5- SUMMARY

Barley has not yet been used as the main ingredient in such common food commodities as bread and biscuit. Barley grain is an excellent source of both soluble and insoluble dietary fiber. Barley β-glucans are recognized to have important positive health impacts. Consequently, partial replacement of wheat with whole barley may result in development of acceptable and functional products. Meanwhile, the admixture of barley will undoubtedly affect the unique dough-producing properties of wheat and consequently the final food product. Clarifying the effects of barley on the mechanical properties of wheat flour dough is crucial for determining both the handling properties of the dough during processing and the quality of the finished food product. Such information may be particularly useful to manufactures seeking specific raw materials for new functional food products.

The present investigation was undertaken to study the possibility of producing some bakery products by inclusion of barley flour in plain wheat bread and biscuit formulations which may have a beneficial effects on human health. The objectives of the present work could be summarized in the following points: 1- Determination the chemical compositions of the barley bread and biscuit. 2- Studying the effects of the partial replacement of wheat flour with barley flour on the rheological properties of wheat flour dough. 3- Studying the effects of partial replacement of wheat flour with barley flour on the sensory properties of the final products to decide the more suitable level of barley flour substitution to prepare consumer accepted products. 4-
Evaluation of the biological properties of the more acceptable barley products.

The results obtained could be summarized in the following points:

1- Chemical composition of wheat and barley flours:

The results indicated that moisture; crude protein, lipids, ash, crude fiber and total carbohydrate contents of 82% wheat flour were 13.20, 11.80, 1.66, 1.15, 1.70 and 83.69 %, respectively while those of 72% wheat flour were 12.30, 10.00, 0.84, 0.38, 0.62 and 88.16 %, respectively. Chemical analysis also showed that moisture, crude protein, lipids, ash, crude fiber and total carbohydrates of whole barley flour (Naked barley) were 11.80, 11.11, 1.81, 2.04, 2.72 and 82.32%, respectively. On the other hand determination of gluten showed 82% and 72% wheat flours contained 9.67 and 11.07 %, respectively while barley flour was found to be free from gluten.

2- Water hydration capacity (WHC) of wheat flour, barley flour and their blends:

Results indicated that water hydration capacity (WHC) of 72% and 82% wheat flours were 103% and 114%, respectively. The higher WHC value of 82% wheat flour could be explained to that 82% wheat flour contained high level of bran comparing with 72% wheat flour, consequently 82% wheat flour absorbed more quantity of water indicating higher values of WHC. The highest value of WHC i.e. 186 % was found with whole barley flour. Results also indicated that blending wheat flour (72% or 82% extraction) with barley flour increased its ability to absorb
more water. WHC of wheat flour increased as the barley replacement level increased.

3- Gas production in dough from wheat flour (82% extraction) blended with different levels of barley flour:

The results showed that gas production in wheat dough increased as the fermentation time extended. Meanwhile, when fermentation period extended beyond 75 – 90 min, no significant increase was found in the amount of gas production. The same trend i.e. increasing gas production as fermentation period extended was also found in dough samples made from wheat flour blended with barley flour. Meanwhile, the replacement level of barley flour showed no significant effect on the amount of gas produced in comparison to control samples made from wheat flour only. It could be conclude that blending of wheat flour with barley flour has no negative effect on the gas production during fermentation process.

4- Farinograph parameters of wheat flour blended with different levels of barley flour:

Data indicated that water absorption values of doughs made from barley / wheat flour blends were higher than that of the ordinary wheat flour dough. Farinograph data showed that water absorption of 82% wheat flour dough increased from 59.8% to 68.1, 75.6, 80.8 and 88.7% for doughs contained barley flour at substitution levels of 15, 30, 45 and 60, respectively. Data showed that mixing time of dough extended from 3.0 min for control sample (100% wheat flour dough) to 4.0, 7.0, 10.0 and 11.0 min for doughs from barley flour with replacement levels of 15, 30, 45 and 60, respectively. On the other hand, time of dough stability of barley contained dough was clearly shorter
than that of control wheat dough. Data showed that stability time of doughs contained 15, 30, 45 and 60% barely flour were 4.0, 4.0, 1.0 and 0.5 min, respectively while wheat dough showed a high stability time which was estimated by 7.0 min.

Farinograph data of 72% wheat flour dough were, water absorption 8.2%, mixing time 2.0 min, dough stability 2.5 min. Farinograph parameters were considerably altered in doughs contained barley flour. Results showed that as barley replacement level increased, water absorption increased, mixing time increased while dough stability decreased.

5- Chemical composition of barley Balady bread:

Chemical analysis indicated that Balady bread made from 82% wheat flour contained 37.2, 7.0, 1.8, 0.35, 2.12 and 88.73% of moisture, protein, ash, lipids, fiber and carbohydrates, respectively. Bread samples made from wheat flour blended with barley flour showed some variations in their chemical composition in comparison with control sample. Results indicated that moisture content of barley bread increased as barley flour increased. Moisture contents of bread samples from 15, 30, 45, 60 and 75% barley replacements were 38, 40, 40.4, 42.47 and 41.7, respectively. Fiber contents of bread samples contained 15, 30, 45, 60 and 75% barley flour were 2.23, 2.35, 2.38, 2.94 and 1.18%, respectively. Moreover, ash contents of barley bread samples were also found to be increased as replacement level of barley flour increased. Chemical analysis of bread samples showed that lipid contents were 0.35, 0.40, 0.48, 64, 0.94 and 1.18% for bread samples contained 15, 30, 45, 60 and 75% of barley flour, respectively. Total carbohydrates were found to be 89.23, 89.49, 90.28, 90.41 and 90.19% in bread
samples contained 15, 30, 45, 60 and 75% of barley flour, respectively. On the other hand, protein content of barley bread decreased as the level of barley flour increased. Data showed that protein content of 15, 30, 45, 60 and 75% bread samples were 6.3, 5.8, 4.7, 4.2, and 4.00, respectively.

6- Chemical composition of barley biscuit:

Chemical analysis showed that biscuit made from 72% wheat flour contained 1.54, 7.1, 1.1, 12.2, 0.62 and 78.98% of moisture, protein, ash, lipids, fiber and carbohydrates, respectively. The results indicated no variations in moisture content of biscuit made from wheat / barley blends comparing with wheat sample. Fiber, ash and total carbohydrates of barley biscuit were found to be increased as barley substitution level increased. Results showed that biscuits with barley contents of 15, 30, 45, 60 and 75% contained 0.68, 0.75, 0.83, 0.93 and 1.08% of fiber, respectively and 1.26, 1.33, 1.42, 1.5 and 1.58% of ash, respectively. Total carbohydrates were found to be 78.77, 78.57, 79.10, 80.43 and 80.64% in biscuit samples contained 15, 30, 45, 60 and 75% of barley flour, respectively and lipid contents were 12.40, 12.63, 12.75, 12.90 and 13.20%, respectively. On the other hand protein content decreased in samples contained high levels of barley flour. Data showed that protein contents of 15, 30, 45, 60 and 75% barley bread samples were 6.89, 6.72, 5.90, 4.24, and 3.50, respectively.

7- Sensory evaluation of barley Balady bread:

Sensory evaluation data showed that Balady bread made from only wheat flour scored the highest values for the different quality attributes. Meanwhile, no significant differences could be found between Balady bread made from barley flour at a
replacement level of 15, 30 and 45% regarding their external color, internal color, taste, odor, separated layers. On the other hand score values of quality attributes of bread significantly decreased as the replacement level of barley flour increased beyond 45%. Based on these findings it could be concluded the possibility of replacing 45% of wheat flour with barley flour in making Balady bread with acceptable sensory quality characteristics.

7- 1- Improving quality characteristics of barley – blend Balady bread:

Trials were made to improve the quality characteristics of Balady bread with high content of barley by adding some of the commercial preparations of baking improvers to bread formula. The baking improvers used were α- 600 and Sultani MB in addition to ascorbic acid. These improvers were added and evaluated at different concentrations with Balady bread contained 60% of barley flour. The baking improver α- 600 was found to be the more effective in improving the quality characteristics of barley enriched Balady bread. Sensory evaluation data indicated that quality characteristics of external color, internal color, taste, odor and separated layers significantly improved as the concentration of the baking improver increased. 2.0% of α- 600 was found to be the optimum level for making barley enriched Balady bread (60%) with good qualities.

Sensory evaluation data also showed that the backing improver named Sultani MB had an improving effect on quality characteristics of barley Balady bread and the improving effect was more pronounced at the higher concentrations of the
improver. Score values of external color, internal color, taste, odor and separated layers indicated that the more suitable concentration of Sultani MB was 2.0%.

The improving effect of ascorbic acid on the sensory quality characteristics of barley blend Balady bread was also evaluated. Sensory evaluation data showed that improving effect of ascorbic acid was more clearly observed at a concentration of 100 PPM. As the concentrations of ascorbic acid increased to 150 – 200PPM, score values for internal color, external color, taste, odor and separated layers were significantly decreased.

8- Sensory evaluation of barley biscuits:

Data indicated that biscuit made from wheat flour scored the highest score values for appearance, crumb color, crust color, texture, taste and odor. However, score values of these characteristics were slightly influenced due to the incorporation of barley flour in making biscuit particularly at high levels of barley replacement. Results showed no significant differences for the appearance crust color and crumb color properties between barley biscuit samples with supplemented levels of 15 – 45%. Texture of barley biscuit was almost similar to that of wheat biscuit with no significant differences even in samples contained high levels of barley (60 – 75%). Score values of taste and odor of barley biscuit indicated that the effect of barley replacement was more observed at high substitution levels in particular for odor property.
8- 1- Improving sensory quality properties of barley- blend biscuits:

Sensory evaluation data of 60% barley contained biscuit showed that α-600 was effective in improving quality characteristics of barley biscuit even at low concentrations. No significant differences could be observed between appearance, crumb color, crust color, texture, odor and taste of control wheat biscuit and those of barley biscuit with added 1.0% of α-600.

The improving effect of Sultani M B on quality characteristics of barley biscuit was evaluated and results obtained indicated that score values for appearance, crumb color, crust color, texture, odor and taste of barley biscuit increased as the concentration of Sultani M B increased up to the concentration on 1.5%. Comparing barley biscuit samples with control wheat biscuit samples showed no significant differences.

Ascorbic acid showed no significant improving effect on the quality properties of barley biscuit.

9- Staling of barley Balady bread:

Fresh Balady bread made from wheat flour showed AWRC value of 340(at zero time storage). This value decreased to 285 and 255 after 24 and 48 h storage at room temperature, respectively. The freshness losses of wheat Balady bread samples stored at room temperature for 24 and 48 h were estimated by 16.18 and 25.00, respectively. On the other hand, Balady bread made from barley flour at the different levels of barley replacement recorded higher value (at zero time storage) in comparison with wheat bread (control). Data showed that AWRC values for bread made form barley replacement levels of
15, 30, 45, 60 and 75% were 335, 360, 380, 408, and 381, respectively. These values decreased to 301, 330, 358, 378 and 348, respectively after 24 h storage at room temperature. The losses of freshness in barley bread at replacement levels of 15, 30, 45, 60 and 75% were estimated by 10.2, 8.3, 5.8, 7.35, and 8.7%, respectively after 24 h storage. Data indicated that freshness of bread made from barley at replacement levels of 15, 30, 45, 60 and 75%, respectively decreased by 14, 11.28, 9.5, 17.9 and 21.0% after storage for 48 h at room temperature. Data showed that freshness of barley bread was much better than of wheat bread. Barley Balady bread with replacement level of 45% retained good freshness comparing with wheat bread.

10- Biological evaluation of barley Balady bread:

Animal bioassay method was followed to clarify the healthy functional properties of 60% barley bread. Male albino rats were used in the present experiments. The biochemical determinations included; body weight, internal organs weights, triglycerides, total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol, and liver function for total proteins, albumin and alanine transaminase and aspartic transaminase activities.

10-1- Body weight:

Statistical analysis for body weight and body weight gain at the end of experimental period showed significant differences between the evaluated diets groups. The lowest gain in body weight was found with rats fed on diet contained cholesterol. Data showed that the initial and final body weights of cholesterol diet groups were 103 and 113 g/ rat, respectively with body weight gain as low as only 8.0 %. On the other hand rats fed on
diets contained barley and wheat breads showed a significant higher body weight after 8 weeks of feeding. The initial and final body weights of rats fed on diet contained wheat bread were 107 and 230 g/ rat, respectively with body weight gain of 105%. The highest body weight gain was recorded with rats fed on diet contained barley bread. The initial and final body weights of rats fed on barley bread were 120 and 275 g/ rats, respectively and the body weight gain was estimated by 113%.

10- 2 -Relative weight averages of internal organs:

Results indicated that relative weight of livers of rats fed on barely bread and wheat bread diets were significantly higher than in those fed on basal and cholesterol contained diets. Relative weight of livers of rats fed on basal, cholesterol - added, wheat bread and barley bread were 2.95, 3.52, 3.66 and 3.56%, respectively. Liver weight of rats group fed on barley diet was significantly lower compared with wheat diet. Spleen relative weights of rats fed on basal diet and those contained cholesterol, wheat bread and barely bread were 0.31, 0.26, 0.21 and 0.23%, respectively. Spleen weight of rats fed on barley diet was significantly higher than in wheat diet. Relative weights of heart, kidney and lung, were significantly lower in rats fed on wheat and barley diet.

10- 3- Serum triglycerides:

The results indicated that incorporating of wheat and barley breads on the diets showed significant lowering effects on serum triglycerides. The initial concentrations of triglycerides in rats fed on wheat and barley diets were 150 and 162 mg/ 100m, respectively which were decreased down to 118 and 113 mg/ 100ml, respectively. Data indicated that wheat bread resulted in
lowering triglycerides by 21.3 %, while barley bread was more effective in lowering serum triglycerides which was estimated by more than 30 %.

10-4- Serum cholesterol.

10-4-1- Total cholesterol:

Total cholesterol concentration in rats fed basal diet (without added cholesterol) was found to be initially 86 mg/100ml and finally 91 mg/100ml at the end of experimental period. The initial level of cholesterol in rats fed cholesterol added diet was determined by 223 mg/100ml which was increased up to 240 mg/100ml after 4 weeks of feeding period. The results indicated that total cholesterol of rats fed basal and cholesterol added diets increased by 5.81 and 7.17 %, respectively at the end of the experimental period. The initial level of total cholesterol in rats fed wheat bread diet determined by 180/100ml decreased to 120/100ml with decreasing level of 33.3 %. Barley bread showed the higher cholesterol lowering effect since the initial level of total cholesterol lowered from 175/100ml to 101/100ml after 4 weeks feeding on diet contained barley bread indicating cholesterol – lowering effect estimated by 42.3%.

10-4-2- Low Density Lipoprotein Cholesterol (LDLc):

The results showed that the initial and final concentrations of LDL in rats fed basal were 19mg /100ml and 20mg / 100ml with change estimated by +5.26%. Meanwhile, in rats fed cholesterol added diet, the initial concentration of LDL significantly increased from 154 mg/ 100 ml to 176mg/ 100 ml
indicating an increasing level of 14.3 % at the end on experimental period.

On the other hand, significant lowering effects were observed for LDL cholesterol in the serum of rats fed wheat and barley bread diets comparing with those fed the basal and cholesterol added diets. After 4 weeks of feeding on wheat bread the level of LDL cholesterol significantly decreased from 102 to 49 mg/ 100 ml. The lowest concentration of LDL cholesterol determined by 25 mg/ 100ml was found in serum of rats fed the barley bread diet for 4 weeks. The greatest lowering effect on LDL cholesterol was found with barley bread diet. The results showed a significant lowering effect of barley bread diet which was as high as more than 71.0% while wheat bread showed a lowering effect estimated by about 51.9%.

10-4-3- High Density Lipoprotein Cholesterol (HDLc):

A considerable decrease was found in serum content of HDL in rats fed the cholesterol added diet. Data showed that the initial value of HDL cholesterol significantly lowered from 51 mg/ 100ml to 42 mg/ 100ml with decreasing level estimated by 17.65 % after 7 weeks feeding on cholesterol - added diet. No observed changes could be found between the evaluated diet groups regarding HDL cholesterol. The initial concentrations of HDL cholesterol in serum from rats fed basal, wheat bread and barley bread diets ranged between 48 to 53mg/ 100ml which were slightly decreased to 47 – 52 mg/ 100ml at the end of 4 weeks feeding. Decreasing rate of HDL cholesterol was found as low as only ranging between 1.89% in barley diet group to about 7.7% in basal diet group with no significant difference between the test groups.
In addition to the concentration of serum cholesterol, there are several ratios that are commonly included in lipid profile tests. These ratios are LDL/total cholesterol, HDL/total cholesterol and LDLc/HDLc.

High density lipoprotein cholesterol (HDLc) is called by medicinal community the good cholesterol while low density lipoprotein cholesterol (LDLc) is known as the bad cholesterol. Therefore, reduction of LDL in considered beneficial in lowering coronary heart disease risk. The highest value of LDL/TC was found in serum of rats fed the cholesterol added diet. Data showed that LDL/TC ratio was significant higher in rats fed the cholesterol added diet with value as high as 0.74. Replacing 60% of wheat flour with barley flour in making Balady bread resulted in reducing LDLc. The results showed that LDL/TC ratios for rats fed wheat and barley bread diets were 0.40 an 0.25, respectively which clearly indicated that barley bread was more effective as cholesterol-lowering factor.

Maintaining a higher proportion of HDLc is positively correlated with reduced coronary heart disease risk. The function of HDLc is transporting cholesterol from tissue to the liver for excretion into bile. In the present study, the highest HDLc/TC ratio (0.52) was found in rats fed barley bread diet which was significantly higher than in rats fed wheat bread diet (0.39).

The LDL/HDL ratio showed a similar trend. The LDLc/HDLc ratios for rats fed wheat and barley diets were 1.04 and 0.48, respectively after 8 weeks of feeding these diets. Significant LDL reduction have been observed with barley diets.
but HDLc was either not influenced or was significantly evaluated.

10-5- Liver function tests:

Results showed that feeding on diet contained wheat or barley bread significantly affected the level of ALT and AST enzymes. The highest level of ALT (28 µ/ L) was found in the hypercholesterolemic rats followed by rat group fed basal diet 17µ/ L. The lower levels of the liver enzyme ALT were found in the serum from rats fed wheat and barley breads with values of 15 and 14µ/ L, respectively with no significant differences.

Data indicated the pronounced effect of diet on the level of AST. It was found that serum from hypercholesterolemic rats showed a level of AST as high as 99 µ/ L followed by basal diet group 97 µ/ L. These values are much higher than normal levels decided by the medicinal community (8 to 48 µ/ L). Feeding the hypercholesterolemic rats for 4 weeks on wheat or barley contained diets showed a significant lowering effect on the level of AST enzyme. The level of AST in rats fed wheat bread was 33 µ/ L while those fed barley bread showed a lower value determined by 30 µ/ L.