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EFFECT OF ADDING BARLEY AND OAT FLOUR ON THE RHEOLOGICAL PROPERTIES OF BREAD DOUGH

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ABSTRACT

The research aims to study effect of adding barley flour by 10, 15, 20%, oat flour 10,15,20% and the two together by 10 +10, 15 +15, and 20 +20% on the rheological characteristics of the dough showed:

First: The results obtained from farinograph adding that as a result of barley at different rates led to increasing the rate of absorption and duration of kneading dough and consistently for maximum strength and the weakness of dough. Also, adding oats, at different rates led to the low rate of absorption, while the access time and the stability of the dough and the dough weakness. In the case of mixing the two together, the results obtained through farinograph led added both of barley and oat together in different proportions led to the low rate of water absorption, while the arrival time, dough development, the dough stability and dough weakness were determined.

Second: the results obtained from extensograph as a result of adding barley at different rates led to a decline in rubber dough and flatten the resistance and the relative number and energy resulting dough. While oats at different rates led to a decline in rubber dough and figure the relative energy and the resulting dough while increasing resistance to flatten. And also in the case of mixing barley and oats together in different proportions led to a decline in rubber dough

Find a summary of the results obtained through can say that the best ratio in addition to barley was 15% and for oats was 10% in the case of mixing barley and oats were best ratio of 15% as well.

INTRODUCTION

Cereal grains form a staple food of the majority of the people in the developing countries and provide between 70-80% of total calories (252 calories /l00gm) and more than 66% of protein in the diet (Juneja et al., 1980).

Wheat is an important cereal because it can be used for preparation of many products, bread is one of the least expensive most important staples in the world, because of their high popularity and large consuming, bakery products (including bread) could be a vehicle to improve the quality and nutritive value, bread considered the one of the simplest food manufactured, and its characteristics may differ from country to country (Abreu et al., 1994).

In Egypt, the average total annual area cultivated with barley grains are 87752 hectare which produced annually 117113 tons (FAO,2010)

The cereals grains are harvested over one billion tons annually. The barley accounts for 12% of the world's total cereal production and occupies fourth position with respect to grain production after wheat, rice and corn, whereas, oats are the fifth largest cereal crop in the world (Jadhav *et al* 1998).

Barley (Hordeum-vulgarel.) contains relatively high concentration of the mixed linkage (1-3(1-4) B-D glucans (B-glucan). Although B-glucan occurs in all cereals, its concentration is highest in oats and barley with values ranging from less than 2% up to 16%, Anderson et al.,(1978).Among the cereal grains, oats and barley have been reported to be the most effective in lowering serum total cholesterol and LDL- cholesterol in humans and animals (Chen et al., 1981, Ranhotra *et al.,*1991, and Braaten *et al.,* 1994)

Cholesterol-lowering ability was first ascribed to oats but more recently to barley (Wang, *et al* ., (1992). It has been hypothesized that, upon ingestion, B-glucan increases small intestinal viscosity due to its lower molecular weight and its tendency to form viscous gummy solutions, resulting in reduced bile acid and cholesterol or triglyceride absorption thus lowering plasma cholesterol kahlon, *et al* ., (1993) as well as altering digestive enzyme activity (Almirall, *et al* ., (1995).

Oat, the third largest cereal crop on Canada and the fifth largest in the world, is an important grain for live stock and poultry feed. It is an excellent good grain because of the high nutritional quality of its protein (Cluskey et al., 1979, USDA 1979).

Several investigators have used oat flour or its components in bread making. Hoseney *et al.,* 1971, demonstrated that, reconstituted containing oat starch had high water absorption and poor bread making characteristics. The present study we aimed and focused on: Studying the chemical composition of raw materials (wheat flour 82% extraction, barley flour and oat flour) and also, studying the effects of barley flour and oat flour addition at different levels on rheological properties of dough.

MATERIALS AND METHODS

Materials:

Wheat variety (Triticum sativum) cultivar "shakha 61", barley (naked barley) grains and) oat (Avena sativa) grains were obtained from Field Crops Institute, Agricultural Research Center, Giza, Egypt; and wheat grain was milled for 82% extraction using Buhler laboratory pneumatic flour mill.

Methods:

Preparation of the flour blends:

The flour blends were prepared according to the ratio outlined in Table (1).

Chemical analysis of raw materials.

a) Moisture content was determined by using an air oven at 105± 2◦c until reaching a constant weight according to A.O.A.C.(1990).
b) Total nitrogen was determined by kjeldahel method according to A.O.A.C.(1990), crude protein content calculated by multiplying total nitrogen by factor of 5.70 for wheat flour
c) Crude fat extracted by ethyl ether using soxhlet apparatus was determined as described in the method of the A.O.A.C.(1990).
d) Ash content was determined in an electric muffle at 525-550◦c until reaching the complete ashing according to A.O.A.C. (1990).

e) Crude fiber was determined according to the official methods of the A.O.A.C. (1990).

f) Total carbohydrates were calculated by difference as follows:
Carbohydrates= 100-(% Protein +%Fat + %Ash+%Fiber).

Table (1): Wheat flour 82% extraction and its mixtures for balady bread making.

Blends No.	wheat flour 82% extraction	Barley flour	Oat Flour
1	100	———	———
2	90	10	———
3	85	15	———
4	80	20	———
5	90	———	10
6	85	———	15
7	80	———	20
8	80	10	10
9	70	15	15
10	60	20	20

Rheological measurements of dough samples:

The rheological measurements were carried out for each of above mentioned flour portions under investigation using farinograph and extensograph were tested at Rheological Laboratory Department of Bread and Dough, Food Technology Research Institute, Giza- Egypt as described by A.A.C.C. methods (1995).

RESULTS AND DISCUSSION

Chemical composition of raw materials:

The chemical composition of wheat flour, barley flour and oat flour used in this investigation are shown in Table (2). It is quite clear that, moisture content was higher in wheat flour and oat flour, they have the percentage (11.0% and 10.20% respectively), whereas, protein percentage was higher in wheat flour (12.27%) as compared with its content in barley flour (12.01%) and oat flour (11.20%). On the other hand, fat and ash contents were higher in oat flour (7.0 and 4.15% respectively) comparing with wheat flour (1.90 and 1.45% respectively) and barley flour (2.75 and 2.40% respectively), While, fiber content in oat flour represented the superiority (10.80%) as compared with its content in barley flour (2.68%) and wheat flour (2.0%). Chemical analysis for the raw materials indicated that carbohydrate content was the highest in wheat flour (82.38%) followed by Barley flour (80.16%) and oat flour (66.85%).

While B-Glucan content in Barely flour represented the superiority (6.30) as compared with its content in oat flour (4.60mg/g) and wheat flour (0.20 mg). These results are in agreement with Dahab(2006).

The primary constituents of the barley kernel are: starch (52–71%), protein (8–13%), lipids (2–3%), non-starch polysaccharides, and portion of β-

glucan (3–11%) (MacGregor and Fincher, 1993). Barley is now gaining renewed interest as a functional food ingredient because it is considered as a rich source of β-glucans (Brennan and Cleary, 2005; Soares et al., 2007).

Oat belongs to the family *Poaceae* and genus *Avena*. *Avena sativa* L. is the species that is currently cultivated (McMullen, 2000). Oats are harvested with their hulls on them (Hoseney, 1994). Among cereals, oats are unique for their high protein as well as lipid contents.

Oat is a perfect source of soluble dietary fiber *ß*-glucan, a non-starchy polysaccharide available in the cell walls of the aleurone layer in bran. The most important beneficial effects of ß-glucan are their contribution to a lowering of serum blood cholesterol and as well moderating blood glucose in diabetics (McMullen, 2000).

The chemical composition of cereal grains (moisture 11–14%) is characterized by the high content of carbohydrates. Available carbohydrates mainly starch deposited in the endosperm, amount to 56–74% and fiber, mainly located in the bran, to 2–13%. The second important group of constituents is the proteins which fall within an average range of about 8–11%. Cereal lipids belong to the minor constituents (2–4%) along with minerals (1–3%). The relatively high content of B-vitamins is, in particular, of nutritional relevance. With respect to structures and quantities of chemical constituents, notable differences exist between cereals and even between species and varieties within each cereal. These differences strongly affect the quality of products made from cereal grains. Because of the importance of the constituents, in the following we provide an insight into the detailed chemical composition of cereal grains including carbohydrates, proteins, lipids, and the minor components (minerals and vitamins) Souci et al., (2008) and Belitz *et al.,* (2009).

Table (2) Chemical composition of wheat flour 82% extraction (WF), barley flour (BF) and oat flour (OF) on dry weight basis.

Raw materials	Moisture	Protein	Fat	Ash	Crude fiber	T.C.	ß- Glucan		
							Soluble	Insoluble	Total
WF	11.00	12.27	1.90	1.45	2.00	82.38	-	0.20	0.20
BF	7.35	12.01	2.75	2.40	2.68	80.16	2.00	4.30	6.30
OF	10.20	11.20	7.00	4.15	10.80	66.85	2.40	2.20	4.60

T.C. Total carbohydrates

Rheological properties for farinograph parameters:

Effect of replacement of wheat flour (82% extraction) by different levels of barley flour on farinograph parameters:

Water absorption, arrival time, dough development time, stability and degree of weakening of wheat flour were determined and the obtained results in Table (3). From the results presented in Table (3) It can be noticed that replacement of wheat flour (82% extraction) by levels of 10, 15 and 20% barley flour increased water absorption from 66.8% in control sample to 67.2, 68.4 and 71.1% respectively. An increase in water absorption has been reported in the literature for various fiber blended wheat flour doughs (Goldstein *et al.,* 2010 and Mi_s *et al.,* 2012). By increasing the bran level

from 10 g/100 g to 40 g/100 g the highest increase in water absorption was recorded for barley bran (63.88 to 76.28 g/100 g) and wheat bran (63.52 to 69.85 g/100 g) (Sudha et al., 2007). It is believed that fiber incorporated dough are known for their ability to absorb significant amounts of water. The presence of a large number of hydroxyl groups which allow more water interactions through hydrogen bonding plays a major role for more water absorption (Rosell *et al.* 2001).

The results revealed also that arrival time increased from 0.5 min in control sample to 1.5, 0.5 and 1% respectively. Also, dough development time of control was similar at levels 15% barley flour and increased 3 and 1.5 min at levels 10 and 20% of barley flour. Stability time increased from 4.5 min in control sample to 5 and 6 min at levels 10 and 15% of barley flour respectively. No difference in stability time was recorded at level 20% barley flour. Weakening of the dough increased 80 B. U. at levels 10 and 20% of barley flour. No difference in weakening dough was recorded at level 15% Barley.

The influence of small amounts of barley flour on the proofing stability was significant. The proofing time was not prolonged as significantly as the dough elasticity in all samples. The dough behavior during oil baking in the oven rise tests was influenced by the addition of barley at an important level, similarly as the specific bread volume in the baking test, but individual differences were found between separate flour samples in accordance with Dogan (2003).

Table (3): Effect of addition barley flour as partial substitute to wheat flour (82 % extraction) on farinograph parameters

Blends	Water absorption %	Arrival time (min)	Dough development time (min)	Stability time (min)	Weakening dough (B.U.)
1	66.8	0.5	1	4.5	60
2	67.2	1.5	3	5	80
3	68.4	0.5	1	6	60
4	**71.1**	**1**	**1.5**	**4.5**	**80**

Blend (1) 100% wheat flour (82% extraction)
Blend (2) 90% wheat flour (82% extraction) + 10% barley flour.
Blend (3) 85% wheat flour (82% extraction) + 15% barley flour.
Blend (4) 80% wheat flour (82% extraction) + 20% barley flour.

Effect of replacement of wheat flour (82% extraction) by different levels of oat on farinograph parameters:

Water absorption, arrival time, dough development time, stability and degree of weakening of wheat flour were determined and the obtained results in Table (4) The results presented in table (4) showed that the effect of oat flour at replacement levels 10, 15 and 20% wheat flour (82% extraction) on farinograph parameters. Water absorption of control sample was 66.8% and it was 65.6, 64.1 and 62.2% at replacement levels of oat flour 10, 15 and 20% respectively. Arrival time of control sample was 0.5 and it was 1, 1 and 1 min. at replacement levels of oat flour 10, 15 and 20% respectively. Also,

dough development increased from 1 min in control sample to 2, 2 and 2 min. and it was stability time at 5.5, 4 and 5.5 min at replacement levels of oat flour 10, 15 and 20% respectively. Weakening of the dough increased by increasing the level of oat flour level of 20% oat flour recorded the highest weakening of the dough. Arrival time and dough stability were higher with the increase of oat flour added to wheat flour 82% extraction. This increase in dough stability was attributed to the increase in protein level which leads the dough to be more stable Pomeranz, (1988). Among cereals, oats are unique for their benefiting from high protein as well as lipid content. However, insufficient gluten content creates a big challenge to making breads out of this kind of cereals. Flour made of one type of bread wheat cultivar plus two types of improved oat lines were employed in this study to make composite oat-wheat flour bread. According to the data obtained from farinograph readings, water absorption capacity and the duration of the dough development increased with an increase in the dough's proportion of oat Peymanpour *et al.* (2012).

Table (4) : Effect of addition oat flour as partial substitute to wheat flour (82% extraction) on farinograph parameters:

Blends	Water absorption %	Arrival time (min)	Dough development time (min)	Stability time (min)	Weakening dough (B.U.)
1	66.8	0.5	1	4.5	60
5	65.6	1	2	5.5	130
6	64.1	1	2	4	160
7	62.2	1	2	5.5	140

Blend (1) 100% wheat flour (82% extraction)
Blend (5) 90% wheat flour (82% extraction) + 10% oat flour.
Blend (6) 85% wheat flour (82% extraction) + 15% oat flour.
Blend (7) 80% wheat flour (82% extraction) + 20% oat flour

Effect of replacement of wheat flour (82% extraction) by different levels of barley flour and oat flour on farinograph parameters:

Water absorption, arrival time, dough development time, stability and degree of weakening of wheat flour were determined and the obtained results in Table (5) Table (5) showed that the effect of replacement of wheat four (82% extraction) by different levels of barely flour and oat flour on farinograph parameters. From the results presented in Table (5) it can be seen that the replacement of wheat flour (82% extraction) by level of 10, 15 and 20% barley flour and 10, 15 and 20% oat flour decreased water absorption from 66.8% in control sample to 63, 61.7 and 64.9%, respectively. Arrival time of control sample was similar at level 10% barley flour and oat flour so increased 0.5 min. in control sample to 1.5 min. at levels 15 and 20% of barley flour and oat flour. Also, increased dough development time from 1 in control sample to 1.5, 4 and 3 min. respectively, while stability time increased from 4.5% in control sample to 6.5, 7 and 6 min., respectively weakening of the dough increased from 6 B.U in control sample to 100, 100 and 100 B.U respectively. From the results, it could be noticed that the best blend was

added 15% naked barley plus 15% oat to 70% wheat flour 82% extraction due to increase arrival time, dough stability time and stability time caused the barley and oat high fiber, protein and ß- glucan.

Incorporation of fiber into wheat flour interacts directly with structural elements of the three dimensional gluten networks and disrupts the starched gluten matrix, and finally affects the rheological behavior of blended dough during mixing, fermentation and baking. However, the addition of these fibers sometime causes a negative effect on the final bread quality. The most notable change is the reduction of loaf volume **(Lai et al., 1989).**

Table (5): Effect of addition barley flour and oat flour as partial substitute to wheat flour (82% extraction) on farinograph parameters

Blends	Water absorption %	Arrival time (min)	Dough development time (min)	Stability time (min)	Weakening dough (B.U.)
1	66.8	0.5	1	4.5	60
8	63	0.5	1.5	6.5	100
9	61.7	1.5	4	7	100
10	64.9	1.5	3	6	100

Blend (1) 100% wheat flour (82% extraction)
Blend (8) 90% wheat flour (82% extraction) + 10% barley+ 10% oat flour.
Blend (9) 85% wheat flour (82% extraction) + 15% barley+ 15% oat flour.
Blend (10) 80% wheat flour (82% extraction) + 20% barley+ 20% oat flour

Rheological properties for extensograph parameters:

Effect of replacement of wheat flour (82% extraction) by different levels of barley flour on extensograph parameters:

Resistance to extension, extensibility, proportional number and energy of wheat flour were determined and the results are obtained in table (6).

The results presented in table (6) showed that the effect of barley flour at replacement levels 10, 15 and 20% to wheat flour (82% extraction) on extensograph parameters. Resistance to extension of blends decreased from 500 B.U. in control sample to 470, 320 and 410 B.U. respectively. Dough extensibility of control sample was 105 mm and it was 100, 102 and 95 mm, at replacement levels of 10, 15 and 20% respectively. Proportional number of blends decreased from 4.76 in control sample to 4.70, 3.13 and 4.32 at replacement levels 10, 15 and 20% of barley flour. Energy of blends decreased from 68 cm^2 in control sample to 58, 40 and 45 cm^2 at replacement levels 10, 15 and 20% of barley flour. From the results extensograph, it could be observed that the fortified wheat flour with barley flour to 20% give the best blend by increasing the parameters of extensograph when barley flour was increased. Also, addition of barley flour up to 20% in the formulation had no effect on rheological properties, but higher amounts exhibited deterioration effect, *i.e.* stability time was increased, while 20% barely flour reduced the resistance of extension but it was still suitable for baking requirements (Ashour and El-Faham, 2003).

Table (6) : Effect of addition Barley flour as partial substitute to wheat flour (82% extraction) on extensograph parameters

Blends	Resistance to extension(B.U)	Extensibility (mm)	Proportional number	Energy (cm^2)
1	500	105	4.76	68
2	470	100	4.70	58
3	320	102	3.13	40
4	410	95	4.32	45

Effect of replacement of wheat flour (82% extraction) by different levels of oat flour on extensograph parameters:

Resistance to extension, extensibility proportional number and energy of wheat flour were determined and the obtained results in table (7).

The results presented in table (7) showed that the effect of oat flour at replacement levels 10, 15 and 20% to wheat flour (82% extraction) on extensograph parameters. Resistance to extension of blends decreased from 500 B.U. in control sample to 170, 160 and 130 B.U. at replacement levels of oat flour 10, 15 and 20% respectively. Dough extensibility of control sample was 105 mm and it was 110, 110 and 105 mm at replacement levels of oat flour 10, 15 and 20% respectively. Proportional number of blends decreased from 4.76 in control sample to 1.55, 1.45 and 1.24 at replacement levels 10, 15 and 20% of oat flour. Energy of blends decreased from 68 cm^2 in control sample to 28, 24 and 18 cm^2 at replacement levels 10, 15 and 20% of oat flour. The data obtained from the extensograph readings showed that the dough energy increased but extensibility property decreased with increase in the proportion of oat in the dough. However, from a sensory point of view, the 10% formula was found to be inferior to control (bread baked from 100% wheat flour) Peymanpour *et al.* (2012).

According to extensibility data obtained in this study, it is important to mention that the decrease in the gluten content of the dough and the increase of bran proportion (ending up with weaker formation of gluten matrix) could not maintain the dough extensibility.

Table (7): Effect of addition oat flour as partial substitute to wheat flour (82% extraction) on extensograph parameters

Blends	Resistance to extension(B.U)	Extensibility (mm)	Proportional number	Energy (cm^2)
1	500	105	4.76	68
5	170	110	1.55	28
6	160	110	1.45	24
7	130	105	1.24	18

Effect of replacement of wheat flour (82% extraction) by different levels of barley and oat flour on extensograph parameters :

From data presented in Ttable (8), it can be seen that the effect of barley flour and oat flour at replacement levels 10, 15 and 20% to wheat flour (82% extraction) on extensograph parameters from data in table (8) it can

be noticed that resistance to extension decreased from 500 B.U. in control sample to 240, 200 and 180 B.U. at replacement levels of 10, 15 and 20% respectively. Also from the same presented table it could be noticed that dough extensibility decreased from 105 mm in control sample to 100, 85 and 90 mm at replacement levels of 10, 15 and 20% of barley flour and oat flour respectively. Also, that proportional number was 4.76 in control sample; it decreased to 2.4, 2.4 and 2.0 at replacement levels of 10, 15 and 20% respectively. From data presented in Table (8) it could be noticed that energy of blends decreased from 68 cm^2 in control sample to 31, 22 and 20 cm^2 at replacement levels 10, 15 and 20% of both barley flour and oat flour.

Table (8): Effect of addition barley and oat flour as partial substitute to wheat flour (82% extraction) on extensograph parameters

Blends	Resistance to extension(B.U)	Extensibility (mm)	Proportional number	Energy (cm^2)
1	500	105	4.76	68
8	240	100	2.4	31
9	200	85	2.4	22
10	180	90	2	20

From the obviously results it could be recommended that the barley and oat had contained the highest in protein, fiber and ß- glucan. The fortification of wheat flour 82% extraction with barley and oat at different ratios, the results reported that the added 15% of barley, 10% of oat and 15% % from barley and oat mixture gave the best blends. Therefore, it could be recommended to use barley and oat for fortified wheat flour to produce balady bread safe, high nutrition value and beneficial health.

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"تأثير اضافة الشعير والشوفان على الخواص الريولوجيه لعجينة الخبز

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يهدف البحث الى دراسة تأثير اضافة دقيق الشعير بنسبة ١٠,١٥,٢٠% والشوفان بنسبة ١٠,١٥,٢٠% والاثنان معا بنسبة ١٠+١٠, ١٥+١٥, ٢٠+٢٠% على الصفات الريولوجية للعجينه.

اولا: اوضحت النتائج المتحصل عليها من الفارينو جراف انه نتيجة اضافة الشعير بنسب مختلفه ادت الى زيادة نسبة الامتصاص ومدة العجن وثبات العجينه للحصول على اقصى قوام وضعف العجينه. كذلك اضافة الشوفان بنسب مختلفه ادت الى انخفاض نسبة الامتصاص بينما زاد من زمن الوصول وزمن تكون العجينه وثبات العجينه وضعف العجينه. اما فى حالة خلط الاثنين كلا من الشعير والشوفان معا بنسب مختلفه فإن النتائج المتحصل عليها من خلال الفارينوجراف ادت الى انخفاض نسبة الامتصاص للماء بينما زاد زمن الوصول وزمن تكون العجينه وثبات العجينه وضعف العجينه.

ثانيا: أوضحت النتائج المتحصل عليها من الاكستنسوجراف انه نتيجة اضافة الشعير بنسب مختلفه ادى الى انخفاض مطاطيه العجينه والمقاومه للشد والرقم النسبي وطاقة العجينه الناتجه. بينما عند أضافة الشوفان بنسب مختلفه ادى الى انخفاض مطاطيه العجينة والرقم النسبى وطاقة العجينه الناتجة بينما زادت المقاومة للشد .وكذالك فى حالة لأضافة خليط اضافة كلا من الشعير والشوفان معا بنسب مختلفه الشعير والشوفان معا بنسب مختلفة ادى الى انخفاض مطاطية العجينة والمقاومة للشد والرقم النسبى وطاقة العجينة الناتجة.

خلاصة البحث من خلال النتائج المتحصل عليها يمكن القول بأن افضل نسبة اضافة للشعير كانت ١٥% وبالنسبة للشوفان كانت ١٠% اما فى حالة خلط الشعير والشوفان كانت افضل نسبة اضافة ١٥% وذلك لأنتاج خبز بلدى قيمتة الغذائية عالية ومفيد صحيا.