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COMPARATIVE STUDY ON THE EXTENT OF STALING ON MULTI–GRAIN BALADI BREAD

[43]

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ABSTRACT

The extent of staling of Five multi-grain Baladi bread types were assessed during 1,2,3 days storage periods in polyethylene bags at room temperature (24 ± 2°C) in comparison with Baladi bread Wheat Flour (82.5% extraction). Measurements included loss of moisture, total water solubles, swelling power, soluble starch and sensory freshness evaluation. After one day storage period, system (1) Sample 6 (70% wheat Flour, extraction 82.5% + 5% corn flour + 5% sorghum flour + 5% rice flour + 5 % barely flour + 5% triticale flour + 5% soy bean flour) and system (2) sample2(40% wheat flour, extraction 82.5% + 10% corn flour + 10% sorghum flour + 10% rice flour + 10% barely flour + 10% triticale flour + 10% chickpea flour) had a faster degree of staling followed by the other studied multi-grain bread types in comparison to system (3I) sample 5 (70% wheat flour, extraction 82.5%+10% soy bean flour + 20% corn flour) and sample (0) control (100% wheat flour, extraction 82.5%). Both the two latter systems were slightly stale. After 3 day storage period, all types of studied multi-grain bread types were rated very stale except both the two latter systems which were stale only. On the other hand, swelling power, total water soluble starch tended to decrease as the storage period increased. Sensory freshness scores of all multi-grain bread types correlated positively with swelling power and soluble starch, and correlated negatively with the storage period. Furthermore swelling power and soluble starch of multi-grain bread types correlated negatively with the storage period.

Key words: Multi-grain bread, Sensory evaluation, Staling

INTRODUCTION

Wheat is considered to be the abundent cereal all over the world and one of the most important cereals crops in Egypt. Wheat is still one of the least expensive cereals used in Baladi bread making. However, the available wheat

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amounts are still less than the populations needs due to the gradual increase in population. Therefore the state imports increasing quantities of wheat around 45% of the population needs to fulfill this gap. According to the central Statisical Organization findings (2000) the state affords 2.8 milliar pounds each year to compensate the high costs of Baladi bread making in Egypt.

In order to decrease the amounts of imported wheat the government had to use some other locally cultivated cereal grains flour in addition to wheat for bread making. Therefore, since 1995 the addition of 20% corn flour (97% extraction) to 80% wheat flour (82.5% extraction) for the production of Baladi bread in Egypt proved to be successful. Meanwhile, some trials were carried out in 2000 in Upper Egypt to add sorghum flour to wheat flour (82.5% extraction) for the production of Baladi bread.

Multi-grain bread provides an excellent solution of the Baladi bread problem. Since the beginning of man civilization mixing of wheat flour with cereal grains flour was used for bread making. Recently a 60% whole wheat bread with added goodness of up to 9 grains was recommended. However, the requirement of freshness by the consum-ers and a definite advantage of extension shelf life of local Baladi bread would be of great interest. One of the very serious problems of such bread is the rapid changes and deterioration in quality or the so-called staling.

Rizk *et al* **(1990)** reported the effect of alpha-amylases from different sources on staling of baladi bread. **Almana and Mahmoud (1994)** carried out a comparative study on the extent of staling in the common types of bread in Saudi Arabia after 3 days of storage at 25°C. **Boyacioglu and D'Appolonia (1994)** investigated staling properties of bread baked from wheat flours and durum wheat flours. **Kweon *et al* (1994)**. Outlined the effects of phospholipid hydrolysate and antistaling amylase on starch retrogradation in bread and wheat flour by DSC. **Achremovicz *et al* (1996)** studied the use of selected improvers in triticale flour breadmaking and the staling rate of bread with these improvers. **Armero and Collar (1996)** outlined antistaling additives, flour type and sour dough process effects on functionality of wheat dough. **Duran *et al* (1995)** investigated low molecular weight dextrins content in bread crumb as related to bread staling.

Schiraldi *et al* (1996) studied the effect of simple recipe breads with different water contents on bread staling. **Sahlstrom and Brathen (1997)** reported the effects of enzyme preparations for baking, mixing time and resting time on bread quality and staling. **Sidhu *et al* (1997 a)** reported a comparison of methods for assessment of the extent of staling in bread.

Forssel *et al* (1998) studied the effects of native and enzymatically hydrolysed soya and oat lecithins in starsh phase transation and bread baking and staling. On the other hand. **Gerrard *et al* (1997)** clarified the role of maltodextrins in staling of bread. Hoseney and Miller (1998) published an overview of the current understnading of bread staling. **Jagannath *et al* (1998)** studied the effect of wrappers, temperature, humidity and modified atmosphere on phase transitions during staling of bread. **Sidhu *et al* (1997b)** outlined measurement of starch properties during staling of Arabic bread. **Ali (2000)** stated that when the loaf of bread is removed from the oven, series of changes start that eventually lead to deterioration of the quality. These changes are collectively termed "staling" and include all the processes that occur during bread storage except microbial spoilage.

Accordingly, the objective of this work was to compare the extent of staling in five multi-grain bread compared to the staling extent of 82.5% extraction wheat flour bread.

MATERIAL AND METHODS

Materials

The following different varieties of cereal and legume seeds were procured from Institute of Agronomy, Agricultural Research Center, Cairo During 2000-2001 Seasons:

1	Wheat	Sacha 68 Variety	(extraction 82.5% Flour)
2	Corn	Cross hybrid Variety	(Whole Flour)
3	Sorghum	Giza 115 Variety	(Whole Flour)
4	Rice	Giza 171 Variety	(Whole Flour)
5	Barely	Giza 123 Variety	(Whole Flour)
6	Triticale	Hybrid Variety	(Whole Flour)
7	Soy bean	Giza 35 Variety	(Whole Flour)
8	Chickpea	Giza 2 Variety	(Whole Flour)

Preparation of multi-grain bread

Five types of multi-grain bread were baked applying the following flour formulae in comparison to 82.5% wheat flour as control:

1- Sample (0) Control (100% wheat flour, extraction 82.5%)
2- System (1) sample 6 (70% wheat flour, extraction 82.5% + 5% corn flour + 5% sorghum flour + 5% rice flour + 5% barely flour + 5% triticale flour + 5% soy bean flour).
3- System (2) sample 2 (40% wheat flour, extraction 82.5% + 10% corn flour + 10% sorghum flour + 10% rice flour + 10% barely flour + 10% triticale flour + 10% chickpea flour).
4- System (3I) sample 5 (70% wheat flour, extraction 82.5% + 10% soy bean flour + 20% corn flour).
5- System (3II) sample 5 (70% wheat flour, extraction 82.5% + 10% chickpea flour + 20% corn flour).
6- System (3II) sample 6 (70% wheat flour, extraction 82.5% + 10% chickpea flour + 20% sorghum flour).

Multi-grain Baladi bread was prepared as outlined by **Hussein (1999)**. The bread was baked at 400°C for 3-5 minutes in a semi-automatic bakery in Hadaei El-Koba, Cairo.

Freshly baked breads, packed in polyethylene bags, were transported to the Laboratory within 2-4 hours after baking. For shelf life assessments, four packages of each type selected at random were stored in an air conditioned room at approximately 24 ± 2°C and 40%rh. Samples were taken daily for evaluation on days 0,1,2 and 3.

Methods

Bread moisture was determined by AACC 44-18. A two stage air-oven method **(AACC, 1983)**. The swelling power procedure as modified by **Martin *et al* (1991)** was used where a bread sample (25g) was suspended in water (150 ml) for 30 min. with gentle stilling. The mixture was centrifuged at 1000 XG for 7 minutes. Swelling power was determined as the weight (grams) of wet sediment per gram of bread.

For total water-soluble material determinations, a sample (5g) of bread was extracted with distilled water (30ml) by agitating the mixture on a wrist-action Shaker for 20 minutes. The slurry was centrifuged at 2000 XG for 5 minutes and the supernatant filtered. The procedure was repeated twice on the residue, and the combined supernatants were dried **(Morad and D'Appolonia, 1980).**

Morad and **D'Appolonia procedure (1980)** to isolate and determine the soluble starch content in the total water-solubles extracted from the bread samples before drying. Three volumes of methanol were added to the total water solubles, and the mixture was heated on a steam bath for 1 hour and left overnight at 4°C. The flocculated soluble starch was collected by centrifugation and dried.

Sensory freshness evaluation of bread was investigated according to the AACC method **(AACC, 1983)**. Eleven trained panelists were asked to mark the biting texture of triplicate samples selected at random that best described their feeling on scale containing the following 6 categories "very fresh 6, fresh 5, slightly fresh 4, slightly stale 3, stale 2 and very stale1".

The results were assessed by analysis of variance and Duncan's multiple range test to identify significant differences at the 0.05 probability level using the statistical Analysis system (SAS) at Cairo University Computing center.

RESULTS AND DISCUSSION

Chemical Changes

Changes in moisture content of various multi-bread types during storage at room temperature are shown in Table (1). After 3 days storage period, moisture losses were only about 2.82-4.28% since breads were packed inpolyethelene bags. In addition, the extent of loss in moisture contents from all studied multi-bread in the three days old breads were Lower than the corresponding values of two days old breads. This means that the main changes in moisture contents of all the studied types of multi-grain breads during storage could be attributed to the redistribution between crumb and crust rather than the loss of moisture by evaporation. Such finding coincides with the logic understanding of bread staling previously reported by **Yasunga *et al* (1968), Mahmoud & Abou-Arab (1989), Almana & Mahmoud (1994) and Hoseney & Miller (1998)**, who pointed out that the development of leatheriness and loss of crispness of fresh bread crust were largely caused by migration of moisture from the moist center crumb or the surrounding air to the crust region during storage. Likewise, **Schiraldi *et al* (1996)** suggested a model for the extension of a crosslink network throughout the bread crumb: water molecules displayed along polymer chains acting as sliders of an interchain zipper and consequent direct interchain crosslinks allow formation of a network that would account for increased firmness of the crumb.

Changes in swelling power of various multi-grain bread types during storage at room temperature are shown in Table (2).

Table 1. Changes is moisture content of various multi-grain bread types during storage at room temperature: (%)[a]

Storage period (day)	Multi – Bread types					
	1	2	3	4	5	6
0	26.60 ± 0.01	25.65 ± 0.02	26.23 ± 0.02	27.50 ± 0.01	27.52 ± 0.02	28.11± 0.01
1	26.18 ± 0.02	25.12 ± 0.03	25.88 ± 0.04	27.16 ± 0.02	27.33 ± 0.01	27.9 ± 0.01
2	25.88 ± 0.03	24.90 ± 0.01	25.52 ± 0.01	26.79 ± 0.01	26.79 ± 0.01	27.49 ± 0.02
3	25.66 ± 0.01	24.55 ± 0.01	25.30 ± 0.03	26.35 ± 0.03	26.56 ± 0.03	27.10 ± 0.03

(a) Data are represented as means ± standatd deviation of 3 replicates.
1= Sample (0) control. 2 = System (I) sample (6). 3= System (2) sample (2); 4= System (3I) sample (5)
5= System (3II) sample (5), 6 = System (3II) sample (6).

Table 2. Change swelling power (a) of various multigrain bread types during storage at room temperature (24 ± 2°C)

Storage period (day)	Multi – Bread types					
	1	2	3	4	5	6
0	4.26 ± 0.01	4.15 ± 0.01	3.84 ± 0.02	4.56 ± 0.01	5.13 ± 0.03	4.86 ± 0.01
1	4.06 ± 0.02	3.95 ± 0.03	3.67 ± 0.01	4.35 ± 0.04	4.91 ± 0.01	4.66 ± 0.03
2	3.87 ± 0.02	3.76 ± 0.01	3.48 ± 0.03	4.13 ± 0:02	4.67 ± 0.02	4.41 ± 0.02
3	3.65 ± 0.04	3.58 ± 0.02	3.32 ± 0.01	3.92 ± 0.01	4.42 ± 0.02	4.19 ± 0.02

(a): Grams of wet sidment per grams (db) of bread
Data are represented as means ± standard deviation of 3 replicates.
1= Sample (0) control, 2= System (1) sample (6). 3 = System (2) sample (2). 4 = System (3I) samples (5)
5 = System (3II) sample (5), 6 = System (3II) Sample (6)

Swelling power (water hydration capacity) decreased as well as the storage period increased. Similar findings were previously reported by **Mahmoud & Abou-Arab (1989), Martin *et al* (1991) and Almana & Mahmoud (1994).**

Changes in total water-soluble materials are represented in Table (3) It is note-worthy that the total amount of soluble material extracted decreased as the storage period increased for all studied types of multi-grain breads. However, after one day storage period, multi-grain bread types showed a faster extent decrease, specially system (1) sample 6 (70% wheat flour, extraction 82.5% + 5% corn flour 5% sorghum flour + 5% rice flour + 5% barely flour + 5% triticale flour + 5% soy bean flour) and system (3II) sample 6 (70% wheat flour, extraction 82.5% | 10% chickpeas flour + 20% sorghum flour) than sample (0) control (100% wheat flour, extraction 82.5%). Such data are in good accordance with **Morad & D'Appolonia (1980), Mahmoud & Abou–Arab (1989) and Almana & Mahmoud (1994).** Meanwhile, the faster decrease of water – solubles extracted from various types of multi-grain bread could be partially due to the high oven-baking temperature performed in baladi-bread bakeries.

Table 3. Change in total water – solubles from various multi-grain bread types during storage at room temperature (24 ± 2°C) (% db)[a]

Storage period (day)	Multi – Bread types					
	1	2	3	4	5	6
0	4.79 ± 0.01	6.02 ± 0.02	5.24 ± 0.01	6.09 ± 0.02	5.40 ± 0.03	7.30 ± 0.01
1	4.57 ± 0.02	5.72 ± 0.02	5.11 ± 0.03	5.82 ± 0.01	5.17 ± 0.01	6.97 ± 0.03
2	4.34 ± 0.01	5.46 ± 0.02	4.98 ± 0.01	5.53 ± 0.01	4.91 ± 0.01	6.62 ± 0.02
3	4.13 ± 0.03	5.19 ± 0.01	4.86 ± 0.02	5.24 ± 0.03	4.67 ± 0.02	6.29 ± 0.01

(a): Data are represented as means ± standard deviation of 3 replicates
1 = Sample (0) control, 2 = System (1) sample (6). 3 = System (2) sample (2), 4 = System (3I) sample (5)
5 = System (3II) sample (5), 6 = System (3II) sample (6)

Changes in soluble starch are shown in Table (4). In all multi-grain bread types the total amount of soluble starch also decreased as the storage period increased. The data are in good agreement with **Almana & Mahmoud (1994) and Boyacioglu & D'Appolonia (1994)** who reported similar findings. **Sahlstrom and Brathen (1997)** reported the relationship between bread firming, starch recrystallization and susceptibility of starch to fungal alpha – amylase.

Table 4. Changes soluble starch extracted from various multi-garin bread types during storage at room temperature (24 ± 2°C) (% db)

Storage period (day)	Multi – Bread types					
	1	2	3	4	5	6
0	1.20 ± 0.01	1.41 ± 0.02	1.17 ± 0.03	1.25 ± 0.01	1.49 ± 0.01	1.10 ± 0.03
1	1.14 ± 0.03	1.35 ± 0.02	1.14 ± 0.04	1.19 ± 0.04	1.43 ± 0.02	1.05 ± 0.02
2	1.09 ± 0.02	1.28 ± 0.01	1.05 ± 0.01	1.13 ± 0.02	1.35 ± 0.01	0.99 ± 0.01
3	1.03 ± 0.01	1.20 ± 0.01	1.00 ± 0.02	1.07 ± 0.01	1.28 ± 0.02	0.95 ± 0.03

(a): Data are represented as means ± standard deviation of 3 replicates
1= Sample (0) control, 2 = System (1) sample (6), 3 = System (2) sample (2), 4 = System (3I) sample (5)
5 = System (3II) sample (5), 6 = System (3II) sample (6).

Sensory Freshness Changes

Mean values obtained from sensory evaluation of multi-grain bread types after 1,2 and 3 days storage periods at room temperature are shown in Table (5). After one day storage period all multi-grain bread types, except system (1) sample 6 (70% wheat flour, extraction 82.5% + 5% corn flour + 5% sorghum flour + 5% rice flour + 5% barely flour + 5% triticale flour + 5% soy bean flour) and system 2 sample 2 (40% wheat flour, extraction 82.5% + 10% orn flour + 10% sorghum flour + 10% rice flour + 10% barely flour + 10% triticale flour + 10% chickpea flour) remained rather fresh, while the Latter bread formula was stale. After 3 days storage period all multi – grain bread types were rated stale, except the two above-mentioned systems were rated very stale.

The extent of staling, expressed as percentages lossess of the original freshness scores, are shown in Table (6) . both system (1) sample 6 (70% wheat flour, extraction 82.5% + 5% corn flour + 5% sorghum flour + 5% rice flour + 5% barely flour + 5% triticale flour + 5% soy bean flour) and system (2) sample 2 (40% wheat flour, extraction 82.5% + 10 corn flour + 10% sorghum flour + 10% rice flour + 10% barely flour + 10% triticale flour + 10% chickpea flour) had a faster staling degree, followed by the other multi-grain bread formula only consisting of flour mixtures, water, yeast and water. As the baking temperature is very high (400°C) for 3 minutes, the crust forms in less than one minute. So, the internal temperature produces the steam that puffs the bread rapidly. Factors such as higher moisture contents, crust staling, crumb staling, increased firmness, increased opacity, increased crumbliness,

Table 5. Changes in sensory (a)– freshness scores (b) of various multi – grain breads during storage at room temperature (24 ± 2°C)

Storage period (day)	Multi – Bread types					
	1	2	3	4	5	6
0	5.8la	5.09a	5.00a	5.63a	5.36d	5.27a
1	4.63b	3.36b	3.09b	4.36b	4.18b	4.00b
2	3.81c	2.36c	2.00d	3.46c	3.27c	2.90c
3	2.81c	1.54d	1.27d	2.54c	2.27d	2.00d

(a) Sensory rating were given numerical values with very fresh =6, fresh = 5, slightly fresh = 4, slightly stale = 3, stale = 2 and very stale =1
(b) * These values are means of 3 replication of 11 panelists. Values in the same column not followed by the same letter are significantly different by Duncan's multiple range test ($p<0.05$).
1=Sample (0) control, 2= System (1) sample (6), 3= System (2) sample (2), 4=System (3I) sample (5)
5= System (3II) sample (5), 6 = System (3II) sample (6).

Table 6. Extent of staling (a) of various multi-grain breads during storage at room temperature

Storage period (day)	Multi – Bread types					
	1	2	3	4	5	6
0	0	0	0	0	0	0
1	20	34	38	23	22	24
2	34	54	60	38	39	45
3	52	70	75	50	58	62

(a) Present loss of the original freshness scores indicates extent of staling.
1= Sample (0) control, 2= System (1) sample (6), 3 = System (2) sample (2), 4= System (3I) sample (5)
5= System (3II) sample (5), 6 = system (3II) sample (6)

the appearance of crystalline regions during staling, bread volume and shape, starch recrystallization, susceplibility of starch to alpha – amylase, baking time and temperature and extractions rate of flours are probably responsible factors for the fast staling rates of multi-grain bread types. These factors influenced the water – hydration capacity and bread firmness during storage. This agrees with previously reported findings of **Axford *et al* (1968), Mahmoud & Abou-Arab (1989), Almana & Mahmoud (1994), Boyacioglu & D'Appolonia (1994), Hoseney & Miller (1998) and Sidhu *et al* (1997a).**

Relationship among chemical, sensory Changes and Storage Periods

To illustrate the relationship among chemical, sensory changes and storage periods of all multi-grain bread types, the correlation coefficients between storage period, bread moisutre, swelling power, total water solubles, soluble starch and sensory freshness scores were computed (Table 7).

Sensory freshness scores of multi-grain bread types correlated positively with swelling power, and soluble starch; and correlated negatively with the storage period. Furthermore swelling power and soluble starch of multi-grain bread types correlated negatively with the storage period. Similar findings were reported by **Almana and Mahmoud (1994)** for Saudi Arabian bread types.

Conclusions

The present study revealed that all multi-grain bread types were susceptible to staling, though in variable limits. System (1) sample (6) 70% wheat flour, extraction 82.5% + 5% corn flour + 5% sorghum flour + 5% rice flour + 5% barley flour + 5% triticale flour + 5% soy bean flour) and System (2) sample 2

Table 7. Correlation coefficients among chemical, sensory changes and storage period of all multi-grain bread types [a]

	Swelling power	Total water Solubles	Soluble starch	Sensory Freshness	Storage period
Moisture	0.85*	0. 56*	0.20	0.52 *	- 0.39
Swelling power		0.47*	0.47*	0.60 *	- 0.49*
Total water solubles			- 0.10	0.24	- 0.35
Soluble Starch				0.43*	- 0.47*
Sensory freshness					- 0.92*
Storage period					

[a] $P < 0.05$

(40% wheat flour, extraction 82.5% + 10% corn flour + 10% sorghum flour + 10% rice flour + 10% barely flour + 10% triticale flour + 10% chickpea flour) were more susceptible to staling than the other studied multi-grain bread types. After one day storage in polyethylene bags at room temperature 24 ± 2°C, the multi-grain bread types became stale or slightly stale.

Swelling power, total water solubles and soluble starch in these breads tended to decrease as storage period increased. However, the faster extent in the decrease of these parameters was correlated with a faster extent of staling.

The present study revealed that more studies are needed on multi-grain breads in formulations and additives to overcome fast staling phenomena of multi-grain breads.

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٢- قســـم علـــوم الأغذيـــة - كلية الزراعة - جامعة عين شمس - شبرا الخيمة - القاهرة

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تناول البحث دراسة معدل بيات الخبز البلدي المصنع من خمس مخاليط حبوب متعددة مختلفة والذي تم تخزينه لمدة ١ ، ٢، ٣ يوم في أكياس من البولي إيثيلين علي درجة حرارة الغرفة (٢٤ ± ٢ درجة مئوية) ومقارنة بالخبز البلدي المصنع من دقيق القمح نسبة استخلاص ٥ر٨٢%.

وتم تقدير النسبة المئوية للرطوبة ، المواد الكلية الذائبة في الماء قوة الانتفاخ ، النسبة المئوية للنشا القابل للذوبان ، بالإضافة إلي تقدير الاختبارات العضوية الحسية للطزاجة .

وقد استبان من نتائج البحث أن الخبز المصنع من خليط حبوب متعددة والمخزن لمدة يوم واحد والمكون من المخاليط التالية:

نظام (١) عينة ٦ (المكون من خليط الحبوب ٧٠% من دقيق القمح نسبة استخلاص ٥ر٨٢% + ٥% دقيق ذرة + ٥% دقيق ذرة رفيعة + ٥% أرز + ٥% دقيق شعير + ٥% دقيق تريتيكال + ٥% دقيق فول صويا) ، نظام (٢) عينة ٢ (المكون من خليط الحبوب ٤٠% دقيق القمح نسبة استخلاص ٥ر٨٢% + ١٠% دقيق ذرة + ١٠% دقيق ذرة رفيعة + ١٠% دقيق أرز + ١٠% دقيق شعير + ١٠% دقيق تريتيكال + ١٠% دقيق حمص).

كان ذو معدل بيات أسرع من الخبز المصنع من خليط الحبوب الأخرى المدروسة بمقارنتها بالنظم التالية:

نظام (I ٣) عينة ٥ (المكون من خليط الحبوب ٧٠% دقيق قمح نسبة استخلاص ٥ر٨٢% + ١٠% دقيق فول صويا + ٢٠% دقيق ذرة) ، العينة (صفر) أي الكونترول والمكونة من ١٠٠% دقيق قمح نسبة استخلاص ٥ر٨٢% .

وقد أظهرت هاتين العينتين معدلا طفيفـا من البيات .

وبالإضافة إلي ما تقدم فإنه بعد تخزيـن الخبز المصنع من خليط حبوب متعددة لمـدة ثلاثة أيام فإن جميع النظم كانت ذات معـدل بيات مرتفع باستثناء هاتين العينتيـن التـي سجلت معدل بيات عادي فقط .

ومن جهة أخرى فإن قـوة الانتفـاخ ، المواد الكلية الذائبة في الماء ، النشا القـابل للذوبان في الماء تناقصت قيمها بزيادة فـترة تخوين الخبز المصنع مـن خليـط حبـوب متعددة .

وقد سجلت الاختبارات العضوية الحسية للطزاجة في جميع أصناف الخبز المصنـع من خليط حبوب متعـددة معـامل ارتبـاط موجب مع قوة الانتفاخ ، النشا القابل للذوبان في الماء ، بيد أنها سجلت معـامل ارتبـاط سالب مع فترة التخزين .

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