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Effects of Oat Flour on Dough Rheology, Texture and Organoleptic Properties of Taftoon Bread

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ABSTRACT

Wheat flour was substituted with oat flour by 0, 10, 20, 30, and 40% to investigate the effect on dough rheology and bread sensory quality and texture. Water absorption and dough development time in oat composite doughs increased with an increasing level of oat flour, whereas dough resistance, extensibility and bread firmness decreased. Dough softening increased with an increased level of oat flour while the addition of oat flour improved bread shelf life and reduced the yellowness of bread. Breads produced with up to 20% oat flour were stable and with good quality as indicated by sensory evaluation. Oat flour had larger particle size in comparison to wheat flour. Breads produced with 30% and 40% oat flour had a bitter after taste, unacceptable to the sensory panelists.

Keywords*:* Bread, Oat, Rheology, Sensory, Texture.

INTRODUCTION

There is a growing demand for a new generation of healthier food product that have good sensory qualities (Gomez, 1995). Nutritional supplementation of staple food products such as bread which is widely used as a major part of most people's diet, has become an effective means to alleviate malnutrition problems. Bread is one of the most important foods in the Iranian diet. Traditional breads in Iran are flat breads such as *taftoon*, *barbary*, *lavash* and *sangak* which are produced using wheat flours with different extraction rates usually 87%, 81%, 80-85% and 95-97%, respectively. However it is necessary to use supplementary ingredients which are familiar and acceptable to consumers, so that the final product is as similar in characteristics as possible to the unsupplemented food product (Krishnan, 1987). The potential use of cereal flours in bread making has been widely studied. Fortification of wheat flour with other cereal flours such as oat, improves the nutritional quality of the composite flours. Oat flour alone is not suitable for breadmaking due to the lack of gluten in its protein profile (Webster, 1986).

Oat is a cereal grain whose origins can be traced back to about 2000 B.C. in the Middle East and areas surrounding the Mediterranean Sea (Webster, 1986). Oat bran, possibly by virtue of its β-glucan content, exerts potentially beneficial physiological activity when consumed as part of the human diet. Chronic disease conditions, such as diabetes, atherosclerosis and digestive diseases, appear to be improved by inclusion of more fibre in the diet. The important nutritional attributes of oats relate to the lowering of blood cholesterol and sugar (Webster1986). Oat contains a high percentage of desirable complex carbohydrates which have been linked to reduced incidence of different kinds of cancers. The presence of total and free sugars in oats is very low in comparison to other cereal grains (Lambo, 2004).

Oats contain the best amino acid composition profile among all the cereal grains in addition to an overall high protein content

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(Lapve, 1994). Oat protein is uniquely different from other cereals. The major protein fraction in oats is the salt-soluble globulin, which is probably the primary reason for the better nutritive value of oats. The higher level of lysine in the globulin fraction than in the glutelin and prolamin fractions conteracts the better nutrious value of oats (Webster, 1986). Cereal proteins are generally considered to be limiting in lysine. Methionine, threonine, and isoleucine are secondary limiting amino acids in cereal proteins. The amino acid composition of oats is remarkably constant over a wide range of protein content with only a slightly negative correlation existing between total protein and lysine percentage. Oat proteins have good hydration and emulsifying properties and are heat stable, with oat globulin denaturation temperature about 114°C.

Whole-grain oats have the greatest percentage of fat among the major cereals with a good balance of the essential fatty acids, which are primarily unsaturated. The high content of oleic and linoleic acid, results in a favorable polyunsaturated to saturated fatty acid ratio of 2:2. Oat flour also has antioxidant properties. On an equal weight basis, the purified oat antioxidant had effectiveness equal to that of commonly used commercial antioxidants such as BHA and BHT (Molteberg, 1995).

Lipase, the major enzyme in oats, causes the rapid release of free fatty acids in damaged or milled oats which can result in off flavours. In industry the action of lipase is controlled by heating the oat groats. Oats also contain high amounts of biotin, thiamin, niacin and pantotenic acid. Oat flour has been shown to be a complex collection of volatile flavour components. Nitrogen heterocycles, formed from Maillard reactions and lipid oxidation products are the key compositional types of flavour volatiles. Heat induced reactions of precursors native to the oat groat are primarily responsible for the development of oat flavour during its normal processing into commercial food products.

Oat product flavor stability is dependent upon lipid composition and resistance to oxidation. The flavor instability of oats correlates directly with the appearance of low molecular weight lipid oxidation products and specifically with pentanal, hexanal, 2, 4 decadien-1-als, and 3, 5-octadien-2-ones (Webster, 1986).

In processing of oats for human food use, the hulls are removed and the interior portion is generally consumed. The main steps in oat processing are cleaning, hulling, steaming and flaking. In the cleaning step, dust, chaff, and other impurities are removed. In the hulling step, oats are graded by size and dried to permit the efficient removal of the hull and then the groats steamed. The two factors that differentiate oats from most other cereal ingredients are their whole-grain identity and their thermal processing requirement, which serve to limit their application potential (Webster, 1986).

MATERIALS AND METHODS

The wheat flour used in this experiment was a commercial bakers wheat flour milled from the “Roshan” variety with a 78% extraction rate. Oat grains from the “Canadian Calibre” variety were cleaned, heat treated, dehulled and blanched in a heating pan for one hour. Processed dehulled samples were milled into flour using a hammer mill. Composite flours were prepared in order to replace 0, 10, 20, 30 and 40% (w/w) of wheat flour with oat flour.

Analytical Procedures

Oat and wheat flours were analyzed according to AACC methods (1990) for moisture content (44-16), protein (46-12), lipid (30-10), ash (08-01) and crude fibre (33-17) (AACC, 1990).

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Rheological and Textural properties

Farinograms were determined using the AACC approved method 54-27 (AACC, 1990). Dough resistancy and extensibility were obtained using the extensograph fixtures of the Instron machine (model 1140). Measurements of bread firmness were obtained by using the puncture test with the Instron universal testing machine provided with a 50 N load cell (Replinger, 1985). A cylindrical probe (diameter 1.27 centimeters) cut the bread cubes (bread thickness of about 0.2-0.4 centimeter) which are placed between two plates with the speed of 50 mm/min and the force deformation curve was recorded. At this deformation level the crosshead was stopped. Shear strength was calculated using the following equation:

$$\text{Shear strength} = \frac{F}{\pi DT}$$

F: Force (gr)
D: Probe diameter (cm)
T: Sample thickness (cm).

Color Evaluation and Particle Size

Color of the composite flours were measured using Hunterlab (data color hunterlab production of Txt Flash Company). Results were expressed in the L, a, b color space. The particle size of the composite flours was determined according to AACC method 50-10 (AACC, 1990).

Bread Baking

Taftoon bread was prepared according to the formula given in Table 1. The ingredients were mixed in a Hobart mixer for 5 minutes (70 rpm). The resultant dough was punched and then fermented for 2 hours at 30-32°C and relative humidity of 85%. The dough was molded (the weight of each molded part was 50 gr), and then fermented for about 10 minutes. The molded doughs were sheeted by passing through the sheeting rools. Breads were baked in an industrial tunnel oven at 245-295°C for about 1.5 minutes, and then packed in polypropylene bags. Bread quality attributes were evaluated after 0, 24, 48, 72 hours storage, at room temperature and refrigeration temperature (4°C).

Table 1. Bread formula.

Ingredients	Content
Flour	1000 (gr)
Salt	1.5 (%)
Sugar	1 (%)
Yeast	1 (%)
Fat	1.5 (%)
Ascorbic acid	60 ppm

Sensory Evaluation

Sensory evaluation of breads were conducted with five samples of wheat bread (control bread), and breads with 10, 20, 30 and 40% of oat flour, by multiple comparison tests with 12 panelists (university students which were trained). Each sample was coded a, b, c, d and e. Each panel member was permitted to form his judgment of the samples individually on the basis of color, flavor and texture. Tests were conducted at the same time of the day, and under uniform conditions of temperature, humidity and light. Panelists were asked to give the scores between 1 to 5 to the coded samples, with 1 related to the best sample and 5 to the worst one. The significance of differences between the total scores of the control and treated samples were evaluated using multiple comparison tables (Kraumer, 1960).

Statistical Analysis

Results were compared with a factorial test as a random design (samples were selected randomly) with 4 replications. LSD tests were used to compare the mean squares of the rheological and textural characteristics of flat breads. A multiple comparison test is used for analysis of organoleptic properties.

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RESULTS AND DISCUSSION

Table 2 summarizes the average of moisture, protein, fat, crude fibre and ash of the oat and wheat flours. The protein and fat levels of oat flour were higher than wheat flour, however the moisture content of wheat flour was higher than oat flour. The heat treatment of oats was responsible for these differences. Higher levels of crude fibre and ash are associated with whole oat flour and presence of oat bran particles. Table 3 indicates average of shear strength in control bread and oat supplemented breads stored at room temperatures and 4°C. The 40% oat flour supplemented bread had a significantly softer texture than all other breads. By increasing the oat flour level, the hardness of the breads decreased. This probably due to the higher levels of fat from oats compared with wheat (see Table 2). Fats have softening properties and act as a lubricant in bread (Rogers, 1988) Also, the dilution of wheat gluten with the addition of oat flour affects bread texture (Pomeranz, 1971).

The crumb firmness evaluation after 72 hours storage showed that oat supplementation delayed bread staling. The effect was notable when oat level was increased from 10% to 40%. The high level of fat which can make complexes with amylose reduces the rate of staling (Pomeranz, 1971). Oat flour also has higher water absorption and water retention values, so the breads had a higher moisture level which delays staling (Rosell, 2001). Kim (1997) observed that increasing the protein content of composite flours, diluted the starch and decreased the rate of staling. However, as can be seen in Table 3, chill temperature increased bread staling (D' Appolonia, 1981).

Oat flour had pronounced effects on dough rheology properties. Farinograph characteristics and absorption increased with increasing the oat flour proportion in the formula (D' Appolonia, 1990). Oat β-glucan played an important role in increasing water absorption and bread moisture. In general, dietary fibre increases water absorption and mixing toler-

Table 2. Moisture, protein, fat, crude fibre and ash of oat and wheat flours.

Flour	Moisture (dry weight)%	Protein%	Fat %	Crude fiber %	Ash %
Wheat flour	8.92	11.19	1.95	1.89	1.68
Oat flour	5.61	16.92	6.10	4.92	1.80

Table 3. Effects of oat flour on bread firmness.

	Sample	Shear strength(gr cm^{-2}) Time (hr)			
		0	24	48	72
Room temperature	Wheat	609.73a [a]	679.54a	767.27a	987.12a
	10%oat	509.97b	522.42b	616.97b	745.88b
	20%oat	473.57c	479.04c	554.27c	661.21c
	30%oat	432.72d	463.52d	526.96d	626.17d
	40%oat	414.73e	421.23d	454.66e	571.22d
Chill temperature (4 Ċ)	Wheat	734.77a	1033.02a	1452.59a	1695.171a
	10%oat	601.98b	768.63b	1128.76b	1160.599b
	20%oat	579.08c	684.25b	793.57c	923.463c
	30%oat	527.15d	597.77c	662.47d	751.557d
	40%oat	488.88e	539.55c	552.09d	602.017e

[a] In each column averages with the same characters (a, b, c, d and e) have no significant differences at 5%level according to LSD test.

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Table4. Farinograph characteristics results of dough with different percent of out flour.

Factor / Flour	Water Absorption (%)	Dough Development Time (min)	Dough Stability Time (min)	Degree of softening after 20 min (Brabender units)
Wheat flour	66.5	4	4	70
10%oat flour	68.5	4	1.75	80
20%oat flour	70.7	4	1.70	80
30%oat flour	71.4	5	1.75	85
40%oat flour	74.8	5.5	1.65	100

Table 5. Dough resistancy and extensibility characteristics results.

Flour	Dough resistancy	Dough extensibility
Wheat flour	375	86
10%oat flour	311	81
20%oat flour	168	80
30%oat flour	166	79
40%oat flour	148	78

ance. Rossel *et al*. (2001) expected such a result due to the hydroxyl groups of the fibre structure which allows more water interaction through hydrogen bonding. Oat starch has higher water absorption than other cereals (Rossel, 2001). This moisture retention property of oats keeps breads fresher for longer periods of time (Gomez, 1995; Ozboy, 1997). Dough development time increased whereas dough stability decreased as the oat flour level increased. The longer development time of the oat-wheat doughs might be due to the higher water absorption and larger particle size of oat flours.

The degree of softening, increased with the increasing oat flour level (Table 4). The same result was obtained by Zhang (1998).

Extensograph results showed dough resistance and dough extensibility decreased as a consequence of oat flour addition, probably due to the effects of gluten dilution, water retention and higher levels of fat.

The addition of oat flour resulted in a loss of flour brightness (L*) and a decrease in flour yellowness (b*), probably due to oat bran colour in the flour (Table 6). The redness of the flour was not changed with the addition of oat flour (a*). The particle size of oat flours was larger than wheat flour and it was also due to using whole oat flour and the presence of bran particles in the flour (Webster, 1986).

The results of sensory evaluation showed that the panelists preferred breads without oat flour. As shown in Table 7, treatments T2 and T3 have no significant difference because there is no significant difference between total scores 25-47 in multiple comparison test by 12 panelists with 5 treatments (according to the multiple comparison table). T1 was the best treatment, and T4 and T5 were the worst. T2 and T3 were moderate, and so were tested again by the 12 panelist (total scores are shown in Table 8). As can be seen, T2 and T3 have no significant difference because there is no significant difference between the total scores 14-22 in the multiple comparison test by 12 panelists and 2 treatment (according to multiple comparison table).

Results indicated that breads with 10% and 20% oat flour were preferred by the panelists.

Breads with 30% and 40% oat flour had a longer shelf life but, because of their bitter taste, were not preferred. After 48 hours, although breads with 30% and 40% oat flour (T2 and T3) had less staling, because of their

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Table 6. Effects of oat flour on flour brightness (L) yellowness (b) and redness (a).

Flour	L factor (L*)	a factor (a*)	b factor (b*)
Wheat	88.39a	1.95a	13.39a
Whole oat	87.34c	1.40b	11.90c
Wheat 10%oat	87.75b	1.90a	13.30a
Wheat 20%oat	87.75b	1.82a	13.28a
Wheat 30%oat	87.69b	1.79a	12.82a
Wheat 40%oat	87.37c	1.73a	12.72b

In each column averages with the same characters (a,b,c) have no significant differences at 5%level according to LSD test.

Table 7. Results of sensory evaluation of breads with different percent of out flour (step1).

Characteristic	Wheat flour T1	Wheat flour +10%oat T2	Wheat flour +20%oat T3	Wheat flour +30%oat T4	Wheat flour +40%oat T5
Flavour	18	28	30	48	55
Colour	18	30	28	49	55
Texture	21	25	34	48	52

Figures are the total scores of 12 panelists. They gave 1 to the best and 5 to the worst sample. There is no significant difference between total scores 25-47 in the multiple comparison test.

Table 8. Results of sensory evaluation of breads with 10 and 20 percent of out flour (step 2).

Characteristic	Wheat flour +10%oat T2	Wheat flour +20%oat T3
Flavour	13	23
Colour	19	17
Texture	16	20

Figures are the total scores of 12 panelists. They gave 1 to the best and 2 to the worst sample. There is no significant difference between total scores 14-22 in multiple comparison test.

undesirably soft texture and bitter taste, were not preferred by the panelists.

Native oat enzymes may be a potential cause of flavour instability in improperly processed oat products. Oat lipase activity is high enough to render lipids in oat and causes an objectionable developing soapy taste, unless inactivated during processing (O'Conner,1992). Lipoxygenase can have two effects on flavor quality. Firstly, because of the high content of PUFA in oat oil, the enzyme can lead to the development volatile aldehydes and ketones. Moreover enzymes can oxidize lipids resulting in non-volatile bitter components being produced. Bitterness in stored oat flour has been attributed to the formation of specific hydro-monoglycerids, so that heat treatment is necessary to inactivate the enzymes (Molteberg, 1995; Webster,1986). In this study, it was observed that oat flour at levels of 10% and 20% can be supplemented for wheat flour without any adverse effect on bread taste.

CONCLUSION

The characteristics of wheat flour and dough were modified to different extents by the addition of oat flour. Oat flour had pro-

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nounced effects on dough properties yielding a higher water absorption and dough development time and lower dough stability and extensibility compared with the control flour. Oat flour addition at levels of 30% and 40%, also affects the texture of bread and produced an undesirably soft bread with a bitter taste. Addition of 10% and 20% oat flour can provide acceptable breads. Furthermore, these breads, have improved nutritional values and longer storage time along with acceptable softness and taste.

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بررسی اثرات استفاده از یولاف بر خصوصیات رئولوژیکی،ارگانولپتیکی و بیاتی نان تافتون

م. صالحی فر و م. شاهدی

چکیده

در این پژوهش آرد گندم به نسبتهای ۰،۱۰، ۲۰، ۳۰ و ۴۰ درصد با آرد یولاف جایگزین شد و از این طریق اثرات افزودن آرد یولاف برخصوصیات حسی، رئولوژیکی وبیاتی بافت نان بررسی گردید. نتایج نشان داد که با افزایش درصد آرد یولاف، درصد جذب آب آرد وهمچنین زمان گسترش خمیر افزایش یافت در حالیکه مقاومت وکشش پذیری خمیر کاهش پیدا کرد. افزایش درصد آرد یولاف موجب کاهش سفتی نان و خمیر حاصل گردید. افزودن آرد یولاف به فرمولاسیون تهیه نان، زمان ماندگاری محصول و زردی رنگ آن را کاهش داد. اندازه ذرات آرد یولاف در مقایسه با آرد گندم درشت تر بود. نانهای تولید شده از مخلوط آرد گندم و ۳۰ درصد و ۴۰ درصد آرد یولاف دارای طعم تلخ قابل ملاحظه بود که برای ارزیابها قابل پذیرش نبود.

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