J. Agric. Sci. Mansoura Univ., 34 (12): 11147 - 11155, 2009

EFFECT OF OKARA ADDITION ON BREAD QUALITY

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ABSTRACT

Okara (the residue of soymilk manufacturing) was used as a protein source in the preparation of pan bread. Okara was dried at low-temperature (40-50°C) in a forced air drying oven, milled to obtain okara flour (OF) and blended with wheat flour 72% extraction at the 10, 20,30 and 40% replacement levels. The influence of this replacement on the rheological properties of dough, chemical, baking, organoleptic properties of bread was investigated. Breads were stored at room temperature for 5days and staling rate was also studied. Results showed that water absorption, dough development time and stability increased, while mixing tolerance index and dough weakening decreased by increasing the level of replacement. Extensibility and dough energy decreased but resistance to extension and the proportional number increased by increasing the level of okara flour. Protein content of bread increased by increasing the level of replacement. Maximum improvement of protein achieved was about 57% by using 40% OF. Loaf weight increased, while loaf volume and specific loaf volume decreased by increasing the level of OF. Clear reduction of bread staling rate caused by okara flour addition. Baking quality and organoleptic evaluation showed that OF can be used to supplement wheat flour in making of pan bread up to 30% replacement level.

Keywords: bread, okara, rheological, staling, baking, quality.

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INTRODUCTION

The residue left from ground of soy bean after extraction of water extractable fraction used for production of soymilk and tofu, is called okara. About 1.1 kg of fresh okara is produced from every kilogram of soybeans processed for soymilk (Khare *et al*., 1995). Huge quantities of okara are produced; e.g. in Japan about 700 000 tons of okara were produced from the tofu production industry in 1986 (Ohno *et al*., 1993). The okara is sometimes used as an animal feed (Noguchi, 1987), in Japan most is burnt as waste (Ohno *et al*., 1993), and in Hong Kong it is dumped in land fills. Okara about 28.4% contains mostly crude fiber composed of cellulose, hemicellulose, and lignin, (Van de Reit *et al*., 1989). They also reported that the levels of minerals and vitamins (mg/100g d.b) were: Ca, 260; Mg, 163; Fe, 6.2; Na, 16.2; K, 1046; Cu, 1.1; Zn, 3.8; Mn, 2.5; P, 396; thiamin, 0.59; riboflavin, 0.04 and nicotinic acid 1.01 for the Edgar cultivar.

Okara could be used to increase the fiber content in cereal products (Rinaldi *et al*., 2000). Soy fibers are supposed to have good nutritional and functional properties (Loison, 1991 and Smouse, 1988). The natural taste and the absence of color of such fibers makes them suitable for incorporation into food products without any change in their quality, unlike those from wheat fibers (Siever *et al*., 1990).

Cereals are generally considered to be poor sources (qualitatively and quantitatively) of proteins, as indicated by their low levels and low biological values. However, okara protein is of better quality than that from other soy products; e.g. the protein efficiency ratio of okara was 2.71 but that of soymilk was only 2.11 (Liu, 1997). The high quality protein fraction of okara has good water holding and emulsifying qualities and contains a peptide with anti hypertension (O'Toole, 1999).

The magnitude of the protein in Egypt has directed research toward the reevaluation of the various natural sources of protein in an attempt to improve the quality and quantity of individual protein intake. Thus, the present study was designed to shed light on some chemical composition of okara and its utilization in the production of pan bread. The effects of replacing wheat flour with 10, 20, 30 and 40% replacement levels on the rheological properties of dough, the chemical properties and the organoleptic characteristics, baking quality as well as staling of bread were aimed.

MATERIALS AND METHODS

Materials

Wheat flour 72% extraction was obtained from North Cairo Flour Mills Company, Egypt. Raw okara was obtained from Soy Processing Unit, Food Technology Research Institute, Agricultural Research Centre, Giza, Egypt. It was packed in a plastic bag and kept in frozen condition to reduce any degradation before drying. All other materials used in dough preparation for pan bread making were obtained from local markets, Cairo, Egypt.

Methods

Preparation of okara flour

Raw okara was dried at 40-50°C in a forced air drying oven, and then milled to pass through a 100-mesh screen.

Preparation of flour blends

Wheat flour 72% extraction was well blended with okara as a protein source to produce individual mixtures containing 10, 20, 30 and 40% replacement levels. All samples were stored in airtight containers and kept at 4°C until required.

Rheological properties

Rheological properties of doughs were evaluated using farinograph and extensograph according to AACC methods No. 54 -10 and 54 – 21 (1983), respectively.

Preparation of pan bread

Pan bread was prepared as follow: yeast (1%) was dissolved in warm water (35°C) then added to the dry ingredients (2% NaCl, 1% sugar, 1% bread improver and 100g wheat flour (72%) with different okara flour blends and shortening (2%), then the mixture was kneaded. The dough was fermented at 30 °C and 80-85% relative humidity for 30 min in a fermentation cabinet then the dough was divided into 150g pieces and placed in the pan and proofed under the same conditions for 45 min. Bread dough loaves were baked at 240 °C for 20–25 min following steaming for 10s. Baked loaves were cooled down at room temperature for 60 min and packed.

Physical evaluation of bread

Volumes of cold loaves were measured by rape seed displacement method. Specific volumes were calculated from loaf and loaf weight taken after 1h of baking.

Sensory evaluation of bread

Sensory evaluation of 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 mouthfeel (10).

Color evaluation.

The color of bread was measured using a spectro-colorimeter 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. Total color difference (ΔE) was calculated as:

$$\Delta E = [(\Delta L)2 + (\Delta a)2 + (\Delta b)2]1/2$$

Freshness of bread

The freshness of bread samples was tested at 1,3 and 5 days of storage at room temperature by alkaline water retention capacity (AWRC) according to method of Yamazaki (1953), as modified by Kitterman and Rubenthaler (1971).

Chemical analysis

Moisture, ash, crude protein, fat and crude fiber contents were determined according to AOAC methods 14.004, 14.006, 2.057, 14.018 and7.065 (2000), respectively. Carbohydrates were calculated by difference.

Statistical analysis

The obtained results were statistically analyzed by analysis of variance (ANOVA) and least significant difference (LSD) was calculated according to McClave and Benson (1991).

RESULTS AND DISCUSSION

Chemical composition of wheat and okara flours

Protein, fat, ash and crude fiber in the okara flour were found to be higher than those in wheat flour as shown in Table (1). However, carbohydrate showed a reversible trend with respect to the previous constituents as seen from the same table. These values agreed with those reported by Van de Reit *et al*., (1989) but were lower than results obtained by Surel and Couplet (2005). They reported that the protein and total dietary fiber of okara were 37.5 and 31.1% on dry matter, respectively.

Table 1: Chemical composition of okara and wheat flours (% on dry weight basis)*

Sample	Moisture	Protein	Ash	Crude fiber	Fat	Carbohydrate
Wheat flour (72%)	11.92	11.82	0.60	0.84	0.96	85.78
Okara flour	5.00	29.30	3.10	10.42	9.00	48.18

*** Data are the average of duplicate analyses.**

The later authors showed that the variation in okara composition depends either on the soymilk preparation process (especially the grinding step) or on the quality of raw materials (seed variety and quality).

Rheological properties of doughs

Farinograph test: Water absorption, dough development time and stability were found to be increased, while mixing tolerance index and dough weakening decreased when okara flour was blended with wheat flour at all replacement levels as represented in Table (2). Increasing water absorption might be due to that okara flour contains more fiber and protein, which retained more water. Increment of okara flour in the dough delays its time of homogeneity and consequently dough developing time and dough weakening. Dhingra and Jood (2004) showed that the gluten content, sedimentation value and water absorption capacity of the flour blends and mixing time of the dough decreased with increase the level of soybean flour.

Table 2: Farinograph characteristics of wheat and okara flour blends

Sample WF : OF	Water absorption (%)	Dough development time (min)	Dough stability (min)	Mixing tolerance index (Bu)	Dough weakening (Bu)
100 : 0 (control)	66.5	5.0	9.5	90	100
90 : 10	69.8	9.0	11.5	80	75
80 : 20	72.0	7.5	10.5	80	90
70 : 30	73.2	10.5	12.5	70	80
60 : 40	74.3	16.0	16.0	40	50

WF = wheat flour OF = okara flour

Extensograph test: The substitution of wheat flour using okara flour decreased the extensibility and dough energy, while increased the resistance to extension and the proportional number as indicated in Table (3). The decrement in dough extensibility may be due to the deficiency of gliadin in okara protein, which is responsible for such property. Ribotta *et al*., (2005) reported that the incorporation of high levels of soy products had negative effects in gluten network formation, extensibility properties and gas retention of dough and final bread quality. Coincidently, Doxastakis *et al.* (2002) showed that the extensibility as measured by the Extensograph procedure, decreased as substituted level and the resting time increased and the resistance/extensibility ratio increased as the proportion of wheat substitution increased. Similar results were showed by Maforimbo *et al*., (2007) who found that soy flour weakened wheat flour dough by increasing SH concentration. On the other hand, substitution of gluten proteins by non-gluten forming proteins causes a dilution effect and consequently weakens the dough.

Table 3: Extensograph characteristics of wheat and okara flour blends.

WF : OF	Dough extensibility (mm)	Resistance to extension (Bu)	Dough energy (Cm^3)	Proportional number (R/E)
100 : 0 (control)	145	280	56	1.9
90 : 10	90	180	20	2.0
80 : 20	75	290	22	3.8
70 : 30	60	520	42	8.6
60 : 40	35	800	36	22.8

WF = wheat flour. OF = okara flour R/E = Resistance to extension/Extensibility

Baking quality of bread

Data presented in Table (4) show the effect of okara flour addition to wheat flour dough on the baking quality of bread. For the control loaf weight was 136.5g and maximal 40% addition of okara flour caused 3.3% increase of this parameter. This is mainly due to high water retention of okara flour. The loaf weight data showed difference between samples according to their water absorption level. Also, the results indicated that the reduction in loaf volume and specific volume of bread when okara flour was used in bread preparation. The reduction in volume and specific volume of bread was 34 and 36% when okara flour was used at 40% level, respectively. The reduction of loaf volume was due to the dilution of gluten as a result of adding okara flour to wheat flour. In addition the lower loaf volume could be attributed to the lack of enough starch because gelatinized starch forms a gel upon cooling. This conclusion could be supported by the data obtained by Shogren *et al.* (2003) and Mohamed *et al.* (2006).

Table 4: Baking quality of pan bread.

WF : OF	Weight (g)	Volume (cc)	Specific volume (cc/g)
100 : 0 (control)	136.5	378	2.8
90 : 10	138.5	318	2.3
80 : 20	138.5	310	2.2
70 : 30	140.0	283	2.0
60 : 40	141.0	251	1.8

WF = wheat flour OF = okara flour

Bread color

Okara flour affected also the crust and crumb color of bread as shown in Table (5). Color of crust and crumb of loaf made with okara flour (OF) was slightly darker (lower "L" value) and more red (higher "a" values) than those of the control sample. This darkening effect was slightly more pronounced at the 40% level of OF addition. However, with the addition of OF at all levels, the crumb color changed to a significant yellow range (higher "b" values). This yellow color contribution could be because OF may be very rich in yellow pigments, mainly xanthophylls, which, when included in the formulation, affected the crumb color, but not to any disadvantage to the consumer. The addition of OF affected the total color difference among these bread samples.

Table 5: Color quality of bread as affected by addition of okara flour.

WF : OF	Lightness "L"	Redness "a"	Yellowness "b"	ΔE
		Crust color		
100 : 0 (control)	53.98	17.02	37.94	0.00
90 : 10	53.49	16.40	36.72	1.45
80 : 20	53.44	16.44	36.10	2.00
70 : 30	45.55	18.72	33.34	9.75
60 : 40	44.36	19.22	32.85	11.10
		Crumb color		
100 : 0 (control)	69.41	2.23	24.33	0.00
90 : 10	70.76	2.87	26.43	2.56
80 : 20	67.81	3.40	28.37	4.48
70 : 30	66.18	4.50	30.56	7.35
60 : 40	66.36	4.69	31.90	8.50

WF = wheat flour OF = okara flour

Total color difference "ΔE" ranged between 1.45-11.10 and 2.56-8.50 for crust and crumb, respectively.

Sensory evaluation of bread

Table (6) represents the mean values and their statistical parameters, respectively for symmetry of shape, crust color, crumb color, crumb texture, break & shred, mouth feel, aroma and taste. As shown from this table, all bread samples were rated lower than the control sample. No significant differences at $p < 0.05$ were noted within all breads and between the control for all sensory characteristics except symmetry of shape and crumb color. The previous results were further supported by measuring the total color difference using Hunter Lab, as indicated in Table 5. The color of the crust of the bread samples were changed and became slightly darker by increased levels of okara flour (40%) in the formulas than control bread, while they still acceptable. These results agreed with those reported by Shogren *et al.* (2003) and Xie *et al.,* (2008).

Table 6: Statistical analysis of sensory evaluation of bread as affected by addition of okara flour.

Characteristics	Control	Okara flour (%)				LSD
		10	20	30	40	
Symmetry of Shape (5)	4.5^{a}	4.2^{ab}	3.95^{ab}	3.6^{ab}	3.5^{b}	0.970
Crust color (10)	8.5	7.95	8.0	7.5	7.5	NS
Crumb color (10)	8.8^{a}	8.7^{a}	8.6^{a}	7.25^{b}	7.95^{ab}	1.326
Crumb texture (15)	13.2	12.7	12.95	12.15	12.0	NS
Break & shred (10)	8.4	8.1	7.85	7.3	7.1	NS
Mouth feel (10)	8.6	8..1	8.0	7.5	7.65	NS
Aroma (20)	17.8	16.8	17.1	16.2	16.1	NS
Taste (20)	18.2	17.1	16.8	15.8	17.2	NS

Values differently superscript are significantly different ($p < 0.05$).

Bread staling

The changes occurred in freshness characteristics of bread samples stored at room temperature for 1, 3 and 5 days are shown in Table (7). It could be observed that the control bread sample had the lowest values of alkaline water retention capacity (AWRC), being 366.5, 340 and 323.5% at 1, 3 and 5 days storage, respectively. However, all tested samples caused a noticeable increase in AWRC values at 1, 3 and 5 days storage compared with the control. The improvement effect of tested samples on the freshness characteristics of the bread could be due to the presence of okara flour in the formulas, which contained more fiber and protein that could retain more water. Mohamed *et al.* (2006) reported that bread samples with higher wheat flour and lower protein content showed higher firmness values. This was expected, due to the higher starch and thus higher amylose content than in the samples with higher protein contents. It is widely accepted that bread staling is caused by amylose and to a lesser extent, amylopectin retrogradation. The high protein content altered the macromolecular content of the bread and thus the overall glass transition of the system. The change in the glass transition was directly related to the molecular relaxation of the bread, which in turn affected the staling process as explained by Parker and Ring (2001).

Table 7: Freshness properties of stored bread.

WF : OF	Alkaline water retention capacity (%)		
	1day	3 days	5 days
100 : 0 (control)	3.66.5	340.0	323.5
90 : 10	385.0	360.0	342.0
80 : 20	393.5	368.5	352.0
70 : 30	397.0	373.0	355.5
60 : 40	404.0	388.5	372.5

WF = wheat flour   OF = okara flour

Chemical composition of bread.

Data presented in Table (8) show chemical composition of ban bread. All bread samples were higher in protein, fat fiber and ash contents than those ofcontrol bread. Fore instance, while the protein content of 40% okara flour was 19.48% that of control bread was only 12.38% with about 57% improvement. This mainly could be explained by the fact that okara is characterized by its high protein and fiber contents. Such improvement is some what lower than that reported in the previous work (Mohamed *et al.,* 2006), which was produced by soy protein isolate with wheat flour. It was also noted that the addition of OF to wheat flour resulted in a large decrease carbohydrate content of the bread. For instance, the carbohydrate content indicated a value 83.32% for the control sample being 68.76% for sample containing 40% OF, with about 17% reduction. So, bread with high protein content is more suitable for use in low carbohydrate diet than bread formulations currently used.

Table 8: Chemical composition of bread as affected by addition of okara flour (% on dry weight basis).

Constituents	Control	Okara flour (%)			
		10	20	30	40
Moisture	34.00	35.50	37.30	38.66	40.00
Protein	12.28	14.07	15.78	17.57	19.48
Fat	1.86	2.27	3.09	3.89	4.64
Fiber	1.24	2.09	3.06	4.00	4.97
Ash	1.20	1.35	1.61	1.85	2.15
Carbohydrate	83.32	80.22	76.46	72.69	68.76

Data are the average of duplicate analyses.

Conclusion

According to the above-mentioned results, it can be concluded that high-protein pan bread with an acceptable quality can be produced using okara flour up to 30% replacement level.

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تاثير اضافة الاوكارا على جودة الخبز

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تم إستخدام المادة المتبقية من صناعة لبن الصويا (الاوكارا) كمصدر للبروتين والألياف في صناعة الخبز الأفرنجي. وقد تم تجفيف الاوكارا على درجة حرارة منخفضة (٤٠-٥٠ °م) ثم طحنها للحصول على الدقيق منها وتم عمل إحلال جزئي لدقيق القمح بإستخدام دقيق الاوكارا وذلك بمستويات ١٠، ٢٠، ٣٠ و٤٠%.

وتم دراسة تأثير هذا الإحلال على الخواص الريولوجية والتركيب الكيماوي وإختبار الخبيز والخواص الحسية للخبز الناتج.

وقد أظهرت النتائج المتحصل عليها زيادة نسبة الماء الممتص والزمن اللازم لتكوين العجائن بالاضافة إلى زيادة ثبات العجينة كلما زاد مستوى الاوكارا كما أظهر ذلك جهاز الفارينوجراف. بينما قلت المطاطية وطاقة العجينة والمرونة بزيادة نسبة الاوكارا كما أظهر ذلك جهاز الاكستنسوجراف.

وأظهر التحليل الكيماوي زيادة المحتوى من البروتين والألياف في الخبز الناتج بزيادة مستوى الاوكارا كذلك زاد وزن الرغيف بينما قل حجمه وتحسن مستوى الطزاجة في الخبز حيث تأخرت ظاهرة البيات.

ومن النتائج المتحصل عليها يمكن التوصية بأنه يمكن انتاج خبز أفرنجي مقبول حسيا وغني بالبروتينات والألياف بإستخدام الاوكارا حتى مستوى ٣٠%.

قام بتحكيم البحث

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