EFFECTS OF OAT AND BARLEY ON SOME BIOCHEMICAL PARAMETERS IN HYPERGLYCEMIC RATS AND THEIR EFFECTS ON PROPERTIES OF DOUGH AND BAKED BREAD

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Abstract:

Considering the effects of oat (*Avena sativa* L.) and barley (*Hordeum vulgare* L.), and their importance in the prevention and control of diabetes mellitus (DM) and cardiovascular diseases, hence the study aims to investigate the effect of adding oat and barley to the diet of hyperglycemic rats and their effects on blood glucose, total cholesterol (TC), High Density Lipoprotein (HDL) and low Density Lipoprotein (LDL) levels, and to examine the effect of mixing flour of wheat with oat and barley on rheological properties of the bread dough, and to evaluate the sensory attributes of baked breads prepared from these mixtures. Thirty male Sprague Dawley rats were divided into five groups (six rats each): Body weight gain and food intake were measured and the Feed Efficiency Ratio (FER) was calculated.

Animals were lightly anesthetized at the end of the experimental period and blood was collected. Blood glucose, total cholesterol (TC), HDL and LDL were estimated. For measurement of dough’s rheological properties, dough prepared from various mixtures of wheat, oat and barley flour were subjected to Farinograph and Extensograph tests, and the baked bread was subjected to orgranoleptic evaluation.

The results showed that body weight gain for groups of rats fed on 40% oat, barley or their mixture were lower than that of positive control group. Rats groups fed on oat, barley and their mixture showed significant (*P* < 0.01) decrease in blood glucose level when compared with the positive control group. Serum cholesterol and LDL levels were significantly (*P* < 0.01) decreased in groups fed on oat, barley and their mixture in comparison with positive control value, on the other hand serum HDL level increased significantly in experimental groups when compared to the value of positive control. Replacement of wheat flour with 40% of oat or barley increase the water absorption and the dough
resistance and extensibility decreased as a consequence of adding either oat or barley flour, wheat flour bread has higher acceptance score, followed by mixture of (wheat 60% + oat 20% +barley 20%).

Keywords: 40% Oat, 40% Barley, Rats, Glucose, Cholesterol, LDL, HDL, Farinograph- Extensograph, Sensory Evaluation.

Introduction:

In recent years, scientists and nutritionists have reached a shared conclusion that whole grains have protective effects against the development of diet-related disorders (Slavin, 2010). Whole grain consumption reduces the risk of major chronic diseases (Zhou et al., 2014), and higher whole grain consumption is associated with a reduced risk of the development of cardiovascular diseases, type 2 diabetes, and certain types of cancer (Lefevre and Jonnalagadda, 2012).

Increasing whole-grain products such as oats and barley in the diet would increase intakes of both total and soluble dietary fiber, a variety of fiber components, especially soluble fiber, have been reported to have beneficial effects on glucose tolerance, particularly on postprandial glucose and insulin concentrations in normal people and people with impaired glucose tolerance. Beneficial health effects also include improving glycemic control in diabetes, decreasing the risk for developing diabetes, and reducing blood lipids (Behall et al., 2004). Both oats and barley are recognized for their valuable fiber constituents having protective and therapeutic effects against the development of diet-related disorders (Brennan and Cleary, 2005; Pins and Kaur, 2006; Keenan et al., 2007 and Wood 2010).

Oat (Avena sativa) is distinct among the cereals due to its multifunctional characteristics and nutritional profile. Recently the importance of oat various components has been reported as it is a good source of dietary fiber especially β-glucan. β-glucans are polysaccharides consisting of glucose residue jointed by beta linkage (Chen and Seviour, 2007 and Butt et al., 2008), they are found at a high level in the cell wall of oat and barley (McIntosh et al 2005). Oat and barley β-glucan linked by linear 1-3 and 1-4 bonds (Chen and Seviour 2007; Butt et al., 2008).
The Food and Drug Administration (FDA) endorsed the relationship between inclusion of soluble fiber β-glucan in the diet and a decrease in serum cholesterol concentration by ratifying health claims for oat and barley fiber (FDA, 2006). The FDA concluded that β-glucan (3 g/day) soluble fiber from oat bran and rolled oats or from wholegrain barley and dry-milled barley products are effective in lowering total and LDL-cholesterol concentrations (Poppitt, 2007). The results of Frost et al. (2011) showed that, the 40% and up to 50% substitution with high fiber barley flour might be feasible to manufacture acceptable cookies that will provide 0.8 g of soluble fiber per serving (30 g). Consuming ~2 servings with 50% barley flour substitution will provide the consumer 1.6 g of β-glucan soluble fiber which is ~50% of the recommended level by FDA.

Considering the effects of barley and oat, and their importance in the prevention and control of diabetes mellitus and cardiovascular diseases, the study aims to investigate the effect of adding oat and barley to the diet of hyperglycemic rats and their effects on blood glucose, total cholesterol, HDL and LDL levels, and to examine the effect of mixing flour of wheat with oat and/or barley on rheological properties of the bread dough, and to evaluate the sensory attributes of baked breads prepared from these flours’ mixtures.

Materials and Methods:

In Egypt during 2012/2013 the average per capita daily bread was 2.8 loaf of bread a day (the net weight of bread loaf is 140 gram) which equal to 392 gm baladi bread per day (Shehata and Mohamed, 2015). Based on β-glucan content of oat and barley, the calculated amount of oat and/or barley needed to provide the sufficient amount of soluble fiber (>3 gm/day), will be 92 gm from oat or barley or their mixture which represent 40% of flour mixtures needed for preparing bread loaf (392 gm) as following: Control wheat bread and tested breads containing wheat 60% + oat 40% (WO); wheat 60% + barley 40% (WB), and mixture of wheat 60% + oat 20% + barley 20% (WOB). The wheat flour was a commercial baker’s flour. Whole oat and barley flour were obtained from the Cairo local market. β-glucan content was determined using β-glucan enzymatic assay kit (Michniewicz, et al. 2003). Wheat, oat and barley flour were analyzed for determination of moisture, protein, lipid, ash, and crude fiber according to AACC methods (1990).
Table (1): Recipe for preparing bread loaf from various wheat, oat and barley mixtures.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Wheat 100% (Control bread)</th>
<th>Wheat 60% + oat 40% (WO 40%)</th>
<th>Wheat 60% + barley 40% (WB 40%)</th>
<th>Wheat 60% + oat 20% + barley 20% (WOB 20+20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour (gm)</td>
<td>229.00</td>
<td>137.00</td>
<td>137.00</td>
<td>137.00</td>
</tr>
<tr>
<td>Oat flour (gm)</td>
<td>----</td>
<td>92.00</td>
<td>----</td>
<td>46.00</td>
</tr>
<tr>
<td>Barley flour (gm)</td>
<td>----</td>
<td>----</td>
<td>92.00</td>
<td>46.00</td>
</tr>
<tr>
<td>Salt (gm)</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Sugar (gm)</td>
<td>23.00</td>
<td>23.00</td>
<td>23.00</td>
<td>23.00</td>
</tr>
<tr>
<td>Dry Milk (gm)</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Yeast (gm)</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Margarine (gm)</td>
<td>11.00</td>
<td>11.00</td>
<td>11.00</td>
<td>11.00</td>
</tr>
</tbody>
</table>

Thirty male Sprague Dawley rats weighing about 110–130 g were obtained from the Egyptian Organization for Biological Products and Vaccines (VACSERA). Rats were housed individually in cages under controlled conditions. They were maintained on a basal diet prepared according to Reeves et al. (1993) for one week as adaptation period. All diets and water were provided ad-libitum. Rats were injected intraperitoneally with a freshly prepared solution of Alloxan monohydrate in saline (300m M NaCl) at a dose of 120 mg/kg of bodyweight after overnight fasting for 12 h according to Al-Shamaony et al. (1994) and Ndiaye et al. (2008). Alloxan was obtained from El-Gomhuryia Company for Chemical industries, Cairo, Egypt. All diagnostic kits were purchased from Gamma Trade for Scientific Services and Consultation, Giza, Egypt.

Since Alloxan injection can provoke fatal hypoglycemia as a result of reactive massive release of pancreatic insulin, rats were kept for the next 24 h on a 5% glucose solution as beverage to prevent severe hypoglycemia (Gupta et al., 1989). Fasting blood samples were collected from the retroorbital sinus in anesthetized rats using a micro hematocrit tube and blood glucose levels were measured to investigate the induction.
of diabetes. Rats displaying blood glucose level of 250 mg/dl were defined as diabetics and were chosen for the experiment (Kulkarni et al., 2002; El-demerdash et al., 2005 and Ragavan and Krishnakumari 2006).

**Experimental Design:**

The experimental animals were divided into five groups (six rats per group): (1) normal control group fed basal diet, (2) Alloxan induced diabetic positive control group (DM) fed basal diet, (3) DM rats fed basal diet 40% oat (DM-oat), (4) DM rats fed basal diet 40% barley (DM-barley) and (5) DM rats fed basal diet 20% oat + 20% barley (DM-oat + barley) for 6 weeks. Oat, barley and their mixture were added to basal diet as replacement of corn starch.

**Measurement of Body Weight and Food Intake:**

Body weight gain and food intake were measured and the Feed Efficiency Ratio (FER) was calculated:

\[
FER= \frac{\text{body weight gain (g)}}{\text{dietary intake (g)}}.
\]

**Biochemical Analysis:**

Animals were lightly anesthetized with diethyl ether after 12 hours of fasting at the end of the experimental period and blood was collected from the retrorbital sinus. Blood samples were centrifuged and sera were obtained. Blood glucose was estimated by commercially available glucose kit based on glucose oxidase method according to Trinder (1969). The method of Allain et al. (1974) was used for the determination of serum total cholesterol (TC), where High Density Lipoprotein cholesterol (HDL) was determined according to the method of Burstein et al. (1970) and the Low Density Lipoprotein cholesterol (LDL) was determined according to Friedwald et al. (1972).

**Rheological properties of breads’ dough:**

For measurement of dough’s rheological properties, dough prepared from wheat100% (Control bread) and breads containing: wheat 60% + oat 40% (WO 40%); wheat 60% + barley 40% (WB 40%), and the mixture of wheat 60% + oat 20% + barley 20% (WOB 20+20%), were subjected to Brabender Farinograph and Extensograph tests according to the methods of AACC (2000). The Farinograph properties included: water absorption, arrival time, mixing time, dough stability and softening.
of wheat flour dough and its blends with oat, barley and their mixture. These properties were determined using a Farinograph type (PL), Germany. 300 grams of tested samples were used. The Extensograph tests were carried out to measure dough resistance, energy and extensibility according to AACC (2000).

**Bread baking:**

Bread loaf was prepared according to the standard formula (Long, 1991). The ingredients were mixed in a dough 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, and then fermented for about 10 minutes. Breads were baked at 245-295°C.

**Sensory evaluation:**

Control wheat bread and tested breads containing wheat 60% + oat 40% (WO); wheat 60% + barley 40% (WB), and mixture of wheat 60% + oat 20% + barley 20% (WOB) were subjected to organoleptic evaluation. Panelists (12 members) were asked to rank various samples for color, taste, aroma, texture and overall quality on a scale of zero to 10 according to the method mentioned by Kraumer and Twig (1960).

**Statistical Analysis:**

The results were expressed as (mean± SE) values. The statistical significance of mean differences between groups was tested by one way analysis of variance (ANOVA). The differences between means were tested for significance using least significant difference (LSD) test at P<0.05 and P<0.01. All the data analysis was performed using SPSS software (Version 16; SPSS Inc Chicago, USA).

**Results and Discussion:**

The chemical composition of wheat, barley 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 barley flour, they have the percentage (11.77% and 10.32% respectively), whereas, protein percentage was higher in wheat flour (12.64%) as compared with its content in oat flour (11.76%) and barley flour (11.41%). On the other hand, fat and ash contents were higher in oat flour (6.50 and 2.69% respectively) compared with wheat flour (1.03% and 0.47% respectively).
and barley flour (3.12% and 2.61% respectively). Fiber content in barley flour represented the highest value (6.25%) as compared with its content in oat flour (6.03%) and wheat flour (0.76%). Chemical analysis for the raw materials indicated that carbohydrate content was the highest in wheat flour (73.32%) followed by barley flour (68.54%) and oat flour (63.60%).

Table (2): Chemical composition of wheat, oat and barley flour (Mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Moisture %</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Ash %</th>
<th>Fiber %</th>
<th>Carbohydrate %</th>
<th>β-Glucan %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>11.77 ± 0.68</td>
<td>12.64 ± 1.05</td>
<td>1.03 ± 0.02</td>
<td>0.47 ± 0.08</td>
<td>0.76 ± 0.32</td>
<td>73.32 ± 1.72</td>
<td>0.51 ± 0.12</td>
</tr>
<tr>
<td>Oat flour</td>
<td>9.42 ± 1.49</td>
<td>11.76 ± 1.15</td>
<td>6.50 ± 0.50</td>
<td>2.69 ± 1.33</td>
<td>6.03 ± 1.66</td>
<td>63.60 ± 4.16</td>
<td>3.05 ± 0.45</td>
</tr>
<tr>
<td>Barley flour</td>
<td>10.32 ± 2.57</td>
<td>11.41 ± 0.52</td>
<td>3.12 ± 0.55</td>
<td>2.61 ± 0.18</td>
<td>6.25 ± 0.37</td>
<td>68.54 ± 1.32</td>
<td>3.65 ± 0.51</td>
</tr>
</tbody>
</table>

With respect to the chemical composition of cereal flour, notable differences exist between cereals and even between species and varieties within each cereal. These differences strongly affect the quality of products (Souci et al., 2008 and Belitz et al., 2009). Among cereals, oats are unique for their high lipid contents. Oat protein is uniquely different from other cereals, as the major protein fraction in oats is the salt-soluble globulin, which is probably the primary reason for the better nutritive value of oats (McMullen, 2000). Barley is now gaining renewed interest as a functional food ingredient because it is considered as a rich source of β-glucan (Brennan and Cleary, 2005; Soares et al., 2007).

Table (3): Mean daily Food intake, body weight gain and FER, blood glucose, serum cholesterol, serum HDL and serum LDL of control and Positive control diabetic rats groups (Mean ± S.E.).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Positive Control (DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food intake gm/day</td>
<td>13.02 ± 0.44</td>
<td>11.07 ± 0.49 **</td>
</tr>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Body weight gain gm/day</td>
<td>3.60± 0.36</td>
<td>3.03± 0.13</td>
</tr>
<tr>
<td>FER</td>
<td>0.28± 0.03</td>
<td>0.27± 0.01</td>
</tr>
<tr>
<td>Blood Glucose mg/dl</td>
<td>101.17± 1.30</td>
<td>281.25± 0.77 **</td>
</tr>
<tr>
<td>Serum Cholesterol mg/dl</td>
<td>91.69± 0.94</td>
<td>117.62± 0.77 **</td>
</tr>
<tr>
<td>Serum HDL mg/dl</td>
<td>45.00± 1.24</td>
<td>30.25± 0.55 **</td>
</tr>
<tr>
<td>Serum LDL mg/dl</td>
<td>37.40± 0.39</td>
<td>69.03± 0.29 **</td>
</tr>
</tbody>
</table>

* Significantly differed from positive control at (P<0.05).

** Significantly differed from control group at (P<0.01).

Data in Table (3) illustrated that, Alloxan induced diabetic rats in positive control group (DM) showed significant (P< 0.01) increments in blood glucose, serum total cholesterol and LDL, and significant (P< 0.01) reduction in the level of serum HDL.

The data in Table (4) showed that, the body weight gain for groups of rats fed on 40% oat, barley or mixture of oat and barley were lower than that of positive control group, and in addition FER values showed the same trend. These effects of oat and barley could be caused by water soluble mixed-linkage β-glucan and its viscosity, and the fact that oat β-glucan has a capacity to form highly viscous solutions (Morgan, 2000; Wood, 2004). Oat fiber prolongs satiety after meals and alleviates constipation. In the stomach and small intestine, it is mediated by a viscosity effect that retards the transport of enzymes to their substrates; increased viscosity also retards the transport of nutrients to the absorbing sites and to the unstirred layer on the absorbing surface. In the large bowel, oat fiber acts as a substrate for fermentation enhancing the formation of butyric acid which is believed to enhance the growth of normal colonic cells but decrease the growth of carcinogenic cells (Mälkki and Virtanen, 2001). Recently Zhou et al. (2014) stated that, a potential mechanism for β-glucan inhibition of food intake and weight gain is through its gel-forming effect, which may delay gastric emptying and reduce or delay the digestion/absorption of macronutrients (Marciani et al., 2001).
Table (4): Mean daily Food intake, body weight gain and FER of hyperglycemic rats fed on oat, barley and mixture of oat and barley (Mean ± S.E.).

<table>
<thead>
<tr>
<th></th>
<th>Positive Control (DM)</th>
<th>DM-Oat</th>
<th>DM-Barley</th>
<th>DM- Oat+ Barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food intake gm/day</td>
<td>11.07± 0.49</td>
<td>13.68± 0.17**</td>
<td>11.75± 0.57</td>
<td>12.10± 0.25</td>
</tr>
<tr>
<td>Body weight gain gm/day</td>
<td>3.03± 0.33</td>
<td>2.62± 0.38</td>
<td>2.15± 0.33**</td>
<td>2.87± 0.35</td>
</tr>
<tr>
<td>FER</td>
<td>0.27± 0.02</td>
<td>0.19± 0.03**</td>
<td>0.18 ± 0.01**</td>
<td>0.24± 0.01</td>
</tr>
</tbody>
</table>

* Significantly differed from positive control group at (P<0.05).
** Significantly differed from positive control group at (P<0.01).

Concerning the effect of oat and barley on blood glucose and serum cholesterol profile, data in Table (5) illustrated that, all rats groups fed on oat, barley and their mixture showed highly significant (P< 0.01) decrease in blood glucose level when compared with the positive control group. Serum cholesterol and LDL levels were significantly (P< 0.01) decreased in groups fed on oat, barley and their mixture in comparison with positive control values, on the other hand serum HDL level increased significantly (P< 0.01) in experimental groups when compared to the value of positive control. These results were matching with that of Liljeberg et al. (1996) who fed test meals containing common barley or high-fiber barley as bread, glucose and insulin responses after bread made with either 50% common barley/50% high-fiber barley flour or a 20/80 ratio of flours were both significantly lower than the control white bread.

The results of present study were in agreement with Behall et al. (2004) who demonstrated that, oat and barley consumption reduces glucose and insulin responses. The higher soluble fiber content resulted in a smoother response curve, lower peak values. The beneficial reductions in glucose and insulin can result if sufficient soluble fiber is consumed; they suggested that increasing the total oat and/or barley content of the diet might lower the risk for type 2 diabetes. The differences noted in glycemic responses between the two grains could be accounted for the
difference in $\beta$-glucan content, in fact, a dose response for soluble fiber for lowering glucose and insulin postprandially has been reported, in addition McMullen (2000) concluded that, the most important beneficial effects of $\beta$-glucan are their contribution to a lowering of serum cholesterol and as well moderating blood glucose in diabetics.

Table (5): Mean blood glucose, serum cholesterol, serum HDL and serum LDL of hyperglycemic rats fed on oat, barley and mixture of oat and barley (Mean+ S.E.).

<table>
<thead>
<tr>
<th></th>
<th>Positive Control (DM)</th>
<th>DM-Oat</th>
<th>DM-Barley</th>
<th>DM-Oat+ Barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Glucose mg/dl</td>
<td>281.25± 0.77</td>
<td>236.58±1.21 **</td>
<td>217.33±1.14 **</td>
<td>225.50±1.56 **</td>
</tr>
<tr>
<td>Serum Cholesterol mg/dl</td>
<td>117.62± 0.77</td>
<td>104.97±1.08 **</td>
<td>96.75±0.72 **</td>
<td>102.19±0.53 **</td>
</tr>
<tr>
<td>Serum HDL mg/dl</td>
<td>30.25±0.55</td>
<td>42.88±1.17 **</td>
<td>39.22±0.49 **</td>
<td>40.37±0.66 **</td>
</tr>
<tr>
<td>Serum LDL mg/dl</td>
<td>69.03±0.29</td>
<td>48.33±0.46 **</td>
<td>43.15±0.29 **</td>
<td>46.98±0.30 **</td>
</tr>
</tbody>
</table>

* Significantly differed from positive control group at (P<0.05).
** Significantly differed from positive control group at (P<0.01).

Evidences suggest that dietary fiber from whole grains may be responsible for some of the beneficial health effects. $\beta$-glucan, a soluble fiber found in oats and barley, has been shown to reduce glycemia (Tosh, 2013) and cholesterolemia (Othman et al., 2011). It was illustrated that, in mice, whole grain oat improved insulin sensitivity and plasma cholesterol profile and the effects were associated with the changes in cecal microbiota composition (Zhou et al., 2014).

Different physiological effects of $\beta$-glucan in isolated form or as a constituent of oat and barley products are related to its viscosity: attenuation of postprandial plasma glucose and insulin responses, high transport of bile acids towards lower parts of the intestinal tract and high
excretion of bile acids or lowering of serum cholesterol levels (Butt et al., 2008).

In the present study, the serum cholesterol, HDL and LDL responses to feeding of oat, barley and their mixture were in line with the findings of Arshadi et al. (2014) and Abo Taleb et al. (2015) who stated that, barley and oat extract simultaneously cause reduction of blood fats and cholesterol. Furthermore, barley and oat extracts reduce concentration of LDL and glucose, and increase concentration of HDL, and the barley extract has more useful effect than oat extract in reduction of blood lipid parameters. Johansson (2006) demonstrated that, oat and barley β-glucans are plant polysaccharides resistant to digestion and absorption in the small intestine, and they attenuate both blood glucose and cholesterol. The reduction of cholesterol by oat and/or barley may be due to the fact that, oat bran increased fecal cholesterol and bile acid excretion and increased production of short-chain fatty acids, on the other hand, barley may decreased cholesterol by the inhibition of the rate-limiting enzymes for cholesterol and bile acid synthesis (Kahlon, 2001). High viscosity retards the mixing of luminal contents which may slow down the transport of digestive enzymes to their substrates, impair the emulsification of lipids, and retard the transportation of nutrients to the absorbing (Mälkki and Virtanen, 2001).

The cholesterol-lowering effects of oats have been attributed to the β-glucan fractions in humans (Othman et al., 2011) and animals (Delaney et al., 2003; Immerstrand et al., 2010 and Bae et al., 2010). Several mechanisms have been proposed for the hypocholesterolemic effect of β-glucan including increasing viscosity of intestinal contents and reduced absorption of dietary cholesterol and reabsorption of bile acids (Lund et al., 1989); increasing binding of luminal bile acids by β-glucan thereby decreasing enterohepatic circulation of bile acids with subsequent increased hepatic uptake of circulating cholesterol for bile acids synthesis; or reducing hepatic cholesterol synthesis secondary to improved insulin sensitivity (Bell et al., 1999); and inhibiting hepatic cholesterol synthesis by acetate (Karlsson et al., 2013) and propionate (Zhang et al., 2012) produced by colonic bacteria fermentation of soluble fibers.
Table (6): The effect of mixing flour (wheat 60%+ oat 40%), (wheat 60%+ barley 40%) and (wheat 60%+ oat 20%+ barley 20%) on rheological properties of the dough by Farinograph analysis.

<table>
<thead>
<tr>
<th></th>
<th>Water Absorption %</th>
<th>Arrival Time (Min)</th>
<th>Dough Development (Min)</th>
<th>Stability Time (Min)</th>
<th>Softening Degree (B.U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat 100% (Control)</td>
<td>55.9</td>
<td>1.0</td>
<td>1.5</td>
<td>2.5</td>
<td>60</td>
</tr>
<tr>
<td>Wheat 60%+ Oat 40%</td>
<td>70.6</td>
<td>4.0</td>
<td>5.0</td>
<td>11.0</td>
<td>30</td>
</tr>
<tr>
<td>Wheat 60%+ Barley 40%</td>
<td>72.8</td>
<td>4.5</td>
<td>5.5</td>
<td>7.0</td>
<td>90</td>
</tr>
<tr>
<td>Wheat 60%+ Oat 20%+ Barley 20%</td>
<td>64.9</td>
<td>3.5</td>
<td>3.5</td>
<td>12.0</td>
<td>100</td>
</tr>
</tbody>
</table>

Quality of wheat flour is a key in making appropriate dough for a given end product. In the current study, qualities of dough prepared from different flour were assessed using Farinograph and Extensograph. From table (6) and figures (1 a, 1 b, 1 c and 1 d) it could be noticed that, replacement of wheat flour with 40% of oat or barley increase the water absorption from 55.9% in control sample to 70.6 and 72.8% in oat and barley dough respectively. This was in agreement with the reports of Goldstein et al. (2010) and Mins et al. (2012) who stated that, there were increases in water absorption for various fiber blended wheat flour dough. This could be explained in accord to Rieder et al. (2012) who illustrated that, the increase in water absorption is probably due to the high $\beta$-glucan content in the barley flour; $\beta$-glucan with its high water-binding capacity would minimize the amount of free water in dough. Therefore, higher amount of water is required to reach a fully developed gluten network in flour containing $\beta$-glucan.

Comparable result have been reported by Sudha et al. (2007) when studying the effect of adding fiber of different sources (wheat, rice, oat and barley) to wheat flour on the rheological properties of the dough, they found that, by increasing the bran level from 10% to 40% the highest increase in water absorption was recorded for barley bran 63.88 to 76.28
g % and wheat bran 63.52 to 69.85 g %. It is believed that fiber incorporated dough are recognized for their capacity to absorb noteworthy amount of water. The presence of a large number of hydroxyl groups allow more water interactions through hydrogen bonds which plays a major role in absorbing more water (Rosell et al., 2001).

Fig. (1): Farinograph and Extensograph tests for dough of wheat 60%+ oat 40%, wheat 60%+ barley 40% and wheat 60%+ oat 20%+ barley 20%.

The data in Table (7) and figures (1 e, 1 f, 1 g and 1 h) showed the Extensograph results for different dough prepared from wheat or its mixture with oat and barley flour, the results illustrated that dough resistance and dough extensibility decreased as a consequence of adding either oat or barley flour, probably due to the effects of gluten dilution, water retention and higher levels of fat (Salehifar and Shahedi, 2007). In the study of Hoseney (1994), as the oat level in the flour increased, the time needed for the preparation of good dough was also increased, due to a weaker formation of gluten matrix. Since pentosans and β-glucan benefit from high water binding capacities, their presence in the oat flour
caused slightly higher water absorption capacities, for dough made of oat as part of the formula in comparison with control. Oat flour had pronounced effects on dough rheological properties.

Table (7): The effect of mixing flour (wheat 60%+ oat 40%), (wheat 60%+ barley 40%) and (wheat 60%+ oat 20%+ barley 20%) on rheological properties of the dough by Extensograph analysis.

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Number (R/E)</th>
<th>Energy (Cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat 100% (Control)</td>
<td>442</td>
<td>86</td>
</tr>
<tr>
<td>Wheat 60%+ Oat 40%</td>
<td>220</td>
<td>80</td>
</tr>
<tr>
<td>Wheat 60%+ Barley 40%</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Wheat 60%+ Oat 20%+ Barley20%</td>
<td>350</td>
<td>55</td>
</tr>
</tbody>
</table>

It could be noticed from Figure (2) that wheat flour bread had higher acceptance score in color, taste, aroma, texture and overall quality, followed by mixture wheat 60%+ oat 20% + barley 20%, wheat 60% + oat 40% and wheat 60% + barley 40%. Sensory evaluation results indicated a low score of oat and barley breads and this could be due to the dark color of bread and the presence of little bitter taste when the percentage of oat and barley increased (Salehifar and Shahedi, 2007). However, among tested mixtures the wheat 60%, oat 20% and barley 20% mixture was the highest in overall quality score, which indicated good acceptability by panelists.
Figure (2): The effect of mixing flour (wheat 60%+ oat 40%), (wheat 60%+ barley 40%) and (wheat 60%+ oat 20%+ barley 20%) on sensory attributes of baked breads.

From the results of the present study, it could be concluded that incorporating of oat 20% and barley 20% in bread loaf flours’ mixture, is recommended especially for people with diabetic mellitus and cardiovascular diseases to get the advantage of increasing daily intake of soluble fiber.

References:


تأثير الشوفان والشعير على بعض المقايسات الحيوية في فئران التجربة المصابة بارتفاع مستوى جلوكوز الدم وأثرها على خصائص العجان والخبز

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الملخص:

لاعتبارات الآثار الصحية للشوفان والشعير وهميتها في الوقاية والتحكم بأعراض امراض ارتفاع مستوى السكر بالدم وأمراض القلب والأوعية الدموية، فإن هذه الدراسة تهدف إلى دراسة أثر إضافة الشوفان والشعير إلى وجبات الفئران المصابة بارتفاع مستوى الجلوكوز بالدم وأثرهما على مستوى الجلوكوز بالدم، مستوى الكوليسترول اللكي، الشحم البروتينية عالية الكثافة (HDL) والشحم البروتينية منخفضة الكثافة (LDL)، بالإضافة إلى دراسة أثر إضافة الشوفان والشعير إلى خليط دقيق القمح على خصائص العجان الناتجة وكذلك تقييم الخصائص الحسية للخبز الناتج من مخلوط دقيق القمح، الشوفان والشعير المختلفة. تم استخدام ثلاثن فئران، (1) مجموعة بارزة وتنقسم إلى خمس مجموعات (6: فئران بكل مجموعة) وهمي: (1) مجموعة الضابطة وتحت خليط القمح، (2) مجموعة الضابطة الإيجابية (مصابا بارتفاع مستوى جلوكوز الدم) وتحت خليط القمح، (3) مجموعة الفئران المصابة بارتفاع مستوى جلوكوز الدم وتحت خليط القمح، (4) مجموعة الفئران المصابة بارتفاع مستوى جلوكوز الدم والتي تغذت على وجبات بها 40% شوفان (DM-oat) و(5) مجموعة الفئران المصابة بارتفاع مستوى جلوكوز الدم والتي تغذت على وجبات بها 60% شعير (DM-barley) لمدة 6 أسابيع. وتم قياس كل من: الزيادة في وزن الجسم وحساب معدل كفاءة الغذاء. وبعد مرور 6 أسابيع وانتهاء فترة التجربة تم سحب عينات الدم من الفئران وتغذير مستويات كل من: جلوكوز الدم، الكوليسترول اللكي، الشحم البروتينية عالية الكثافة (HDL) والشحم البروتينية منخفضة الكثافة (LDL). وكذلك تم تقييم خصائص العجان الناتجة من استخدام مخلوط خليط القمح، الشوفان والشعير وتحمل الخصائص الحسية للخبز المنتج من استخدام المخلوط السابق. أظهرت نتائج الدراسة حدوث انخفاض معنوي في وزن الفئران التي تغذت على كل من الوجبات المحتوية على 40% شوفان. 

المجلد الثاني- العدد الأول- مسلسل العدد (3)- يناير 2016
أو 40% شعير أو خليط الشوفان والشعير، بالإضافة إلى أن تلك المجموعات أظهرت انخفاضاً معنوياً في نسبة الجلوكوز بالدم عند مقارنتها بنتائج المجموعة الضابطة الإيجابية، كما انخفضت معنوياً مستويات كل من الكوليسترول الكلي والشحوم البروتينية منخفضة الكثافة في المجموعات التي تغذت على الشوفان 40% والشعير 40% وخليط الشوفان 20% والشعير 20%، بينما ارتفعت معنوياً قيم الشحوم البروتينية عالية الكثافة لتلك المجموعات عند مقارنتها بنتائج المجموعة الضابطة الإيجابية. وأظهرت نتائج تقييم خصائص العجائن أن استبدال 40% من القمح بكلا من الشوفان أو الشعير أدى إلى ارتفاع نسبة امتصاص الماء وأرتفاع مقاومة العجائن للفرد مع انخفاض في انخفاض في التغذية. وأظهرت نتائج التقييم الحسي للخبز الناتج أن خبز القمح هو الأعلى في التقليل بالنسبة إلى اللون والطعم والرائحة والملمس والجودة الكلية وليه الخبز المصنوع من خليط (القمح 64% + الشوفان 24% + الشعير 24%).