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Production of Egyptian Gluten-Free Bread

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Abstract: This investigation aimed to produce gluten-free bread (GFB) for celiac disease patients. GFB doughs made from rice flour, corn starch, defatted soy flour and chickpea flour at different levels with addition of 3 % xanthan gum, which had pronounced effect on viscoelastic properties yielding strengthened and gave a farinograph and extensograph curves similar to the curves of wheat flour dough. The obtained farinograph results showed evident increase ($p<0.05$) in water absorption, arrival time, dough development time and dough stability of all gluten-free dough samples as compared with control. Also, extensograph results showed that dough elasticity and consequently proportional number were gradually increased in the GFB blends, while, extensibility and dough energy were decreased. Regarding the chemical composition of GFB samples, it could be noticed that protein, fat and ash contents were gradually increased from 10.10, 1.67 and 0.95 in the control sample to 12.94, 1.75 and 1.90 % in GFB blend 3, respectively. While, crude fiber and carbohydrate contents were slightly decreased in GFB samples. Also, GFB samples exhibited good sensory properties and there were no significant differences between those samples and the control in all organoleptic properties. It could be concluded that Egyptian gluten-free bread from native starchy flours can be produced with low cost and high quality.

Key words: Gluten-free bread · Celiac disease · Rheological properties · Chemical composition

INTRODUCTION

Celiac disease or gluten sensitive enteropathy is a chronic disorder of the small intestine caused by exposure to gluten in the genetically predisposed individuals [1,2]. It is characterized by a strong immune response to certain amino acid sequences found in the prolamin fractions of wheat, barley and rye [3].

When people with celiac disease eat foods or use products containing gluten, their immune system responds by damaging or destroying the intestinal villi leading to the malabsorption of nutrients, thus adversely affecting all systems of the body [4].

Celiac disease is now regarded as one of the most common genetic diseases, occurring in 1 of 130-300 of the global population [5,6]. Intestinal symptoms can include diarrhea, abdominal cramping, pain and distention and untreated celiac disease may lead to vitamin and mineral deficiencies, osteoporosis and other extra intestinal problems.

The gluten-free diet remains until now the only treatment for Celiac disease. Gluten free diet has benefits such as the recovery of the villi of the small intestine and reduced risk of malignant complications [7].

Since the diet of celiac patients must be completely free of any gluten, so all the products from wheat, rye, barley and oat must be replaced with corn, rice, millet equivalents and various types of starch (corn, rice and potato) or appropriate mixtures. Hydrocolloids (such as pectin, guar gum and xanthan gum) are added to naturally gluten-free flours to mimic the viscoelastic properties of gluten and to improve structure, sensory attributes and shelf-life of these products [8,9]. Also, soybean proteins were used for fortification of bakery products by improving their protein quality, mechanical behavior and storage life [10,11].

When gluten-free flour is mixed to form dough, it does not form a continuous phase or dough structure and consequently fails to produce good quality bread [12]. Therefore, this study was designed to study the effect of using some different gluten-free flour mixtures on the rheological properties of the dough produced. Also, evaluation of quality parameters of the baked end-product was another target.

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MATERIALS AND METHODS

Materials: Egyptian rice flour (commercial name ATIFCO), compressed yeast and salt were purchased from the local market, while wheat flour (82% extraction), Corn starch, defatted soy flour and chickpea flour were obtained from the Agriculture Research Center, Giza, Egypt. Xanthan gum supplied by Degussa Texturant Systems, Germany.

METHODS

Experimental Treatments: Preparation of gluten-free flour mixtures: Gluten-free flour blends were individually blended to be homogenized, then packed in polyethylene bags, tightly closed and kept at room temperature until using. The composition of produced blends is showed in Table 1.

Processing of Gluten-free Breads (GFB): To prepare the doughs of control and Gluten-free breads, 2% compressed yeast dissolved in warm water (40 °C) and 1% salt were added separately to the prepared flours, while xanthan gum was added at 3% to the gluten-free flour mixtures and mixed to form the doughs, which are left at room temperature for 40 min. to complete fermentation. The doughs are cut into loaves, which baked at 400 °C for 2 min in an electric oven in the Agriculture Research Center, Giza, Egypt. Measurements of the loaves were carried out after cooling to room temperature for 1 hr as described by Gallagher *et al.* [13].

Analytical Methods

Rheological Properties of Blended Flour Mixtures: Dough samples for the rheological tests were prepared as those used in bread making, but without added yeast. Farinograph and extensograph properties were assessed according to the method described by A.A.C.C. [14].

Gross Chemical Analyses: Moisture, crude protein, fat, crude fiber and ash contents of control and GFB samples were determined according to A.O.A.C. [15]. Total carbohydrate was calculated by subtraction.

Organoleptic Properties of Produced Breads: Control and GFB loaves were sensory evaluated after baking by twenty panelists according to the method described by Kramer and Twigg [16].

Statistical Analysis: The original sensory panel data and other results were statistically analyzed using analysis of variance (ANOVA) and least significance difference (LSD) at a significance of probability 5 % [17].

RESULTS

Effect of Different Gluten-free Flour Blends on Dough Rheological Properties: Farinograph properties of control and gluten-free flour blends are shown in Fig. 1 and Table 2. The standard farinograph curve obtained from wheat flour dough showed water absorption of 56.1% and a very short time to reach the consistency of 500 BU (1.0 min). The farinograms of gluten-free flour blends showed that all farinograph properties were increased ($P<0.05$) as compared with control. Whereas the dough development time of the control was 1.5 min, which increased obviously in the gluten-free flour blends and reached to 10.0 min in blend 2. The dough stability, when 500 BU of consistency is reached, was affected by different flour blends. The highest stability was observed in blend 2 (14.5 min) and the lowest in blend 1 (6.5 min) as shown in Table 2.

Extensograph Properties: Table 3 and Fig. 2 show the extensograph properties of control and GFB mixtures. The table indicated that the elasticity and proportional number were obviously increased ($P<0.05$) in all the gluten-free

Table 1: Blending levels of gluten-free flour mixtures

	Ingredients (%)				
Treatments	Wheat flour	Rice flour	Corn starch	Defatted soy flour	Chickpea flour
Control	100	-	-	-	-
Blend 1	-	50	40	5	5
Blend 2	-	50	35	7.5	7.5
Blend 3	-	50	30	10	10

Table 2: Farinograph properties* of control and gluten free flour mixtures

	Treatments			
Parameter	Control	Blend1	Blend 2	Blend 3
Water absorption (%)	56.1[c]	66.2[a]	61.5[b]	60.7[b]
Arrival time (min)	1.0[c]	3.0[b]	8.5[a]	2.5[b]
Dough development (min)	1.5[c]	5.0[b]	10.0[a]	4.5[b]
Dough stability (min)	6.0[c]	6.5[c]	14.5[a]	11.0[b]

*Means in the same row with different superscripts are significantly different (P<0.05)

Table 3: Extensograph properties* of control and gluten free flour mixtures

	Treatments			
Parameter	Control	Blend1	Blend 2	Blend 3
Elasticity (B.U)	140[c]	225[b]	260[b]	320[a]
Extensibility (m.m)	85[a]	30[b]	25[b]	30[b]
Proportional number (R/E)	1.7[c]	7.5[b]	10.4[a]	10.7[a]
Dough energy (cm^2)	33.1[a]	24.6[b]	29.3[a]	29.9[a]

*Means in the same row with different superscripts are significantly different (P<0.05)

Table 4: Chemical composition* of control and gluten-free bread samples

	Treatments			
Components (%)	Control	Blend1	Blend 2	Blend 3
Moisture	10.00[b]	10.22[a]	10.09[b]	10.05[b]
Crude protein	10.10[c]	11.78[b]	12.61[a]	12.94[a]
Fat	1.67[b]	1.72[a]	1.74[a]	1.75[a]
Crude fiber	1.00[a]	0.95[a]	0.98[a]	0.99[a]
Ash	0.95[c]	1.29[c]	1.59[b]	1.90[a]
Carbohydrate	76.28	74.04[b]	72.99[c]	72.37[c]

*Means in the same row with different superscripts are significantly different (P<0.05)

Table 5: Sensory quality criteria* of control and gluten-free bread samples

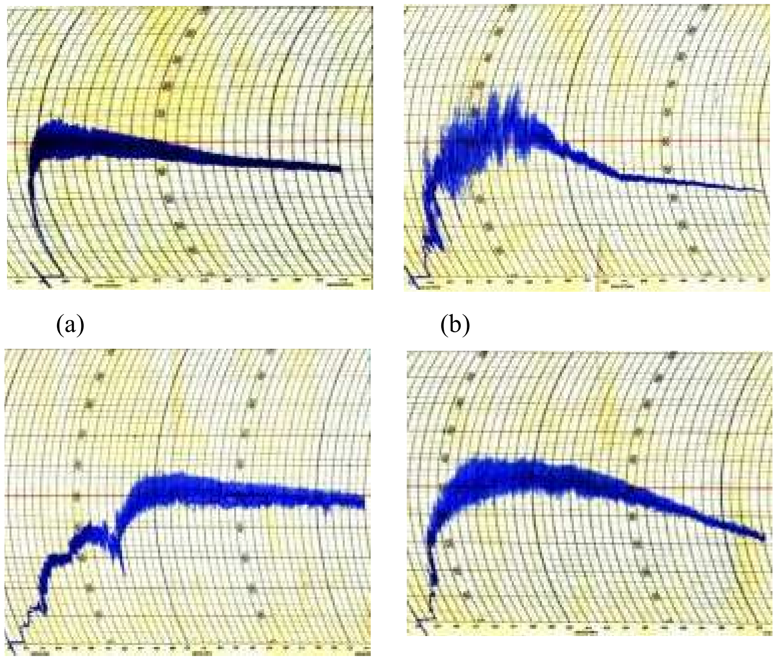
	Organoleptic properties								
Treatments	Appearance (20)	Separation of layers (20)	Roundness (15)	Crumb (15)	Color (10)	Taste (10)	Odor (10)	Overall acceptability (100)	Overall acceptability mean**
Control	18.9[a]	20.0[a]	14.5[a]	9.6[a]	9.5[a]	9.0[a]	9.6[a]	91.1[a]	13.01
GFB 1	18.3[a]	19.0[a]	14.0[a]	9.1[a]	9.0[a]	8.7[a]	9.5[a]	87.6[a]	12.51
GFB 2	18.6[a]	19.3[a]	14.3[a]	9.4[a]	9.3[a]	8.9[a]	9.8[a]	89.6[a]	12.80
GFB 3	18.5[a]	19.1[a]	14.3[a]	9.3[a]	9.2[a]	8.8[a]	9.6[a]	88.8[a]	12.69

*Means in the same column with different superscripts are significantly different (P<0.05)

**Average of seven organoleptic properties

flour blends when compared with control and reached to 320 B.U and 10.7 in blend 3, respectively. On the other hand, a slight decreased of dough energy was noticed in gluten-free flour samples (from 33.1 for control to 24.6 cm^2 for blend1). Regarding the dough resistance to extension, it was also found an evident decrease (P<0.05) in all tested samples (from 85 to 25 m.m) as shown in Table 3.

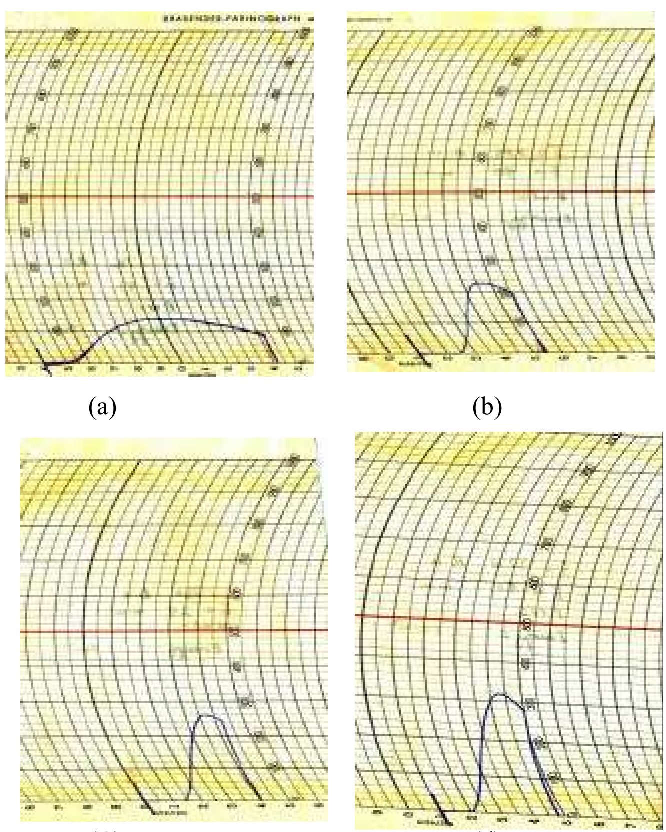
Chemical Composition of Gluten-free Breads (GFB): Table 4 shows that the moisture content was slightly increased in all GFB samples when compared with control. While, protein, fat and ash contents were obviously increased (P<0.05) in the same samples and reached to 12.94, 1.75 and 1.90 % in GFB3, respectively. On the other hand, a slight decrease in crude fiber and carbohydrate contents was noticed in the same samples. The control



(a) (b)

(c) (d)

Fig. 1: Farinogram: A Control sample (wheat flour dough). B, C and D gluten-free flour blends 1, 2 and 3, respectively



(a) (b)

(C) (d)

Fig. 2: Extensogram: A Control sample (wheat flour dough). B, C and D gluten-free flour blends1, 2 and 3, respectively

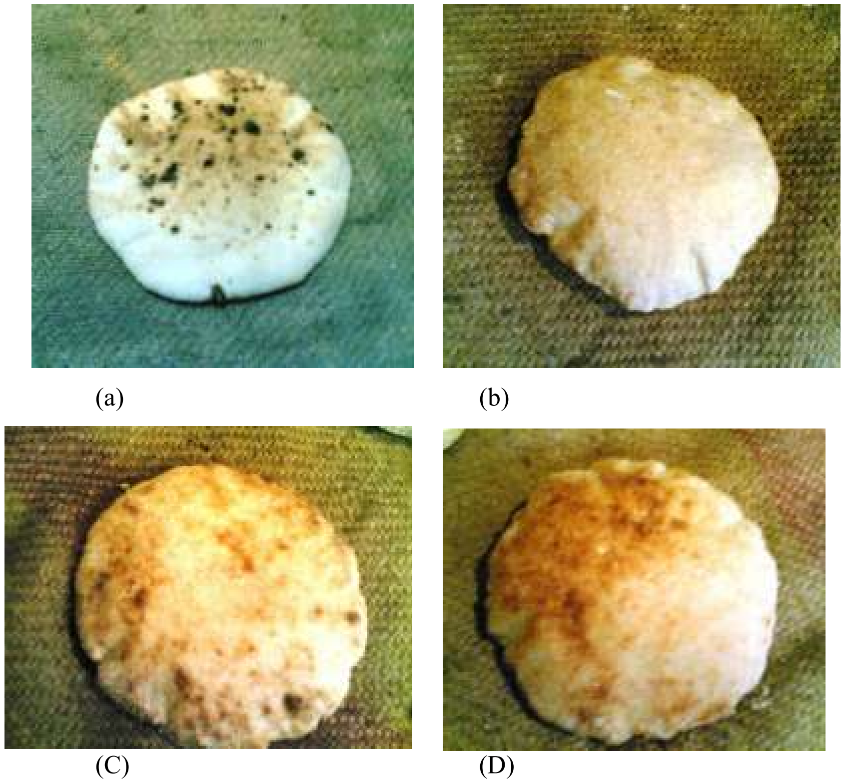


Fig 3: A Control sample (wheat flour bread). B, C and D GFB 1, 2 and 3, respectively.

sample was 1.00 and 76.28 % respectively, while GFB samples were ranged from 0.95 to 0.99% and 72.37 to 74.04 %, respectively.

Sensory Quality Criteria of Gluten-free Breads (GFB): GFB samples were sensory evaluated and compared with the control (wheat bread) as shown in Table 5 and Fig. 3. The Table showed that there were no significant differences among control and different GFB samples in the all organoleptic properties. With regard to the overall acceptability, GFB2 sample was the more acceptable (89.6 %) to the panelists, while GFB1 sample was the lowest acceptable sample (87.6 %).

DISCUSSION

Farinograph characteristics which determine the required water amount to form the dough and the dough properties showed that blended different gluten-free flours at different levels mainly increased the water absorption, arrival time, dough development and stability. The differences in water absorption are mainly caused by the greater number of hydroxyl group which exist in the fiber structure and allow more water interaction through hydrogen bonding as reported by Rosell *et al*. [18]. Also, Lazaridou *et al.* [8] indicated that the hydrocolloids addition improved the water absorption and rheological properties due to the hydrophilic nature of these biopolymers. Dough stability which indicate the dough strength was also increased, probably due to the formation of hydrogen bonds, also gelatinized rice starch has been shown to be capable of forming a three-dimensional network that retains gases and expands during the fermentation and baking of GFB [19].

Extensograph parameters of gluten-free dough samples showed progressive increase in elasticity and consequently proportional number when compared with control, due to addition of xanthan gum to starch pastes, which caused increase in viscosity, elasticity, restrict retrograding and syneresis of the starch based systems as reported by Chaudemanche *et al.* [20].

Chemical composition of GFB samples showed evident increase in protein, fat and ash contents in all GFB samples, probably due to addition of soy and chickpea flours substituting part of wheat flour in yeast leavened bread making, which are rich in protein content and the other components as reported by Fiquerola *et al.* [21]. On the other hand, a slight decrease in crude fiber and carbohydrate contents was noticed in the same samples when compared with control.

Sensory evaluation of GFB samples has revealed that there were no significant differences among control and GFB samples in all the organoleptic properties. Furthermore, GFB2 and 3 samples had the higher level of acceptance than GFB1 sample.

It could be concluded that Egyptian gluten-free bread from native starchy flours can be produced with low cost, which serve as energy source for celiac patients who can not consume diets containing gliadin and other similar proteins coming from wheat, rye, barley and oat.

REFERENCES

1. Hamer, R.J., 2005. Coeliac disease: background and biochemical aspects. Biotechnology Advances, 23: 401-408.
2. Laurin, P., M. Wolving and K. Falth-Magnusson, 2002. Even small amounts of gluten cause relapse in children with celiac disease. J. Pediatric Gastroenterol. Nutrition, 34: 26-30.
3. Hill, I.D., M.H. Dirks, G.S. Liptak, R.B. Colletti, A. Fasano and S. Guandalini, 2005. Guideline for the diagnosis and treatment of coeliac disease in children: recommendations of the North American Society for pediatric gastroenterology, hepatology and nutrition. J. Pediatric Gastroenterol. Nutrition, 40: 1-19.
4. Feighery, C., 1999. Celiac disease. British Medical J., 319: 236-239.
5. Fasano, A. and C. Catassi, 2001. Current approaches to diagnosis and treatment of celiac disease: an evolving spectrum. Gastroenterol., 120: 636-651.
6. Fasano, A., I. Berti, T. Gerarduzzi, T. Not, R.B. Colletti and S. Drago, 2003. Prevalence of celiac disease in at-risk and not-at-risk groups in the United States: A large multicenter study. Archives of Internal Medicine, 163: 286-292.
7. Seraphin, P. and S. Mobarhan, 2002. Mortality in patients with celiac disease. Nutritional Rev., 60: 116-118.
8. Lazaridou, A., D. Duta, M. Papageorgiou, N. Belc and C.G. Biliaderis, 2007. Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. J. Food Engineering, 79: 1033-1047.
9. Moore, M.M., M. Heinbockel, P. Dockery, H.M. Ulmer and E.K. Arendt, 2006. Network formation in gluten-free bread with application of transglutaminase. Cereal Chem., 83: 28-36.
10. Ribotta, P.D., S.F. Ausar, M.H. Morcillo, G.T. Perez, D.M. Beltramo and A.E. Leon, 2004. Production of gluten-free bread using soybean flour. Journal of the Sci. Food Agric., 84: 1960-1974.
11. Sanchez, H.D., C.A. Osella and M.A. de la Torre, 2004. Use of response surface methodology to optimize gluten-free bread fortified with soy flour and dry milk. Food Sci. Technol. Intl., 10: 5-9.
12. Ranhotra, G.S., R.J. Loewe and L.V. Puyat, 1975. Preparation and evaluation of soy-fortified gluten-free bread. J. Food Sci., 40: 62-64.
13. Gallagher, E., T.R. Gormley and E.K. Arendt, 2003. Crust and crumb characteristics of gluten-free breads. J. Food Engineering, 56: 152-161.
14. A.A.C.C., 2000. Bread firmness by universal testing machine. In Approved methods of the AACC (74-09), St. Paul, MN, USA: American Association of Cereals Chemists.
15. A.O.A.C., 1995.Official Methods of Analysis of the Association of official analytical chemists 6 th ed.Arlington Virginea, U.S.A.
16. Kramer, A. and B.A. Twigg, 1974. Fundamentals of quality control for the food industry, avi-Publishing Co, west Port, CT.
17. Steel, R.G. and J.H. Torrie, 1980. Principles and procedure of statistics analysis. Biometrical approach. 2 nd ed. MC Graw-Hill Book Co. INC New York, N.Y.
18. Rosell, C.M., J.A. Rojas and D.B. Benedito, 2001. Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloids, 15:75-81.
19. El-Dash, A.A., 1991. Molecular structure of gluten and viscoelastic properties of dough: a new concept, Proceedings of the first Brazilian congress proteins, UNICAMP, pp: 513-530.
20. Chaudemanche, C. and T. Budtova, 2008. Mixtures of pregelatinised maize starch and k-carrageenan: Compatibility, rheology and gelation. Carbohydrate Polymers, 72:79-589.
21. Fiquerola, E., M.A. Estevz and E. Castillo, 1987. Supplementation of wheat flour with chickpea (Cicer arietinum) flour. I. Preparation of flours and their properties for bread making. Arch Latiniom Nutrition, 37:378-387.