını göstermektedir. Genel olarak, bu ekmeğin tipinde 33 farklı uçucu bileşik olduğu görülmüştür. Bu bileşiklerin çoğu aldehit, alkol ve keton bileşikleridir.

Anahtar Kelimeler

Ekmeğin, hamur, fırın mayası, uçucu bileşikler.

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INTRODUCTION

Barbari is one of the favorite breads in Iran and some Middle East countries. This type of bread is known in other countries like Afghanistan, Turkey, and Arabic countries [1]. Bakery yeast, sourdough and sodium bicarbonate are used to make this kind of bread. Sourdough is a method of fermentation and is made by mixing wheat flour and water without adding starter. The natural microorganisms in flour are used to leaven the dough and are called the mother culture [2]. Sourdough is a system containing lactic acid bacteria and yeast [3].

Another method of leavening is to apply bakery yeast (*Saccharomyces cerevisiae*). When the bakery yeast is added during preparation of dough, its starch is converted into sugar, alcohol, and carbon dioxide. CO₂ bubbles cause the development and leavening of the dough. Sodium bicarbonate is a chemical leavening agent, which has been identified as baking soda and is often used because of low cost, speed up production, and easy transportation [4]. Chemical agents sometimes can leaven the dough regularly and are much better than yeast, because they do not need the long-time activity or environmental conditions to produce gas.

One of the disadvantages of chemical leavening agents is that these agents are not able to create flavor as compared to yeast; so, they can be used with yeast to solve the problem [4]. It seems that these methods have effect on textural characteristics, flavor and the staling process. The effect of bakery yeast and sourdough (with or without lactic acid) has been studied extensively on the flavor and odour of bulky breads [2,5-8].

The connection between sensory characteristics and volatile compounds of bulky breads has been studied [9]. Researchers have studied the effects of sourdough, time, and temperature of fermentation [10] and the amount of yeast, fermentation time, and temperature [11] on the textural parameters of bulky breads. Also, the effect of sourdough is investigated on the rheological characteristics of dough and bulky bread [3], volatile compounds and bread texture [12]. Since studies on flat breads are less compared to bulky breads

and the volatile compounds of flat breads have not been identified in Iran and the use of different methods of fermentation to produce the flat bread, the aim of this study was to evaluate the effect of sourdough, bakery yeast, sodium bicarbonate, and combination of sodium bicarbonate and bakery yeast as leavening methods on quality parameters of texture, staling process, volatile compounds, and other sensory characteristics of Barbari bread, which is one of the traditional flat bread which is of interest to Iranian people.

MATERIALS and METHODS

Material

Wheat flour with 82% extraction, moisture of 14.2% (wheat bran, w.b), ash of 0.82%, protein of 9.7%, wet gluten of 29%, and falling number of 300-s was prepared by Morvarid Damavand Flour Company, Iran. Instant active dry bakery yeast in powder form was prepared by Fariman Company, Mashhad, Iran. Salt and sodium bicarbonate were obtained from a local supermarket.

Preparation of sourdough

Sourdough was produced according to this method: 100 g of wheat flour, 1 ml of vinegar, 2.5 g of yogurt, and 1 g of salt were mixed with 60 ml of water, and thereafter, sourdough was fermented at a temperature of 28 to 30°C for 20 h.

Formulation and baking bread

Four types of bread were prepared. Leavening factors were used to make the bread dough, including bakery yeast (0.5% w/w of the weight based on flour), sourdough (40% w/w based on the weight of the flour), sodium bicarbonate (0.5% w/w based on the weight of the flour), and the combination of bakery yeast and sodium bicarbonate in equal proportions (0.25% w/w based on the weight of the flour), and to prepare the samples of bread dough, water (60% w/w based on the weight of the flour), salt (2% w/w based on the weight of the flour weight), and the dough leavening various agents were mixed in a dough mixer (GLE barhardt, model 11 INIMAT, Germany) at 60 rpm for 15 min. Then, the dough containing sourdough for 4 h and the dough containing bakery yeast and combination of bakery yeast and sodium bicarbonate for 1 h were placed at a temperature of 28 to 30°C for

fermentation.

Fermentation has not taken place in the sample containing sodium bicarbonate because of the absence of lactic acid microorganisms or bakery yeast, so this does not need time for fermentation to take place. Then, 650 g per dough were taken and made round and placed for 15 min on the table for secondary fermentation to take place on it. Then, the samples were shaped oval with a thickness of 1.2 ± 0.2 cm, length of 35 ± 2 cm, and width of 5 ± 2 cm and were cooked at 200°C for 10 min. Barbari bread treated with bakery yeast, sourdough, sodium bicarbonate and combination of sodium bicarbonate and bakery yeast were marked as B₁, B₂, B₃, and B₄, respectively.

Measuring moisture and pH

Moisture content and pH of bread samples were measured according to standard methods AACC number (44-15) and (52-02), respectively [13].

Method of measuring textural characteristics

Textural characteristics of the samples were studied using a texture analyzer (TA-CT3, Brookfield corp, USA). In this experiment, the texture profile analysis test (TPA) and a cylindrical probe (35 mm diameter) were used in pretest speed and test speed, respectively for 5 and 0.5 mm/s. Regulated Load cell was 25 kg. In this method, the size of the bread samples was $15 \times 100 \times 100$ mm and strain deformation was 15%. Hardness, adhesiveness, gumminess, chewiness, cohesiveness and springiness were evaluated.

Method of measuring the staling

Staling of bread was investigated using differential scanning calorimetry (DSC). 30 ± 5 mg of the bread samples were weighted and placed in a completely sealed aluminum pan without air. Samples were heated at 25 to 200°C and speed of temperature at 5°C min^{-1} . Onset point (T_o), peak top (T_p), and enthalpy (j/g) re-crystallization of starch (Retrogradation) were measured at 24, 48 and 72 h after baking [14].

Volatile compounds

Volatile compounds were isolated by using the solid-phase micro-extraction method (SPME) and identified by gas chromatography/mass

spectroscopy (GC-MS). For each SPME analysis, 10 g of bread sample, containing both crust and crumb, were introduced into a 50 ml vial with a teflon-lined septum fit at its top. The SPME needle was introduced into the vial, which was then immersed in a water bath at 60°C . The SPME fibre (2 cm-50/30 mm DVB/Carboxen/PDMS Stable Flex Supelco, Bellefonte, PA, USA) was exposed to the headspace for 60 min. After the end of the extraction time, the fibre was inserted into the injector port of the gas chromatograph (GC) for thermal desorption of the volatiles for 5 min [5]. The GC analyses were performed using a Hewlett Packed model HP 6890 gas chromatograph coupled to a GC-MS HP 5973 mass spectrometer. HB₁ column with a 0.25 mm film thickness, $60 \text{ m} \times 0.32 \text{ mm i.d.}$ was used. The GC temperature program was 60°C , held for 3 min, then increased by 7°C/min to 230°C . The carrier gas was helium with a column flow of 2 ml/min. The injector was at 250°C in splitless mode. Mass spectra were recorded by electronic impact (EI) at 70 eV. The scan mode was used to detect all the compounds in the range m/z 40-300. The identification of volatile compounds was performed in comparison with standard compounds and MS data obtained with those in Wiley 275.

Sensory characteristics

Sensory characteristics of Barbari bread were investigated by 10 trained panelists using scoring tests. A piece of bread was given to each panelist to eat and samples were compared in term of shape, down surface and up surface, odor, flavor, color, hardness and softness of texture and chewiness, scoring 1 (poor) to 5 (excellent) [15].

Statistical Analysis

The experiments were performed in a completely randomized design. All experiments were conducted in triplicates and the mean values and standard deviations were reported. Analysis of variance (ANOVA) was performed and results were separated using the Multiple Ranges Duncan's test ($p < 0.01$) and results of sensory properties were analyzed using the non-parametric Friedman test, using statistical software of Statistical Package for the Social Sciences (SPSS), Version 22; (SPSS, Inc. New Jersey, USA).

Table 1. pH and moisture of bread samples*.

Bread samples	pH	Moisture (%)
B ₁	5.916 ± 0.015b	33.544 ± 0.701b
B ₂	5.206 ± 0.070a	33.407 ± 2.125b
B ₃	7.823 ± 0.159d	29.551 ± 0.978a
B ₄	7.24 ± 0.04c	32.354 ± 0.915ab

B₁; Barbari bread with bakery yeast, B₂; Barbari bread with sour dough, B₃; Barbari bread with sodium bicarbonate and B₄; Barbari bread with combination of bakery yeast and sodium bicarbonate; *Values are the averages of triplicates ± standard deviations. Different letters in each column are indicative of significant statistical difference (P < 0.01) between the values.

Table 2. Textural Characteristics of the Bread samples.

Bread samples	Hardness1 (N)	Adhesiveness (mj)	Hardness 2 (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (mj)
B ₁	14.610 ± 1.296ab	1.646 ± 0.706ab	14.095 ± 1.050a	0.793 ± 0.032a	7.370 ± 5.014a	11.622 ± 1.146a	81.880 ± 46.690a
B ₂	21.932 ± 2.00b	1.800 ± 0.330ab	20.989 ± 2.201a	0.790 ± 0.036a	4.31 ± 0.113a	17.336 ± 2.426a	74.963 ± 12.564a
B ₃	33.676 ± 6.940c	2.426 ± 0.907b	32.571 ± 6.836b	0.806 ± 0.015a	4.340 ± 0.078a	27.249 ± 6.143b	118.370 ± 27.308a
B ₄	10.650 ± 2.451a	0.373 ± 0.372a	10.555 ± 2.410a	0.863 ± 0.065a	7.253 ± 4.769a	9.195 ± 2.088a	60.133 ± 23.229a

RESULTS AND DISCUSSION

Moisture and pH

The amount of moisture and pH of samples are shown in Table 1. According to Table 1, sample B₂ has the lowest pH and sample B₃ has the highest pH value. The low pH in sample B₂ is due to the use of sourdough to produce bread which is the production of acid by lactic acid bacteria in sourdough. The use of alkaline substance (sodium bicarbonate) increases pH in sample B₄. pH of bread samples depends on the amount of yeast added, fermentation time, and other additives [16]. The amount of moisture in samples B₃ was less than other samples and had significant difference with samples B₁ and B₂, but no difference was seen in sample B₄ (P ≤ 0.01).

Textural characteristics of bread samples

Bread texture is one of the main parameters of quality. Hardness of texture means the loss of soft texture which occurs for two reasons: (i) the low moisture content of the bread, or (ii) retrogradation of starch [17]. If the bread hardness is increased, it reflects the staling of bread [18]. Texture of bread samples' parameters are shown in Table 2. As shown in the table, there is no significant difference between samples B₁ and B₂, and also between B₁ and B₄ in term of

hardness (P ≤ 0.01).

But, hardness is more in B₃ bread samples as compared to other samples. The reason for this hardness is as a result of the use of sodium bicarbonate alone. Although, sodium bicarbonate can be used as a chemical leavening agent, but when used alone without yeast or leavening agent, it creates unfavorable conditions [4]. In samples B₁ and B₄ using bakery yeast, hardness is less. Bakery yeast (*Saccharomyces cerevisiae*) helps to produce enzymes, such as maltase, invertase, and zymase, but is not able to produce hydrolyze proteins. Produced sugar of these enzymes can help to conserve water in the bread crumb.

According to Martin and Hosney (1991), crosslinking between gluten and starch was formed during baking after swollen of starch and these links are stronger during maintenance of bread [19]. Bakery yeast produce CO₂ during fermentation which increases the specific volume of bread [20] and textural characteristics of bread, especially hardness that is partly related to the specific volume of bread and more bread volume, bread will be softer. Hardness in sample B₄ is less than B₁, but this difference was not significant (P ≤ 0.01).

In the samples of B₄, the amount of sodium bicarbonate (0.25% w/w based on the weight of the flour) is added and the pH reached 7.24 ± 0.40 . This pH does not have effect on the yeast growth and activity. However, the best pH for yeast activity is 5.5, but the yeast can adapt and activate in other pH even at pH= 3 to 8 [21].

Also, adding sodium bicarbonate increases the activity of alpha-amylase [22]. Amylase decreases the hardness in the bread due to the reduction of gelatinized power of starch and prevention of crosslinking between gluten and starch [19]. Also in samples B₂, it was due to the use of sourdough in their formulation and protolytic activity of lactic acid bacteria leading to decomposition of gluten, and affecting the gluten network and also affecting the characteristics of the final product. Flander et al. showed that a direct link between the uses of sourdough, increase the specific volume and reduce the bread harness [10]. Majzoobi et al. obtained the hardness of Barbari bread from flour particles and various factors as 2.51 to 5.90 N [23].

Adhesiveness is the required force to overcome the tension between the food ingredients with another material that is in contact with the food (like the mouth, tongue, or even a metal surface) [17]. Among the bread samples studied, samples B₃ had the highest amount and samples B₄ had the least amount of adhesiveness. Crumb of all the bread in the mouth easily become a ball and is needed to chew; this shape of the texture in the mouth is called cohesiveness. Cohesiveness of bread is controlled by moisture content of the bread and strength of gluten network around the air bubbles [17]. The studied bread samples were not significant in terms of cohesiveness ($P \leq 0.01$).

Majzoobi et al. obtained the cohesiveness of Barbari bread made from different flour particle size and different factors as 0.91 to 1.01 [23]. Springiness is the ability to recover its original shape after removal of required force to deform. Chewiness is the work needed to chew a solid food until it is ready to devour. Gumminess is the force required to break a semi-solid material ready to devour and is obtained by multiplying hardness and adhesiveness [24-26]. Bread samples were not significantly different

in terms of the amount of springiness, gumminess and chewiness ($P \leq 0.01$).

Staling of samples bread

The mean values of enthalpy, onset point (T_0) and peak top (T_p) of bread samples regardless of the time of maintenance is summarized in Table 3. According to the results, the enthalpy of samples B₁ and B₂ were significantly different, but no significant difference was observed in samples B₃ and B₄ ($P \leq 0.01$). Average enthalpy of samples B₃ was higher than other samples (447.38 ± 86.150 J/g) and sample B₄ was lower than the rest of the studied samples (237.57 ± 78.9 J/g). High enthalpy reflects more energy to melt the retrogradation crystals of starch [27]. So, B₃ samples showed more staling as compared to other.

According to the report of Al-Dmoor et al. (2009), by adding sodium bicarbonate, the maximum gelatinized starch is made up. Sodium bicarbonate cannot ideally produce CO₂ alone, but also should be used with bakery yeast or weak acid leavening agents [4]. In fact, the use of sodium bicarbonate with yeast increases amylase activity [22]. As a result, amylose is broken before cooking which is responsible for retrogradation of the starch and becomes too simple sugars which is consumed by yeast during fermentation; therefore, the mean values of enthalpy and therefore staling is reduced in these bread [28]. The mean values of T_0 in samples B₁ and B₂ had no statistically significant difference, but in samples B₁, B₂ and B₃, significant difference was observed. Also, in samples B₄, a significant difference was observed and in samples B₂ and B₄, there was no significant difference ($P \leq 0.01$).

Samples B₂ and B₄ showed significant difference in terms of mean values of T_p , but with samples B₁ and B₃, they are significant. The highest values of T_0 and T_p are seen in samples B₃ and B₁ is the least amount of samples. Table 4 shows the average enthalpy values, T_0 and T_p in three time (24, 48 and 72 h after baking), regardless of the type of treatment (fragmentation method). As shown in the table, the average enthalpy values are significantly different in the three times studied ($P \leq 0.01$), and increased over time,

Table 3. Enthalpy variations, Peak and onset point temperatures of bread samples regardless of the time of maintenance .

Bread samples	ΔH (j/g)	T_p (°C)	T_o (°C)
B ₁	266.994 ± 76.135b	113.353 ± 8.732a	69.458 ± 8.266a
B ₂	275.132 ± 78.939b	118.081 ± 2.419b	75.225 ± 5.086ab
B ₃	447.385 ± 86.150c	125.648 ± 3.822c	81.133 ± 4.25c
B ₄	237.574 ± 78.939a	117.851 ± 3.192b	76.405 ± 4.360b

ΔH : Recrystallization enthalpy showing retrogradation, T_p : peak temperature, T_o : onset point Temperature. B₁: Barbari bread with bakery yeast, B₂: Barbari bread with sour dough, B₃: Barbari bread with sodium bicarbonate and B₄: Barbari bread with combination of bakery yeast and sodium bicarbonate; *Values are the averages of Triplicates ± Standard deviations. Different letters in each column are indicative of significant statistical difference (P < 0.01) between the values.

Table 4. The average enthalpy values, T_p and T_o in three time (24, 48 and 72 h after baking), regardless of the type of treatment.

Storage time (h)	ΔH (j/g)	T_p (°C)	T_o (°C)
24	244.313 ± 82.359a	117.581 ± 5.705a	75.746 ± 4.480ab
48	273.636 ± 87.495b	114.817 ± 6.846a	70.858 ± 8.556a
72	402.365 ± 96.014c	123.802 ± 3.916b	80.061 ± 3.360b

which represent an increase of retrogradation and staling of bread. Salehifar et al. found similar results [14]. Some reactions occurred between gelatinized starch granules and gluten networking during storage of bread, leading to a reduction in kinetic energy and therefore the hardness of bread is increased. The mean values of T_o and T_p in 24 and 48 h after baking together showed no significant difference, but the mean difference values of T_o in 48 and 72 h after cooking was significant. Also, average value of T_p in 24 and 48 h after baking with its value at 72 h showed a significant difference (P ≤ 0.01).

Volatile compounds

Volatile compounds of bread samples are shown in Table 5. Generally, 34 volatile compounds were identified by gas chromatography-mass spectrometry (GC-MS), including alcohols, ethers, aldehydes, ketones, and carbonyl. Number of volatile compounds identified in samples B₄, B₃, B₂, and B₁ were 22, 20, 16 and, 23, respectively. One of the most important identified compounds is alcohols, such as ethanol and 3-methyl-butanol. These substances are observed in samples B₄, B₂, and B₁. Ethanol is one of the most important compounds caused by yeast (*S. cerevisiae*) fermentation and lactic acid bacteria.

The percent of this compound (RPA) in samples B₂ is greater than the other samples. The amount of ethanol is destroyed during cooking (Rehman et al., 2006). 3-Methyl-1-butanol is an iso-alcoholic that arises through Ehrlich pathway cycle in yeast cells [29]. The existence of this compound in samples B₂ is for this reason, 'that during sourdough fermentation, amino acids caused by proteolytic enzymes bacteria is produced' which are the precursor of iso-alcoholic [2].

Wu et al. obtained a high percentage of ethanol and 3-methyl-butanol in breads from sourdough [12]. Also, Birch et al. obtained high percentage of 3-methyl-butanol in a yeast breads. One of the most important compounds found in breads are aldehyde and ketone compounds [8]. Of the aldehyde compounds, 3-methyl-butanol and 2-methyl-butanol are seen more than other aldehydes in the bread. The percentage of these compounds is more in B₁ and then B₄ samples as compared to other samples.

3-Methyl-butanol like Iso-alcohol can occur through the Ehrlich pathway in yeast cells [29]. 2-Methyl-butanol is obtained as the Maillard reaction of amino acid isoleucine during cooking. Hexanal is found in all samples. The percentage of this compound is more in B₂ samples as compared

to other samples. This combination was seen in results of Wu et al. and Plessas [12,30]. Decanal is also aldehyde found in samples B₁.

Hexanal and decanal can also be produced by lipids oxidation found in flour by lipoxygenase enzyme [8]. Of the ketone compounds detected were 2, 3 butanedione or diacetyl (in samples B₁, B₂, and B₃), 2, 2- butanone (in all samples), 2, 3 pentanedione (in sample B₂) and 2-propanone (in samples B₂ and B₃).

The main source of ketones is the Maillard reaction. In addition, 2, 3 butanedione is produced by decarboxylation of hydroxy acids out of the yeast cells; yeast cells are responsible for producing such acids (Lilly et al., 2000). Ketone compound concentrations in samples B₁ are more than the rest of the samples. This compound was also observed in the results of Birch et al. and Plessae et al. [8,30].

The most important identified ester compounds are ethyl acetate. The composition is observed in samples B₁, B₂, and B₄. The percent of ethyl acetate in samples B₁ and B₄ produced by bakery yeast is more. Ethyl acetate occurs from the reaction of alcohols and acids. In walls of yeast alcohol, acetyltransferase enzyme activities are also produced in the fermentation time [31]. In sample B₂, lactic acid bacteria heterofermentative in sourdough produce ethyl acetate [2,32]. This compound has also been found in the results of Plessas et al.

Acetic acid is the detected compounds in samples of B₂, B₁ which is higher in B₂. Lactic acid bacteria in sourdough lead to an increase in the amount of acid in samples B₂. Acetic acid production improved dough quality during leavening. Lactic acid bacteria in sourdough produce lactic acid and the ration of lactic acid to acetic acid is highly effective in the final flavor bread [2]. Unfortunately, in this study, lactic acid was not identified with the use of GC-MS. According to Table 5, volatile compounds have also been identified in the breads.

In samples of B₂ and B₃, these compounds were higher. The existence of these compounds is

due to the Maillard reaction at high temperature during cooking [33]. In addition to the above compounds, aromatic hydrocarbons and aliphatic were also identified in the studied samples. Aliphatic hydrocarbons were detected in samples B₃. In results of Wu et al., some aliphatic hydrocarbons were observed [12].

Aromatic hydrocarbons were observed in samples B₁ and then B₄. The origin of these compounds can contain additives, such as benzoyl peroxide added to bleach flour [34]. Some of aromatic compounds have been observed in the results of Wu and et al [12]. Other identified compounds can be noted as toluene. This compound is produced by fuel in the oven during baking. This compound has been observed in all the four samples.

Limonene is a terpene compound which is observed in samples of B₁, B₃, and B₄. This compound is observed in some of the results of some researches [8,12]. In general, the number of volatile compounds to produce odour was seen in samples B₄ more than other samples. Most of the compounds were identified in samples B₁, B₄ which uses bakery yeast to produce the dough are ethanol, 3-methyl-butanol, ethyl acetate, 3-methyl-butanal and 2-methyl-butanal.

The percent of these compounds is used more in samples B₁ as compared to samples B₄ which uses high yeast to produce the dough. Most compounds identified in samples B₂ which uses sourdough in the production of dough are ethanol, hexanal, 2-methylfuran, and acetic acid. Since the formulation of B₃ samples yeast or sourdough have not been used, so many products that were obtained during fermentation in the sample were not found or observed with low rates.

Sensory characteristics

Sensory characteristics of bread (shape, up surface, down surface, color, texture, chewiness, odour, and flavor) were scored by panelist group. Results of these scores are shown in Table 6. Bread samples were not significantly different in terms of appearance ($P \leq 0.01$), but were significantly different in terms of other characteristics ($P \leq 0.01$). As shown in Table 6, B₁ samples are superior

Table 5. Headspace analysis of volatile compounds of bread samples.

RT (min)	Compound	Relative	peak area	%	
		B1	B2	B3	B4
Alcohols					
4.06	Ethanol(Ethyl alcohol)	10.55	8.881	nd	9.28
6.16	3-Methyl-1-butanol	11.61	8.148	nd	4.70
Aldehydes					
4.36	Isobutyraldehyde	2.22	nd	2.48	2.25
4.38	2-Methyl-propanal	3.17	2.25	nd	2.12
4.97	3-Methyl-1-butanal	7.03	3.28	2.39	6.60
5.06	2-Methyl-butanal	7.52	3.54	2.75	5.49
6.79	N-Hexanal	2.041	12.32	10.05	8.92
15.82	Decanal	2.23	nd	nd	n
Ketones					
4.15	2-Propanone	nd	2.33	6.97	nd
4.49	2,3-Butanedione(Diacetyl)	5.42	2.34	nd	2.17
4.55	2-Butanone	1.52	2.43	6.47	2.28
5.30	2,3-Pentanedione	nd	2.69	nd	nd
Esters					
4.67	Ethyl acetate(Acetic ether)	13.23	4.41	nd	9.12
Furans					
5.02	Furan-2-methyl	2.48	14.94	19.50	6.57
5.18	Furan-3-methyl	nd	4.01	nd	nd
5.51	Furan-2-ethyl	nd	2.64	4.71	1.73
11.17	Furan-2-pentyl	1.83	2.38	9.02	5.06
7.24	Furfura	0.92	nd	nd	2.02
Aliphatic hydrocarbons					
4.23	Pentane	nd	1.17	5.40	nd
5.62	Heptane	nd	nd	3.91	2.66
7.20	n-Octane	nd	3.86	3.64	1.41
16.16	Dodecane	nd	nd	4.75	1.52
19.8	Pentadecane	1.73	2.38	1.14	nd

Table 5. The Composition of the Essential Oils of *Anthemis coelopoda* var. *coelopoda*. (continue)

Aromatic hydrocarbons					
6.44	Benzen-methyl(Toluene)	4.50	4.85	8.06	4.95
8.04	Benzen-1,4-dimethyl	2.96	nd	nd	nd
8.41	Benzen-1,3-dimethyl	1.51	nd	nd	3.79
8.91	Benzen-1,2-dimethyl	2.22	nd	nd	1.12
10.50	Benzen-1-ethyl-2-methyl	nd	nd	nd	0.92
11.99	Benzen-1-methyl-3-(1-methyl ethyl)	6.38	nd	nd	nd
Organic acids					
4.37	Acetic acid	1.12	7.76	nd	1.92
Terpenes					
12.22	Limonene	2.62	nd	4.30	3.61
13.74	BETA-Thujene	5.56	nd	nd	nd

RT: Retention time ; nd; not detected; B₁; Barbari bread with bakery yeast, B₂; Barbari bread with sour dough, B₃; Barbari

Table 6. Score of sensory evaluation of breads.

Bread samples	Up surface	Down surface	Colour	Texture	Chewiness	Odour	Flavour	Total
B ₁	1	1	2	2	2	1	1	1
B ₂	3	2	3	3	3	2	3	3
B ₃	4	3	4	4	4	4	4	4
B ₄	2	1	1	1	1	3	2	2

B₁; Barbari bread with bakery yeast, B₂; Barbari bread with sour dough, B₃; Barbari bread with sodium bicarbonate and B₄; Barbari bread with combination of bakery yeast and sodium bicarbonate.

than other samples in term of up surface, odour, and flavor and B₃ sample is in fourth rating in term of surface, color, texture, chewiness, odour, and flavor (Table 6).

In samples B₄ and B₁ due to the use of bakery yeast, fermentation was done and material for producing flavor of fermentation and yeast activity took place. In the formulation of B₁ as compared to B₄ samples, more yeast is used (0.5% w/w based on the weight of the flour) and as shown in Table 5, the percentage of aldehyde and alcohol compounds in samples B₁ is more than B₄ samples. Samples B₄ in terms of down surface, color, texture, and chewiness were dominated to other samples (Table 6). Measuring hardness and chewiness samples using a texture

analyzer is less in B₄ samples as compared to other samples (Table 2), although this difference is not significant ($P \leq 0.01$).

CONCLUSION

Examining bread samples in terms of texture, staling process and sensory characteristics showed that bread containing bakery yeast are softer in term of texture and longer stale. Examining the volatile compounds in breads showed that although the number of detected volatile compounds in the samples produced with a combination of bakery yeast and sodium bicarbonate is more, but the percentage of alcohol and aldehyde compounds responsible for the odour and flavor is more in samples produced

by yeast (because of the use of more bakery yeast in the formulation). So, these samples were scored in high rank by panelist group in term of odour and flavour. The use of sourdough is the preferred method for the production of bread. But sourdough should be enriched with homofermentative and heterofermentative lactic acid bacteria to create a better flavor and texture.

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