Biochemical studies on the effect of dietary fibers on lipids and carbohydrate metabolism in rats

Maha J. Balgoon, Karima S. Mohamed, and Sawsan H. Mahassni

Department of Biochemistry, Faculty of Science, King Abdulaziz University, Jeddah, KSA.

Abstract: Recent work has focused on the role of natural and purified fiber preparations in the regulation of cholesterol metabolism. Although fiber has been increasingly recognized as an important dietary constituent, controversy and confusion still exist about the physiological effects of dietary fiber. The aim of the present study was to assess the influence of various sources of dietary fibers (natural and purified) on levels of serum & liver lipids, serum lipoproteins and serum glucose of rats. Seventy-two Wister rats were divided into six groups. One group of rats was fed on the control diet, while two groups of rats were fed on the control diet supplemented with oat bran or wheat bran as sources of natural fiber. The other three groups of rats were fed on the control diet supplemented with either pectin, guar gum or cellulose as sources of purified fiber. From results obtained in this study it can be concluded that the oat bran and the wheat bran diets have similar hypocholesterolemic effect in rats, while the oat bran diet is less useful in lowering the risk of coronary heart disease. Moreover, the oat bran diet has a hypoglycemic effect compared to the wheat bran diet. Comparing the control diet with the control diet supplemented with various sources of purified fibers, cellulose had no hypolipidemic effect, whereas the pectin diet significantly reduced levels of cholesterol and triglycerides in the serum and in the liver and glucose while it diet increased serum level of HDL-cholesterol. The guar gum diet was able to lower levels of cholesterol and triglycerides in the serum and in the liver and also to increase the serum HDL-cholesterol level of rats. But these effects were still less than that obtained with the pectin diet.
[Maha J. Balgoon, Karima S. Mohamed, and Sawsan H. Mahassni, **Biochemical studies on the effect of dietary fibers on lipids and carbohydrate metabolism in rats**] Nature and Science 2011; 9(10):99-108]. (ISSN: 1545-1003). http://www.sciencepub.net/nature.

Keywords: dietary fiber; lipid; carbohydrate metabolism; rat

1. Introduction:

Dietary fibers possess unique chemical and physical characteristics responsible for eliciting an array of physiological responses (***Chery et al., 2006***). Currently, 2 general classifications of fiber exist, soluble (e.g., gums, pectins) and insoluble (e.g., cellulose, wheat bran, soy hulls) (***Prosky et al., 1992***). One physicochemical property of fiber, viscosity, is recognized as affecting physiological responses (***Schneeman., 2001***). In several epidemiological studies, dietary fiber, especially insoluble fiber (nonviscous, slowly fermentable), has been associated with a lower risk for type 2 diabetes and cardiovascular disease (***Schulze et al., 2005; Jenkins et al., 2000***). Coronary artery disease is the major cause of death in the United States and in most Western countries (***American Heart Association, 2003***).

Observational epidemiologic studies have indicated that elevated serum cholesterol is the most common and important modifiable risk factor for coronary heart disease (***Greenland et al., 2003***). Clinical trials have documented that reductions in total and LDL-cholesterol by dietary and pharmacologic interventions decrease the risk of coronary events (***LaRosa et al., 1999***). Therapeutic lifestyle changes, including dietary intervention are the first-line approach for the prevention and treatment of hypercholesterolemia (***Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults, 2001***). Prospective cohort studies have reported a significant inverse association between total fiber intake and the risk of coronary heart disease (***Bazzano et al., 2003***).

The increasing incidence of type 2 diabetes and associated morbidity poses an enormous challenge for public health. The implementation of prevention programmes directed towards individuals at high risk might reduce overall morbidity and thus the cost to the healthcare system (***Wareham and Griffin, 2001***). Type 2 diabetes is a major public health issue in most countries around the world. Efficacy trials have demonstrated that lifestyle modification programs can significantly reduce the risk of type 2 diabetes (***Lammi et al., 2007***).Several studies have shown that the adverse metabolic effects of high-carbohydrate diets are neutralized when fiber and carbohydrate are increased simultaneously in the diet for diabetic patients. In particular, these studies demonstrated that a high-carbohydrate/high-fiber diet significantly improves blood glucose control and reduces plasma cholesterol levels in diabetic patients compared with a low-carbohydrate/low-fiber diet (***Riccardi and Rivellese, 1991).***

We conducted this study to assess the effects of different sources of dietary fiber (oat bran, wheat bran, pectin, guar gum and cellulose) intake on the lipid profile and serum glucose in rats.

2. Materials and Methods:

Chemicals and Kits used in the present study were purchased from Merck (Germany), BDH (UK), Biomerieux (France), Stanbio (USA), crescent diagnostics (KSA) and Biosystem (Spain). Seventy two male wistar rats of 120-150 g body weight were purchased from King Fahad Medical Center were housed in separate in a screen wall cages under controlled environmental conditions (20-25 ºC, 55-60 % relative humidity and 12 hours light dark cycle) where, food and water were offered ad-libitum. The rats were acclimatized for one week before the experiment started. Then each group of twelve rats was fed one of the six experimental diets in pelleted form. The dietary fiber sources included: natural sources oat bran and wheat bran and purified sources which included pectin, guar gum and cellulose.

The control diet (C) was obtained from Grain and Flour Mills organization, Jeddah, KSA. This diet contained 8.44% moisture, 5.59% ash, 19.91% protein, 3.09% fat, 59.55% soluble carbohydrate and 4.08% fiber. The other different five experimental diets contained 10% (w/w) dietary fiber and 90% control diet (C) were prepared by suspending 100g of each diet in 100ml deionized water. The diet was repelleted and allowed to air dry in well ventilated area and stored in tightly sealed plastic bags at -20^o C. Samples of all experimental diets were analyzed according to the **Association of Official Analytical Chemists "AOAC" (1986)**. The nutrient composition of the experimental diet were shown in table (1)

Table (1): The nutrient composition of the experimental diet according to AOAC.

	Control + oat bran (CO)	Control + wheat bran (CW)	Control + pectin (CP)	Control + guar agar(CG)	Control + cellulose (CC)
moisture	8.97	9	9.7	9.84	8.69
ash	5.21	5.71	5.28	5.05	5.05
protein	19.05	19.30	17.87	18.75	19.05
fat	4.27	2.67	2.27	2.92	2.7
carbohydrate	59.52	59.06	61.91	61.02	61.4
fiber	3.98	4.16	2.97	2.42	3.11

At the end of the experiment period (5 weeks) the animals in all groups were weighed and blood samples were taken by cardiac puncture under light ether anesthesia after a fasting period of 18 hours. Serum was prepared by centrifuging blood at 5000 rpm for 20 minutes. Serum samples were then liquoted and stored at -20ºC until analysis. After blood collection, all animals were sacrificed by decapitation and for each animal liver and heart were excised, rinsed in isotonic sterile saline, blotted dry with filter paper and weighed. The selected tissues were kept in plastic vials containing ice cold sterile saline at -80˚C. The following analyses were done: Total lipids were assessed as described by ***Knight et al. (1972)***, triacylglycerol ***(Bucolo & David, 1973)***, total cholesterol ***(Svensson, 1982)***, high-density lipoprotein-cholesterol (HDL-c) ***(Lopes-Virella et al., 1988)***, low-density lipoprotein-cholesterol (LDL-c) ***(Freidwald et al., 1972)***and serum glucose according to method of ***Trinder et al. (1969).*** During the period of the experiment conducted some other measurements as body weight, body weight gain, food consumption and dietary efficiency ratio were monitored weekly. Statistical analysis was carried out by the aid of a digital computer, using SPSS version 15 program according to the technique described by ***(Norusis, 2007).***

3. Results:

Results presented in table (2) demonstrate significant change in the percentage of serum total cholesterol in rats fed on oat bran and wheat bran diet by - 19.1% & - 24.7% respectively when compared with normal control. In the meantime the concentrations of triacylglycerol, total lipids and glucose were significantly decreased in group fed on oat bran by -33.1%, -30.3% and -28.6% respectively. Whereas, there are a persistent decrease in triacylglycerol and total lipids levels by -37.1% and -42.6% for wheat bran group respectively. While, there is no significant change in glucose level in the same group. In comparison with normal group, there are no significant changes in LDL- cholesterol and HDL- cholesterol in both groups.

Table (2): the effect of Natural fiber diet on serum investigated parameters:

	T. Chol	LDL - C.	HDL - C	TAG	T. lipid	Glu
	(mg/dl)					
Control						
Mean ± S.E	111.27 ± 3.96	75.08 ± 4.46	13.33 ± 0.51	111.5 ± 7.45	275.75 ± 15.3	60.33 ± 4.7
Control + Natural fiber						
Control + oat bran						
Mean ± S.E % change P<	90.08 ± 1.56 - 19.1% 0.05	72.92 ± 4.18 - 3.9% N.S.	15.67 ± 1.31 17.6% N.S.	76.83 ± 7.09 -33.1% 0.05	192.41 ± 11.1 -30.3% 0.05	43.08 ± 2.71 -28.6% 0.05
Control + wheat bran						
Mean ± S.E % change P<	83.83 ± 4.59 - 24.7% 0.05	70.08 ± 4.3 -6.7% N.S.	13.5 ± 1.65 1.26% N.S.	70.17 ± 2.91 -37.1% 0.05	158.17 ± 8.23 -42.6% 0.05	60.83 ± 7.29 0.8% N.S.

HDL- cholesterol in both groups.

Table (3) shows a significant decrease in total cholesterol, LDL-cholesterol, HDL-cholesterol, triacylglycerol and total lipids in pectin fed rats, compared to normal control. In the meantime, there is no change in glucose level in rats fed on pectin. As regard to guar gum and cellulose, non significant changes in serum total cholesterol, LDL cholesterol, TAG and glucose concentrations were observed, compared to normal group. There is a significantly sharp increase in HDL-cholesterol in group of rats fed on guar gum which not observed in rat fed on cellulose. The overall plasma total lipids concentrations were lowered after rats consumed the guar gum and cellulose by -37.5% and -21.2% respectively.

Table (3): the effect of purified fiber diet on serum investigated parameters:

	T. Chol	LDL - C.	HDL - C	TAG	T. lipid	Glu
	(mg/dl)					
Control						
Mean ± S.E	111.27 ± 3.96	75.08 ± 4.46	13.33 ± 0.51	111.5 ± 7.45	275.75 ± 15.3	60.33 ± 4.7
Control + purified fiber						
Control + pectin						
Mean ± S.E % change P<	73.45 ± 7.43 -34% 0.05	32.18 ± 4.16 -57.1% 0.05	17.45 ± 1.09 30.9% 0.05	53.82 ± 5.02 -51.7% 0.05	132.73 ± 6.86 -51.8% 0.05	51.27 ± 1.63 -15% N.S.
Control + guar gum						
Mean ± S.E % change P<	100.83 ± 4.16 -9.4% N.S.	72.75 ± 3.78 -3.1% N.S.	17.17 ± 1.53 28.8% 0.05	93.5 ± 8.98 -16.14% N.S.	172.41 ± 19.2 -37.5% 0.05	65.3 ± 2.09 8.23% N.S.
Control + cellulose						
Mean ± S.E % change P<	111.58 ± 4.04 0.27% N.S.	73.42 ± 4.79 -2.2% N.S.	13.92 ± 0.34 4.4% N.S.	104 ± 4.54 -6.7% N.S.	217.17 ± 15.8 -21.2% 0.05	54.33 ± 2.76 -10% N.S.

In comparison with normal group, data represented in table (4) significant decrease total cholesterol contents in liver of tested diets except in group of rats fed on cellulose which shows a non significant change in the hepatic cholesterol content. In the meantime, a non significant change in TAG in oat bran, wheat bran, guar gum and cellulose compared to normal control. On the other hand, pectin reduces triacylglycerol by -10.3%. Within group analyses indicated that changes in the liver weighs and Hepatosomatic index were not statistically significant in either the natural fiber or purified fiber fed groups. In addition, the heart weighs and cardiosomatic index did not significantly change over the intervention period in either group.

Table (4): The effect of natural and purified fiber diets on serum investigated parameters:

	T. chol	TAG	Liver wt	Hepatosomatic index	Heart wt	Cardiosomatic index
	(mg/dl)		(g)	(g/g body wt)	(g)	(g/g body wt)
Control						
Mean ± S.E	**2.67 ± 0.12**	2.03 ± 0.06	8.71 ± 0.3	3.38 ± 0.11	1.07 ± 0.05	0.41 ± 0.01
Control + Natural fiber						
Control + oat bran						
Mean ± S.E % change P<	2.42 ± 0.04 -9.36% 0.05	2.00 ± 0.04 -1.5% N.S.	9.32 ± 0.29 7% N.S.	3.17 ± 0.07 -6.2% N.S.	1.13 ± 0.03 5.6% N.S.	0.38 ± 0.01 -7.3% N.S
Control + wheat bran						
Mean ± S.E % change P<	2.44 ± 0.04 -8.6% 0.05	2.01 ± 0.0 4 0.1% N.S.	8.26 ± 0.21 -5.5% N.S.	3.18 ± 0.05 -5.9% N.S.	0.96 ± 0.03 -10.28% N.S.	0.37 ± 0.01 -9.8% N.S.
Control + purified fiber						
Control + pectin						
Mean ± S.E % change P<	2.13 ± 0.02 -20.22% 0.05	1.82 ± 0.06 -10.3% 0.05	8.58 ± 0.3 -1.5% N.S.	3.63 ± 0.06 6.5% N.S.	1.04 ± 0.04 -2.8% N.S.	0.44 ± 0.02 7.3% N.S.
Control + guar gum						
Mean ± S.E % change P<	2.26 ± 0.03 -15.35% 0.05	1.91 ± 0.04 -5.9% N.S	8.34 ± 0. 24 -4.24% N.S.	3.43 ± 0.06 1.47% N.S.	0.98 ± 0.05 -8.4% N.S.	0.43 ± 0.03 4.8% N.S.
Control + cellulose						
Mean ± S.E % change P<	2.59 ± 0.04 -3% N.S.	2.02 ± 0.06 -0.5% N.S.	7.87 ± 0. 2 -9.64% N.S.	3.20 ± 0.09 5.3% N.S.	0.96 ± 0.04 -10.3% N.S.	0.38 ± 0.01 -7.3% N.S.

No statistical differences were recorded in the body weight and body weight gains between all different diets during the experimental period. In the meantime, feed consumption did not differ significantly in groups of rats fed on oat bran, wheat bran and cellulose fibers during the subsequent weeks. On the other hand, during the last two weeks significant decrease in feed consumption in those rat groups fed on guar gum and pectin.

Feeding different kinds of fibers had no significant effects on the dietary efficiency ratio values during the five weeks of the experiment except in group of rats fed on oat bran which shows a significant increase when compared with control group.

4. Discussion:

Evidence from human clinical as well as epidemiologic trials indicates that dyslipidemia is one of the most important modifiable risk factors for coronary heart disease (CHD). Dyslipidemia is generally characterized by increased fasting concentrations of total cholesterol (TC), LDL cholesterol (LDL-C), and triglycerides (TG), in conjunction with decreased concentrations of HDL cholesterol (HDL-C). At present, these lipid imbalances are most routinely treated with pharmacological therapy (***Varady and Jones, 2005***). Certain commonly prescribed pharmacological agents include: 3-hydroxy-3-methylglutaryl CoA reductase inhibitors (statins), bile acid sequestrants, nicotinic acid, fibric acids, as well as the cholesterol absorption inhibitor, ezetimibe (***Ferdinand. 2004***). Although these drugs produce desirable shifts in lipid levels within a short period of time, several safety concerns have surfaced regarding the long term use of these pharmacological agents. In view of these safety issues, the implementation of non pharmacological therapies that beneficially modulate lipid profiles without the risk of adverse affects would be highly advantageous (***Taylor et al., 2003***).

Improving hyperglycemic peaks is one of the main therapeutic targets in diabetic patients. It might also be of importance in glucose-tolerant or even in normal subjects in reducing risk factors for diabetes and cardiovascular diseases (***Kendall et al., 2006***).

Interest in the role of dietary fiber in lipid and carbohydrate metabolism has remained high since the early suggestion that decreased incidence of western diseases in certain African populations resulted from consumption of diets high in dietary fiber (***Andersson et al., 2009***).

This study was designed to test the effect of different sources of dietary fiber (natural and purified), upon the lipids, lipoproteins and glucose of rats. In addition some performance parameters such as body weight, feeding consumption and dietary efficiency ratio were determined.

The fibers were chosen to represent different dietary fiber sources with different chemical composition and physical properties. In this study, lipotropic substances were not used as these substances create an artificial state, which resulted in an accumulation of fat in liver, independently of the addition of soluble or insoluble fiber components (***Shinnick et al., 1990***).

1. Diet supplemented with natural fibers:

The consumption of oat bran has been recommended as a beneficial adjunct to lipid lowering diets (***Gerhardt and Noreen, 1998***). This recommendation is supported by the results of the present study that demonstrate a significant reduction in serum cholesterol in rats fed on oat bran diet as compared to the control group. Metabolic ward and ambulatory studies show a 12-26 % reduction in average serum cholesterol levels with oat bran supplementation (***Andersson et al., 2010)***.Similarly, a significant reduction in serum cholesterol level with oat bran diet (19.1%) was detected. ***Bae et al., (2009)***, reported a 30.4% decrease in plasma cholesterol in cholesterol fed rats supplemented with oat bran .these differences in the results may be due to the source of oat bran and the normocholeserolemic rats used in our study.

Feeding rats the wheat bran diet significantly decreased serum cholesterol level by 24.7% when compared to the control group. Our results confirm the previous finding that wheat bran reduces serum cholesterol levels (***Zhao et al., 2009***). Other studies have not found wheat bran to be an effective cholesterol lowering agent (***Ullrich, 1987***). It has been shown that, in general, wheat bran has a variable influence on serum cholesterol level (***Drzikovab et al., 2005***).

The mechanism by which natural fibers reduces serum cholesterol is not definitively established. The most likely postulates: increased fecal loss of bile acids due to their gum fractions which interfere with the formation and / or stability of the micelles (***Theuwissen & Mensink, 2008***). ***Keenan et al., (2007)*** reported that certain plant fibers inhibit 3-hydroxy-3-methylglutryl Co A reductase activity and simultaneously decrease cholesterol synthesis.

There is a significantly sharp decrease in TAG in group of rats fed on oat and wheat bran by 33% and 37% respectively. These results were in line with the previous studies by ***Chan & Heng, (2008)***. In contrast, ***Kirby et al., (1981)*** and ***Vahoury et al., (1994)*** demonstrated that these fibers has no effect on serum TAG. This might be due to the large discrepancy between the experimental diets tested.

In fact, the possible mechanism by which natural fibers might modify TAG has shown in vitro, that these fibers may drastically inhibit the hydrolytic activity of pancreatic lipase on triacylglycerol. This is in agreement with other finding showing a large increase in the lipid ileal output with oat and wheat supplementation in rats (***Kelly et al., 2007***).

As for the level of HDL and LDL cholesterol in serum, results from the present study shown that there were no significant differences between natural fiber diets and control group. In contrast to our results, ***Chen & Anderson, (1997)*** demonstrated that oat and wheat bran lowered serum LDL cholesterol and raised HDL cholesterol concentrations that is may be due to upregulation of LDL receptor and enhanced LDL catabolism, and there is evidence supporting this ***(Fernandez et al., 2005)***.

The present study revealed a significant decrease in total lipids in groups of rats fed on oat bran and wheat bran diets as compared to normal group. These results are consistent with a previous study (***Anderson et al., 2007***).

On the basis of epidemiological studies, our results could be interpreted as an indicator of reduced cardiovascular risk (***Purushutharma et al., 2008***)

Regarding carbohydrate metabolism, dietary fiber plays its most important role in modulating glucose absorption, as reflected in portal glycemic values. ***Wood et al., (2000),*** found that feeding rats different mixtures of dietary fibers containing soluble fiber induced lower plasma glucose levels than control diet. Our results confirm this observation showing that average serum glucose level lower on the oat bran diet when compared to control group.

However there are many studies demonstrating that dietary fiber can modify plasma glucose and insulin responses after a single test meal. Water soluble fibers exert a hypoglycemic effect by delaying gastric emptying, shortening intestinal transit time, and reducing glucose absorption. They may also slow starch hydrolysis (***Schulze et al, 2005***).

We did not find evidence for the effect of the wheat bran diet on serum glucose level as compared to the control diet. The failure of wheat bran to effect fasting glucose levels is in accordance with the finding of other investigators such as ***Nestel***

et al., (1984), who found no change in a number of indices of glucose metabolism and utilization, healthy men consuming high wheat bran diets.

Dietary efficiency ratio was obviously better for the oat bran diet than for the control diet. The higher dietary efficiency ratio the less amount of food needed to obtain a given body weight. The sustained higher dietary efficiency ratio for the oat bran diet may be due to the high fermentability of oat bran fiber (***Mongeau et al., 1990***).

2. Diet supplemented with purified fibers:

Recent work has focused on the role of purified fiber preparations in the regulation of cholesterol metabolism (***Liu et al., 2005***). Cellulose as a purified fiber, which was used in our study, had no effect on serum and hepatic cholesterol levels. Lack of hypocholestolemic effect by cellulose feeding is consistent with the previous studies reported in human (***Vincent et al., 2006***) and in animals (***Brown et al., 2002***). Because cellulose intake does not have a significant effect on serum cholesterol concentration, it could be used as placebo (***Bell et al., 1998***).

In the present study, where fasting serum samples were analyzed a 34% lower cholesterol level in rats fed on pectin diet as compared to the control diet was observed. This is in agreement with the finding of ***Nishina et al*** (***1991***) in that cholesterol free pectin diet reduces serum cholesterol concentration by 30% in rats. In the mean time the pectin supplemented diet also attenuated the accumulation of liver cholesterol, and this is in agreement with the finding of ***Hexeberg et al***., (***1994***).

However, the reduction in the liver cholesterol level and the hypocholesterolemic effect produced by pectin are primarily explained by an increase in the catabolism of cholesterol (***Rade et al., 2008***). Also, ***Isaksson et al., (2005)*** found that pectin inhibited intestinal absorption of bile acids and thus considered that it indirectly reduces the plasma and liver cholesterol levels by the prevention of absorption of bile acids. Further investigations have shown that maximum bile acid binding occurs at low pH. The pH of bile is 7.0 – 7.4, but solution of pectin themselves have provided a suitable environment, with stomach acid perhaps trapped in gel within which bile acid binding could occur (***Theuwissen & Mensink R ,2008).***

Tiwary (2007) suggested that pectin may alter hepatic cholesterol synthesis via volatile fatty acids produced during bacterial degradation of pectin in the large bowel. Thus, the bacterial metabolism in the hindgut may influence the level of serum cholesterol in two ways: through metabolites of carbohydrate fermentation such as volatile fatty acid and by an alteration in colonic metabolism of bile, e.g. accelerate 7- - dehydroxylaion of primary bile acids, which would in turn influence colonic reabsorption (***Yang et al., 2003***). On the other hand, ***Savage et al., (2005)*** suggested that a simple increase in fecal steroid excretion is unlikely to be the sole explanation for the hypocholestrolemic effect of pectin.

Previous studies of hypocholesterolemic effect of pectin have not reported changes in HDL cholesterol (***Czerwinski et al., 2004***). In our current experiment, there was a significant increase in HDL cholesterol level in rats fed on pectin diet as compared with those fed on control diet. However, ***Stass-Wolthuis et al., (1979)*** demonstrated that the decreasing in total serum cholesterol level with pectin was accounted for by increasing in HDL cholesterol levels. This could mean that the favorable effect of pectin on total cholesterol is somewhat counteracted by the effect on HDL cholesterol, as a high level of HDL cholesterol is thought to protect against the development of atherosclerotic complication (***Vahouny et al., 1999***).

Furthermore, the results obtained in the present study indicate that the lowest level of serum LDL cholesterol was obtained in rats fed on the pectin diet. In accordance with our finding, ***Demark et al., (2003)*** showed that pectin interact with serum LDL cholesterol. The observed interaction appear to be of significant important since LDL is the major biological carrier of cholesterol and the principle ingredient of atherosclerotic lesions found in diseased cardiovascular tissue.

The results from our study indicate the dietary pectin can reduce serum TAG levels when compared to the control group. These finding are in accordance with the reports of ***Nishina et al., (1991).*** Liver TAG was also shown to be reduced in rats given the pectin diet compared to control diet which is consistent with observations of other workers (***Vigne et al., 1987***). The reduction in hepatic TAG could be related to the lower serum TAG levels observed in rats fed on pectin diet, as hepatic TAG pools are related to VLDL secretion (***West et al., 1990***).

The results from our study indicate that dietary pectin can lower (not significantly) serum glucose level by 15.0% as compared to the control diet. This hypoglycemic effect of pectin could be due to slowing of carbohydrate digestion and absorption, a slower gastric emptying of pectin-containing diet, or by changing the distribution of carbohydrate in the small intestine (***Poutanen et al., 2007***). Some studies have reported that the effects of pectin on blood glucose levels is to reduce the rise of blood glucose and the rebound hypoglycemia and to reduce the insulin response and slow gastric emptying time (***Wu rsch and Pi-Sunyer, 2001***). Furthermore, this effect of pectins could be related to their viscosities and it may inhibit glucose absorption by reducing the convective effect of intestinal motor activity (***Zijlstra et al., 2008***).

Viscous polysaccharids with no methyl groups, such as guar gums have been shown to be hypocholesterolemic (***Jenkins et al., 1976***). In the present study inclusion of guar gum into the diet of rats was observed to reduce serum total cholesterol level by 9.4 % compared to control. Although the effect was not significant, thus tendency should indicate the hypocholesterolemic effect of guar gum. The lowering of the serum cholesterol level by the guar gum diet was in the present study somewhat less than indicated in some other studies. This may partly be due to the short experimental period. It has been actually suggested that the guar gum effect is not complete until within several weeks (***Minekus et al., 2005***).

However, rats fed guar gum or pectin had similar effects on liver cholesterol levels were significantly lower than those fed on control diet. Our results confirm the observation of ***Shinnick et al., (1990)*** which indicated that rats fed guar gum or pectin had significantly lower liver cholesterol concentrations than rats fed cellulose.

Although the serum level of LDL-cholesterol was not altered by the guar gum diet in our results, it is clear from this study that serum HDL-cholesterol level increased in rats fed the guar gum diet compared with those either fed on the cellulose or the control diets. Moreover, guar gum and pectin diets had a similar increasing effect on serum HDL-cholesterol level. In accordance with the present study**, *Chen and Anderson, (1979),*** reported that rats fed a diet containing guar gum had a higher plasma HDL-cholesterol and lower total cholesterol concentrations than those fed a cellulose diet.

Epidemiological findings have shown that ratio of serum HDL-cholesterol to total cholesterol is inversely related to various coronary risk factors (***Brown et al., 2002***). However, the interpretation of the present results with regard to the ratio of serum HDL-cholesterol to total serum cholesterol, which are 12.0, 17.0, 23.8 for control, cellulose, guar gum and pectin diets respectively, it can be concluded that pectin is more effective than guar gum is reducing the risk of coronary heart diseases.

Although the serum triglyceride levels were not significantly different in the guar gum diet compared with either the control or the cellulose diets, it is clear from these results that the guar gum diet was able to markedly lower serum triglyceride levels. These observations are consistent with the previous work (***Frias and Sgarbieri 2004***).

Some studies (***Goossens et al., 2002***) reported that guar gum did not reduce plasma glucose. Our results were in line with previous observation showing that there was no effect of the guar gum diet on the level of serum glucose compared with control diet.

Food intake during the experimental period of rats fed the control diet supplemented with purified fiber (pectin, guar gum, cellulose) was lower than of rats fed the control diet. While each diet maintained a linear increase in body weight gain throughout the 5-week feeding period. The rats of body weight gain were, however slower in the groups given pectin or guar gum diets compared with those given control diet, but the differences were not significant (***Kestin et al., 1996***). It is unlikely that the marked reduction in food intake could be responsible for the slight weight reduction.

The mechanism of the reduction effect of pectin and guar gum on food intake is not clear and could be one or a combination of possibilities such as, a lack of palatability, mechanical difficulties with eating a diet that readily forms a gel on contact with moisture or more profound effects on regulatory mechanisms (***Davies et al., 1991***).

References

1. American Heart Association (2003). Heart disease stroke statistics – 2004 update. Dallas, TX: American Heart Association.
2. Anderson J. W., Jones A. E. & Riddell-Mason S. (2007): Ten different dietary fibers have significantly different effects on serum and liver lipids of choleserol-fed rats. J. Nutr. 124: 78–83.
3. Andersson E., Tina I., Karl S., Bergensta H., Marie W., Rickard O., and Per Hellstrand P (2009): Effects of oats on plasma cholesterol and lipoproteins in C57BL/6 mice are substrain specific. British Journal of Nutrition, 103, 513–521.
4. Andersson K., Immerstrand T., Swa¨rd K, (2010): Effects of oats on plasma cholesterol and lipoproteins in C57BL/6 mice are substrain-specific. Br J Nutr 103, 513–521.
5. Association of Official Analytical Chemists ”AOAC” (1986): official methods of analysis, Washington,DC.
6. Bae Y., Lee S., Kim S., (2009): Effect of partially hydrolyzed oat beta-glucan on the weight gain and lipid profile of rat. Food Hydrocolloids 23, 2016–2021
7. Bazzano LA, He J, Ogden LG, Vupputuri S, Loria C, Myers L et al. (2003). Dietary fiber intake and reduced risk of coronary heart disease

in US men and women. Arch Intern Med 163, 1897–1904.
8. Bell L., Hectrone K., Reynolds H., Balm T., and Hunninghake D. (1998): cholesterol lowering effectof psyllium mucilloid: adjunct therapy to a prudent diet for patients with mild to moderate hypercholesterolemia. J. Am Med. Assoc. 261:3419-3423.
9. Brown L, Rosner B, Willett WW, Sacks FM. (2002): Cholesterol-lowering effects of dietary fiber: a meta-analysis. Am J Clin Nutr.;69:30–42.
10. Bucolo G., and David R., (1973): Quantitative determination of serum triglycerides by the use of enzymes. Clin. Chem., 19: 476 - 482.
11. Chan, M. Y. and C. K. Heng (2008). "Sequential effects of a high-fiber diet with psyllium husks on the expression levels of hepatic genes and plasma lipids." Nutrition 24(1): 57-66.
12. Chen W. & Anderson J., (1997): effect of plant fiber in decreasing plasma cholesterol. Proc. Soc. Exp. Bio. Med 162:310-313
13. Cheryl L. Dikeman, Michael R. Murphy, and George C. Fahey Jr (2006): Dietary Fibers Affect Viscosity of Solutions and Simulated Human Gastric and Small Intestinal Digesta. J. Nutr. 136: 913–919,.
14. Czerwinski J, Bartnikowska E, Leontowicz H, et al. (2004) dietary fiber meals positively affect plasma lipid profile in rats fed cholesterol-containing diets. J Nutr Biochem 15, 622–629.
15. Davies I., Brown J., and Livesey G. (1991): energy values and energy balance in rats fed on supplements of different kinds of dietary fiber. Br. J. Nutr.65:415-433.
16. Demark-Wahnefried W, Bowering J, Cohen PS (2003). Reduced serum cholesterol with dietary change using fat-modified and purified fibers supplemented diets. J Am Diet Assoc 90, 223–229.
17. Drzikova B, Dongowski G & Gebhardt E (2005) Dietary fiber rich wheat-based products affect serum lipids, microbiota, formation of short-chain fatty acids and steroids in rats. Br J Nutr 94, 1012–1025.
18. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2001). Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol (Adults Treatment Panel III). JAMA 285, 2486–2497.
19. Ferdinand, K. C. (2004): The importance of aggressive lipid management in patients at risk: evidence from recent clinical trials. Clin. Cardiol. 27: 12–15.
20. Fernandez L., Ruiz R., Conde A., Sun D., Erickson M. & McNamaraJ. (2005): oat bran reduces plasma LDL in guinea pigs by altering hepatic cholesterol homeostatsis. J. Lipid Res. 36: 1128–1138.
21. Frias A, and Sgarbieri V(2004): Guar gum effects on food intake, blood serum lipids and glucose levels of Wistar rats. Plant Foods Hum Nutr, 153:15-28.
22. Friedwald W., Levy R., and Fredrickson D., (1972): Estimation of the concentration of low density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge.Clin Chem., 18: 499-502.
23. Gerhardt L. and Noreen B. (1998): Full-Fat Rice Bran and Oat Bran Similarly Reduce Hypercholesterolemia in Humans. Human Nutrition and Metabolism.24: 865- 869.
24. Goossens I, Geurten P, Brouns F (2002): The effect of guar gum addition to a semisolid meal on appetite related to blood glucose, in dieting men. Eur J Clin Nutr, **56:**771-778.
25. Greenland P, Knoll MD, Stamler J, Neaton JD, Dyer AR, Garside DB et al. (2003). Major risk factors as antecedents of fatal and nonfatal coronary heart disease events. JAMA 290, 891–897.
26. Hexeberg S., Willusmsen N., Hexeberg E., and Berge R.,(1994): A study on lipid metabolism in heart and iver of cholesterol and pectin fed rats. Br J. Nutr.71:181-192.
27. Isaksson G, Lundquist I, Ihse I. (2005): Effect of dietary fiber on pancreatic enzyme activity in vitro. Gastroenterology. 82:918–24.
28. Jenkins D., Wolever T., Leads A., Gassull M., and Haisman P. (1976): effect on lipids of very high intakes of fiber in diets low in saturated fat and cholesterol. Eng.J. Med.329:21-26.
29. Jenkins DJ, Kendall CW, Axelsen M, Augustin LS, Vuksan V(2000). Viscous and nonviscous fibres, nonabsorbable and low glycaemic index carbohydrates, blood lipids and coronary heart disease. Curr Opin Lipidol.;11:49–56.
30. Keenan JM, Goulson M, Shamliyan T, (2007): The effects of concentrated barley beta-glucan on blood lipids in a population of hypercholesterolaemic men and women. Br J Nutr 97, 1162–1168.
31. Kelly S, Summerbell C, Brynes A. (2007): Whole grain cereals for coronary heart disease. The Cochrane Database of Systematic Reviews CD005051.
32. Kendall C., Augustin L., Emam A., Josse A., Saxena N., and Jenkins D., (2006): The glycemic

index: methodology and use .Nestle Nutr Workshop Ser Clin Perform Programme. 11: 43-53. discussion 53-56.
33. Kestin M, Moss R, Clifton PM, Nestel PJ.(1996): Comparative effects of three cereal brans on plasma lipids, blood pressure, and glucose metabolism in mildly hypercholesterolemic men. Am J Clin Nutr;52:661–6.
34. Kirby R., Anderson J.,Sieling B., Chen W., Miller R., and Kay R., (1981):oat bran lowers serum low density lipoprotein cholesterol concentrationof hypercholestrolemic men. Am J. clin nutr. 34:824-829
35. Knight J., Andreson S., and Rawle J., (1972): Sulfo-Phosphovanillin reaction for the estimation of total serum lipids. Clin. Chem., 18-199.
36. Lammi, N., Taskinen, O., Moltchanova, E., et al. (2007). A high incidence of type 1 diabetes and an alarming increase in the incidence of type 2 diabetes among young adults in Finland between 1992 and 1996. Diabetologia, 50, 1393–1400.
37. LaRosa JC, He J, Vupputuri S (1999). Effect of statins on risk of coronary disease: a meta-analysis of randomized controlled trials. JAMA 282, 2340–2346.
38. Liu S, Stampfer M., Hu F., Giovannucci E, Rimm E, Manson J., Hennekens C., Willett W.(2005): Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. Am J Clin Nutr. 1999;70:412–9.
39. Lopes-Virella M., Klein R., Lyons T., Stevenson H., and Witztum J., (1988): Glycosylation of LDL enhances cholesteryl ester synthesis in human monocyte-derived macrophages. Diabetes. 37: 550-57.
40. Minekus M, Jelier M, Xiao JZ, et al. (2005): A fibre cocktail of fenugreek, guar gum and wheat bran reduces oxidative modification of LDL induced by an atherogenic diet in rats. Mol Cell Biochem, 294:145-153.
41. Mongeau R., Brassard R., Malcom S., and Shah B.(1990): effect of dietary fiber on body weight and blood lipids in a long term rat experiment. Cereal chemistry. 68:448-453.
42. Nestel P., Nolan C., Bazelman J., and Cook R. (1984): Effect of high starch diet with low or high fiber content on postabsorptive glucose production in normal subjects. Diabetes care. 7:207-210.
43. Nishina P., Schneemen B., Freedland R., (1991): effect of dietary fibers on non fasting plasma lipoprotein and apolipoprotein level. J. Nutr. 121:431-437.
44. Norusis M., (2007): SPPS 15.0 advanced statistical procedures. Upper Saddle River, N. J: Prentic Hall.
45. Poutanen K, Laaksonen DE, Autio K, Mykka¨nen H, Niskanen L.(2007): The role of carbohydrates in the prevention and management of type 2 diabetes. In: Biliaderis CG, Izydorczyk MS, editors. Functional food carbohydrates. New Mexico: CRC Press;. p. 387–412.
46. Prosky L, Asp NG, Schweizer TG. DrVries JW, Furday I.(1992) Determination of insoluble and soluble fiber in food and food products: collaborative study. J Assoc off Anal Chem.; 75:360–6.
47. Rader DJ, Alexander ET, Weibel GL, et al. (2008): Role of reverse cholesterol transport in animals and humans and relationship to atherosclerosis. J Lipid Res 50, S189–S194.
48. Riccardi A. and Rivellese A. (1991). Effects of dietary fiber and carbohydrate on glucose and lipoprotein metabolism in diabetic patients. Ame Diab Ass. 14 (12), 1115-1125
49. Savage AP, Adrian TE, Carolan G, Chatterjee VK, Bloom SR.(2005): Effects of dietary fibers on intestinal transit time and on the rate of gastric emptying in healthy volunteers. Gut.;28:166–70.
50. Schneeman BO. Dietary fiber and gastrointestinal function (2001). In: McCleary BV, Prosky L, editors. Advanced dietary fiber technology. Ames (IA): Blackwell Sciences; p. 168–76.
51. Schulze MB, Liu S, Rimm EB, Manson JE, Willett WC, Hu FB (2005): Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. Am J Clin Nutr.; 80:348–56.
52. Shinnick F., Ink S., and Marlett A. (1990): dose response to dietary fiber fraction in cholesterol fed rats. J Nutr. 120:561-568
53. Stasse-Wolthuis M., Hautvast J., Hermus R., Katan M., zondervan j., et al (1979): the effect of natural high fiber diet on serum lipids, fecal lipids and colonic function. Am. J. Clin.Nutr.32:1881-1888.
54. Taylor A., Grace K., Swiecki J., Hyatt R., Gibbs H., Sheikh M., O'Malley G, Lowenthal P., West M., Spain J., Maneval K. & Jones L. (2001): Lipid-lowering efficacy, safety, and costs of a large-scale therapeutic statin formulary conversion program. Pharmacotherapy 21: 1130–1139.
55. Theuwissen E & Mensink RP (2008) Water-soluble dietary fibers and cardiovascular disease. Physiol Behav 94, 285–292.

56. Tiwary CM, Ward JA, Jackson BA. (2007): Effect of pectin on satiety in healthy US Army adults. J Am Coll Nutr. 16:423–8.
57. Trinder (1969): determination of glucose in blood using glucose oxidase with alternative oxygen acceptor. Ann. Clin. Biochem.
58. Ullrich L., (1987): evaluation of high fiber diet in hyperlipidemia: a review. J.Am. College of nutrition 6:19-25
59. Vahouny gv, ro. T, gallo ll, et al (1999): Dietary fibers and lymphatic adsorption of cholesterol in the rat. Am J Clin Nutr 31 (suppl 10): S208.
60. Vahoury G., Khalafi R., Satchithanandam S., Wtkins D., and Story J. (1994): dietary fiber suplemmentation and fecal bile acids, neutral steroids and divalent cations in rats. J. Nut.117: 2009-2015.
61. Varady K. and Jones P. (2005): Combination Diet and Exercise Interventions for the Treatment of Dyslipidemia: an Effective Preliminary Strategy to Lower Cholesterol Levels?. American Society for Nutritional Sciences. 24:1829- 1835
62. Vigne J., Larion D., Borel P., Portugl H., and Pauli A. (1987): effect of pectin, wheat and cellulose on serum lipids nd lipoproteins in rats feed on low or high fat diet.Br. J. Nutr.58:405-413.
63. Vincent R, Roberts A, Frier M, Perkins AC, MacDonald IA, Spiller RC(2006). Effect of bran particle size on gastric emptying and small bowel transit in humans: a scintigraphic study. Gut.;37:216–9.
64. Wareham NJ, Griffin SJ (2001) Should we screen for type 2 diabetes? Evaluation against National Screening Committee criteria. BMJ 322:986–988
65. West C., Sullivin D., and Katan M.(1990): boys from populations with high carbohydrate intake have higher fasting triacylglycerol levels than boys from populations with high fat intake. Am. J. Epidemol. 131: 271-282.
66. Wood P., Welsz J., Fedec P., and Burrows V. (2000): large scale preparation and properties of oat fraction enriched in (1-3)(1-4) D. glucan. Cereal Chem.66-97
67. Wursch P, Pi-Sunyer FX (2001). The role of viscous soluble fiber in the metabolic control of diabetes. A review with special emphasis on cereals rich in beta-glucan. Diabetes Care.; 20:1774–80.
68. Yang JL, Kim YH, Lee HS, et al. (2003) Barley beta-glucan lowers serum cholesterol based on the up-regulation of cholesterol 7alpha-hydroxylase activity and mRNA abundance in cholesterol-fed rats. J Nutr Sci Vitaminol (Tokyo) 49, 381–387.
69. Zhao Z., Xu, Z., Le, K., Azordegan, N. and Moghadasian, M (2009): Lack of evidence for antiatherogenic effects of wheat bran or corn bran in apolipoprotein E-knockout mice. J Agric Food Chem 57, 6455-60
70. Zijlstra N, Mars M, de Wijk RA,Westerterp-Plantenga MS, de Graaf C.(2008): The effect of viscosity on ad libitum food intake. Int J Obes (Lond).; 32:676–83.

9/30/2011