International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:02, Issue:06

HYPOCHOLESTEROLEMIC PERSPECTIVES OF THE PSYLLIUM HUSK BASED DIETETIC COOKIES

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ABSTRACT

Psyllium husk is functional in prevention and cure of physiological ailments like hypercholesterolemia. Cookies were prepared with addition of 20% psyllium husk along with control to appraise the efficacy of psyllium husk in normal and hypercholesterolemic subjects. Cookies were provided to each subject for administering 10 g/day fibre. In normal subjects research was conducted in years 2009-10 and 2010-11 to get sturdy results trailing the same in hypercholesterolemics. Statistical analysis revealed that in normal subjects lipid profile affected non-significantly and significant impact on lipid profile of hypercholesterolemics was noted. Elevated base line concentration of cholesterol 231.50±6.46 mg/dL, LDL 158.78±8.91 mg/dL, VLDL 35.92±1.36 mg/dL and LDL/HDL 4.99±0.25 were significantly reduced to 202.90±7.26 mg/dL, 134.60±8.13 mg/dL, 30.40±1.05 mg/dL and 4.09±0.17, respectively in 2009-10. Similar momentous decline was noted in 2010-11. Percent decrease in cholesterol was 12.35 & 11.26%, LDL 15.22 & 14.10% and VLDL 13.48 & 12.08%, respectively during two years for hypercholestrolemic subjects. Conclusively, present explorations indicate that psyllium husk diet is potent as functional component against hypercholesterolemia and is friendly to normal subjects.

Keywords: Hypercholesterolemia, dietary fiber, dietary intervention psyllium husk, cholesterol

INTRODUCTION

Dietary components have proved recognized links with human health. Improper nutrient intake and deskbound life style are associated with ailments like hypercholesterolemia, diabetes mellitus and cardiovascular disorders. Functional foods are emerging implementations as

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preventive and curative appliances against health infirmity (Schwager *et al*., 2008). Globally, cardiovascular disease (CVD) is the leading cause of mortality. Approximately, 56% of CVDs and 18% of heart strokes are attributed to higher cholesterol level; ≥200 mg/dL (WHO, 2011). Diet based therapies like food diversification and functional foods are supportive against the peril (Butt *et al*., 2009). Low glycemic foods like whole grains, fruits, vegetables and high fibre foods are linked with regulation of high density lipoproteins (HDL) reducing prevalence of hypercholesterolemia (Flavin and Jacob, 2010). The National Cholesterol Education Program (NCEP) recommends LDL<100 mg/dL and HDL not <40 mg/dL prevent the strokes (Grundy, 2004). The principal reason is higher levels of cholesterol and LDL while, HDL is decreased than the suggested level. Consequently, plaques of cholesterol and contraction of arteries work as barrier in blood flow leading to atherosclerosis (Gijsen *et al*., 2008).

Foods containing the functional components like dietary fibre especially the arabinoxylans have potential to cure physiological ailments (Qaisrani *et al*., 2016). US Department of Health and Human Services, (2010) recommends 25 g/day intake of total dietary fibre containing at least 6 g soluble fibre. The considerable fibre sources include psyllium husk, guar gum, oats and some other cereals (Qaisrani *et al*., 2016). Psyllium husk seems to be an effective source against hypercholesterolemia (Galisteoa *et al*., 2010). It contains high water soluble fibre that decreases postprandial glucose levels and calms the lipid profile in hypercholesterolemic patients (Ziai *et al*., 2005).

Psyllium seeds "Isabgol" from the *Plantago ovata* Forsk is commercially cultivated crop of India and Pakistan (Dhar *et al*., 2005). The husk is about 10-25% of dry seed (w/w) making mucilaginous gel after water assimilation (Fischer *et al*., 2004). Psyllium husk is applied in functional foods and in ice cream (Qaisrani *et al*., 2014). The Food and Drug Administration (FDA) has permitted use of psyllium husk containing foods mainly because of its related health claims (Leeds, 2009). The viscous fibre from psyllium husk reduces cholesterol from 4.80 to 14.80% and LDL from 7.00 to 20.20% therefore decreasing the LDL/HDL ratio addressing the complexity of hypercholesterolemia, an important factor essential for decreasing CVD risks (Jones, 2008).

FDA recommends a dose of 10g/day of psyllium husk against hypercholesterolemia (Ganji and Kuo, 2008) mixed with foods. In Pakistan, cereals based products like cookies can be a suitable vehicle to add in psyllium husk being cheap and liked by all age groups. Present research was planned to prepare dietetic cookies to evaluate the therapeutic role of psyllium husk against hypercholesterolemia.

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MATERIALS AND METHODS

Product development was carried out in Postgraduate Research Laboratory, National Institute of Food Science and Technology (NIFSAT), University of Agriculture, Faisalabad and efficacy trials were conducted at Dera Ghazi Khan Distt., Punjab, Pakistan.

1. Procurement of raw materials

For the preparation of dietetic cookies, indigenous psyllium husk (*Plantago Ovata* Forsk) was acquired from Qarshi Industries (Pvt.) Ltd. Pakistan while non-nutritive sweeteners; aspartame and sorbitol, straight grade flour and shortening were procured from the local market. Dietetic cookies supplemented with psyllium husk of an acceptable quality regarding sensory attributes and dietary fibre content were developed (AACC, 2000). The research results have been published earlier by the same author (Qaisrani *et al*., 2014).

2. Efficacy studies

The efficacy study for two consecutive years was conducted. The plan and perspective were communicated to volunteers clearly. Written consent to participate in the project was taken. Selection of subjects was made on the basis of anthropometric information, vital sign records and baseline values of serum lipid profile for study in normal and in hypercholesterolemic subjects. Volunteers with no significant differences in the base line values among normal individuals were preferred and same pattern was followed for hypercholesterolemic subjects with the study plan presented in Table 1.

Table 1: Efficacy study plan

	(Normal Subjects)		(Hypercholesterolemic Subjects)	
Groups	G_1	G_2	G_1	G_2
Cookies	D_1	D_2	D_1	D_2

D_1 = control

D_2 = dietetic cookies

Twenty selected subjects among normal individuals were further divided in to two groups of ten each. One group was afforded with control and other group consumed dietetic cookies during two months. The subjects were examined regularly to appraise any obscurity. To observe the effect of respective cookies on serum lipid profile the blood samples were drawn after one month. In hypercholesterolemic subjects the same pattern was adopted to evaluate the effect of treatment.

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2.1 Blood sampling and determination

Initially blood sample of each volunteer was drawn to determine base line values. Samples were collected on monthly basis to evaluate the effect of fibre supplementation.

2.1.1. Serum assessment

Serum from the collected blood sample was obtained through centrifugation (Model: 800, Centrifugal Machine, China) at 4000 rpm for 6 min (Uchida *et al*., 2001) and was examined for lipid profile (commercial kits through Microlab-300, Merck, Germany).

Serum Lipid profile

The extracted serum was analyzed for total cholesterol and triglycerides by CHOD–PAP and GPO-PAP methods, respectively following the protocols of Kim *et al*. (2011). Serum was evaluated for high density lipoprotein by using the HDL-cholesterol precipitant method (Al-shatwi *et al.,* 2010). Low density lipoprotein and very low density lipoprotein were measured by using the method of Al-shatwi *et al.* (2010) and McNamara *et al*. (1990), respectively.

2.2. Statistical analysis

Study results were analyzed statistically using Cohort version 6.1 (Costat-2003). Analysis of variance technique (ANOVA) using two factor factorial CRD was applied to estimate the level of significance. Tukey test was applied in efficacy studies for means comparison (Steel *et al*., 1997).

RESULTS

Efficacy study was carried out in normal and hypercholesterolemic subjects by providing control and dietetic cookies. The planned modules T-I (2009-2010) & T-II (2010-2011) were conducted in two consecutive years.

Lipid profile

Total cholesterol

Statistical analysis regarding effect of treatments on total cholesterol in all groups during the year 2009-10 (Trial-I), 2010-11 (Trial-II) are depicted in Tables 2 and Table 3. Mean squares revealed non-significant differences due to treatments and study intervals in normal individuals while significant variations in hypercholesterolemic subjects.

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Table 2. Mean squares for effect of dietetic cookies on lipid profile of normal subjects

SOV	Df	Cholesterol		LDL		HDL		Triglycerides		LDL/HDL		VLDL	
		T-I	T-II	T-I	T-II	T-I	T-II	T-I	T-II	T-I	T-II	T-I	T-II
Treatments (A)	1	405.08^{NS}	535.21^{NS}	612.80^{NS}	458.49^{NS}	30.41 NS	19.89 NS	300.78^{NS}	354.29^{NS}	0.361 *	0.278*	12.04^{NS}	13.94 NS
Duration (B)	2	25.59 NS	78.25 NS	65.42 NS	92.43 NS	1.31^{NS}	2.02^{NS}	6.06^{NS}	8.26^{NS}	0.029 *	0.037*	0.24^{NS}	1.06^{NS}
A × B	2	103.16^{NS}	132.52^{NS}	135.92^{NS}	154.89^{NS}	1.99^{NS}	2.91^{NS}	115.84^{NS}	113.01^{NS}	0.060 *	0.059*	4.63^{NS}	5.01^{NS}
Error	54	89.59	113.19	103.12	94.03	5.84	5.66	97.47	97.77	0.004	0.003	2.47	3.35
Total	59												

Table 3. Mean squares for effect of dietetic cookies on lipid profile of hypercholesterolemic subjects

SOV	Df	Cholesterol		LDL		HDL		Triglycerides		LDL/HDL		VLDL	
		T-I	T-II	T-I	T-II	T-I	T-II	T-I	T-II	T-I	T-II	T-I	T-II
Treatments (A)	1	5591.21 **	5748.10 **	7156.96 **	4619.51 **	17.35 NS	16.24 NS	799.13^{NS}	829.48^{NS}	5.50 **	3.75 **	31.93 **	28.59 *
Duration (B)	2	793.22**	792.09**	462.38**	975.69**	2.66^{NS}	2.29^{NS}	1759.31 NS	1909.01 NS	0.39 *	0.71 *	70.39 **	71.57 **
A × B	2	1325.74 **	1398.54 **	1122.63 **	582.67**	2.13^{NS}	1.77^{NS}	432.48^{NS}	392.06^{NS}	0.72 *	0.39 *	17.26 *	13.13 *
Error	54	117.221	118.428	63.596	61.377	3.483	3.454	322.591	325.229	0.026	0.025	4.181	4.136
Total	59												

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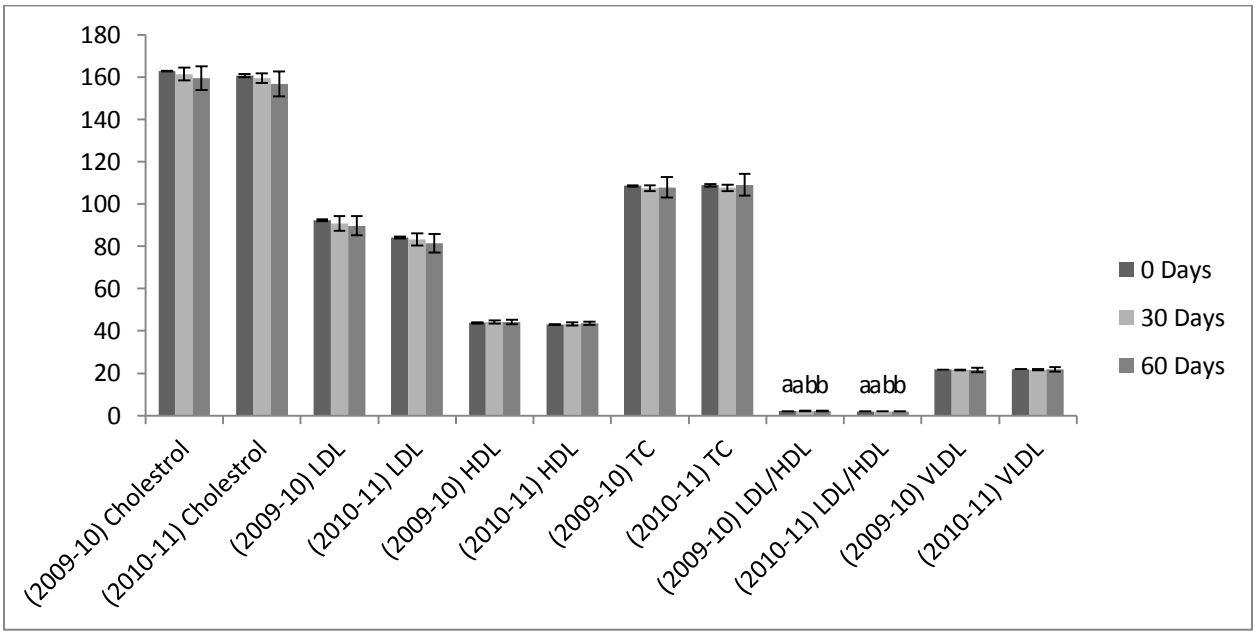
Normal subjects in trial I (Fig. 1) rely on control cookies had the base line value 163.00±5.98mg/dL changing non-significantly after 60 days. The group fed on psyllium husk cookies showed non-momentous decline in base line value after two months. In Trial-II (normal subjects), similar trend were observed confirming the validity of data. It is demonstrated (Fig. 2) that in hypercholesterolemic individuals (Trial-I) cholesterol concentration varied from 233.70±8.74 to 237.52±7.19mg/dL and 231.50±6.46 to 202.90±7.26mg/dL in control and psyllium based groups from initiation to termination of study, respectively. The two treatments (control and psyllium husk based) behaved reasonably different. Likewise, in Trial-II cholesterol concentration varied from 234.55±8.77 to 238.66±7.23mg/dL and 232.59±6.54 to 205.40±7.29mg/dL in control and psyllium husk based groups at 0 to 60th day, respectively (Fig 2).

Fig. 1. Graph of Means for effect of dietetic cookies on lipid profile of normal subjects



Percent reduction in total cholesterol due to dietetic cookies ranged from 5.38 to 5.56% in normal subjects (Fig. 3). In hypercholesterolemic individuals the values varied from 12.35 to 11.26% comparing the base line values in 2009-10 and 2010-11, respectively (Fig. 4).

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Fig. 2. Graph of Means for effect of dietetic cookies on lipid profile of hypercholesterolemic subjects

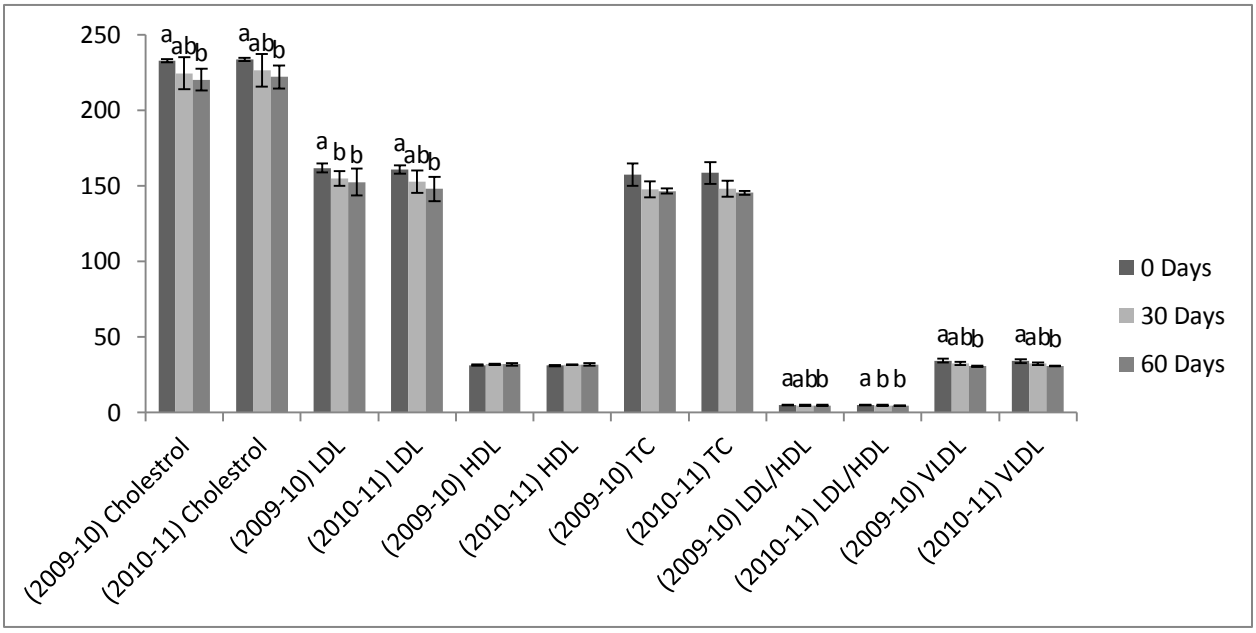

Fig. 3. Graph of percent decrease in lipid profile of normal subjects

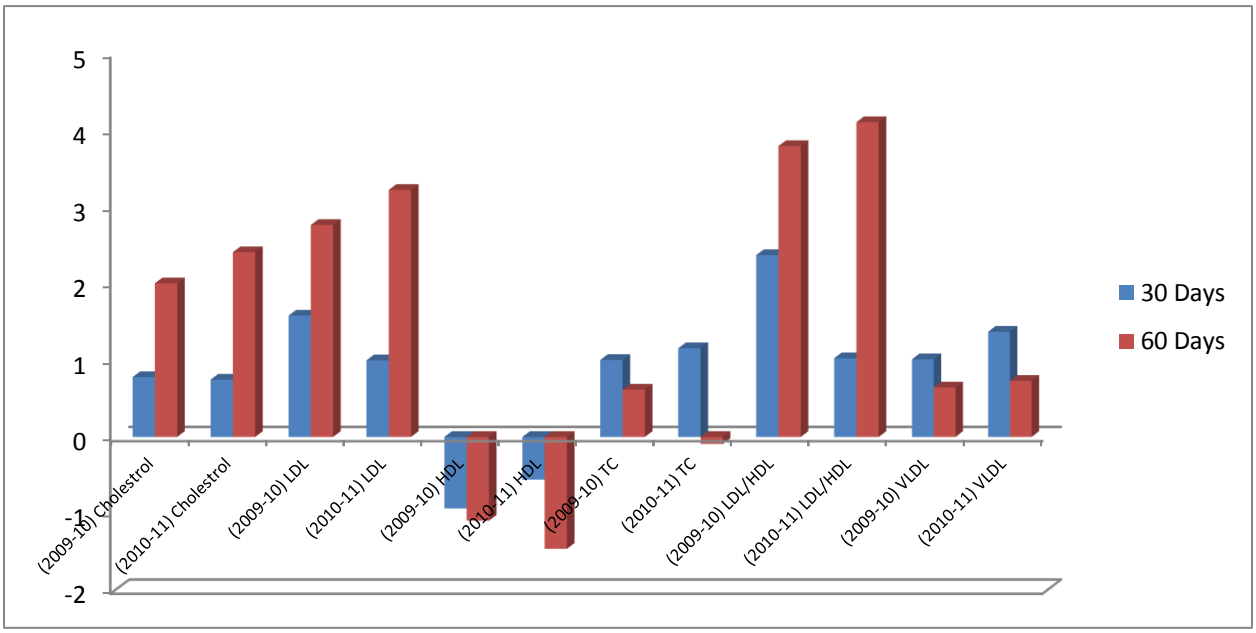

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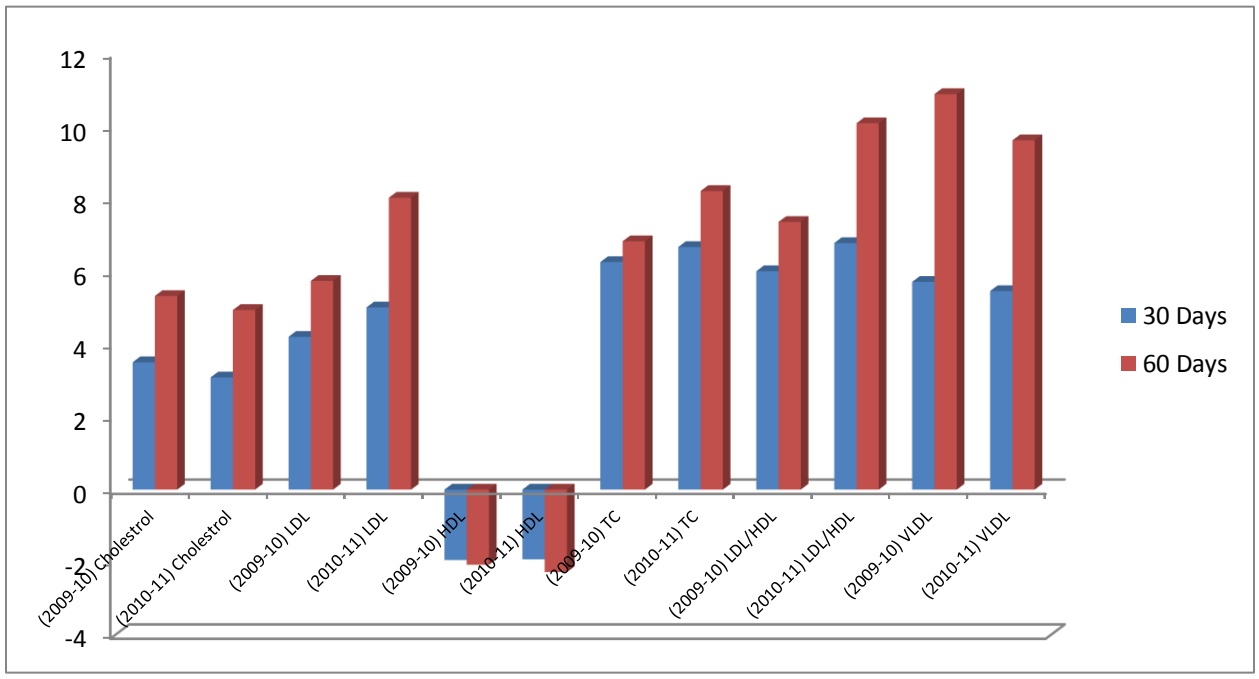
Fig. 4. Graph of percent decrease in lipid profile of hypercholesterolemic subjects



Low density lipoproteins

Mean squares regarding low density lipoproteins (LDL) in Tables 2 & 3 illustrated non-significant variations among normal subjects whereas, significant differences were observed for this trait in hypercholesterolemic individuals as function of treatments.

In normal subjects (Trial-I), means for the years 2009-10 expounded that in control, LDL values varied from 92.79±3.88, 94.31±4.78 and 94.39±3.53mg/dL, in psyllium husk treatment group 91.84±4.94, 87.41±4.59 and 85.15±3.49mg/dL at 0, 30 and 60 days, respectively. Similar non-significant differences were observed in Trial-II (Fig. 1). In hypercholesterolemic subjects (Trial-I) means regarding LDL explicated non-significant increase from 164.78±7.22, 166.86±8.85 and 170.38±6.68mg/dL in control whereas, decline from 158.78±8.91, 143.11±7.80 and 134.60±8.13mg/dL in dietetic cookies consuming group at mentioned intervals, respectively. Similar diminishing pattern (Trial-II) in subjects rely on psyllium based cookies was observed with the mean LDL values of 158.07±8.87, 142.27±7.75 and 135.77±8.07mg/dL at 0, 30 and 60 days, respectively (Fig. 2).

Percent decline in LDL due to psyllium husk ranging from 7.28 to 8.09% in normal subjects (Fig. 3) and in hypercholesterolemic individuals a significant diminish as 15.22 to 14.10% after 60 days was observed (Fig. 4).

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High density lipoproteins (HDL)

Mean squares regarding HDL explicated non-significant variations due to treatments and time in normal (Table 2) and hypercholesterolemic (Table 3) groups.

The Fig. 3 depicted a non-significant rise in HDL from 2.46 to 3.13% in normal subjects and 3.45 to 4.27% in hypercholesterolemics considering the base line values (Fig. 4).

Triglycerides

Mean squares in Table 2 and 3 presented non-significant effect of treatments on triglycerides level in normal and hypercholesterolemic subjects. The mean values have been presented for clear image of the change in triglycerides as an effect of treatment and time (Fig. 1,2).

Percent reduction in triglycerides ranged from 4.88 to 3.58% in normal subjects (Fig. 3). In hypercholesterolemics, overall reduction was 7.05 to 8.40% considering initial values of the psyllium treated groups (Fig. 4).

LDL/HDL ratio

Mean squares for LDL/HDL ratio expounded significant differences due to treatments and days in normal subjects (Table 2) and hypercholesterolemic subjects (Table 3).

In normal subjects LDL/HDL ratio varied from 2.14±0.06 to 2.18±0.05 and 2.08±0.11 to 1.88±0.08 at 0 and 60 days in control and psyllium husk treated groups, respectively in Trial-I. Similar, significant trend regarding this trait was observed during the year 2010-11 (Fig. 1). In hypercholesterolemic subjects, LDL/HDL values ranged from 5.33±0.14 to 5.48±0.12 and 4.99±0.25 to 4.09±0.17 among two treatments at 0 and 60 days, respectively during 2009-10. Likewise pattern was observed in the following year 2010-11 (Fig. 2).

Very low density lipoproteins (VLDL)

Mean squares regarding VLDL showed non-significant variations due to treatments and study intervals in normal subjects (Table 2) while momentous differences in hypercholesterolemic subjects (Table 3).

In hypercholesterolemic volunteers (Trial-I) means VLDL values were 33.02±1.54 to 31.04±1.02mg/dL and 35.92±1.36 to 30.40±1.05mg/dL whereas, in Trial-II the concentrations varied from 32.97±1.54 to 30.69±1.00mg/dL and 35.51±1.34 to 31.22±1.04mg/dL at 0 and 60 days in control and dietetic cookies consuming groups, respectively (Fig. 2).

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The results indicated that VLDL diminished from 4.84 to 5.53% and 13.48 to 12.08% considering the base line values in normal and hypercholesterolemic subjects, respectively (Fig. 3,4).

DISCUSSION

Total cholesterol

Some other studies are in corroboration with recent findings of decreasing plasma cholesterol with psyllium husk (Khossousi *et al.*, 2008; Murad *et al.*, 2011). Agarwal *et al.* (2007) documented decrease in serum cholesterol level of normal subjects consuming psyllium husk. **Uehleke *et al.* (2008)** also reported that psyllium husk based diet is effective therapy for mild to moderate hypercholesterolemia. Hypocholesterolemic potential of fibre from psyllium husk can be accredited to increased faecal excretion of cholesterol and bile acids (Yu *et al.*, 2009). The increased efficiency in the LDL receptor lowers cholesterol by improving uptake of low density lipoprotein from blood (Shreshtha *et al.*, 2006).

Low density lipoproteins

The exploration of Murad *et al.* (2011) supported the present data reporting significant decrease in LDL cholesterol in hypercholesterolemic subjects with psyllium husk. In another study, moderately hypercholesterolemic individuals exhibited significant reduction in LDL with consumption of husk supplemented diet (Wei *et al.*, 2009). Present results for LDL reduction in hypercholesterolemic individuals are in agreement with Cicero *et al.* (2010) that husk powder consumption resulted significant LDL decline in human subjects. The investigation of Shreshtha *et al.* (2006) also delineated the synergistic ability of psyllium with phytochemicals against hypercholesterolemia. Jones *et al.* (2005) observed significant reduction in LDL concentration probing that combined use of viscous fibre, vegetable proteins and plant sterols decreased LDL (29%) in hypercholesterolemics.

The proposed mechanism of LDL reduction by psyllium husk is through inhibition of cholesterol synthesis and dietary cholesterol absorption (WSCPSG, 1998). According to Rosendaal *et al.* (2004), fibre showed non-significant effect on LDL level in healthy volunteers. The increase in LDL receptor improves uptake of LDL from the blood circulation (Shreshtha *et al.*, 2006). Different studies proved the ability of psyllium husk to enhance the LDL receptor, a key factor by which the sterols are removed from blood **(Agarwal *et al.*, 2007;** Jones, 2008**).**

High density lipoproteins (HDL)

Results for non-significant effect of cookies on HDL are close with work of Chawla and Patil (2010) who reported non-substantial changes in HDL in humans after psyllium husk

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consumption. Higher level of HDL prevents LDL accumulation in the inner walls of the arteries. The HDL is involved in transportation of cholesterol from arteries and tissues to liver revealed as good lipids in the body. It decreases accumulated cholesterol in the endothelium by recovering cholesterol from peripheral cells and other lipoproteins to liver for excretion in bile (Ha *et al.,* 2005). HDL in healthy humans remained unaffected after consumption of psyllium husk (Rosendaal *et al.*, 2004; Agarwal *et al.*, 2007; Sartore *et al.,* 2009). In contrast various research results expounded that psyllium husk caused significant increase in HDL in people with primary hypercholesterolemia (Sola *et al.*, 2007; Karim *et al.*, 2010; Murad *et al.*, 2011).

Triglycerides

Earlier, Agarwal *et al.* (2007) observed non-significant differences in triglycerides as effect of psyllium diet in normal individuals. Contrarily, the results reported by Vega-Lopez *et al.* (2003) exhibited significant effect of psyllium supplementation. In hypercholesterolemic individuals, the non-momentous reduction in serum triglyceride concentration with psyllium husk supplemented cookies is in agreement with the results of Murad *et al.* (2011). Comparable result for the efficacy of psyllium husk is reported by Wei *et al.* (2009); expounded non-significant differences in triglyceride after two weeks treatment with psyllium in borderline hypercholesterolemic subjects. Afterwards, Maki *et al.* (2009) reported non-momentous effect of Hydroxypropylmethylcellulose on triglycerides in primary hypercholesterolemics strengthening the results of present study.

LDL/HDL ratio

The dietary fibre attaches and captures the dietary fat that is excreted with faeces and does not become the part of blood even in the presence of diets containing trans fats. Psyllium is influential in managing blood lipid profile by significantly increasing the HDL. Psyllium husk reduced LDL/HDL ratio (2.4%) in hypercholesterolemic patients (Jenkins *et al.*, 2002). Sartore *et al.* (2009) further supported the instant results reporting significantly lowered LDL/HDL in hypercholesterolemic subjects due to psyllium husk consumption.

Very low density lipoproteins (VLDL)

In hypercholesterolemic individuals, reduction in VLDL with psyllium husk supplemented cookies is in agreement with the findings of Shrestha *et al.* (2006); inferred that effect of psyllium might be related to gender and hormonal differences. The results of Chandalia *et al.* (2000) also indicated significant reduction (12.5%) in VLDL with the use of high fibre diet. Abnormalities in lipid profile due to alteration in lipoproteins (LDL, HDL and VLDL) resulting in disorders like atherosclerosis thus leading to ischemic diseases among human subjects (Ahmad, 2011). High density lipoproteins are active cholesterol transporters towards liver for

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supplementary metabolic activities as compared to low density lipoproteins. Therefore, lower ratio of LDL/HDL is favourable in normal cholesterol metabolism. Hypercholesterolemia, high VLDL and low HDL levels, obesity and hyperinsulinemia are linked with the incidence of coronary heart diseases (Zaman *et al.*, 2008).

CONCLUSION

Concluding through discussion, foods containing psyllium husk or soluble fibres are effective in managing the lipid profile with special reference to cholesterol and LDL. Conversely, the good cholesterol *i.e.* HDL-cholesterol increases non-significantly. It is further perceived that cookies containing psyllium husk are effective in modulating lipid metabolism. Owing to the existence of active ingredient *i.e.* arabinoxylan, dietetic cookies could be efficacious in managing the lifestyle-related disorders with special reference to hypercholesterolemia. It is therefore inferred that therapeutic food should be hosted in dietary modification for managing lipid profile.

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