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Effect of Flaxseed Supplementation on Nutrient Adequacy and Iron Status of Coronary Heart Disease Patients

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ABSTRACT Sixty at risk of coronary heart disease subjects in the age group of 40-60 years were selected from Punjab Agricultural University, Ludhiana. The subjects were equally divided into three groups i.e. E_1, E_2 and C respectively. Flaxseed in powdered form was supplemented at the levels of 5 and 10 g to E_1 and E_2 groups respectively for a period of two months, while C group was not supplemented. The effects of flaxseed powder were studied on nutrient and hematological profile of the subjects. After the supplementation, significant ($p<0.05$) decrease in the energy intake was reported in E_2 group while protein intake significantly ($p<0.05$) increased in E_2 group and total fat intake reduced significantly ($p<0.05$) in all three groups. Decrease in energy intake could be due to flaxseed supplementation which is good source of soluble fibre thus gives feeling of fullness and reduced the food intake which ultimately decreased the energy intake. The mean intake of vitamin B_2, B_3 and vitamin C decreased in all the three groups, though it was non-significant. Further, an increase in haemoglobin was reported in experimental groups which could be due to presence of protein, copper, folic acid and vitamin B_6 in flaxseed which helped in hemopoesis and thus improved iron status.

INTRODUCTION

Coronary heart disease (CHD) is one of the major causes of mortality and morbidity in population of both, developed as well as developing countries. In India, heart attack ranks second in the ten selected diseases which are responsible for deaths. In the year 2003, the prevalence of CHD in rural and urban areas of India was estimated to be 3-4 and 8-10 per cent which was two and six folds respectively higher when compared to the prevalence 40 years ago (Goyal and Yusuf 2006). By the year 2020, India will have the largest cardio- vascular death burden in the world which would account for one-third of all deaths (WHO 2004).

The well-known causation factors for CHD are wrong food habits and diet proves to be a cornerstone in its prevention. High energy intake, infrequent meals, high fat intake, especially harmful fats like *trans* fats, proteins of animal origin, high sugar coupled with decreased physical activity, lack of exercise, lack of mental relaxation, passive entertainment etc have a direct impact on the development of these conditions. *Trans* fats put at a greater risk of many diseases like CHD by raising bad cholesterol, lowering good cholesterol and increasing abnormal clotting of blood (Khosla 2006).

Flaxseed (*Linum usitatissimum*) traditionally known as linseed or *alsi*, is an ancient oilseed that has been a part of the human diet for thousands of years. It contains 41% fat, of which 73% are polyunsaturated fatty acids (PUFA), 18% are monounsaturated fatty acids (MUFA) and 9% are saturated fatty acids (SFA) making it a low saturated fat food. It is an excellent source of omega-3 essential fatty acid i.e. alpha linolenic acid (Bloedon 2004). It is a good source of dietary fibre (25-30%) of which 6-8% is soluble fibre. High-fibre foods are called low energy density as these provide fewer calories relative to the total weight of the food and are also more filling. Flaxseeds are more filling than other foods. The fibre present in it swells to form a gel-like substance in the intestine which increases intestinal transit time thereby delays gastric emptying. Consuming the proper amount of polyunsaturated fat, as found in flaxseed, can help to give us that "full" feeling without the harm of saturated fats, and thereby help us to maintain a healthy diet. Flaxseed also contains 21% protein and also is a good source of folic acid, vitamin B_6, vitamin E as well as minerals like magnesium, phosphorous and copper (Anonymous 2005). Folic acid helps in the formation of the heme part of hemoglobin, copper in the form of copper- protein complex called ceruloplasmin and vitamin B_6 helps in hemoglobin synthesis. Vitamin E is a strong antioxidant which converts free radicals into less toxic and reactive form and

also plays an impor-tant role in maintaining stability and integrity of cell membrane (Joshi 2008). Hence the present study has been undertaken to find out the effects of flaxseed supplementation in the nutrient intake and iron status of at risk CHD male patients.

MATERIALS AND METHODS

Selection of Subjects: A sample of 60 male subjects free from serious complications, aged 40-60 years at risk of CHD i.e. total cholesterol levels ≥200mg/dl and triglyceride levels ≥160 mg/dl were selected from the OPD of the P.A.U hospital, Ludhiana and were equally divided into three groups, E_1, E_2 and C. Collection of data pertaining to general information was done through a questionnaire.

Dietary Survey: Dietary intake of the subjects was recorded by "24 hour recall method" for three consecutive days using standardized containers before and after the supplementation. The average nutrient intake was calculated using MSU Nutri-guide computer programme (Song et al. 1992). The average raw amounts in gm of each and every item of food consumed for three consecutive days for each subject was fed in the hardware and nutritive value of diets were recorded.

Hematological Profile of the Subjects: Heamoglobin (Hb), Packed cell volume (PCV) and Red Blood cell count of the subjects of all the groups were analyzed by standardized methods before and after supplementation to assess iron status of the subjects. Mean corpuscular volume (MCV), Mean corpuscular Haemoglobin concentration (MCHC) and Mean corpuscular Haemoglobin (MCH) were calculated.

Supplementation of the Flaxseed Powder: Flaxseeds were procured from the Department of Plant Breeding, Genetics and Biotechnology, P.A.U, Ludhiana and were cleaned, washed, sun-dried and roasted at 150°C for 5 minutes and grinded in a coffee grinder. The flaxseed powder was provided in zip-lock bags to the subjects of experimental groups for 60 days on weekly basis which helped to monitor their regularity in consumption of flaxseed powder. The subjects of E_1 and E_2 group were supplemented with 5 and 10g flaxseed powder respectively, while C group was not supplemented. All the subjects were on medication as per their physician. The subjects of the experimental groups were advised to add flaxseed powder to cooked food (*dhal*, vegetable)/ stuffed in *chapatti*/ mix in milk/ curd/ take with water etc. They were also advised to keep flaxseed powder in a refrigerator so as to prevent rancidity of powder due to high amounts of PUFA.

Statistical Analysis: The data was analyzed with the help of various statistical tools such as mean, standard error of the mean (SE) and percentage. To test the significance student's 't' test was applied using Microsoft Excel Computer Programme Package.

RESULTS AND DISCUSSION

Demographic Information of the Subjects: In the present study subjects above 40 years were chosen being more prone to CHD. As depicted in table 1, the mean age of onset was 51±1.53, 52.3±1.1, 52.2±1.73 yrs in E_1, E_2 and C groups respectively. Further the mean monthly per capita income in the three groups was Rs. 8107±761, 11122±744 and 10319±809 and thus belonged to higher socio-economic status. The data showed that 90, 85 and 75 percent of subjects in the three groups were involved in desk work and used to work for >8 hrs/day. It was further seen that 20, 20 and 30 per cent of the subjects used to bring their office work at home very often. Thus, it was concluded that the subjects were leading a stressful life and stress is an important risk factor in causation of heart-attack. Further, the data revealed that majority of the subjects had a family history of hypercholesterolemia, hypertriglyceridaemia followed by hypertension.

***Clinical Manifestations*:** The common problems of all the subjects were lethargy, tiredness and breathlessness. The percentage of subjects facing the problem of lethargy and tiredness were 25, 20 and 20 percent in the three groups respectively and problem of breathlessness was faced by 35, 30, 25 and 10, 15 and 20 percent subjects in the three groups. The subjects of experimental groups were relieved from the problems of lethargy, tiredness and breathlessness which could be due to supplementation of flaxseeds being rich in magnesium which helps in functioning of heart-beat and maintenance of blood pressure.

Nutrient Intake: The mean daily nutrient intake by the subjects before and after the supplementation is presented in table 2.

Energy and Protein: The initial mean daily intake of energy among the subjects in E_1 E_2 and C group was 1889±98, 1940±79 and 1960±65 Kcal respectively. The final mean intake was 1837±79,

Table 1: Demographic information of subjects (Mean±SE) (N=20 per group)

Characteristics	E_1	E_2	*C*
Mean age (yrs)	51±1.53	52.3±1.1	52.2±1.73
Mean monthly Per capita income (Rs)	8107±761	11122±744	10319±809
Nature of Work			
Desk work	17 (90)	16 (85)	15 (75)
Carry office work at homeoften	4 (20)	4 (20)	6 (30)
Working hours >8	8(40)	8 (40)	8 (40)
Consume Alcohol Yes	5 (25)	7 (35)	3 (15)
Smoking			
Smokers	3 (15)	1 (5)	-
Family History	13 (65)	18 (90)	15 (75)
Type of Family History*			
Hypertension	6 (46)	7 (39)	4 (27)
Hypercholesterolemia	4 (31)	9 (50)	6 (40)
Hypertriglyceridemia	3 (23)	-	4 (27)
Heart attack	3 (23)	4 (22)	1 (7)
Stroke	1 (8)	-	-
Diabetes	4 (31)	2 (11)	2 (13)
Consumption of			
Fried	19(95)	15 (75)	18 (90)
Steamed	20 (100)	20 (100)	20 (100)
Baked	15 (75)	17 (85)	15 (75)
Frequency of Eating Out			
Once a week	1 (5)	1(5)	1(5)
Once a month	6(30)	8 (40)	9 (45)
Rarely	13 (65)	11 (55)	10 (50)
Liking			
Sweets (ladoo,rasgula, barfi)	5 (25)	10 (50)	7 (35)
Salty (namkeen, chips, samosa etc.)	17 (85)	5 (25)	10 (50)

Figures in parentheses indicate percentages
* Multiple responses

1884±69 and 1966±61 Kcal in all the groups. There was a non-significant decrease in energy intake in E_1 but a significant ($p<0.05$) decrease was reported in E_2 group. The decrease in energy intake after supplementation in the experimental groups could be due to presence of fibre which increases transit time and delays gastric emptying thus gives the feeling of fullness, hence it reduced the energy intake. Further, a decrease in the consumption of visible fat and refined cereals by the subjects resulted in decrease in the intake of total energy. Khosla (2008) reported that by decreasing calorie intake, atherosclerosis could decrease by 40 per cent which further decrease the incidence of CHD. The initial and final mean daily protein intake was 79.85±11.85, 87.28±12.97, 76.87±8.55 and, 81.02±9.87, 91.29±12.39, 78.87±8.39g in all three groups respectively. The intake of protein was higher than suggested intake given by Ghafoorunissa and Krishnaswamy (2000). A significant ($p<0.05$) increase was reported in the mean daily intake of protein in E_2 and C group. The increase could be due to increased consumption of milk and milk products and pulses as Punjabis are fond of milk and milk products and daily intake of curd/ lassi and pulses are daily dietary regimen of Punjabi population.

Carbohydrates: The initial and final mean intake of carbohydrates was 241±9.87, 243± 10.84, 254± 8.16g and 233±8.29, 231±9.34, 251±7.68g respectively. A significant decrease in intake of carbohydrates was reported in group E_1 ($p<0.01$) and E_2 ($p<0.05$) while a non significant decrease was reported in C group. The decrease could be due to low intake of cereals, roots and sugar and jaggery. Mann (1997) reported that high carbohydrate diet had been associated with increased triglycerides, decreased HDL-C which is the existing risk of CHD.

Fats and Oils: The initial and final mean daily fat intake was 67.15±5.24, 68.87±4.14, 70.82±4.38g and, 64.48±4.57, 65.92± 3.66, 69.27±4.04g in the three groups respectively. The mean intake decreased significantly ($p<0.05$) in all the three groups. This was due to the reduction in changed consumption pattern from *paranthas* to *chapatti* and decrease in the consumption of non-vegetarian foods. The mean daily intake of PUFA in

Table 2: Mean daily nutrient intake of the subjects (Mean ± SE) (n=20 each)

Nutrients	*Initial*	*Final*	*Difference*	*t-value*	*Suggested intake##*
Energy (Kcal)					1800- 2400
E_1	1889±98	1837±79.	-51.68	1.5^{NS}	
E_2	1940±79	1883±69	-56.365	2.18*	
C	1960±65	1966±61	6	3.7*	
Protein (g)					50- 60
E_1	79.85±11.85	81.02± 9.87	1.17	0.24 ^{NS}	
E_2	87.28±12.97	91.29±12.39	4.01	2.1*	
C	76.87± 8.55	78.87± 8.39	2	2.1*	
Carbohydrates (g)					300- 340
E_1	241.23± 9.87	233.14± 8.29	-8.09	2.21*	
E_2	243.19±10.84	231.28± 9.34	-11.91	2.77*	
C	253.82± 8.16	251.82± 7.68	-2	1.67 ^{NS}	
Total Fat (g)					40- 60
E_1	67.15± 5.24	64.48± 4.57	-2.67	2.35*	
E_2	68.67± 4.14	65.92± 3.66	-2.75	2.08*	
C	70.82± 4.38	69.27± 4.04	-1.55	2.12*	
Saturated Fat (g)					<20
E_1	46± 0.86	41± 0.72	-5	3.63**	
E_2	41± 0.98	38± 0.58	-3	2.43*	
C	42± 0.92	44± 0.69	2	2.05*	
Polyunsaturated Fat (g)					>18.56
E_1	13± 0.52	12± 0.42	-1	2.04*	
E_2	15± 0.45	13± 0.38	-2	2.72*	
C	11± 0.23	8± 0.42	-3	3.85**	
P:S Ratio					0.8-1
E_1	0.282± 0.0006	0.272±0.005	-0.01	1.76^{NS}	
E_2	0.357± 0.0004	0.342±0.0002	-0.015	2.02*	
C	0.258± 0.0013	0.299±0.001	0.039	3.74**	

^{NS} Non significant
** Significant at 1%
* Significant at 5%
$^{##}$ Ghafoorunissa and Krishnaswamy (2000)

E_1, E_2 and C group was 13±0.52, 15±0.45, 11±0.23 and, 12±0.42, 13±0.38, 8±0.42g before and after the study period. The intake in all the groups was quite less than suggested intake. The initial and final mean intake of P:S ratio was 0.282, 0.357, 0.258 and 0.272, 0.342 and 0.299 in the three groups respectively. The ratio intake was less than the suggested value of 0.8-1. Further, a significant ($p<0.01$) decrease in P: S ratio was observed in E_2 group whereas significant ($p<0.05$) increase was observed in C group. In comparison to people from other states, Punjabis are more vulnerable to heart attacks due to high fat content in their diet. The increasing incidence of CHD is due to nature of diet rich in butter, *desi ghee*, sugar etc. Moreover there is mushrooming growth of fast food corners in the city which resulted in wrong eating habits.

Percent Contribution of Carbohydrates, Protein and Fat to the Total Energy Intake: The percent contribution of carbohydrates to total energy before and after the study period was 50.9, 50.14, 51.8 and 50.77, 49.12, 51.76 percent respectively in the three groups. Sharma (2004) also suggested the 50-60 percent of the total calorie intake should be met from carbohydrates. In the present study, dietary protein contribution to the total energy intake increased from 16.91, 18.0 and 15.69 percent to 17.64, 19.39 and 16.21 percent due to more intake of pulses and milk and milk products. The percent contribution by fat to the total energy was 32, 31.86 and 32.52 to 31.59, 31.5 and 32.03 in the three groups respectively. Among all the subjects, the percentage of energy contributed by fat before and after supplementation was higher than the suggested values of 15-20 per cent. Vindon et al. (2001) suggested that in order to lower LDL-C and improve HDL-C, there is a need to improve percentage of calories from complex carbohydrates along with 10 percent calories each from saturated fatty acids, PUFA and MUFA.

Vitamins: The average intake of vitamins by the subjects before and after study is presented in table 3.

Thiamine and Riboflavin: Table 2 depicted,

Table 3: Mean daily intake of vitamins by the subjects (Mean ± SE) (n=20 each)

Vitamins	*Initial*	*Final*	*Difference*	*t-value*	*Suggested intakes#*
Thiamine (mg)					1.2
E_1	1.72± 0.08	1.66± 0.07	-0.06	1.26 NS	
E_2	1.66± 0.10	1.59± 0.10	-0.07	1.42 NS	
C	1.88± 0.08	1.65± 0.06	-0.23	2.24*	
Riboflavin (mg)					1.4
E_1	1.33± 0.07	1.25± 0.06	-0.08	1.56 NS	
E_2	1.35± 0.09	1.28± 0.08	-0.07	1.25 NS	
C	1.42± 0.06	1.41± 0.06	-0.01	0.99 NS	
Niacin (mg)					16
E_1	12.03± 0.87	12.08± 0.87	-0.05	1.56 NS	
E_2	10.58± 0.43	10.61± 0.43	-0.03	1.21 NS	
C	12.13± 0.58	12.12± 0.58	-0.01	0.03 NS	
Vitamin C (mg)					40
E_1	156.25±18.28	153.75±17.48	-2.5	1.08 NS	
E_2	154.07± 3.34	149.58±30.94	-4.49	0.99 NS	
C	206.07±35.90	203.12±35.74	-2.19	1.75 NS	
Folic Acid (µg)					100
E_1	128.51± 5.75	126.51± 5.72	-2	1.67 NS	
E_2	114.49± 6.47	110.49± 5.72	-4	1.75 NS	
C	129.87± 6.16	121.97± 5.44	-7.9	3.43**	

#ICMR (2003) NS Non significant
**Significant at 1% level* Significant at 5% level

the initial mean daily intake of thiamine in the three groups was 1.72±0.08, 1.66±0.10 and 1.88±0.08mg respectively and it decreased to 1.66±0.07, 1.59±0.10 and 1.65±0.06 mg. The mean daily intake of riboflavin was 1.33±0.07, 1.35±0.09, 1.42±0.06 and 1.25±0.06, 1.28±0.08, 1.41±0.06mg before and after the supplementation in all the three groups respectively. A statistically non-significant decrease was observed in all the three groups. Whole cereals, pulses contributed to thiamine and riboflavin in the diet. The decrease could be due to decrease in cereal intake after the study period.

Niacin and Folic Acid: The initial and final mean daily intake of niacin was 12.03±0.87, 10.58±0.43, 12.13±0.58 and 12.08±0.87, 10.61±0.43, 12.12±0.58 mg in all the three groups respectively which was less than the suggested intake. Choudhary (2004) too reported the non significant decrease in niacin levels among subjects of coronary heart disease. Kumar (2000) reported that niacin is the best and cheapest nutrient for lowering total cholesterol, triglycerides, bad cholesterol and raising good cholesterol. The mean daily intake of folic acid was 128.51±5.75, 114.49±6.47 and 129.87±6.16µg and the final mean intake was 126.51±5.72, 110.49±5.72 and 121.97±5.44 µg in the three groups respectively. A non-significant decrease in folic acid was observed among the subjects of E_1 and E_2 group while a significant ($p<0.01$) decrease was observed in C group. This decrease was due to less availability of green leafy vegetables, less intake of root vegetables and cereals. Joshi (2008) reported that folic acid helps in the formation of the heme part of hemoglobin and is one of the most important B complex vitamins, which is associated with lowering risk of CHD by reducing homocysteine concentrations. Kochler et al. (2001) reported an inverse relationship between folic acid intake and homocysteine in both men and women.

Ascorbic Acid: The initial and final mean daily intake of vitamin C was 128.51±5.75, 114.49±6.47, 129.87±6.16mg and 126.51±5.72, 110.49±5.72, 121.97±5.44mg respectively. The intake was very high than the suggested intake of 40 mg in all the three groups both, before and after the study period as the subjects used to consume *amla*, guava, and other citrus fruits which are considered as the excellent sources of ascorbic acid. Loria et al. (2000) reported that ascorbic acid plays an important role in preventing CHD by scavenging free radicals.

Minerals: Table 4 depicts the average minerals intake by the subjects before and after supplementation period.

Calcium and Phosphorous*:* The initial and final mean intake of calcium was 1343.94, 1324, 1409 and 1316.68, 1308.1, 1354.6 mg in E_1, E_2 group and C groups respectively. A significant decrease

Table 4: Mean daily intake of minerals by the subjects (Mean ± SE) (n=20 each)

Minerals	*Initial*	*Final*	*Difference*	*t-value*	*Suggested intakes#*
Calcium (mg)					400
E_1	1344±77.42	1317±75.66	-27	3.11**	
E_2	1324±94.39	1308±87.43	-16	0.91 NS	
C	1410±64.45	1355±47.10	-55	2.16*	
Phosphorous (mg)					400
E_1	1648±58.95	1638±57.34	10	1.42 NS	
E_2	1542±74.97	1521±71.66	21	1.75 NS	
C	1722±31.75	1677±21.94	45	2.5*	
Sodium (mg)					-
E_1	267.72±46.35	262.22±43.24	5.51	1.08 NS	
E_2	244.12±35.61	238.12±32.61	6	1.18 NS	
C	247.12±32.57	237.12±27.96	10	1.86 NS	
Potassium (mg)					-
E_1	1541±89.97	1545±90.15	4	2.29*	
E_2	1552±75.40	1557±75.63	5	1.05 NS	
C	1590±56	1565±42.78	25	1.36 NS	
Iron (mg)					30
E_1	15.46± 0.59	15.08± 0.54	0.38	2.77*	
E_2	14.98± 0.58	14.28± 0.39	0.70	2.13*	
C	16.32± 0.37	15.57± 0.31	0.75	2.83*	

#ICMR 2003
**Significant at 1% level
* Significant at 5% level
NS Non significant

was observed in E_1 ($p<0.01$) and C ($p<0.05$) group whereas a non- significant decrease was observed in E_2 group. This was due to less intake of green leafy vegetables. Weaver (2000) reported that intake of 700-800 mg/d of dietary calcium reduced 1-2 mmHg systolic blood pressure (strong risk factor for CHD). The initial and final mean intake of phosphorous was 1648.61, 1542.13, 1722mg and 1638.61, 1521.13, 1677mg. A non-significant decrease in mean daily intake was reported after the supplementation among the subjects of E_1 and E_2 group whereas a significant ($p<0.01$) decrease was observed in C group. The mean intake of phosphorous was almost four-fold than suggested intake of 400mg as diet was rich in milk and milk products. Suter et al. (1999) reported that high intake of calcium, phosphorous, magnesium and folate are significant modulators of CHD and stroke. The high intake of these nutrients can be achieved by the intake of wheat bran, flaxseeds, soyabean etc.

Sodium and Potassium: The intake of sodium decreased non significantly among the subjects of all the three groups from 267.72, 244.12 and 247.12 to 262.22, 238.12 and 237.12mg respectively which was due to less intake of roots, green leafy vegetables. Ghafoorunissa and Krishnaswamy (2000) suggested that high blood pressure patients should restrict intake of sodium rich foods like green leafy vegetables (GLV's), beet root, dry fruits etc, salt intake greater than 8g/ day increase the risk of CVD by increasing blood pressure. The initial and final intake of potassium was 1541.06, 1551.75, 1589.86 and 1545.4, 1557.1, 1565.36mg. A significant ($p<0.05$) increase was observed in E_1 group whereas non-significant increase was observed in E_2 and C group. This was due to more intake of fruits like plums, citrus fruits, banana and other vegetables like tomato, cauliflower which are rich in potassium.

Iron: The initial and final mean daily intake of iron was 15.46±0.59, 14.98±0.58, 16.32 ±0.37 and 15.08±0.54, 14.28±0.39, 15.57±0.31mg and intake was less than the suggested intake of 30 mg. The iron intake was half when compared with suggested intake. Further, a statistically significant ($p<0.05$) reduction in mean iron intake was observed in all the three groups which could be due to less availability of green leafy vegetables. Fleming et al. (2001) reported that higher iron stores are associated with low risk of CVD.

Hematological Profile of the Subjects

Hemopoetic indices of the subjects were analyzed before and after supplementation and are presented in table 5.

***Haemoglobin (Hb) Level* :** The mean values

Table 5: Hematological profile of the subjects before and after the study (n=20 each)

Variable	*Group*	*Initial*	*Final*	*Difference*	*t-value*	*Reference Standard*
Hb (g/dl)	E_1	12.24±0.18	12.4±0.15	0.16	1.63^{NS}	12-16^{+}
	E_2	12.26±0.17	12.5±0.17	0.24	1.44^{NS}	
	C	12.21±0.24	12.01±0.19	-0.20	1.2^{NS}	
PCV (%)	E_1	36.71±0.53	37.3±0.44	0.59	1.63^{NS}	36-47^{++}
	E_2	36.77±0.52	37.5±0.51	0.73	1.44^{NS}	
	C	36.63±0.73	36±0.57	-0.63	0.85^{NS}	
RBC count(10^6/mm^3)	E_1	4.08±0.06	4.15±0.05	0.07	1.63^{NS}	3.9-5.6^{++}
	E_2	4.09±0.06	4.17±0.06	0.08	1.4^{NS}	
	C	4.06±0.08	4.01±0.06	0.05	1.64^{NS}	
MCV (fl)	E_1	89±0.68	90±0.7	-1	-	84-95^{+}
	E_2	88±0.7	90±0.75	-2	-	
	C	90±0.88	89.97±0.95	-0.03	-	
MCHC (%)	E_1	33.34±0.25	33±0.3	0.34	1.63^{NS}	33-38^{+}
	E_2	33±0.4	33±0.47	0	-	
	C	34.3±0.3	33.2±0.33	-1.1	-	
MCH (pg)	E_1	29.8±0.21	30±0.23	-0.2	-	28-32^{+}
	E_2	29±0.3	29.9±0.34	-0.9	-	
	C	30.2±0.35	29.95±0.35	-0.25	-	

$^{+}$Harper (1965)
$^{++}$Davidson and Passmore (1987)
^{NS}Non significant
**Significant at 1% level
Figures with different superscripts in a column differ significantly

of Hb before and after supplementation in the three groups were 12.24±0.18, 12.26±0.17, 12.21±0.24g/dl and 12.4±0.15, 12.5± 0.17 and 12.01±0.19g/dl respectively. There was an increase in Hb level in the subjects of E_1 and E_2 group which could be due to presence of copper, folic acid and Vitamin B_6 in flaxseed. Copper is the chief component of the enzyme ceruloplasmin that helps in the transfer of iron to haemoglobin and is essential for haemopoesis. Folic acid and vitamin B_6 help in the formation of the heme part of hemoglobin and, hence hemoglobin synthesis.

Packed Cell Volume (PCV) (%): As seen in the Table 4, the mean values of PCV before and after supplementation were 36.71±0.53, 36.77±0.52, 36.63±0.73% and, 37.3± 0.44, 37.5±0.51, 36±0.57% in the three groups respectively. The increase in PCV values in experimental groups could be due to flaxseed supplementation. Conversely PCV value got decreased in C group.

Red Blood Corpuscles Count (RBC Count, 10^6/mm^3): The mean values of the three groups before and after supplementation were 4.08±0.06, 4.09±0.06, 4.06±0.08 10^6/mm^3 and 4.15±0.05, 4.17±0.06 and 4.01±0.06 10^6/mm^3 respectively. A non-significant increase in experimental groups was observed, which could be due to presence of folic acid in flaxseed which helps in the maturity of RBC and, hence resulted in more RBC count.

Mean Corpuscular Volume (MCV): The initial mean values of MCV reported among the subjects of three groups were 89±0.68, 88±0.7 and 90±0.88 *fl* which increased to 90±0.7, 90±0.75 and 89.97±0.95 *fl* after the study. The mean values obtained before and after the study were within the normal range of 84-95 *fl*.

Mean Corpuscular Haemogloin Concentration (MCHC): The mean values of MCHC among the subjects were 33.34±0.25, 33±0.4, 34.3±0.3 and the final values obtained were 33±0.30, 33±0.47 and 33.2±0.33g/dl. However, the values so obtained were within the normal range of 33- 38g/dl.

Mean Corpuscular Haemogloin (MCH): The initial mean values of MCH were 29.8± 0.21, 29± 0.3, 30.2± 0.35 and final values were 30± 0.23, 29.9± 0.34 and 29.95± 0.35pg respectively in the three groups. There was a non significant increase in all the groups. The values so obtained fall with in normal range 28-32 pg. The increase in hemopoetic indices in the experimental groups could be due to beneficial effects of flaxseed supplementation.

Correlation Coefficient (r) Between Nutrient Intake and Hematological Profile: It was observed that energy intake was positively and significantly ($p<0.05$) correlated to Hb, PCV and RBC, the value of (r) being 0.33, 0.368 , 0.352;

0.338, 0.383, 0.417 and 0.318, 0.382 and 0.372 among the subjects of three groups. Protein and iron was positively and significantly ($p<0.05$) correlated with Hb, PCV and RBC, the value of (r) being 0.38,0.4, 0.4; 0.39, 0.4, 0.4 and 0.36, 0.4, 0.35 respectively in the three groups . Further it was seen that ascorbic acid was positively and significantly ($p<0.01$) correlated to Hb in E_2 and C group, the value of (r) being 0.41, 0.43 and 0.49 respectively.

CONCLUSION

The present study revealed that supplementation of 10g flaxseed powder will prove more beneficial to at risk CHD patients as compared to 5g in improving nutritional and hematological profile as flaxseed is a good source of vitamin B6, folic acid, minerals like magnesium, phosphorous and copper. It is also a good source of vitamin E which is a strong antioxidant thereby it maintains the integrity of cell membranes. So flaxseed as a food supplement should be encouraged in at risk CHD patients.

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