

## Comparison Between the Effects of Different Sources of Dietary Fiber on Blood Lipid Profile in Rats

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### Abstract

This study was conducted to investigate the effect of different sources of dietary fiber on serum lipids and lipoproteins in Sprague-Dawley rats, namely total cholesterol (TC), Low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) triglyceride (TG), and (HDL-C/LDL-C) ratio. The experimental diets included casein diet, untreated wheat bran diet, soaked wheat bran diet, Arabic white bread diet, lupine diet, chickpea and pectin diet. Each group of rats (6/group) was fed one of the seven prepared diets for 6 weeks. Untreated wheat bran has hypercholesterolemic effect since it significantly ( $p < 0.05$ ) increased TC, LDL-C and decreased HDL-C values as compared with treated bran diets. The soaking process lowered significantly ( $p < 0.05$ ) TC and LDL-C levels in comparison with casein diet. Chickpea diet had higher significant value of HDL-C than soaked wheat bran and lupine diets. However, it was not significantly different from casein and untreated wheat bran diet. In addition, Chickpea diet had a significantly higher HDL-C value than pectin diet. The values of HDL-C of the Lupine diet are not significantly different ( $p > 0.05$ ) from casein and pectin diets, but it has also decreased LDL-C. White bread was found to have no hypocholesterolemic effect in comparison with treated brans groups and control group; it raised TG, TC and LDL-C levels. Pectin had a similar behavior in a remarkable decrease blood TC and LDL-C cholesterol. White bread was found to have no hypocholesterolemic effect in comparison with treated brans groups and control group; it raised TG, TC and LDL-C levels. It is concluded that the behavior of cereals and legumes varies in its effect on cholesterol-lowering ability. Preparation of wheat bran foods by soaking improve some physiological characteristics of insoluble fibers, particularly lowering total cholesterol TC and low-density lipoprotein cholesterol LDL-C).

**Keywords:** Dietary fiber, Arabic bread, Wheat bran, Soaking, Chickpea, Lupine, Pectin, Lipoproteins, Rat.

### 1. Introduction

Dietary fiber is defined as the endogenous components of plant materials in the diet, predominantly non-starch polysaccharides and lignin, which are resistant to digestion by human enzymes (Anderson et al., 1990a). Dietary fibers can be classified into two major groups depending on their solubility in water. The structural or matrix fibers (Lignins, cellulose, and some hemicelluloses) are insoluble; whereas the natural gel-forming fibers (pectins, gums, mucilages, and the remainder of the hemicelluloses) are soluble (Anderson et al., 1990b; Brown et al., 1999).

The recent interest in DF can be mainly attributed to the hypothesis, proposed by Burkitt and Truswell in 1970s, which linked a number of chronic diseases, such as; constipation, diverticulosis, cardiovascular diseases (CVD) or cancers, in Western countries to deficiency in DF intake (Lairon et al., 2003). Dietary fibers are thought to have a beneficial effect in the prevention of some diseases such as obesity, heart diseases, cancers (particularly colon and breast), diabetes and gastrointestinal tract (GIT) disorders. Also, dietary fibers have a role in the treatment of other diseases like hyperlipidemia, diabetes, obesity, constipation, hemorrhoids and diverticuloses (Gray, 1995; O'Sullivan, 1998).

About 75% of individuals with hypercholesterolemia respond to dietary intervention (Anderson et al., 1990b). Jenkins et al. (2002a) recently summarized nutrition approaches to decreasing serum LDL-cholesterol values, which is a major risk factor for CHD. These nutrition interventions, that have the potential to decrease serum LDL-cholesterol values by 35%, included: fats with low saturation degree, low cholesterol diet, increased intake of soluble fibers.

Legumes, especially good sources of soluble fiber, are a common dietary constituent of ethnic communities exhibiting lower rates of cardiovascular disease (CVD) (Pittaway, 2006). Soluble fiber acts in the upper gut where it slows digestion and absorption and decrease serum cholesterol concentrations, effects which may be beneficial in diabetes, hyperlipidemia, and in weight control (ADA, 1987; Leeds and Hussain, 1998; Anderson, 1986). Many evidences stated that the consumption of legume kernel fibre may beneficially modify

coronary and colonic health. For example, two human intervention studies were conducted by Fechner & Jahreis in 2010 to determine the efficacy of a native lupine kernel fibre (*L. angustifolius* Boregine) on the prevention of risk factors for gastrointestinal or cardiovascular diseases. The four-week intervention with lupine fibre-enriched food in hypercholesterolemic subjects decreased the total cholesterol and LDL.

The effect of lupine consumption in humans has been elucidated by Weiße et al in 2010; where lupine protein compared to casein slightly lowered the concentration of LDL cholesterol in hypercholesterolemic subjects. In addition, lupine has shown anti-atherogenic effects in laboratory animals due to its lipid-lowering properties (Millán-Linares et al, 2014). Recently in 2014, Millan-Linares et al reported in their paper that lupine (*Lupinus angustifolius* L.) is an herbaceous plant typical of the Mediterranean region. Millan-Linares suggested that lupine seeds can be incorporated as a protein source in both animal feed and in a variety of human foods.

Chickpea (*Cicer arietinum* L) is a member of the Leguminosae and is the fifth most important legume in the world, as reported by Faris and Takruri in 2002. Chickpea dip, which is prepared from chickpea, tahinah (sesame butter) and lemon juice or citric acid, is a very popular dish in South Asian as well as Mediterranean countries, including Jordan (Faris and Takruri, 2002).

On the other hand, diets rich in lignin and cellulose, which are insoluble fibers, were reported to have no significant effect in altering total serum cholesterol, triglycerides, high density lipoprotein, or the ratio of high density lipoprotein to total cholesterol in healthy normolipidemic subjects (Anderson and Hanna, 1999). The effect of different dietary fibers (pectin, wheat bran and cellulose) on serum and liver lipids in male Sprague-Dawley rats, was also investigated by Anderson et al. in 1994. It was shown that rats fed pectin had significantly lower serum and liver cholesterol concentration than rats fed cellulose or wheat bran.

Cereal products are estimated to cover 50-60% of the daily intake of energy and 40-60% of the daily protein intake in the diet of people in most Middle Eastern countries. Bread and other bakery products are the most cereal-based products consumed in these countries (Takruri et al., 1990).

Wheat and its products are the major part of the diet for people in many regions of the world (Levrat-Verny et al, 1999). In Jordan, commercial bread tops the food items that provide dietary fiber with a 38.2 % of the 30.9 gm total dietary fiber per capita per day (Takruri and Tukan, 1998). Wheat bran is considered a rich source of insoluble fibers, which constitute more than 95% of extractable fiber (Chen et al, 1998). Accordingly, it is known that wheat bran has no significant hypocholesterolemic activity (Roberfroid, 1993; Poutanen 1998).

It is expected that many factors could alter the physico-chemical properties of dietary fiber (Lopez et al, 1998). Such factors may include soaking and fermentation (Hallberg et al., 1987; Kent and Evers, 1994). The bioavailability of Ca, Zn, Fe and Mg was enhanced in Sprague-Dawley rats as a response to feeding wheat bran processed under such practices (Takruri, 2002). It is locally practiced to add soaked wheat bran to bread in order to improve loaf characteristics. It is hypothesized that preparation of wheat bran foods by soaking could improve some physiological characteristics of insoluble fibers, including the cholesterol-lowering ability.

Although, several studies have been done to investigate these effects, but there is still insufficient data for comparing of some of wide spectrum of DF sources with their impacts on blood lipid profile. Therefore, the objective of this work was to investigate the effect of different sources of dietary fiber on serum lipids in rats, namely total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglyceride (TG), and the ratio of high-density lipoprotein to low-density lipoprotein (HDL/LDL).

## 2. Materials and Methods

### 2.1 Sample preparation

Hard red winter wheat (*Triticum aestivum*) bran, obtained from the Modern Flour Mills and Macaroni Factories Co., was used in the study to prepare the untreated and water soaked wheat bran. In the soaking process, hot tap water (55°C) was added to the bran in a ratio of (1:1 w/v bran to water). Rapid mixing was done for 15 minutes and then the mix was left for 120 minutes to be soaked. The wet bran was spread as a thin layer over aluminum trays (1-2 cm thickness) and oven-dried at (82.2°C) for about 4 hours. The dried bran was milled using a hammer mill. Arabic bread, lupine and chickpea were purchased from normal bakeries and markets available in Jordan. Pectin was purchased from CP Kelco, DK-4623 Lille Skensved (Denmark).

### 2.2 Experimental diets

Experimental diet mixtures were planned to reach an isocaloric, isonitrogenous content. The casein and corn oil were adjusted according to the protein and fat, respectively, provided by different types of wheat bran, lupine and chickpea amounts. The composition of the mineral and vitamin mixtures was added as given by Reeves (1997). The experimental diets included casein diet (zero-bran) as a control, untreated wheat bran diet, Soaked wheat bran diet, Arabic white bread diet, lupine diet, chickpea diet and pectin diet. All diets were kept at 4°C until used for feeding. The ingredients of the diets used in the animal experiment are shown in Table (1).

**Table (1): Composition of experimental diets fed to rats (1-4)**

| Ingredient<br>(gm/100gm)                 | Type of diet |                         |                      |                       |        |          |        |
|--|--------------|-------------------------|----------------------|-----------------------|--------|----------|--------|
|  | Casein       | Untreated<br>wheat bran | Soaked<br>wheat bran | Arabic White<br>bread | lupine | Chickpea | Pectin |
| Test food                                | -            | 16                      | 16                   | 70                    | 16     | 16       | 7      |
| Casein <sup>(1)</sup>                    | 14           | 11.8                    | 11.8                 | 5.6                   | 11.3   | 11.8     | 14     |
| Starch                                   | 69.7         | 56.7                    | 56.7                 | 9.7                   | 57.3   | 56.7     | 62.7   |
| Corn oil                                 | 9            | 8.2                     | 8.2                  | 7.0                   | 8.1    | 8.2      | 9      |
| Fat-soluble<br>vitamins <sup>(2)</sup>   | 1            | 1                       | 1                    | 1                     | 1      | 1        | 1      |
| Water-soluble<br>vitamins <sup>(3)</sup> | 2            | 2                       | 2                    | 2                     | 2      | 2        | 2      |
| Salt mixture <sup>(4)</sup>              | 4            | 4                       | 4                    | 4                     | 4      | 4        | 4      |
| DL-methionine                            | 0.3          | 0.3                     | 0.3                  | 0.3                   | 0.3    | 0.3      | 0.3    |
| Total                                    | 100          | 100                     | 100                  | 100                   | 100    | 100      | 100    |

(1) Casein source: BDH Chemical Ltd. Poole/England.

(2) Fat-soluble vitamins mixture: (4000IU vitamin A, 1000 IU vitamin D<sub>2</sub>, 10 IU vitamin E) /1 g fat (Reeves, 1997).

(3) Water-soluble vitamin mixture: 0.5g thiamin, 0.4 g riboflavin, 0.4g pyridoxine, 45.0g ascorbic acid, 4.0g pantothenic acid, 4.0g niacin, 2.5g choline, 25 mg inositol, 10 mg paraminobenzoic acid, 0.002g cyanocobalamine 0.02g biotin and 0.2g folic acid, made up to 1 kg with powdered sucrose (Reeves, 1997).

(4) Salt mixture: 0.21g Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>K<sub>2</sub>SO<sub>4</sub> . 24H<sub>2</sub>O, 350g CaCO<sub>3</sub>, 250g KH<sub>2</sub>PO<sub>4</sub>.3H<sub>2</sub>O, 0.26g CoCl<sub>2</sub>.6H<sub>2</sub>O, 0.5g CuSO<sub>4</sub>.5H<sub>2</sub>O, 9.42g Fe<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> .7H<sub>2</sub>O, 102.26g MgSO<sub>4</sub>.7H<sub>2</sub>O, 1.22g MnSO<sub>4</sub>.4H<sub>2</sub>O, 0.25g KI, 135.48g K<sub>2</sub>HPO<sub>4</sub>.3H<sub>2</sub>O, 127.58g NaCl, 63.5mg NaF, 81.5mg H<sub>3</sub>BO<sub>3</sub>, 3.55g ZnSO<sub>4</sub>.7H<sub>2</sub>O, 17.0mg LiCl, 8.9mg VCl<sub>3</sub>, 0.28g CrK (SO<sub>4</sub>)<sub>2</sub> .12H<sub>2</sub>O, 6.01mg SeO<sub>2</sub>, 6.48mg MoO<sub>3</sub>(Reeves, 1997).

### 2.3 Animal experimentation

Forty two young male adult albino rats (Sprague-Dawley) were housed individually in plastic cages with wire bottom (North Kent Plastic Cages, England), in an animal room with a 12-hour light: dark cycle at a temperature of 22±1°C. All animals had free access to tap water and special diets (given ad libitum). The animals were randomly divided into seven groups of six animals each according to body weights. The difference in mean weight between any two groups did not exceed 1 gm. Each group of rats was fed one of the seven prepared diets for 6 weeks.

### 2.4 Serum sampling

At the end of the experiment, animals were fasted for 12-14 hours and were anesthetized with chloroform in order to prepare them for surgery. The animals were placed on a shelf above chloroform soaked cotton in a glass container, for 1 to 2 minutes. The container must have a firmly closing lid to prevent escape of the animals during the early stages of anesthesia. Then the blood was collected by cardiac puncture and was centrifuged at 3200 rpm for 15 minutes (Clement, GS 150 Centrifuge, Australia) to obtain serum. Serum samples were stored frozen at -18°C until analyses were performed.

### 2.5 Serum lipids and lipoproteins assays

Total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) were performed using kits purchased from (LABKIT-Pol.Industria, Barcelona, Spain). Serum TC was analyzed by the cholesterol esterase (CH-E) -cholesterol oxidase (CH-O) procedure as described by (Siedal et al., 1981). Serum TG were analyzed by the lipoprotein lipase (LPL), glycerol kinase (G-K) and glycerol-3-phosphate oxidase (GP-O) procedure as described by (Fossati and Principe, 1982). Serum HDL-C analysis depends on the precipitation of the serum chylomicrons, VLDL-C and LDL-C by adding phosphotungstic acid and magnesium ions to the sample. Centrifugation leaves only the HDL-C in the supernatant and then HDL-C was determined enzymatically (Lopes-Virella et al., 1977). Biochemical test for serum low density lipoprotein cholesterol was performed using kits purchased from (SYRBIO diagnostic reagents for laboratories under license of EUROBIO Laboratories Paris,France). The principle of the serum LDL-C analysis depends on the precipitation of LDL-C by heparin at its isoelectric point (pH 5.04). After centrifugation, HDL and VLDL remain in supernatant (Wieland and Siedel , 1983). The ratio of HDL-C/LDL-C was calculated by dividing the HDL-C values by LDL-C values.

### 2.6 Statistical analysis

Statistical analysis of data was performed using SAS (Statistical Analysis System) package. Analysis of variance (ANOVA) with Duncan's Multiple Range Test (Steel and Torrie, 1980), was used to find the differences among mean values of the following parameters: TC, TG, HDL-C, LDL-C and HDL-C/LDL-C ratio. Significance was accepted at ( $p < 0.05$ ).

### 3. Results

Table (2) shows serum lipids and lipoprotein cholesterol in mg/dl and the ratio of HDL-C /LDL-C values of rats fed casein diet (fiber-free diet), untreated wheat bran diet, soaked wheat bran diet, Arabic white bread diet, lupine diet, chickpea diet and pectin diet.

**Table (2): Serum lipids and lipoprotein-cholesterol values of rats fed the experimental diets for 6 weeks in mg/dl. (1-3)**

| Type of diet         | TC                         | TG                         | HDL-C                       | LDL-C                     | HDL-C/LDL-C              |
|----------------------|----------------------------|----------------------------|-----------------------------|---------------------------|--------------------------|
| Casein               | 84.54 <sup>b</sup> ± 13.0  | 37.18 <sup>b</sup> ± 5.36  | 48.11 <sup>abc</sup> ± 11.1 | 23.27 <sup>b</sup> ± 3.65 | 2.12 <sup>b</sup> ± 0.5  |
| Untreated Wheat Bran | 94.34 <sup>a</sup> ± 8.65  | 33.66 <sup>bc</sup> ± 3.44 | 51.77 <sup>ab</sup> ± 7.6   | 32.37 <sup>a</sup> ± 9.96 | 1.67 <sup>b</sup> ± 0.44 |
| Soaked Wheat Bran    | 64.40 <sup>d</sup> ± 5.96  | 35.48 <sup>b</sup> ± 6.19  | 42.02 <sup>c</sup> ± 5.02   | 10.82 <sup>c</sup> ± 3.24 | 4.22 <sup>a</sup> ± 0.94 |
| Arabic White bread   | 88.48 <sup>ab</sup> ± 8.30 | 48.71 <sup>a</sup> ± 8.57  | 34.87 <sup>d</sup> ± 5.22   | 31.23 <sup>a</sup> ± 5.26 | 1.12 <sup>b</sup> ± 0.12 |
| Lupine               | 66.27 <sup>cd</sup> ± 4.27 | 31.79 <sup>bc</sup> ± 6.14 | 47.50 <sup>bc</sup> ± 2.62  | 9.83 <sup>c</sup> ± 1.86  | 5.04 <sup>a</sup> ± 1.03 |
| Chickpea             | 74.25 <sup>c</sup> ± 3.54  | 26.54 <sup>c</sup> ± 5.02  | 55.09 <sup>a</sup> ± 2.98   | 10.78 <sup>c</sup> ± 1.79 | 5.22 <sup>a</sup> ± 0.77 |
| Pectin               | 71.80 <sup>cd</sup> ± 5.31 | 36.46 <sup>b</sup> ± 5.51  | 46.68 <sup>bc</sup> ± 6.65  | 12.22 <sup>c</sup> ± 3.53 | 4.21 <sup>a</sup> ± 1.64 |

(1) Means of 6 rats ± SD in mg/dl

(2) Means with different letters in their superscript within the same column are significantly different ( $p < 0.05$ ).

(3) TC: total cholesterol ; TG : triglycerides; HDL-C: high-density lipoprotein –cholesterol; LDL-C : low density lipoprotein-cholesterol.

Mean values of total cholesterol for rats fed soaked wheat bran, lupine and chickpea diets are significantly lower ( $p < 0.05$ ) than casein and untreated wheat bran diets, however, diets of those three treatments are not significantly ( $p > 0.05$ ) different from pectin diet.

Feeding Arabic bread diet resulted in a significantly higher TC values than soaked, lupine and chickpea and pectin diets. However, this result was not significantly different from those fed casein and untreated bran diets.

Rats fed chickpea diet had TG mean value which is significantly lower ( $p < 0.05$ ) than that of soaked wheat bran, casein and pectin diets; however, it was not significantly different from both fermented and untreated wheat bran diets. Both soaked wheat bran and lupine diets were not significantly different from casein, untreated wheat bran and pectin diets. White bread had the highest significant value in comparison with the other test diets.

Regarding HDL-C values, it is obvious from table (2) that rats fed chickpea diet had significantly ( $p < 0.05$ ) the highest value among all diets, however, it was not significantly different ( $p > 0.05$ ) from casein and untreated wheat bran diets. Both soaked wheat bran and lupine diets were not significantly different ( $p > 0.05$ ) from casein and pectin diet, whereas only soaked wheat bran diet has a significantly lower HDL-C value than untreated one. Arabic wheat bread was significantly ( $p < 0.05$ ) the lowest HDL-C value among test diets.

Rats fed soaked wheat bran, lupine and chickpea diets had significantly ( $p < 0.05$ ) lower levels of LDL-C than those fed casein and untreated wheat bran diets. However, soaked wheat bran, lupine and chickpea diets had no significant difference ( $p < 0.05$ ) from pectin diet, regarding LDL-C. As a result, the HDL-C/LDL-C ratio was significantly ( $p < 0.05$ ) higher in rat groups fed soaked wheat bran, lupine and chickpea diets than other test diets. The HDL-C/LDL-C ratio for bread diet was not significantly different ( $p > 0.05$ ) from both casein and untreated diets, while it was significantly ( $p < 0.05$ ) lower than the other test diets.

### 4. Discussion

This study aimed mainly at identifying the effect of effect of different sources of dietary fiber and the extent to which the processing of wheat bran could alter its effect on serum lipids and in addition, to confirming the hypocholesterolemic effect of pectin, in comparison with fiber-free diet (casein diet). The present study confirms the effect of pectin in lowering the cholesterol level in sera of rats receiving standard balanced diet (Reeves, 1997). This finding is in agreement with that reported by many researchers (Asp et al., 1981; Vigne et al., 1987; Mazur et al., 1990; Nishina et al., 1991; Fernandez, 1995; Garcia-Diez et al., 1996; and Bladergroen et al., 1999).

Results of present study were supported by those reported by Garcia-Dies et al. (1996) who observed a

reduction of (-27%) for serum cholesterol in rats fed pectin at 7% level in comparison with fiber-free diet. They indicate that pectin, by enhancing fecal bile acid excretion, may cause increased hepatic synthesis of bile acids and liver depletion of cholesterol in rats, which results in a higher rate of cholesterol synthesis and reduced serum cholesterol concentrations.

The results of our study were also supported by the results of Anderson et al. (1994) who tried to explain the hypocholesterolemic property of pectin, in comparison to cellulose control (-18% and -25% for serum cholesterol and liver cholesterol, respectively) suggesting that the pectin intake increases fecal excretion of bile acids and increases short chain fatty acids (SCFA) production in the colon. Nishina et al. (1991) observed a 30% lower cholesterol concentration in rats fed a cholesterol-free pectin (8%) diet. They attributed this reduction of plasma cholesterol levels not to an inhibition of de novo synthesis, because HMG-CoA reductase activity increased by two folds in pectin fed animals, but to an inhibition of biliary cholesterol and bile acid reabsorption and to the increased cholesterol turnover.

Another explanation of pectin-induced reduction of plasma cholesterol is that dietary pectin affects sphingomyelin metabolism through lowering sphingomyelin concentration in VLDL which in turn reduces the whole plasma cholesterol; it was reported to reduce total cholesterol by 37% (Bladergroen et al., 1999). Naturally occurring pectins differ in the extent of methoxylation, i.e. methanol esterification of the galacturonic acid carboxyl residues. This can be expected to influence considerably the interaction of pectin with other substances in the gastrointestinal tract and thereby its physiological effects (Asp et al., 1981).

The effects of pectins might be due to induced changes in the viscosity of intestinal contents, a property directly linked to the molecular properties of the different pectins (Vigne et al., 1987). Moreover pectins might alter the ultrastructure and some functions of the intestinal mucosa. These combined influences might impair or delay intestinal lipids synthesis and lower the lymph lipid output. This might in turn decrease the liver cholesterol and triglyceride accumulation and promotes beneficial changes in serum lipid and lipoprotein patterns.

Although it is generally agreed that soluble fibers lowers LDL cholesterol in clinical studies, the hypocholesterolemic responses vary depending on the physicochemical properties of the fiber tested, gender and age have been found to be important variables to consider (Mazur et al., 1990; Fernandez, 1995).

From table (2), it is obvious that rats fed untreated wheat bran diet had higher TC, LDL-C than casein (fiber-free diet). The hypercholesterolemic effect of wheat bran is well established (Asp et al., 1981; Vigne et al., 1987; Mazur et al., 1990; Nishina et al., 1991; Fernandez, 1995; Garcia-Diez et al., 1996; and Bladergroen et al., 1999). The finding of the present study regarding untreated wheat bran diet is consistent with that reported by Nishina et al. (1991) who found that the concentration of LDL cholesterol in wheat bran-fed animals was significantly higher than in the fiber-free controls and pectin-fed animals. The same finding was reported in the study conducted by Anderson et al. (1994) where a (7%) increase in the serum total cholesterol was observed in animals fed wheat bran-containing diet compared to cellulose control diet. These authors suggested that wheat bran, which is rich in cellulose -an insoluble fiber- produces short chain fatty acids (SCFA) in the colon to a lesser extent than does soluble fiber, and does not inhibit sterol synthesis.

It can be noticed that the soaked wheat bran diet had significantly lower values of TC and LDL-C than casein and untreated wheat bran diets, however, it is not significantly different from pectin diet. Little information is known about the effect of soaking method because of the scarcity of studies dealing with the effect of such method on serum lipids. It has been reported by Vuksan et al. in 1999 that processed high wheat fiber resulted in a reduction in the ratio of total to HDL cholesterol that was not seen with untreated wheat bran or low-fiber control, suggesting that changes in short chain fatty acid production may provide useful effect in the metabolism of fiber in influencing serum lipids.

In other studies, fermentation had resulted in a reduction of both hemicellulosic and cellulosic fraction, which may behave as a soluble fraction and as a result this could be effective in altering serum cholesterol (Amaral-Collaco, 1998). Other processes, like extrusion cooking have been reported to increase the soluble fiber content of wheat bran and other food by-products rich in insoluble dietary fiber. The extent of hydration may be also effective in liberating secondary bonds making the reactive sites available for interaction with lipid compounds. Regarding HDL-C, rats fed untreated wheat bran diet did not differ significantly from, that of casein, which is also consistent with what had been reported by Nishina et al. (1991), who found that HDL-cholesterol was not significantly different in animals fed a wheat bran-containing diet in comparison with fiber free controls, however, it tended to be higher in animals fed a wheat bran-containing diet.

Chickpea diet had higher significant value of HDL-C than soaked wheat bran and lupine diets. However, it was not significantly different from casein and untreated wheat bran diet. In addition, chickpea diet had a significantly higher HDL-C value than pectin diet. Soaked wheat bran as well as lupine diets are not significantly different ( $p > 0.05$ ) from casein and pectin diets, whereas only soaked wheat bran diet has a significantly lower HDL-C value than untreated wheat bran diet, but it has also decreased LDL-C. It is not easy to explain this finding, since HDL carry a substantial proportion of the total plasma cholesterol in the rat;

the increase in HDL cholesterol will also be associated with a similar elevation in total plasma cholesterol concentrations. These results can be discussed in the view of Fechner & Jahreis study, (2010), where the total cholesterol and LDL concentration decreased by 12% and 15% compared to baseline, respectively. In addition, they suggested that the intake of lupine fibre increased satiety and modified nutritional behaviour positively (lower intake of energy, fat, protein and cholesterol), which can support long-term weight loss and protect against diet-induced obesity (a major risk of CVDs). They concluded that the inclusion of this palatable lupine fibre into the diet can help predisposed people in prevention of coronary heart disease.

Pittaway examined the effect of including chickpeas in an 'Australian' diet on CVD risk factors; specifically the effect of chickpeas on serum lipids and lipoproteins compared to a higher-fibre wheat-supplemented diet. Small but significant reductions in mean serum total cholesterol and low density lipoprotein cholesterol (LDL-C) were reported following the chickpea diet compared to the wheat (Pittaway, 2006). However, since HDL-cholesterol represents a much smaller proportion of the total plasma cholesterol in man than in the rat (20-30% compared to 70-80%) (Asp et al., 1981), the elevation of HDL cholesterol in man is not necessarily reflected in significant alterations in plasma cholesterol levels. In view of these results we are cautious to make an extrapolation of this study to be applicable at the human level. In their human study lupine protein compared to casein slightly lowered the concentration of LDL cholesterol in hypercholesterolemic subjects, without altering HDL cholesterol.

Finally, we may suggest that the soaking, process of wheat bran results in a favorable effect on serum lipids through affecting the physicochemical properties of wheat bran rendering insoluble fraction of fiber behave like a soluble one. In addition it was shown from the present investigation that the soaking, lupine, and chickpea diets may have a protective role against CHDs by lowering the total cholesterol, LDL-C and to some extent, increasing HDL-C in rat groups fed these diets.

## 5. Conclusions

From the results obtained from this study, the following can be concluded; (1) Untreated wheat bran had a hypercholesterolemic effect by increasing total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C) and decreasing high-density lipoprotein (HDL-C) values. (2) Chickpea diet had higher significant value of HDL-C than soaked wheat bran, lupine and pectin diets. In addition, Chickpea diet had a significantly higher HDL-C value than pectin diet. Although the values of HDL-C of the Lupine diet are not significantly different ( $p > 0.05$ ) from casein and pectin diets, it has decreased LDL-C. (3) Pectin resulted in a remarkable hypocholesterolemic effect. (4) Soaking, process had a lowering effect of total cholesterol (TC) levels in rat groups fed this treated bran diet, compared to untreated one. Hence, soaking, process may have a protective role against (coronary heart disease) CHDs by lowering the low-density lipoprotein cholesterol (LDL-C) in rats fed this treated bran diet. (5) Arabic bread made from wheat flour of around 80% extraction rate, diet resulted in higher total cholesterol (TC), triglycerides (TG) and low-density lipoprotein cholesterol levels (LDL-C).

## 6. Recommendations

Based on the obtained findings, the following recommendations are suggested; (1) Further research is needed to investigate the effect of other sources of dietary fiber (e.g. lentil...etc.) on blood lipids and lipoprotein. (2) It is recommended to study the effect of different types of dietary fiber on other parameters such as blood glucose and protein quality indices. (3) Further research is needed to investigate the effect of other processes rather than soaking, (for example; fermentation, extrusion cooking and adding enzymes). (4) It is recommended to study the effect of factors of (time of soaking, acidity, pH, temperature) during wheat bran processing and the effect of such factors on the physiological behavior especially the cholesterol lowering ability.

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