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EFFECT OF RAW AND PROCESSED OAT BRAN ON LIPID PROFILE OF NORMAL, HYPERCHOLESTEROLEMIC AND DIABETIC RATS

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ABSTRACT

The core objective of current research is to explore the functional properties of diets containing raw and processed oat bran to combat lifestyle disorders *i.e.* cardiovascular diseases. For the purpose, raw oat bran was procured from Ayub Agricultural Research Institute (AARI), Faisalabad and it was processed through extrusion technique. In addition, three types of studies were conducted on the basis of diets i.e. study I (normal rats), study II (hypercholesterolemic rats) and study III (diabetic rats). Moreover, the efficacy study was carried out to observe the effects of different levels of raw and processed oat bran on biological profile of blood Sprauge-Dawley rats. Results showed that the cholesterol, LDL and triglycerides level reduction was found significantly different when raw and processed oat bran diets fed to normal, hypercholesterolemic and diabetic rats. The highest reduction was recorded when fed on diet containing 30% processed oat bran. The processed oat bran exhibited more reduction as compared to raw oat bran. Conclusively, it is suggested that processed oat bran should be introduced in diet based therapy to control lifestyle-related disorders.

Keywords: Oat bran, β-glucan, cholesterol, LDL, triglycerides.

INTRODUCTION

The occurrence of bioactive molecules in the plants provides them imperative position in diet based regimes. However, significant amount of these bioactive ingredients have been lost during processing. In addition, some of the bioactive compounds hold multifaceted positions for their consumption that these add high nutritional value to the foods (Butt *et al.*, 2007). Cereals especially oat is one example as it contains several nutrients of higher worth and containing phytochemicals. In this perspective, presence of bioactive ingredients in oat are of significance importance especially β-glucan. These ingredients own several operational and nutritional functions.

The β-glucans in the oat groat are more concentrated in the bran fraction than in the endosperm fraction. Contrary to oats, the β-glucans in barley and rye are more evenly distributed throughout the endosperm (Cui and Wang, 2009). Oat bran possess 6.03% moisture, 15.23% protein, 55.38% carbohydrate, 14.13% total dietary fiber (TDF), 4.5% β-glucans 6.8% fat and 2.43% ash (Usman *et al*., 2010).

The β-glucan is a significant constituent of soluble dietary fiber in barley and oats. β-glucan is generally considered a branched semi-flexible and linear polymer. It is stitched up of glucose units linked by D-(1-4) with a casual glycoside (1-3)-glycosidic. The configuration of the chain depends on the relative amount of (1-4)- and (1-3)-glycosidic bond between replicating units of glucose. As it is typical polysaccharides in aqueous solutions, it has a strong tendency to associate and the viscosities of the solutions are high (Johansson *et al*., 2000).

The β-glucan contains both soluble and insoluble components of dietary fiber but oat β-glucan is classified as soluble fiber (AACC, 2000). After over thirty years of extensive research into the numerous and diverse claims for its benefits, it is now evident that fiber is distinctive in its considerable physiological benefits (Yun *et al*., 2003). The β-glucan is an alternative and appropriate source of dietary fibre that can be added to foods. It can also be added in variety of foods such as dairy, cereal, meat and other products depends upon the choices for selection of fibre in the diet.

The potential physiological mechanisms behind the efficacy of β-glucan are its ability to retard the absorption rate of food in the intestine due to increased viscosity, thus balancing the cholesterol and triglycerides level in the blood (Wood, 2000; Jenkins *et al.*, 2008). Hence keeping in mind the factors discussed above, the current study was designed with objective to elucidate the health claims of oat bran β-glucan.

MATERIALS AND METHODS

Materials: Two oat varieties *i.e.* Avon and Sargodha-81 grown commercially were procured from Ayub Agricultural Research Institute (AARI), Faisalabad.

Milling: The milling process of oats includes three steps as described below. In the first step, cleaning and sizing of the material was carried out to remove the dust, chaff, rocks, other grains and other foreign material from the oats. In the second step, dehulling of oat was carried out passing the each variety through de-huller. The outer hull from inner groat of each variety was separated. The lighter oats are separated and groats are taken for further processing. In the final step, the groats obtained after dehulling was milled through Quaderumate Senior Mills. The oat bran was separated from flour in several grinding and sieving operations to a coarse fraction (bran) and fine fraction (endosperm flour).

Efficacy studies: The sprague Dawley rats were procured from National Institute of Health (NIH) Islamabad and housed in Animal Room of National Institute of Food Science and Technology, UAF. These different efficacy trials were conducted in different studies as described below. The diets were based on the inclusion of dietary fiber which contains β-glucan as active ingredient.

Study I: Normal rats: The efficacy trials were conducted initially on normal rats. They were acclimatized by feeding basal diet for a period of one week. Then these rats were divided into three groups comprising of 10 rats each in group. The diets prepared from the selected treatments were fed for a period of 8 weeks (Table I, II).

The feed & water intake were monitored on daily basis, while body weights were recorded weekly throughout the experimental period. Blood samples were collected through cardiac puncture and EDTA coated tubes were used for serum collection (Uchida *et al*., 2001). Serum samples were further analyzed for various assays by using Microlab-300.

Study II: Induced hypercholesterolemia: The rats were fed on high cholesterol diet containing cholesterol (2%) and cholic acid (0.5%) to induce hypercholesterolemia. After one week, lipid profile of each rat was monitored to assess induction of hypercholesterolemia.

Study III: Induced diabetic mellitus: Diabetic mellitus was induced in the rats by injecting Streptozotocin (STZ) @ 65mg/kg body weight, dissolved in 0.05M citrate buffer (pH 4.5), intravenously. The blood glucose of each rat was monitored after injecting STZ to check the glucose response.

Treatment Plan

Table I: Raw oat bran groups

	Normal rats				**Diabetic group**				**Hypercholestromic group**			
groups	1	2	3	4	1	2	3	4	1	2	3	4
	D0	D1	D2	D3	D0	D1	D2	D3	D0	D1	D2	D3

10 rats/group (Total 120 rats)

D0: control Diet (placebo); D1: Diet with 10% oat bran, D2: Diet with 20% oat bran, D3: Diet with 30% oat bran

Table II: Processed oat bran groups

	Normal rats				**Diabetic group**				**Hypercholestromic group**			
groups	1	2	3	4	1	2	3	4	1	2	3	4
	D0	D1	D2	D3	D0	D1	D2	D3	D0	D1	D2	D3

10 rats/group (Total 120 rats)

D0: control Diet (placebo); D1: Diet with 10% processed oat bran, D2: Diet with 20% processed oat bran, D3: Diet with 30% processed oat bran

Serum lipid profile: The serum lipid profile including cholesterol, high density lipoproteins, low density lipoproteins, triglycerides, blood glucose and serum insulin were measured according to their respective protocols. The total cholesterol concentration was estimated by liquid cholesterol CHOD-POP method described by Allain (1974). High-density lipoprotein concentration was estimated by using the HDL-cholesterol kits by the method described by Assmann (1979). The serum samples were also analyzed for low density lipoproteins (LDL) following the procedure of McNamara *et al*. (1990). The blood triglycerides concentration was estimated by liquid triglycerides GPO-PAP method described by Anoni *et al.* (1982).

Statistical Analysis: The data obtained for each parameter were subjected to analysis of variance using Statistical Package (Costat-2003, Co-Hort, v 6.1.) through 2-factor factorial CRD. Each treatment contains three replicates.The levels of significance ($P \leq 0.05$ & $P \leq 0.01$) following the principles outlined by Steel *et al. (*1997).

RESULTS AND DISCUSSION

Effect of oat bran on lipid profile of normal, hypercholestrolemic and diabeteic rats: In normal rats, cholesterol level ranged from 84.74 to 81.53 mg/dL and 85.03 to 81.56 mg/dL when fed on different diets

containing various levels of raw and processed oat bran, respectively (Table III). Likewise, in hypercholestrolemic rats, cholesterol level decreased from 226.84 to 203.75 mg/dL and 225.56 to 198.22 mg/dL after the administration of diets containing raw and processed oat brans, respectively. However in diabeteic rats, 1.13%, 4.34% and 6.77% reduction in cholesterol was observed in case of raw oat bran whilst 3.36%, 6.49%, and 9.13% reduction in cholesterol was noticed with 10, 20 & 30% processed oat bran diets (Table V).

The normal rats when given diets containing 10, 20 and 30% raw oat bran showed 2.13, 3.38 and 4.38% reduction in serum LDL, respectively as compared to normal rats fed on control diet. In case of diets containing 10, 20 and 30% processed oat bran resulted 2.54, 3.45 and 5.23% decrease in serum LDL, respectively (Table VI). Among the hypercholesterolemic rats, the highest LDL level was recorded in the rats fed on control diet and it reduced from 145.84 to 124.73 mg/dL and 151.53 to 126.03 mg/dL fed on diets containing various levels of raw and processed oat bran, respectively (Table VII). In diabetic rats, the diet containing 30% processed oat bran showed the highest reduction (11.92%) in LDL but at same level of raw oat bran, this reduction was 9.42% (Table VIII).

Regarding HDL level of normal rats fed on raw and processed oat bran, the results in Table IX indicated that it ranged from 38.57 to 39.40 mg/dL and 38.49 39 to 40.17 mg/dl respectively. In hypercholesterolemic rats, **t**he diets containing 10, 20 and 30% raw oat bran showed 1.70, 3.66 and 5.76% increase in HDL level, respectively while the diets containing 10, 20 and 30% processed oat bran exhibited 2.19, 4.40 and 7.10% increase in HDL level, respectively (Table X). However, the HDL level in diabetic rats ranged from 39.15 to 41.08 mg/dL in raw oat bran diets and 39.56 to 41.83 mg/dL in processed oat bran diets (Table XI).

The triglycerides level in normal rats decreased from 74.20 to 72.89 mg/dL when fed on raw oat bran and 74.44 to 71.87 mg/dL in processed oat bran diets (Table XII). But In hypercholesterolemic rats, **t**he triglycerides level varied from 106.54 to 101.33 mg/dL fed on raw oat bran whilst showed reduction from 106.50 to 98.67 mg/dL when fed on processed oat bran (Table XIII). However, the triglycerides level was found significantly the highest in the diabetic rats when fed on control diet and it varied from 95.59 to 91.92 mg/dL and 96.90 to 92.45 mg/dL when different levels of raw and processed oat bran was given, respectively (Table XIV).

Table III. Effect of raw and processed oat bran diets on cholesterol (mg/dL) of normal rats

	ROB (mg/dL)			POB(mg/dL)		
	2010	**2011**	**Mean**	**2010**	**2011**	**Mean**
Control	84.73	84.74	84.74a	85.48	84.58	85.03a
10%	83.62	83.76	83.69b	84.00	83.13	83.57b
20%	83.19	82.65	82.92c	83.17	82.35	82.76bc
30%	81.55	81.51	81.53d	81.96	81.17	81.56c
Mean	83.27	83.17		83.65	82.81	

Means carrying same letters do not differ significantly

Table IV. Effect of raw and processed oat bran diets on cholesterol (mg/dL) of hypercholesterolamic rats.

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	**2011**	**Mean**	**2010**	**2011**	**Mean**
Control	223.18	230.50	226.84a	223.43	227.69	225.56a
10%	209.10	214.56	211.83b	207.87	210.25	209.06b
20%	204.45	210.20	207.33ab	209.66	200.26	204.96b
30%	200.39	207.11	203.75b	195.90	200.54	198.22c
Mean	209.28 aa	215.59		209.22	209.69	

Means carrying same letters do not differ significantly

Table V. Effect of raw and processed oat bran diets on cholesterol (mg/dL) of diabetic rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	**2011**	**Mean**	**2010**	**2011**	**Mean**
Control	116.42	117.40	116.91a	119.00	117.83	118.41a
10%	115.12	116.06	115.59b	115.88	112.97	114.43b
20%	111.34	112.34	111.84c	112.49	108.95	110.72c
30%	109.84	108.16	109.00d	108.03	107.17	107.60c
Mean	113.18	113.49		113.85	111.73	

Means carrying same letters do not differ significantly

Table VI. Effect of raw and processed oat bran diets on LDL (mg/dL) of normal rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	30.62	30.30	30.46a	30.70	30.81	30.76a
10%	29.95	29.67	29.81ab	30.08	29.88	29.98b
20%	29.72	29.14	29.43bc	29.79	29.60	29.70b
30%	29.09	28.88	28.99c	29.26	29.05	29.15c
Mean	29.85	29.50		29.96	29.84	

Means carrying same letters do not differ significantly

Table VII. Effect of raw and processed oat bran diets on LDL (mg/dL) of hypercholesterolamic rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	141.87	149.82	145.84a	151.58	151.47	151.53a
10%	133.88	144.51	139.20ab	142.38	141.22	141.80b
20%	127.64	135.19	131.41cd	136.67	135.15	135.91c
30%	121.36	128.09	124.73c	125.63	126.43	126.03d
Mean	131.19	139.40		139.07	138.57	

Means carrying same letters do not differ significantly

Table VIII. Effect of raw and processed oat bran diets on LDL (mg/dL) of diabetic rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	58.52	57.14	57.83a	57.55	56.25	56.90a
10%	57.23	55.71	56.47b	55.46	54.36	54.91b
20%	56.78	55.12	55.95b	53.21	53.29	53.25c
30%	51.98	52.78	52.38c	49.35	50.89	50.12d
Mean	56.13	55.19		53.89	53.70	

Means carrying same letters do not differ significantly

Table IX. Effect of raw and processed oat bran diets on HDL (mg/dL) of normal rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	38.57	38.57	38.57	38.14	38.84	38.49
10%	38.90	38.75	38.86	38.72	39.10	38.91
20%	39.36	38.91	39.14	39.55	39.37	39.46
30%	39.71	39.09	39.40	40.76	39.58	40.17
Mean	39.15	38.83		39.29	39.22	

Means carrying same letters do not differ significantly

Table X. Effect of raw and processed oat bran diets on HDL (mg/dL) of hypercholesterolamic rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	53.40	57.00	55.20c	56.42	57.06	56.74b
10%	55.63	56.65	56.14bc	58.27	57.68	57.98ab
20%	59.29	55.32	57.30ab	60.62	58.08	59.35a
30%	61.07	55.69	58.38a	61.70	59.84	60.77a
Mean	57.35	56.17		59.25	58.16	

Means carrying same letters do not differ significantly

Table XI. Effect of raw and processed oat bran diets on HDL (mg/dL) of diabetic rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	38.83	39.47	39.15c	39.15	39.97	39.56b
10%	39.20	40.22	39.71b	40.25	40.72	40.49ab
20%	41.52	39.15	40.34ab	42.05	39.67	40.86ab
30%	41.77	40.79	41.08a	42.64	40.78	41.83a
Mean	40.33	39.90		41.02	40.28	

Means carrying same letters do not differ significantly

Table XII. Effect of raw and processed oat bran diets on triglycerides (mg/dL) of normal rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	74.03	74.37	74.20	74.84	74.03	74.44
10%	74.17	73.84	74.01	73.82	73.94	73.88
20%	75.01	74.00	73.50	73.84	72.82	73.33
30%	72.79	72.99	72.89	72.02	71.73	71.87
Mean	73.50	73.80		73.63	73.13	

Means carrying same letters do not differ significantly

Table XIII. Effect of raw and processed oat bran diets on triglycrides (mg/dL) of hypercholesterolamic rats

Diets	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	106.54	106.55	106.54a	106.79	106.21	106.50a
10%	103.45	105.45	104.45ab	99.98	107.99	103.99ab
20%	106.12	100.30	103.21b	102.40	102.14	102.27bc
30%	102.33	100.33	101.33b	98.50	98.84	98.67c
Mean	104.61	103.16		101.92	103.80	

Means carrying same letters do not differ significantly

Table XIV. Effect of raw and processed oat bran diets on triglycerides (mg/dL) of diabetic rats

Diet	ROB (mg/dL)			POB(mg/dL)		
	2010	2011	Mean	2010	2011	Mean
Control	95.40	95.77	95.59a	97.49	96.31	96.90a
10%	93.12	95.38	94.25b	95.44	95.03	95.24b
20%	92.92	94.10	93.51b	94.20	94.07	94.14c
30%	92.30	91.54	91.92c	92.50	92.40	92.45d
Mean	93.44	94.20		94.91a	94.45	

Means carrying same letters do not differ significantly.

It is evident from the results regarding lipid lowering attribute of raw and processed oat bran from different studies i.e. normal, hypercholesterolemic and diabetic rats showed that the addition of either raw or processed oat bran in the diets significantly reduced cholesterol, LDL & triglycerides and enhance HDL level in all studies, however processed oat bran exhibited better results. Overall, it was observed that bran supplementation in any form proved more helpful to attenuate the lipid abnormalities.

In the present studies, maximum decline in cholesterol level in rats fed on diets containing processed oat bran was observed than the rats fed on diets containing raw oat bran which might be due to differences in the extractability of β-glucan regarding raw and processed oat bran. The processing methods have increased the extractability of β-glucan and it ultimately increased the β-glucan content in processed diets of rats so it reduced more cholesterol level than rats fed on raw oat bran diet.

The findings of Andersson *et al*. (2010) have supported the results found in the present study in which they observed reduction in cholesterol, LDL & triglycerides in mice fed on diets containing raw or processed oat bran. The results of some other studies are also in agreement with the findings of present studies which showed a decline trend in plasma lipid profile

especially cholesterol with raw and processed oat bran diets (Welch *et al*., 1995). Immerstrand *et al*. (2009) have also reported that hypercholesterolemic rats fed on processed oat bran diet exhibited significant reduction (17%) in plasma cholesterol. In another study, Anderson *et al.* (2000) reported a decline in plasma cholesterol of rats fed on oat bran β-glucan. Likewise, results have been found in hypercholesterolemic rats on cholesterol lowering when subjected to raw or processed oat bran diets.

The present results showing significant effect of diets containing oat bran on HDL are in agreement with previous work of Kerkhof *et al*. (2003) who reported considerable changes for HDL in human subjects after consumption of oat bran bread. Similarly, Beck *et al*. (2009) reported changes in HDL of human subjects by daily intake of oat β-glucan. The findings of Deveries (2004) also supported the present results as they stated that HDL-cholesterol increased after consumption of a diet containing oat bran. The results for momentous effects of diet containing oat bran are in line with Andersson *et al*. (2000) investigation, they expounded that oat bran β-glucan affected HDL significantly.

The triglycerides are fats that can clog arteries and increase risk for heart attacks and stroke. The dietary fiber especially oat bran has shown to reduce triglycerides level. The reduction in plasma triglyceride has been reported due to a decrease in hepatic secretion of low density lipoproteins (LDL) and very low density lipoproteins (VLDL), determined after blocking the clearance of triglyceride-rich lipoproteins with soluble fibers that is a characteristic of all cholesterol-lowering fibers.

The oat bran β-glucan also involves in the bile acid circulation and it binds the bile acids and decreases their absorption from the intestine. As a result, LDL cholesterol is removed from the blood and converted the bile acids by the liver to replenish the bile acids excreted in the stool and ultimately, reduced the triglycerides level in the blood. The same mechanism for regulating triglycerides by oat bran supported the present results of decreasing triglycerides by oat bran in Sprague Dawley rats have been reported by several researchers (Kerkhoffs *et al*., 2003).

Conclusion: It is evident that diets containing processed oat bran appeared more effective in modulating lipid metabolism as compared to diet containing raw oat bran. In addition, oat bran is a good source of dietary fiber with special reference to soluble β-glucans. The highest cholesterol reduction was recorded when fed on diet containing 30% processed oat bran. However, percentage of decreasing cholesterol was recorded in an ascending order i.e hypercholesterolemic > diabetic > normal rats. The presence of active ingredients especially β-glucan could be beneficial in managing the lifestyle related dieases.

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