Egypt. J. Food Sci. **Vol. 45,** pp. 29 - 41 (2017)

Characteristics of Pan Bread and Balady Bread Produced from Different *Saccharomyces Cerevisiae* Strains

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THIS STUDY aimed to compare three *Saccharomyces cerevisiae* strains (*S. cerevisiae* FC-620, *S. cerevisiae* FH-620 and *S. cerevisiae* FAT-12) with *S. cerevisae* F-707 (traditional strain) for application in production of some bakery products such as balady and pan bread. The physical measurements (weight, volume and specific volume) and texture profile analysis of pan bread, as well as freshness, color measurements and sensory evaluation of pan and balady bread produced by four strains were investigated. The balady and pan bread produced by *S. cerevisiae* FH-620 and *S. cerevisiae* FC-620 strains as a fermentative agents had the best properties of bread quality, meanwhile *S. cerevisiae* FAT-12 strain had the lowest properties as compared with the traditional strain.

Keywords: *Saccharomyces cerevisiae*, Ban bread, Balady bread.

Introduction

Baker's yeast is a mass of viable cells of *Saccharomyces cerevisiae* strain under aerobic conditions. *S. cerevisiae* grows with a rapid rate of reproduction (Eskarous, 1979). A dough is inoculated with baker's yeast and incubated at the required temperature and time. The CO_2 produced during the incubation period of the baking process defined as gassing power that is the primary leavening agent in bread products (Damtew, 2008 and Rezaei et al., 2014).

Baker's yeast is a type of yeasts used in bread making known as *S. cerevisiae*. Baker's yeast is one of the oldest products of industrial fermentation that was used traditionally. It is still one of the most important materials in industries based on its use for bread making, a stable food for large section of world's population. Baker's yeast is used widely in traditional bakeries to produce different kinds of baked goods (Damtew, 2008).

S. cerevisiae is extensively used due to its ability to raise dough by fermenting mainly maltose and sucrose present in the dough to ethanol and carbon dioxide. The fermentative capacity of the yeast is thus an extremely important parameter in baker's yeast production (Reed and Nagodawithana, 1991). Fermentation of sugars into carbon dioxide (CO_2), ethanol and secondary metabolites by baker's yeast during bread making leads to leavening of dough. However, the role of yeast in bread making is not limited to gas production. Yeast cells are also partly responsible for bread flavor and affect dough rheology (Rezaei et al., 2014).

The dough is inoculated with baker's yeast and incubated at the required temperature and time. The CO_2 produced during the incubation period of the baking process results in a raised dough with specific taste and smell (Damtew, 2008). In addition, Rezaei et al. (2014) reported that the baker's yeast (*S. cerevisiae*) is the primary leavening agent in bread products. Fermentation of sugars into carbon dioxide (CO_2), ethanol and secondary metabolites by baker's yeast during bread making leads to leavening of the dough. However, the role of yeast in bread making is not limited to gas production. Yeast cells are also partly responsible for bread flavor and affect dough rheology.

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Seleem and Mohamed (2014) used the traditional strain of baker's yeast to investigate the effect of adding some aromatic and medicinal plants as natural antioxidants and antimicrobial agents on pan bread characteristics such as physicochemical parameters, sensory evaluation and shelf life. In addition, Yaseen et al. (2007) used the traditional strain to evaluate the suitability of partially replacing wheat flour using triticale flour in Egyptian balady bread making and its effects on organoleptically and freshness of bread. The target of this study is comparing new strains of *S. cerevisiae* (FC-620, FH-620 and FAT-12) with *S. cerevisae* F-707 (a traditional strain) as a fermentative agent in the production of pan and balady bread.

Materials and Methods

Activation of yeast strains

Yeast strains (*S. cerevisiae* FC-620, *S. cerevisiae* FH-620 and *S. cerevisiae* FAT-12) were obtained from Microbial Chemistry Dept. collection, National Research Center, Dokki, Giza, Egypt. While, *S. cerevisae* F-707 (traditional strain) were obtained from baker's yeast factory. The yeast strains were transferred to a fresh YMP agar slants (3 g yeast extract, 3 g malte extract, 5 g peptone and 20 g agar per liter of distilled water) and incubated at 30°C for 24hr.

Cultivation of yeast strains

Fifty ml of YMPS broth medium (3 g yeast extract, 3 g malte extract, 5 g peptone and 20 g sucrose per liter of distilled water) were placed in 250 ml Erlenmeyer flasks, then autoclaved for 30 min at 121°C. The sterile medium in each flask was inoculated by a loopful of an active yeast culture slant, incubated for 24 hr at 30°C under shaking condition (150 rpm), then used as a stock inoculum (Soares et al., 2003). At the end of incubation period, the yeast cells were recovered from the growth medium by centrifugation at 4500 rpm for 5 min and used for pan bread and balady bread production.

Pan bread making

Pan bread was prepared according to Lazaridou et al. (2007) as follows: yeast (2%) was dissolved in 174 ml warm water (35°C) and then added to the dry ingredients (2% NaCl, 2% sugar and 300 g wheat flour 72 % extraction). The shortening (2%) was then added and the mixture was kneaded in the farinograph mixing bowl for 4 min at a low speed then for 2 min at high speed. The dough was fermented for 30 min at 30°C and 80-85% relative humidity in a fermentation cabinet. The dough was divided into 150g pieces, placed in the pan and proofed under the same conditions for 45 min. Bread dough were baked at 240 °C for 20–25 min following steaming for 10s. Baked pan bread was cooled down at room temperature for 60 min.

Balady bread making

According to Yaseen et al. (2007) balady bread was prepared by mixing wheat flour (82% extraction), baker's yeast (1%), sodium chloride (1.5%) and water for about 6 min to form the needed dough. The dough was left to ferment for 1 hr at 30ºC and 85% relative humidity, then divided into 150 g pieces. The pieces were arranged on a wooden board that had been sprinkled with a fine layer of bran and left to ferment for about 45 min at the same temperature and relative humidity. The pieces of fermented dough were flattened to about 20 cm in diameter. The flattened loaves were proofed at 30-35ºC and 85% relative humidity for 15 min and then were baked at 400-500ºC for 1-2 min. The loaves of bread were allowed to cool on racks for about 1 hr.

Physical measurements of pan bread

Weight, volume and specific volume of pan bread were determined using rapeseeds as described in AACC (2000).

Color measurements of bread (pan and balady)

The color of bread samples was measured using a spectrocolorimeter with the CIE color scale (Hunter, Lab scan XE). This instrument was standardized against the white tile of Hunter Lab color standard (LX No.16379): X= 77.26, Y= 81.94 and Z= 88.14. The L*, a* and b* values were reported. The Hue angle (H*) and Chroma (C*) were calculated (Mohammad, 2010).

Freshness of bread (pan and balady)

Freshness of each packed samples were tested at room temperature during storage for 24 and 48 hr by alkaline water retention capacity (AWRC) according to the method of Yamazaki (1953), as modified by Kitterman and Rubenthaler (1971) as follows:

Five grams of bread sample (placed into dry plastic centrifuge tube of 50 ml capacity) and 25 ml $NaHCO_3$ solution (8.4 g sodium bicarbonate dissolved in 1 L of distilled water) were added. The tube was stoppered and shacked until all samples were wet, then the mixture was left for 20 min with shaking every 5 min. The contents were then centrifuged at 2500 rpm for 15 min. The supernatant was decanted and the precipitate left for 10 min. at 45 angles (to get rid of free water). The gain in weight is expressed in percent. Loss of freshness (%) was calculated using the following equation :

$$\text{Loss of freshness} = \frac{\text{AWRC (zero time) - AWRC (n time)}}{\text{AWRC (zero time)}} \text{X} 100$$

Where n= time of storage

Sensory evaluation of pan bread

Sensory evaluation of toast bread was performed by 10 trained panelists as described by Kulp et al. (1985) for symmetry of shape (5), crust color (10), break & shred (10), crumb texture (15), crumb color (10), aroma (20), taste (20) and mouth feel (10).

Sensory evaluation balady bread

Balady bread loaves were evaluated organoleptically by 10 trained panelists according to El-Farra et al. (1982). The tested characteristics were general appearance (20), separation of layers (20), roundness (15), distribution of crumb (15), crust color (10), taste (10) and odor (10).

Texture profile analysis (TPA) of pan bread crumb

Texture parameters such as hardness, adhesiveness, springiness, cohesiveness, resilience, gumminess and chewiness of bread samples were measured objectively by using a texture analyzer TA-CT3 (Brookfield, U.S.A.) as adopted by the standard method of AACC, method 74-09 (AACC, 2000). The probe was calibrated according to the instruction before conducting the test. A cube of sample (2cm × 2cm × 2cm) was cut from the middle of sample (bread) and was placed centrally beneath the probe [(p/36 cylinder probe (36mm)] in order to meet with a consistent flat surface. The compression test was selected in texture analysis using a 10 kg load cell and sample was compressed to 45% of its original height. The strain required for 45% compression was recorded using the following conditions: test speed: 1.0 mm/s, post test speed: 5 m/s, compression distance: 8mm and trigger type: auto 20 g. Data was analyzed using Texture expert Version 1.05 (Stable Micro system Ltd) software. The practical definitions of standard TPA terms are illustrated in Fig. 1 as follows.

1- The hardness value is the peak force of the first compression cycle of the product.
2- Cohesiveness is how well the product withstands a second deformation relative to how it behaved under the first deformation. It is measured as the area of work during the second compression divided by the area of work during the first compression. (Refer to Area 2/Area 1 in the below graph).
3- Springiness is how well a product physically springs back after it has been deformed during the first compression. Springiness is measured by the distance of the detected height of the product on the second compression (Length 2 on the below graph), as divided by the original compression distance (Length 1). The original definition of springiness used the Length 2 only, and the units were in mm or other units of distance.
4- Gumminess only applies to semi-solid products and is Hardness × Cohesiveness (which is Area2/Area1).
5- Chewiness only applies for solid products and is calculated as Gumminess × Springiness.
6- Resilience is how well a product "fights to regain its original position". The calculation is the area during the withdrawal of the first compression, divided by the area of the first compression. (Area 5/Area4 on the below graph).
7- Adhesiveness is defined as the negative force area for the first bite representing the work required to pull the plunger away from the food sample.

Statistical analysis

Results were subjected to one-way analysis of variance (ANOVA) of the general liner model (GLM) using SAS (1999) statistical package. The results were the average of three experiments ($p \leq 0.05$).

Results and Discussion

Characteristics of pan bread produced by different S. cerevisiae strains

Baker's yeast produced by different *S. cerevisiae* strains (FC-620, FH-620 and FAT-12) was used as fermentative agents for pan bread production and compared with pan bread produced by the traditional strain (*S. cerevisae* F-707). The sensory characteristics, physical measurements (pan bread weight, volume and specific volume), freshness, texture properties of bread crumb and color of pan bread produced by different *S. cerevisiae* strains were investigated and compared with the other studies.

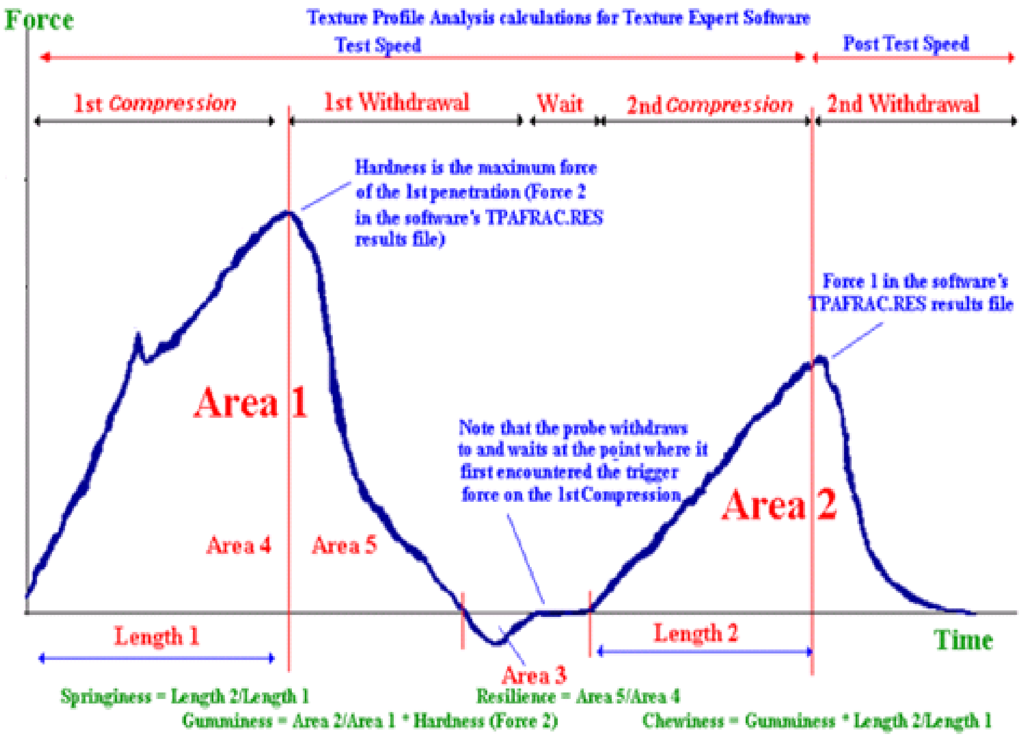

Fig. 1. Calculations of texture profile analysis.

Physical measurements of pan bread

Pan bread weight, volume and specific volume of the pan bread produced by different *S. cerevisiae* strains are shown in Table 1. The results indicated that the weight of pan bread produced by different *S. cerevisiae* strains ranged from 131 to 137 g with no significant differences between weights of pan bread produced by all strains.

Regarding the volume and specific volume of the pan bread produced by different *S. cerevisiae* strains, data in the same table (Table 1) indicate that volume and specific volume of pan bread ranged from 404 to 454 cm^3 and from 3.07 to 3.33 cm^3/g, consecutively. The highest values in these respects were recorded for pan bread of *S. cerevisiae* FH-620 and *S. cerevisiae* FC-620 with significant differences between them and those produced by traditional strain. Meanwhile, no significant differences were observed between traditional strain and *S. cerevisiae* FAT-12. One of the most important characteristics for consumer acceptability is the specific volume. A high ratio of volume per weight is desired by the consumers (Hager et al., 2012).

TABLE 1. Physical characteristics of pan bread produced by different *S. cerevisiae* strains.

Yeast strains	Weight (g)	Volume (Cm^3)	Specific volume (Cm^3/g)
***S. cerevisiae* FC-620**	$134^a \pm 2.0$	$433^b \pm 3.0$	$3.24^a \pm 0.03$
***S. cerevisiae* FH-620**	$137^a \pm 1.5$	$454^a \pm 1.5$	$3.33^a \pm 0.05$
***S. cerevisiae* FAT-12**	$131^a \pm 1.5$	$404^c \pm 1.5$	$3.07^b \pm 0.02$
Traditional strain	$132^a \pm 1.0$	$411^c \pm 4.5$	$3.11^b \pm 0.01$
LSD	6.1	11.4	0.11

Means followed by different subscripts within column are significantly different at the 5% level.

The difference in volume as well as specific volume of pan bread samples produced by different yeast strains could be referred to the variation in the production and the ability to retain carbon dioxide formed during the fermentation period. Meanwhile, the difference of weight may be attributed to the variation in moisture loss during the baking process (Mohammad, 2010). These results are in accordance with those obtained by Seleem and Mohamed (2014), who reported that the specific volume of control pan bread was 3.25. Also Ibrahim (2011) stated that the specific volume of control pan bread was 3.01.

Freshness of pan bread

Deterioration in bread quality by increasing storage time after baking as measured by consumer acceptance has been defined as bread staling (Martin et al., 1991). Alkaline water retention capacity (AWRC) is a simple and quick test to follow staling of bread. Higher values of AWRC mean higher freshness of the bread. The change in freshness characteristics of pan bread produced by different *S. cerevisiae* strains stored at room temperature for 0, 24 and 48 hr are shown in Table 2.

TABLE 2. Alkaline water retention capacity as indicator for freshness properties of pan bread produced by different *S. cerevisiae* strains.

Yeast strains	Storage period (h.)				
	Freshness (%)			Loss of freshness (%)	
	0	24	48	24	48
***S. cerevisiae* FC-620**	359.0 ^{a} ± 3.0	322.8 ^{ab} ± 3.4	298.8 ^{ab} ± 3.4	10.09 ^{b} ± 0.20	16.77 ^{b} ± 0.25
***S. cerevisiae* FH-620**	362.0 ^{a} ± 2.0	326.6 ^{a} ± 2.2	304.4 ^{a} ± 2.2	9.78 ^{b} ± 0.11	15.92 ^{c} ± 0.15
***S. cerevisiae* FAT-12**	355.0 ^{a} ± 1.0	316.3 ^{b} ± 0.7	291.7 ^{b} ± 1.3	10.91 ^{a} ± 0.06	17.84 ^{a} ± 0.14
Traditional strain	356.0 ^{a} ± 2.0	319.5 ^{ab} ± 2.5	295.5 ^{ab} ± 2.5	10.25 ^{b} ± 0.19	17.00 ^{b} ± 0.24
LSD	8.3	9.4	9.7	0.59	0.78

Means followed by different subscripts within column are significantly different at the 5% level.

Results indicate that the pan bread produced by *S. cerevisiae* FH-620 strain had the highest values of freshness compared to the other three strains with no significant differences between them and traditional strain. Meanwhile, the significant differences were observed between pan bread freshness of *S. cerevisiae* FH-620 and *S. cerevisiae* FAT-12 during storage of pan bread for 24 and 48 hr. In addition, the results showed that the staling rate was increased by increasing the storage period. The highest freshness state was recorded for *S. cerevisiae* FH-620 as the loss of freshness after 48 h. was 15.92 % compared with 16.77, 17.00 and 17.84 % for *S. cerevisiae* FC-620, traditional strain and *S. cerevisiae* FAT-12, respectively with significant differences between the obtained values. These results agree with those of Erazo-Castrejon et al. (2001), who found that the bread firmness was increased by increasing the storage period.

Color properties of pan bread

Crust and crumb color of pan bread were evaluated using a Hunterlab spectrocoloremeter. The (L*) scale ranges from 0 black to 100 white; the (a*) scale extends from a negative value (green hue) to a positive value (red hue); and the (b*) scale ranges from negative blue to positive yellow. The L*, a*, and b* values for crust and crumb of all prepared pan bread samples are summarized in Table 3. The results indicate that the L*, a*, and b* values for crust of pan bread produced by different *S. cerevisiae* strains ranged from 56.83 to 60.10, from 14.23 to 16.14 and from 34.52 to 36.15, respectively. Meanwhile, the L*, a*, and b* values for crumb of pan bread produced by different *S. cerevisiae* strains ranged from 72.13 to 73.51, from 1.61 to 1.98 and from 21.48 to 21.84, consecutively, These results agree with those of Mohammad (2010).

The L* value of crust was lower for pan bread produced by *S. cerevisiae* FAT-12 with significant differences between them and the other strains. So, the pan bread of *S. cerevisiae* FAT-12 was darker in color as the L* value was 56.83 compared to the other values. No significant differences in a*, b* and chroma values of crust were found among the different pan bread samples of different *S. cerevisiae* strains. Meanwhile, the hue angle of pan bread crusts showed a significant difference between *S. cerevisiae* FAT-12 strain and *S. cerevisiae* FH-620 strain, where the hue angles were 67.89 and 65.03, respectively.

With regard to the pan bread crumbs, no significant differences in color parameters were found for pan bread samples produced by different *S. cerevisiae* strains except a* value and hue angle, where the highest value of a* was recorded for pan bread produced by *S. cerevisiae* FC-620 strain with significant difference between them and *S. cerevisiae* FH-620 strain and *S. cerevisiae* FAT-12 strain. Meanwhile, no significant difference in a* value was found between *S. cerevisiae* FC-620 strain and traditional strain.

Concerning the hue angle of pan bread crumbs, data in the same table (Table 3) show that the highest value being 85.76 was recorded for pan bread produced by *S. cerevisiae* FAT-12 strain with no significant difference between them and pan bread produced by *S. cerevisiae* FH-620 strain. Meanwhile, significant difference was observed in hue angle between pan bread crumbs of *S. cerevisiae* FAT-12 strain and the other strains.

TABLE 3. Crust and crumb color of pan bread produced by different *S. cerevisiae* strains.

Color parameters		Yeast strain				LSD
		S. cerevisiae FC-620	*S. cerevisiae* FH-620	*S. cerevisiae* FAT-12	Traditional strain	
Crust	L* value	59.38 ^{a} ± 0.21	60.10 ^{a} ± 0.32	56.83 ^{b} ± 0.05	59.65 ^{a} ± 0.18	0.84
	a* value	14.23 ^{a} ± 0.05	16.14 ^{a} ± 0.08	14.69 ^{a} ± 0.70	15.08 ^{a} ± 0.75	2.00
	b* value	34.52 ^{a} ± 0.42	34.65 ^{a} ± 0.29	36.15 ^{a} ± 0.82	35.16 ^{a} ± 1.19	3.00
	Hue angle (H*)	67.60 ^{ab} ± 0.21	65.03 ^{b} ± 0.06	67.89 ^{a} ± 1.38	66.79 ^{ab} ± 0.31	2.80
	Chroma (C*)	37.34 ^{a} ± 0.41	38.23 ^{a} ± 0.30	39.02 ^{a} ± 0.50	38.26 ^{a} ± 1.38	3.04
Crumb	L* value	72.33 ^{a} ± 0.36	72.41 ^{a} ± 0.15	73.51 ^{a} ± 0.17	72.13 ^{a} ± 0.59	1.42
	a* value	1.98 ^{a} ± 0.08	1.79 ^{ab} ± 0.03	1.65 ^{b} ± 0.02	1.61 ^{b} ± 0.07	0.21
	b* value	21.84 ^{a} ± 0.15	21.58 ^{a} ± 0.15	21.48 ^{a} ± 0.07	21.70 ^{a} ± 0.06	0.46
	Hue angle (H*)	84.82 ^{c} ± 0.16	85.26 ^{bc} ± 0.03	85.61 ^{ab} ± 0.04	85.76 ^{a} ± 0.17	0.47
	Chroma (C*)	21.93 ^{a} ± 0.16	21.65 ^{a} ± 0.15	21.54 ^{a} ± 0.07	21.76 ^{a} ± 0.07	0.48

Means followed by different subscripts within row are significantly different at the 5% level.

Sensory properties of pan bread

Sensory characteristics of pan bread (Fig. 2) *i.e.,* symmetry of shape, crust color, break and shred, crumb texture, crumb color, aroma, taste and mouth feel were evaluated as presented in Table 4. It could be observed from the results, that the pan bread produced by *S. cerevisiae* FH-620 strain has recorded higher overall acceptability than the other strains except crumb color, where the highest value in this respect was recorded for pan bread produced by *S. cerevisiae* FC-620 strain. Significant differences were noted between pan bread of *S. cerevisiae* FH-620 strain and traditional strain for all sensory characteristics except crust color, break and shred, crumb color and aroma.

On the other hand, the pan bread produced by *S. cerevisiae* FAT-12 strain had the lower overall acceptability with no significant differences between them and other strains for all sensory characteristics. These results are closely in agreement with those obtained by Mohammad (2010), who reported that the sensory characteristics of pan bread (control) were 4.6, 9.1, 8.6, 13.8, 9.2, 18.4, 19.3 and 9.1 for symmetry of shape, crust color, break and shred, crumb texture, crumb color, aroma, taste and mouth feel, respectively.

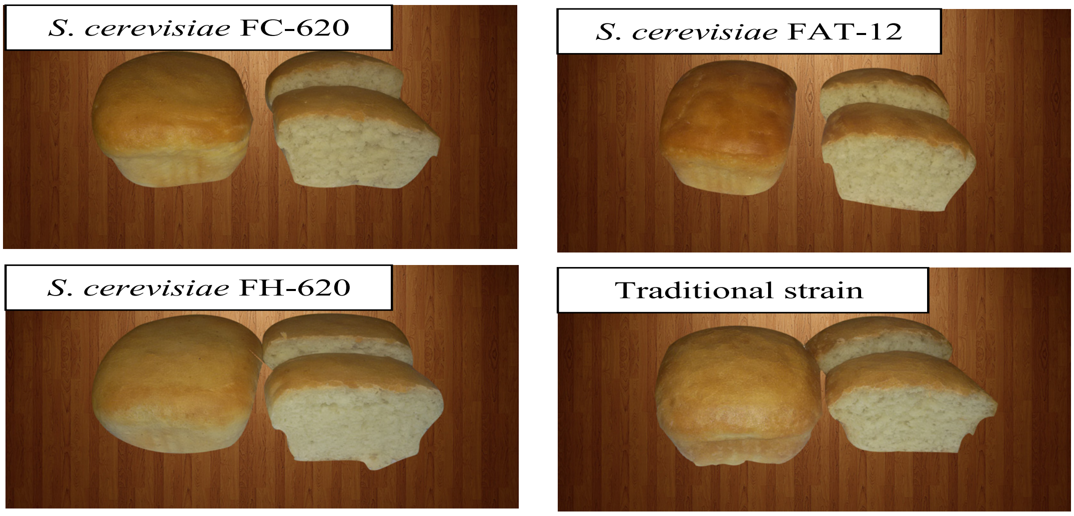

Fig. 2. Photographs of pan bread of different *S. cerevisiae* strains.

TABLE 4. Sensory evaluation of pan bread produced by different *S. cerevisiae* strains.

Yeast strain	Symmetry of Shape (5)	Crust color (10)	Break & shred (10)	Crumb texture (15)	Crumb color (10)	Aroma (20)	Taste (20)	Mouth feel (10)
***S. cerevisiae* FC-620**	4.50^{ab} ± 0.22	8.90^{a} ± 0.23	8.50^{a} ± 0.27	14.10^{a} ± 0.23	9.40^{a} ± 0.16	18.50^{a} ± 0.37	18.30^{ab} ± 0.26	8.80^{ab} ± 0.20
***S. cerevisiae* FH-620**	4.90^{a} ± 0.10	9.40^{a} ± 0.22	8.70^{a} ± 0.26	14.10^{a} ± 0.23	9.30^{ab} ± 0.26	18.70^{a} ± 0.30	18.80^{a} ± 0.36	9.20^{a} ± 0.20
***S. cerevisiae* FAT-12**	4.10^{b} ± 0.28	8.70^{a} ± 0.21	8.00^{a} ± 0.33	12.80^{b} ± 0.20	8.50^{c} ± 0.27	17.60^{a} ± 0.40	17.80^{b} ± 0.29	8.40^{b} ± 0.22
Traditional strain	4.20^{b} ± 0.20	8.90^{a} ± 0.31	8.70^{a} ± 0.37	13.00^{b} ± 0.30	8.60^{bc} ± 0.31	17.60^{a} ± 0.50	17.80^{b} ± 0.20	8.40^{b} ± 0.31
LSD	**0.60**	**0.71**	**0.89**	**0.70**	**0.73**	**1.15**	**0.81**	**0.68**

Means followed by different subscripts within column are significantly different at the 5% level.

Texture profile analysis of pan bread

Texture profile analysis (hardness, cohesiveness, adhesiveness, springiness, gumminess, chewiness and resilience) of pan breads produced by different *S. cerevisiae* strains are shown in Table 5. From the results, it could be observed that the pan bread produced by *S. cerevisiae* FH-620 strain had the lowest value of hardness (516g) followed by *S. cerevisiae* FC-620 strain (586g), then traditional strain (736g). Meanwhile, the pan bread produced by *S. cerevisiae* FAT-12 strain had the highest value of hardness being 810 g. Low values for crumb hardness are desired, since consumers relate high hardness values to a stale bread product (Heitmann et al., 2015).

The variation in hardness may be referred to variation in starch content of pan breads produced by different *S. cerevisiae* strains as reported by Heitmann et al. (2015). They reported that the starch content of the produced breads by lager yeast s-23, ale yeast T-58, ale yeast us-05 and wheat beer yeast WB 06 were 60.9, 65.3, 60.2 and 64.9%, respectively. The variation in starch content may be referred to the variation in enzyme activities of different *S. cerevisiae* strains which degrade starch into more fermentable sugars (Heitmann et al., 2015). Also, the decrease in the crumb hardness can be explained by the increase in the bread volume (Table 1). These results are consistent with those obtained by Wanga et al. (2002) and Yamsaengsung et al. (2010), who stated that the increased bread volume is directly related to the decreased hardness values.

The results in the same Table (Table 5) reveal also that chewiness and gumminess values were increased by increasing the hardness of pan breads. Therefore, the chewiness and gumminess values had a similar trend of hardness. These results agree with those obtained by Ibrahim (2011) who reported that both gumminess and chewiness are parameters dependant on hardness.

Chewiness and adhesiveness are two texture parameters easily correlated with sensory analyses through trained panels (Esteller et al., 2004). In this respect, the results indicate that the pan bread produced by *S. cerevisiae* FH-620 strain had the lowest values of chewiness (3885 gmm) and adhesiveness (0.10 mJ). In the same time, they rated higher sensory characteristics as previously mentioned (Table 4). These results agree with those obtained by Boz and Karaoglu (2013), who reported that the chewiness values of bread crumb had a negative correlation with sensory properties.

TABLE 5. Texture profile analysis of pan bread produced by different *S. cerevisiae* strains.

Texture analysis	*S. cerevisiae* FC-620	*S. cerevisiae* FH-620	*S. cerevisiae* FAT-12	Traditional strain
Hardness (g)	586	516	810	736
Hardness work cycle 1 (mJ)	21.80	20.80	39.30	28.80
Recoverable work cycle 1 (mJ)	11.80	11.9	20.2	15.0
Hardness work cycle 2 (mJ)	20.70	20.50	34.50	27.10
Recoverable work cycle 2 (mJ)	9.10	11.0	22.4	15.4
Cohesiveness	0.950	0.986	0.878	0.941
Adhesiveness (mJ)	0.30	0.10	0.40	0.30
Springiness (mm)	7.62	7.64	7.51	7.56
Springiness Index	0.95	0.96	0.94	0.95
Gumminess (g)	556.4	508.6	711.1	692.6
Chewiness (gmm)	4240	3885	5340	5236
Resilience	0.54	0.57	0.51	0.52

The internal resistance of bread crumb is evaluated by cohesiveness which is a characteristic of mastication. Cohesiveness is defined as how well the product withstands a second deformation relative to how it behaved under the first deformation (Wang et al., 2006 and Boz & Karaoglu, 2013). Also Ibrahim (2011) reported that the cohesiveness quantifies the internal resistance of food structure. In general, high cohesiveness is desirable in bread because bread can form a bolus, rather than disintegrate, during mastication (Onyango et al., 2010). The highest value in this respect was recorded for pan bread produced by *S. cerevisiae* FH-620 strain being 0.986, followed by *S. cerevisiae* FC-620 strain (0.950), then traditional strain (0.941). Meanwhile, the pan bread produced by *S. cerevisiae* FAT-12 strain had the minimum value of cohesiveness being 0.878.

With regard to springiness and resilience of pan bread produced by different *S. cerevisiae* strains, the results in the same table (Table 5) indicate that pan bread produced by *S. cerevisiae* FH-620 strain had the highest values of springiness (7.64 mm) and resilience (0.57). Meanwhile, pan bread produced by *S. cerevisiae* FAT-12 had the lowest values of springiness (7.51 mm) and resilience (0.51). The results reveal also that the cohesiveness, springiness and resilience showed similar trends. Both, springiness and resilience, give information about the recovery capacity after stress. A subjective evaluation of springiness is normally made by consumers and consists of slightly pressing the piece of food, by hand or with the mouth, and verifying how easily it returns to the original size (Ibrahim, 2011). In addition, Kadan et al. (2001) reported that resilience is the ability of a material to return to its original shape after a stress.

Production of balady bread by different S. cerevisiae strains

Freshness of balady bread

The freshness of balady bread produced by different *S. cerevisiae* strains was evaluated by alkaline water retention capacity (AWRC) method as presented in Table 6. Data showed that the balady bread produced by *S. cerevisiae* FH-620 strain had the highest values of freshness compared to the other three strains with no significant differences between them at all studied storage time.

TABLE 6. Alkaline water retention capacity as indicator for freshness properties of balady bread produced by different *S. cerevisiae* strains.

Yeast strains	Storage period (hr)				
	Freshness (%)			Loss of freshness (%)	
	0	24	48	24	48
***S. cerevisiae* FC-620**	306.7 [a] ± 2.7	274.4 [a] ± 2.8	253.0 [a] ± 2.2	10.54 [bc] ± 0.13	17.51 [b] ± 0.01
***S. cerevisiae* FH-620**	309.2 [a] ± 1.6	277.4 [a] ± 1.8	255.8 [a] ± 1.4	10.29 [c] ± 0.12	17.28 [b] ± 0.03
***S. cerevisiae* FAT-12**	302.3 [a] ± 1.3	268.9 [a] ± 1.1	248.0 [a] ± 1.6	11.05 [a] ± 0.02	17.97 [a] ± 0.18
Traditional strain	303.8 [a] ± 3.4	271.1 [a] ± 3.1	249.4 [a] ± 3.0	10.77 [ab] ± 0.03	17.91 [a] ± 0.07
LSD	9.4	9.2	8.4	0.34	0.38

Means followed by different subscripts within column are significantly different at the 5% level.

The highest antistaling effect was recorded for balady bread produced by *S. cerevisiae* FH-620 as the loss of freshness after 24 and 48 hr. were 10.29 and 17.28%, respectively. Considerable differences in loss of freshness were found between *S. cerevisiae* FH-620 and the other strains except *S. cerevisiae* FC-620. These results agree with those obtained by Mohammad (2010) who reported that the freshness of control balady bread was 302.2 and 297.6% at zero and 24 hr. of storage, respectively. In addition, Yaseen et al. (2007) noticed that the freshness loss of control balady bread was 17.65 % during storage for 48 hr.

Color properties of balady bread

Results in Table 7 indicate that the L*, a*, b*, hue angle (H*) and chroma (C*) values for crust of balady bread produced by different *S. cerevisiae* strains ranged from 56.68 to 58.92, from 6.04 to 7.31, from 24.69 to 25.49, from 74.01 to 76.42 and from 25.61 to 26.52, in succession. Meanwhile, the L*, a*, b*, hue angle and chroma values for crumb of balady bread produced by different *S. cerevisiae* strains ranged from 56.50 to 57.81, from 5.03 to 5.60, from 22.00 to 22.71, from 75.72 to 77.31 and from 22.70 to 23.29, respectively.

Regarding crust color of balady bread, the L* value was lower for balady bread produced by *S. cerevisiae* FAT-12 with significant difference between them and those produced by the other three strains. No significant differences in a*, b*, hue angle and chroma values were found between balady bread of traditional strain and balady breads of the other *S. cerevisiae* strains.

Concerning crumb color of balady bread, no significant differences in color parameters were found between balady bread of traditional strain and balady breads of different *S. cerevisiae* strains except a* values and hue angle. The highest value of a* was recorded for balady bread produced by *S. cerevisiae* FC-620, while the lowest value was recorded for balady bread of traditional strain with significant difference between them. So, the lowest value of hue angle was recorded for balady bread produced by *S. cerevisiae* FC-620 with significant difference between them and the other three strains.

The color of bread (pan or balady bread) is formed by the Maillard reaction and caramelisation. This complex series of reactions between reducing sugars and amino acids is responsible for color. A difference in L* values and hue angle (Tables 3 and 7) was expected due to the Maillard reactions and caramelisation process, which are influenced by water, reducing sugars, amino acids and fermenting power of the used yeast (Gallagher et al., 2003). The establishing of Maillard products is influenced by the amount of reducing sugars and free amino acids in the dough which will form pigments by performing the reaction. A darker color may refer to the ability of the yeast to produce protease, thus releasing amino acids (Ormrod et al., 1991), and the amount of reducing sugars, which are not fermented (Goesaert et al., 2005).

TABLE 7. Crust and crumb color of balady bread produced by different *S. cerevisiae* strains.

Color parameters		Yeast strain				LSD
		S. cerevisiae FC-620	*S. cerevisiae* FH-620	*S. cerevisiae* FAT-12	Traditional strain	
Crust	**L* value**	$58.92^{a} \pm 0.16$	$58.13^{a} \pm 0.43$	$56.68^{b} \pm 0.32$	$57.89^{a} \pm 0.17$	1.14
	a* value	$7.31^{a} \pm 0.35$	$6.60^{ab} \pm 0.10$	$6.04^{b} \pm 0.13$	$6.80^{ab} \pm 0.17$	0.82
	b* value	$25.49^{a} \pm 0.29$	$25.46^{a} \pm 0.19$	$25.02^{a} \pm 0.37$	$24.69^{a} \pm 0.21$	1.07
	Hue angle (H*)	$74.01^{b} \pm 0.90$	$75.48^{ab} \pm 0.11$	$76.42^{a} \pm 0.09$	$74.60^{ab} \pm 0.49$	2.02
	Chroma (C*)	$26.52^{a} \pm 0.18$	$26.30^{a} \pm 0.21$	$25.74^{a} \pm 0.39$	$25.61^{a} \pm 0.16$	0.98
Crumb	**L* value**	$56.96^{ab} \pm 0.21$	$57.81^{a} \pm 0.39$	$56.50^{b} \pm 0.28$	$56.86^{ab} \pm 0.24$	1.12
	a* value	$5.60^{a} \pm 0.16$	$5.15^{ab} \pm 0.13$	$5.23^{ab} \pm 0.10$	$5.03^{b} \pm 0.10$	0.48
	b* value	$22.00^{b} \pm 0.14$	$22.71^{a} \pm 0.14$	$22.56^{ab} \pm 0.13$	$22.32^{ab} \pm 0.27$	0.69
	Hue angle (H*)	$75.72^{b} \pm 0.32$	$77.22^{a} \pm 0.24$	$76.94^{a} \pm 0.29$	$77.31^{a} \pm 0.37$	1.20
	Chroma (C*)	$22.70^{a} \pm 0.17$	$23.29^{a} \pm 0.16$	$23.16^{a} \pm 0.10$	$22.88^{a} \pm 0.24$	0.69

Means followed by different subscripts within row are significantly different at the 5% level.

Sensory properties of balady bread

Sensory evaluation of balady bread (Fig. 3) *i.e.*, general appearance, separation of layers, roundness, crumb distribution, crust color, taste and odor are summarized in Table 8. Results showed that, the balady bread produced by *S. cerevisiae* FH-620 strain was rated higher overall acceptability than the other strains. Significant differences were noted between balady bread of *S. cerevisiae* FH-620 strain and traditional strain for all sensory characteristics except roundness, taste and odor.

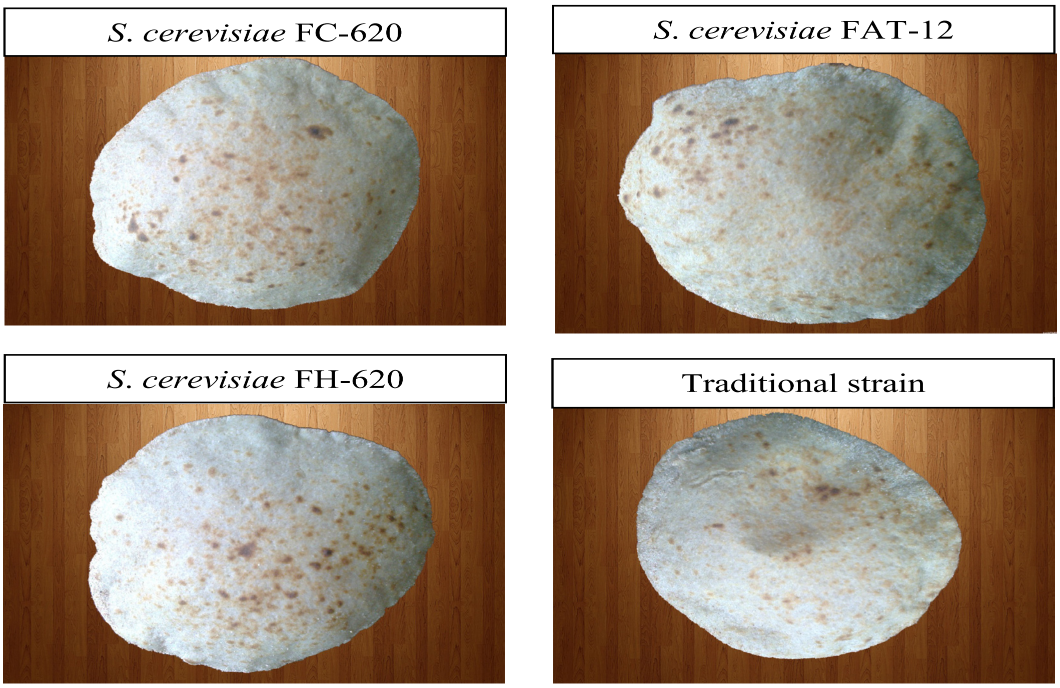

Fig. 3. Photographs of balady bread of different S. cerevisiae strains.

On the other hand, no significant differences were found between the balady breads of *S. cerevisiae* FC-620, traditional strain and *S. cerevisiae* FAT-12 strain. These results are in accordance with those obtained by Mohammad (2010), who reported that the sensory evaluation of control balady bread was 17.71, 17.66, 14.45, 12.80, 8.79, 8.41 and 8.58 for general appearance, separation of layers, roundness, crumb distribution, crust color, taste and odor, consecutively. Meanwhile, these results are somewhat higher than those obtained by Yaseen et al. (2007) who stated that the sensory characteristics of balady bread (control) were 12.85, 17.75, 11.60, 11.45, 6.70, 7.60 and 8.20 for general appearance, separation of layers, roundness, crumb distribution, crust color, taste and odor, respectively.

TABLE 8. Sensory evaluation of balady bread produced by different *S. cerevisiae* strains.

Sample	General appearance (20)	Separation of layers (20)	Roundness (15)	Distribution of crumb (15)	Crust color (10)	Taste (10)	Odor (10)
***S. cerevisiae* FC-620**	18.10 [b] ± 0.18	18.20 [ab] ± 0.25	13.50 [b] ± 0.17	13.00 [b] ± 0.30	8.10 [ab] ± 0.31	8.10 [a] ± 0.28	8.50 [a] ± 0.27
***S. cerevisiae* FH-620**	18.90 [a] ± 0.18	18.80 [a] ± 0.20	14.10 [a] ± 0.18	13.90 [a] ± 0.28	8.80 [a] ± 0.25	8.75 [a] ± 0.23	9.00 [a] ± 0.26
***S. cerevisiae* FAT-12**	17.90 [b] ± 0.31	17.50 [b] ± 0.31	13.60 [ab] ± 0.27	13.00 [b] ± 0.26	8.10 [ab] ± 0.38	8.25 [a] ± 0.23	8.30 [a] ± 0.33
Traditional strain	17.80 [b] ± 0.25	18.00 [b] ± 0.21	13.60 [ab] ± 0.16	12.90 [b] ± 0.28	7.85 [b] ± 0.28	8.25 [a] ± 0.31	8.30 [a] ± 0.33
LSD	0.68	0.70	0.57	0.80	0.89	0.75	0.86

Means followed by different subscripts within column are significantly different at the 5% level.

Conclusion

The target of this study was to compare between new yeast strains and the traditional strain in the production of balady and pan bread with evaluation of the produced breads by determination of sensory properties, physical measurements, freshness, color and texture profile analysis. The results indicated that the characteristics of pan and balady breads produced by *S. cerevisiae* FH-620 and *S. cerevisiae* FC-620 were better than pan and balady breads produced by the traditional strain. Meanwhile, the characteristics of pan and balady breads produced by *S. cerevisiae* FAT-12 were little than pan and balady breads produced by traditional strain.

Acknowledgment

This work was financially supported by the National Research Center, Dokki, Cairo, Egypt. The authors would like to thank Dr. Essam Abdel-Fattah Saleh and Dr. Mohamed Ramadan El-Gohary for their kind help and support.

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(*Received:*12/4/2017;

*accepted:*22/8/2017)

خصائص خبز القوالب والخبز البلدى المنتج من سلالات السكاروميسس سرفيسيا المختلفة

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تهدف هذه الدراسة الى المقارنة بين ثلاث سلالات من السكاروميسس سرفيسيا (سكاروميسس سرفيسيا FC-٦٢٠، سكاروميسس سرفيسيا FH-٦٢٠ ، سكاروميسس سرفيسيا FAT-١٢) بسلالة مصنع لانتاج خميرة الخباز من حيث تطبيقها فى إنتاج بعض منتجات المخابز مثل الخبز البلدى وخبز القوالب. وتم تقييم الخواص الفيزيائية (الوزن، الحجم والحجم النوعى) وتحليل خصائص القوام لخبز القوالب وكذلك تقييم الطزاجة والقياسات اللونية والتقييم الحسى للخبز البلدى وخبز القوالب المنتج من الاربعة سلالات. وقد أظهرت النتائج أن الخبز البلدى وخبز القوالب المنتج من سلالة سكاروميسس سرفيسيا FH-٦٢٠ وسلالة سكاروميسس سرفيسيا FC-٦٢٠ كعوامل تخمير ذات صفات أفضل لجودة الخبز ، بينما سلالة سكاروميسس سرفيسيا FAT-١٢ ذات صفات منخفضة مقارنة بسلالة المصنع.