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Effect of Wheat Flour Supplementation with Oat Flour on Bread Quality

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Abstract

Oats contain a high percentage of protein with balanced composition of amino acids which have proved them highly nutritive value in comparison to other cereals. The current study was designed to evaluate the quality of bread manufacture from mixtures of wheat and oats flour by75%, 25%, respectively and from wheat flour only by determination chemical composition, rheological properties (Farinograph and extensograph), anti-nutritional factors (phytic acid, tannins, oxalates, saponins and trypsin inhibitor), physical properties and sensory evaluation. The obtained results indicated that the highest protein, carbohydrates and energy value recorded with wheat flour samples while, the samples the highest fat, fiber and ash recorded with oat flour. Oats flour contains different amounts of anti-nutritional factors such as phytic acid, tannins, oxalates, saponins and trypsin inhibitor. The mean values were 31.7, 0.75, 7.75, 0.53, 2.10 and 50.1 mg/g, respectively. Rheological properties indicated that the highest water absorption, arrival time, dough development and degree of softening recorded for oats flour sample. The highest dough stability recorded for 75% wheat flour + 25% oat flour and *verse versa* for wheat flour. The highest Elasticity and P.N recorded for oats flour. The highest dough extensibility and dough energy recorded for wheat flour. The highest protein and carbohydrates contents recorded for control bread. The highest fat, fiber, ash and energy value contents recorded with bread with 25% oat flour. The highest bread weight and bread volume

recorded with control bread (100% wheat flour). On the other hand, bread yield and total baking loss recorded the highest values with bread (75% wheat flour + 25 % oat flour). At zero time of storage period all tested sensory properties of oats bread recorded a high score (9 - 9.5). At the end of cold storage for 4 weeks all tested sensory properties of all tested bread samples markedly decreased with significant differences when compared to zero time of cold storage.
Key words: Oats flour, wheat flour and Bread quality.

Introduction

Oat belongs to the kingdom Plantae and its binomial name is *Avena sativa*. It is a member of to *Poaceae* family **Davidson *et al.*, (1991)**. It is a self-pollinating hexaploid crop. Due to its rich nutritional composition, it is the sixth largest crop growing in the world following wheat, maize, rice, barley and sorghum. Oat is 'Rabi' crop, mainly harvested in temperate regions. It is rapidly growing crop and is used as multi-cut fodder especially for the bovine cattle. Oats has numerous uses in foods as rolled or crushed into oat meal, which can be consumed as porridge and may be added in bakery products such as cookies and bread **(Butt *et al.*, 2008)**.

Oats provide more protein, fiber, iron and zinc than other whole grains. They have high nutritive value both for people and animals because of good taste and an activity of stimulating metabolic changes in the body. Oats were reported to be unique among cereals as they are therapeutically active against diabetes, dyslipidemia, hypertension, inflammatory state and vascular injury than other grains which are predominantly insoluble, such as wheat or rice. This review highlights the nutritional value of oats, β-glucan in them as biologically defense modifier, their mode of action against various diseases and enlists various fermented and non-fermented products of oats available in market **(Sangwan *et al.*, 2014)**.

Oat is the only cereal in which the major portion of the grain protein is soluble in salt and thus classified as globulins and only a small proportion of water soluble albumins and alcohol soluble prolamin. Phenol compounds present in oats and its by-products have a considerable antioxidant potential **(Sobotka *et al.*, 2012)**.

Oat beta-glucan which is a soluble dietary fiber slows down the rate of cholesterol absorption and thus facilitates the improvement of gastrointestinal functions and glucose metabolism. Beta-glucan along with insoluble fiber delays the overall absorption of cholesterol and glucose **(Aman *et al.*, 2004)**.

Oats are generally considered ―healthy", being touted commercially as nutritious which has led to wider appreciation of oats as human food. Oat grout or whole grains (after removal of hull) contain all three parts of the grain – the germ, endosperm and bran, rich in all valuable nutrients. In comparison to other cereals, these are characterized constitute a large amount of total protein, carbohydrates (primary starch content), crude fat, dietary fiber (non-starch), unique antioxidants and considerable vitamins and mineral content. A good taste and an activity of stimulating metabolic changes in the body make nutritive value of oats high for both people and animals **(Peterson, 2004)**.

Oat β-glucan as a functional ingredient. In addition to β-glucan, oat contains other dietary fibers, vitamins, minerals, antioxidants, sterols, and other bioactive compounds, proteins of high lysine content and oil of favorable ratio of polyunsaturated to saturated lipid. These compounds can help to prevent of some serious diseases such as some cancers, cardiovascular problems, high serum cholesterol level and heart disease **(Sudha *et al.*, 2007)**.

It is well known that dietary oat have been reported to reduce serum cholesterol and obesity, prevent coronary heart disease, and improved symptoms of diabetes. Numerous studies indicated that oat have high contents of β-glucan which is beneficial to human health, as it is considered to be responsible for these health benefits. Oat contains 2.0 - 7.5% β-glucan, 13 - 20% protein, 2 - 12% crude fat, and about 60% starch **(Aro *et al.*, 2007)**.

In Egypt, the total yield of bread grains does not satisfy the needs of the country. The total production of wheat grains covers only about 55% of the total needs. The way to overcome this problem is to search for the native cereal sources which could be used with wheat flour bread making. In Egypt, as well as the Middle East, the most popular type of bread is a flat (baladi bread), circular loaf (1 cm thickness, 10 to 30 cm diameter) consisting of two layers. It is commonly made from high extraction flour (82%) and prepared by a straight dough method. Balady bread dough is softer (70–75% water), fermented to 2 h and baked at a substantially higher temperature (400–500ºC) for 1–2 min **(Mousa *et al*., 1979)**.

The main problem regarding the uses of oats in higher quantities is inferior baking quality due to the lack of gluten proteins and the high content of β-glucan and other dietary fibers. In wheat dough, hydration and mixing results in the development of a gluten-stabilized matrix which retains the carbon dioxide produced by yeast fermentation. The development of gas during the proofing and baking process is responsible for the development of the volume and texture of the bread by heat-setting the gluten network as well as gelatinization of the starch **(Hoseney *et al*., 2007)**.

The rheological properties of wheat oat or all oat dough's during mixing have been studied by farinograph and mixograph. Increased water absorption and decreased stability of the dough with increased proportion of oats were detected **(Mariotti *et al*., 2006)**.

Oats (*Avena sativa L*.), have received increased interest in human foods due to the dietary benefits which associated with β-glucans. However, the use of oats in baked products has been limited due to the inability of oat flour to form cohesive, visco-elastic dough that can retain gas, as that found in the gluten network of wheat dough. Addition of wheat gluten to oat flour improves the processing properties of the dough and the quality of the final product **(Flander *et al*., 2007)**. Thereupon, the effect of wheat flour supplement with oat flour on bread quality was studied.

2. Materials And Methods

Material:

The materials used in the investigation and their sources were as follows:

Wheat flour (72% extraction) and oat flour were purchased from local market of Shibin El-Kom city, Menoufia Governorate. Active dry yeast, buffalo milk and salt were also obtained from local market, at Shibin El-Kom city, Menoufia Governorate.

Methods

Technological methods

Preparation of bread

Bread was produced as baladi bread from wheat flour 72% extraction and water replaced by milk but the percentage of each compressed yeast and sodium chloride was decreased to 1%, 4.16 % butter , 1.66 % corn oil, the relative humidity in the fermentation was 65%. Also, dough supplemented with ferrous sulfate (16.6 mg/1000g). The times for fermentation were 30 min. The flat dough was baked in oven at 380-400°C for 3-4.5 min. The loaves were allowed to cool at room temperature before sensory evaluation **(Hamouda, 2015)**.

Analytical methods

Moisture, Protein (N x 6.25 Keldahl method), fat (hexane solvent, Soxhielt apparatus), fiber and ash were determined according to the method recommended by **A. O. A. C. (2010)**. Carbohydrate calculated by differences as follows:

% Carbohydrates = 100 - (% moisture + % protein + % fat + % ash + % fiber).

Energy value was estimated by the sum of multiplying protein and carbohydrates by 4.0 and fat by 9.0 according to **FAO (1982)**.

Anti–nutritional factors

The tannin content was determined using the Vanillin-HCl reagent method of **Burns, (1971)**. The oxalate content of the samples was determined using the potassium permanganate titration method of **Dye, (1956),** while the phytic acid content was determined using the method of **Mc Cance and Widdowson, (1935)**.

Physical properties of bread

Bread characteristics or baking qualities were evaluated as method described of **See *et al.*, (2007)** through measuring loaf height, loaf volume and specific volume, 30 min after removal from the oven. Loaf volume was determined using the rapeseed displacement method, bussing alfalfa seeds instead of rapeseeds. Each loaf (n=6) was weighed and the volume was measured 60 min after being taken from the oven. The specific loaf volume was reported as cm3/g of the loaf.

Sensory evaluation

Before and after storage period, samples of bread were subjected to sensory tests by ten judges according to **Watts *et al.*,**

(1989). Judging scale for colour, aroma, taste, texture and overall acceptability was as follows: very good 8-9, good 6-7, fair 4-5, poor 2-3 and very poor 0-1.

Statistical analysis

Statistical analysis were performed by using computer program statistical package for social science (SPSS), and compared with each other using the suitable test. All obtained results were tabulated. Statistical analysis has been achieved using IMB-P-C computer by SPSS program **(SPSS, 1998)**.

Results And Discussion

Chemical composition of wheat flour and oat flours

Data presented in Table (1) show the chemical composition of wheat flour (72% extraction) and oat flour as dry weight. It is clear to be noticed that the highest protein, carbohydrates and energy value recorded with wheat flour. The mean values were 14.20, 83.39% and 401.07 kcal/100g, respectively. While, the highest fat, fiber and ash recorded with oat flour. The mean values were 6.10, 6.73 and3.38%,, respectively. These results are in agreement with **Sadiq *et al.*, (2008)**. They reported that oat flour contained two times more ash, and three times more fat, than both analysed bread flours. It should be stressed, that oat fat is rich in polyunsaturated fatty acids, and its digestibility is higher than in other cereals. Also, **Usman *et al*., (2010)** mentioned that oat bran possess 6.03% moisture,15.23% protein, 55.38% carbohydrate, 14.13% total dietary fiber (TDF), 4.5% β-glucans 6.8% fat and 2.43% ash.

Anti-nutritional factors of oats flour

Data presented in Table (2) show the anti-nutritional factors of wheat and oats flour. It is clear to be noticed that wheat flour recorded the highest values of phytic acid, saponins and trypsin inhibitor when compared with oats flour. The mean values were (41.7mg/g, 2.65 mg/g and 54.1 TIU/g), and (31.7mg/g, 7.75mg/g, 2.1mg/g and 50.1TIU/g), respectively. On the other hand, the highest tannins and oxalic acid recorded for wheat oats. The values were 2.85 mg/g and 0.45%, respectively. These results are in agreement with **Satinder *et al.*, (2011)**. They mentioned that the presence of anti-nutritional factors in brans is one of the major drawbacks, limiting their nutritional and food quality. Phytic, trypsin inhibitor, oxalates, tannins and polyphenols are the major undesirable constituents which restrict direct utilization of brans in diet. Also, **Khan *et al.*, (2009)** reported that the presence of anti-nutritional components in different cereal brans. All cereal brans had a wide range of phytic acid (27.69-42.82 mg/g). High oxalate content was observed in rice bran and minimum in oat bran (0.309 to 0.445%). Oat bran had a minimum amount of saponin, while a higher concentration of saponins were found in rice bran (1.99 to 3.30 mg/g). Trypsin inhibitor activity was 49.74-54.25 TIU/g.

Farinograph of wheat and oats flour:

Data presented in Table (3) show the farinograph of wheat and oats flour and its mixtures (75% wheat flour + 25% oat flour). The obtained results indicated that the highest water absorption (%), arrival time (min), dough development (min) and degree of softening (B.U) recorded for oats flour sample. The values were 75 %, 3.5 min., 4.5 min, 100 B.U., respectively. While, the highest dough stability recorded for 75% wheat flour + 25% oat flour. The value was 17 min. On the other hand, wheat flour recorded the lowest water absorption (%), arrival time (min), dough development (min), dough stability and degree of softening (B.U). The values were 58.5%, 1.0 min., 1.5 min., 12 min. and 40 B.U., respectively. These results are in agreement with **Zhang *et al.*, (1998)**. They maintained that the increased water absorption by wheat-oat flour blends was due to a high B-glucan content of oats. Also, **Subda *et al.*, (1998)** reported that 5-20% oat flour additive shortened the peak time by 1 min, compared to wheat dough. Oat bran and flakes appear to have enriched the dough with water absorptive bran particles responsible for the extension of the time of dough formation.

Extensograph of wheat and oats flour:

Data given in Table (4) show the extensograph of wheat and oats flour and its mixtures (75% wheat flour + 25% oat flour). The obtained results indicated that the highest elasticity (B.U) and P.N recorded for oats flour. While, the highest dough extensibility (mm) and Dough energy (cm^2) recorded for wheat flour. The values were (380 BU & 5.84) and (175 mm & 85 cm^2), respectively. These results are in agreement with **Lapvetelainen *et al.*, (1994)** they reported that dough extensibility and resistance measured with an extensigraph decreased following the addition of 3 and 6% of high-protein oat flour to wheat flour. Also, **Gambuoe *et al.*, (2001)** demonstrated that dough extensibility was greater in oat flour blends (172 mm) than in blends containing bran and flakes (166 and 162 mm, respectively).

Chemical composition of oat bread:

Data given in Table (5) show the chemical composition of bread supplement with oat flours as dry weight (D/W). It is clear to mention that the highest protein and carbohydrates contents were recorded for control bread (100% wheat flour). The mean values were 11.7 and 82.33% as dry weight, respectively. While the highest fat, fiber, ash and energy value contents recorded with bread with 25% oat flour. The mean values were 6.85, 8.05, 1.59 % and 395.69 kcal/100g as dry weight, respectively. These results are in agreement with **Sadiq *et al.*, (2008)** they reported that oat flour contained two times more ash, and three times more fat, than both analysed bread flours. It should be stressed, that oat fat is rich in polyunsaturated fatty acids, and its digestibility is higher than in other cereals. **Angioloni and Collar, (2012)** they reported that oat is characterized by a high content of lipids, 2-3 times more than other cereals and a high protein content that can be a great exogenous source of amino acids.

Physical properties of bread:

The physical properties of bread supplemented with oats flour are shown in Table (6). It is obvious that the highest bread weight and bread volume recorded with control bread (100% wheat flour). The mean values were 214 g and779cm^3, respectively. On the other hand, bread yield and total baking loss recorded the highest values with bread (75% wheat flour + 25 % oat flour). The mean values were 678 % and 15.9 %, respectively. These results are in agreement with **Flander *et al*., (2007)** They found that the use of oats in baked products has been limited due to the inability of oat flour to form cohesive, visco-elastic dough that can retain gas, as that found in the gluten network of wheat dough. Addition of wheat gluten to oat flour improves the processing properties of the dough and the quality of the final product.

Sensory properties of oats bread during cold storage at 5°C for 1 months:

Data presented in table (7) show the sensory properties of oats bread during cold storage at 5°C for 1 month. It is clear to be noticed that at zero time of storage period all tested sensory properties (color, flavor, taste, texture, crispness, appearance, mouth feeling and overall acceptability) of oats bread recorded a high score (9 - 9.5). With progress of cold storage for two weeks all tested sensory properties of oats bread samples slightly decreased. The values ranged from 8.2 to 8.8. While, at the end of cold storage for 4 weeks all tested sensory properties of oats bread samples markedly decreased with significant differences when compared to zero time of cold storage. The values ranged from 7.8 to 8.1. These results are in agreement with **Surówka, (2002)** they reported that staling process was monitored by hardness, chewiness, and resilience of the crumb during 72 hours of storage. Hardness of the wheat-oat loaves was not significantly different to control, both on the day of baking, as well as after storage..On the day of baking wheat-oat bread revealed significantly lower chewiness as compared to standard, but after storage both loaves were comparable in this aspect.

Also, similar results are in agreement with **Flander *et al*., (2007)** they mentioned that bread with the share of residual oats flour received high consumer acceptance (37 points), comparable to control bread (38 points) despite of lower volume. The applied amounts of oats flour did not influence the moisture content and texture profile during storage.

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Table (1): Chemical composition of wheat flour (72% extraction) and oat flour (g/100g DW).

Components	Wheat flour	Oats flour
	Mean ± SD	Mean ± SD
Moisture %	-----	-----
Protein %	14.20±0.2	13.69±0.23
Fat %	1.19±0.11	6.10±0.10
Fiber %	0.63±0.31	6.73±0.06
Ash %	0.59±0.20	3.38±0.12
Carbohydrates %	83.39±0.08	70.10±0.20
Energy value (Kcal/100g)	401.07	390.06

D/W = Dry weight W/W= Wet weight

Mean under the same column bearing different superscript letters are different significantly ($p \leq 0.05$).

Table (2): Anti-nutritional factors of oats flour

Anti-nutritional factors	Phytic acid (mg/g)	Tannins (mg/g)	Oxalates (%)	Saponins (mg/g)	Trypsin Inhibitor (TIU/g)
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Wheat flour	41.70±0.30	2.85±0.11	0.45±0.10	2.65±0.20	54.10±0.12
Oats flour	31.7±0.10	7.75±0.12	0.53±0.01	2.10±0.31	50.1±0.11

Mean under the same column bearing different superscript letters are different significantly ($p \leq 0.05$).

Table (3): Farinograph of wheat flour, oats flour and their mixture

Samples	Water absorption (%)	Arrival time (min.)	Dough development (min.)	Dough stability (min.)	Degree of softening (B.U)
Wheat flour	58.5	1.0	1.5	12.0	40.0
Oats flour	75.0	3.5	4.5	2.0	100.0
Wheat flour + oats flour (75% +25%)	59.5	1.5	2.0	17.0	00.0

Table (4): Extensograph of wheat flour, and oats flour their mixture

Samples	Elasticity (B.U)	Dough extensibility (mm)	PN	Dough energy (cm^2)
Wheat flour	280	175	1.60	85
Oats flour	380	65	5.84	28
Wheat flour + oats flour (75% +25%)	350	115	3.04	25

Table (5): Chemical composition of wheat bread and wheat bread supplements with oat flours (g/100gD/W)

Components	Control bread (100% wheat flour)	Bread supplements with 25% oat flour
Moisture %	-----	-----
Protein %	11.70 ±0.03[a]	11.48 ±0.05[a]
Fat %	1.59 ±0.10[b]	6.85 ±0.010[a]
Fiber %	3.60 ±0.04[b]	8.05 ±0.10[a]
Ash %	0.78 ±0.02[b]	1.59 ±0.01[a]
Carbohydrates %	82.33±0.01[a]	72.03±0.00[b]
Energy value (Kcal/100g)	390.43±0.02[a]	395.69±0.01[a]

D/W = Dry weight

Means under the same raw bearing different superscript letters are different significantly ($p \leq 0.05$).

Table (6) Physical properties of bread supplemented with oats flour

Type of bread	Weight of bread (g)	Volume of loaf bread (cm^3	Yield of bread (%)	Total baking loss (%)
Bread control (100% Wheat flour)	214.0±20[a]	779.0 ±20[a]	142.0 ±0.3[b]	14.50 ±0.2[b]
Bread (75 % Wheat + (25%) oat flour	140.4±0.4[b]	210.0 ±0.30[b]	678.0 ±0.4[a]	15.90 ±0.2[a]

Mean under the same column bearing different superscript letters are different significantly ($p < 0.05$).

Table (7): Sensory properties of bread during cold storage at 5°C for 1 months

Items / Storage period (weeks)	Color	Flavor	Taste	Texture	Crispness	Appearance	Mouth feeling	Overall acceptability
Zero time (0)	9.0 [a]	9.0 [a]	9.0 [a]	9.0 [a]	9.0 [a]	9.2 [a]	9.2 [a]	9.5 [a]
1	8.7 [a]	8.5 [a]	8.7 [a]	8.5 [a]	8.6 [a]	9.0 [a]	9.0 [a]	9.2 [a]
2	8.3 [ab]	8.3 [ab]	8.5	8.2 [ab]	8.3 [ab]	8.8 [a]	8.8 [a]	8.7 [a]
3	8.0 [ab]	8.0 [ab]	8.3 [ab]	8.0 [ab]	8.0 [ab]	8.5 [ab]	8.5 [ab]	8.5 [ab]
4	7.8	7.8[bc]	8.0 [ab]	7.8 [c]	7.8 [c]	8.0 [ab]	8.1 [ab]	8.0 [ab]

Mean under the same column bearing different superscript letters are different significantly ($p \leq 0.05$).

تأثير تدعيم دقيق القمح بدقيق الشوفان على جودة الخبز

أميرة عبد الحميد عبد الرشيد ــ عماد محمد الخولى ـ ليلى أحمد حلمى البديوى
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يحتوي الشوفان على نسبة عالية من البروتين وتركيبة متوازن من الأحماض الأمينية التي لها قيمة غذائية عالية بالمقارنة مع غيرها من الحبوب .وقد تم فى هذه الدراسة تقييم جودة الخبز الناتج من مخلوط دقيق القمح و الشوفان بنسبة ٧٥ % +٢٥٪ على التوالى بالمقارنة بالخبز من دقيق القمح من خلال تقدير التركيب الكيميائي والخواص الريولوجية (الفارينوجراف والأكستنسوجراف)، والعوامل المضادة للتغذية (حمض الفيتيك، التانينات، الأوكسالات، السابونين ومثبط التربسين)، الخصائص الطبيعية والحسية. وأشارت النتائج المتحصل عليها أن أعلى قيم من البروتين، والكربوهيدرات، والطاقة سجلت مع دقيق القمح. في حين أعلى قيم من الدهون والألياف والرماد سجلت مع دقيق الشوفان. وجد أن دقيق الشوفان يحتوي على نسب مختلفة من العوامل المضادة للتغذية مثل حمض الفيتيك، التانينات، الأوكسالات، الصابونين ومثبط التربسين.حيث كانت القيم ٣١.٧، ٠.٧٥، ٧.٧٥، ٠.٥٣، ٢.١٠ و ٥٠.١ ملج / جم، على التوالي .وأشارت الصفات الريولوجية أن أعلى امتصاص للماء، وزمن الوصول والتطور للعجينة ودرجة المرونة سجلت لعينة دقيق الشوفان .في حين أعلى ثبات للعجينة سجلت مع عينة ٧٥٪ دقيق القمح + ٢٥٪ دقيق الشوفان والعكس مع دقيق القمح .أعلى مرونة و P.N سجلت مع دقيق الشوفان, في أعلى قيم لتمدد العجينة و الطاقة للعجينة سجلت مع عينة دقيق القمح. أظهر التركيب الكيماوى للخبز أن أعلى قيمة من البروتين والكربوهيدرات سجلت لعينات الخبز الكنترول (١٠٠٪ دقيق قمح). في حين أن أعلى قيم من الدهون، والألياف والرماد والطاقة سجلت مع عينة الخبز (٢٥٪ من دقيق الشوفان+ ٧٥% دقيق القمح). واظهرت الصفات الطبيعية أن أكبر وزن وحجم للخبز سجلت مع عينة الخبز الكنترول (١٠٠٪ دقيق القمح). ومن ناحية أخرى، سجل العائد للخبز والخسارة الكلية للخبز أعلى القيم مع عينة مخلوط الخبز (٧٥٪ دقيق القمح + ٢٥٪ من دقيق الشوفان). في بداية فترة التخزين سجلت كافة الصفات الحسية (لعينة خبز الشوفان درجات عالية (٩-٩،٥). في حين في نهاية فترة التخزين البارد لمدة ٤ أسابيع حدث انخفاض بشكل ملحوظ لكل الصفات الحسية مع وجود فروق معنوية كبيرة إذا ما قورنت ببداية التخزين البارد لكل العينات المختبرة.

الكلمات الافتتاحية: دقيق القمح ـ دقيق الشوفان ـ جودة الخبز