Impact of supplementation of broccoli powder (*Brassica oleracea* Lvar *italica* plenck) on blood glucose and lipid profile of non-insulin dependent diabetics

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ABSTRACT: Ninety non-insulin dependent diabetic male pateints in the age group of 40-60 years free from serious complications of diabetics were selected from the Ludhiana Mediways Hospital who were under the supervision of Diabetologist.Selection was based on their fasting and post prandial blood glucose level followed by blood pressure.The selected subjects were divided into three groups I, II and III, each group having thirty subjects each. The subjects of group I was given no treatment. While the subjects of group II and III were supplemented with 10 gm of Broccoli floret and leaf powder by incorporating it in *missi roti* respectively for a period of 3 months along with nutrition counselling. The nutrition education regarding the disease, its symptoms, causes, complications and dietary modifications using appropriate charts, health benefits of broccoli, physical exercise benefits was given for 3 months during supplementation after 15 days interval to the subjects of group II and III through individual and group contact using demonstration. Based on the blood glucose, lipid profile and blood pressure analysis of the subjects, supplementation of 10 g of Broccoli (*Brassica oleracea* L var *italica* plenck) floret, and leaf powder along with nutrition counseling significantly ($P \leq 0.01$) reduced the fasting blood glucose by 17.2 and 11.7 per cent, post prandial glucose level by 14.1 and 11.9 per cent in the subjects of group II, and III respectively. Significant ($p \leq 0.01$) reduction in total cholesterol 8.4 and 9.5 per cent, triglycerides 10.7 and 6.2 per cent, LDL-C 11.1 and 8.0 per cent, VLDL-C 10.5 and 9.4 per cent, and an increase in HDL-C 6.8 and 3.7 percent in the subjects of group II and III was observed after supplementation of broccoli floret and leaf powder along with nutrition counseling respectively. The ratio of total cholesterol to HDL-C reduced to 14.6 and 9.4 mg/dl and LDL- C to HDL-C reduced to 16.6 and 11.2 mg/dl in the subjects of group II, and III respectively. Supplementation of 10 g of Broccoli (*Brassica oleracea* L var *italica* plenck) floret, and leaf powder significantly reduced the systolic blood pressure by 4.9 and 3.8 per cent, and diastolic blood pressure by 7.4 and 5.7 per cent in the subjects of group II and III respectively. Non significant changes were observed in the subjects of group I.With the intervention of broccoli, significant improvement was observed in blood glucose, lipid profile and blood pressure of the selected diabetics.

Key words: Blood glucose, blood pressure, broocoli floret and leaf powder, nutrition counselling.

Diabetes represents a spectrum of metabolic disorders, which has become a major health challenge worldwide. The unprecedented economic development and rapid urbanization in Asian countries, particularly in India has led to a shift in health problems from communicable to non-communicable diseases. Of all the non-communicable diseases, diabetes and cardiovascular diseases lead the list.

India has been declared as the "Diabetic capital of the world". It has been estimated that the global burden of type 2 diabetes mellitus for 2010 was 285 million people which is projected to increase to 438 million in 2030 would be 65 per cent increase. Similarly, for India this increase is estimated to be 58 per cent, from 51 million people in 2010 to 87 million in 2030. India, the world's second most populous country, now has more people with type 2 diabetes (more than 50 million) than any other nation (IDF, 2010).

The burden of diabetes is to a large extent the consequence of macrovascular (coronary artery disease, peripheral vascular disease, and atherosclerosis) and microvascular (like retinopathy, neuropathy, and nephropathy) complications of the disease (Permutt *et al*., 2005). The prevalence of retinopathy is high among the Indian Type 2 diabetic subjects. Diabetic nephropathy develops in about one third of patients with diabetes and its incidence is sharply increasing in the developing world, with the Asia-Pacific region being the most severely affected. In 2003, diabetic nephropathy was the most common cause of end stage renal disease in 9 of 10 Asian countries (Lee, 2003).

The commercial success of functional foods has led to intense interest in the discovery and the characterization of plant based bioactive compounds. In the post-genomic era, it remains true that the goal of the pharmaceutical industry is not simply to find novel drug targets, but to find small molecule compounds that modulate their biological activity. Plants have always been an exemplary source of drugs and many of the currently available drugs have been derived directly or indirectly from them. The ethnobotanical information

reports about 800 plants that may possess anti-diabetic potential (Grover *et al*., 2002). Broccoli is known as the "Crown Jewel of Nutrition" since it posses all the nutrients namely vitamins, minerals, secondary metabolites and fiber proclaiming its exceptional health benefits. The breakdown products of the sulfur containing glucosinolates, isothiocyanates are the active principles in exhibiting the anticancer property at every stage (Vasanthi *et al*., 2009).

Broccoli has been reported as one of the main sources of natural antioxidants i.e., phenolic compounds and vitamins and chemopreventive compounds i.e., glucosinolates and their degradation products, isothiocyanates (Olga *et al*., 2009). The organosulfur chemicals namely glucosinolates and the S-methyl cysteine sulphoxide found in broccoli in concert with other constituents such as vitamins E, C, K and the minerals such as iron, zinc, selenium and the polyphenols namely kaempferol, quercetin glucosides and isorhamnetin are presumably responsible for various health benefits of broccoli (Vasanthi *et al*.,2009). A great deal of research on functional foods like anticarcinogens has focused on broccoli and on a single bioactive component within broccoli, sulphoraphane. Some researchers have concluded that the evidence for health benefits from sulpharaphane is strong enough to warrant product development and broccoli sprouts with a uniformly high concentration of sulphoraphane are patented, commercially available product (Moreno et al., 2006). Sulforaphane is the biologically active isothiocyanate produced when glucoraphanin is metabolized by the enzyme myrosinase (Mithen, 2001). Sulforaphane is found in highest concentrations in broccoli sprouts, but it is also found in mature broccoli and other cruciferous vegetables, such as cauliflower, cabbage, and kale. The studies suggest that Sulforaphane has the potential to reduce risk of various types of cancers, diabetes, atherosclerosis, respiratory diseases, neurodegenerative disorders, ocular disorders, and cardiovascular diseases. Traditionally, Nrf2-mediated induction of phase 2 detoxification enzymes has been recognized as the major mechanism by which Sulforaphane protects cells (Faway & Nehad, 2011).

Keeping in mind the beneficial effects of broccoli and its potentials in the management of diabetes, the present research study was undertaken to study effect of supplementation of broccoli floret and leaf powder along with nutrition counseling on blood profile of non insulin dependent diabetes.

MATERIALS AND METHODS

Procurement and Processing of the Material: The raw material broccoli floret and leaves were procured from the vegetable farm of PAU, Ludhiana. Fresh leaves & floret were thoroughly washed to remove unwanted material and dirt, cut in small sizes, blanched in boiling water for 10-15 sec and dried at room temperature for 1-2 h by spreading on filter paper followed by drying in hot air oven at 40-50˚C for 4-6 hours. Dried floret and leaves were powdered.

Product development: Five products namely, Missi roti, Dalia, Dhokla, chana dhal and barley snacks were prepared with incorporation of broccoli floret and leaves. But for convenience of the patient, 10 g of broccoli floret and leaves powder was given in the form of missi roti. *Missi roti* was prepared by using 65 g of wheat flour and 25 g of besan and 10 g of broccoli floret and leaves powder separately.

Selection of subjects: Ninety non-insulin dependent diabetic male patients in the age group of 40-60 years free from serious complications of diabetes were selected from the Ludhiana Mediways Hospital. Selection was based on their fasting and post prandial blood glucose level followed by blood pressure. The selected subjects were divided into three groups I, II and III, each group having thirty subjects each.

Feeding trials: The subjects of group I was given no treatment.The subjects of group II and III were given treatments. In the treatment, the subjects of group II and III were supplemented with 10 g of Broccoli floret and leaf powder separately in *missi roti* respectively for a period of 3 months. One serving of *missi roti* in breakfast and two servings of *missi roti* was provided during lunch and dinner to each patient under treatment. The feeding trials were conducted after receiving a consent letter from the subjects.

Nutrition intervention: Along with supplementation nutrition counseling was given. The nutrition education was given for 3 months during supplementation after 15 days interval to the subjects of group II and III through individual and group contact. Subjects were imparted nutrition education regarding the disease, its symptoms, causes, complications and dietary modifications using appropriate charts, health benefits of broccoli, physical exercise benefits and demonstration during the feeding trails.

Observation recorded: General and diabetic information pertaining to age, education, marital status, occupation, size and type of family, physical activities, food habits, causes and symptoms of the disease were recorded for all the subjects through questionnaire schedule. Blood pressure was recorded with sphygmomanometer (Maclead, 1984). Blood analysis was done for glucose (Trinder, 1969), serum total cholesterol (TC) (Richmond, 1973), triglycerides by DHBC Colorimetric method (Fossati and principle 1982), LDL-cholesterol (Friedwalds *et al*.,1972), HDL cholesterol (Lopes-virella et al.,1997) VLDL cholesterol (Triglycerides /5).Ratio of total cholesterol to HDL-C and LDL-C to HDL-C was also calculated. The blood analysis was conducted with the help of a laboratory technician.

Statistical analysis: The data on all the blood parameters was analysed statistically. The mean with standard error, percentages, paired t-test and their statistical significance was ascertained using Statistical Package for Social Sciences (SPSS) version 16.0.

RESULTS AND DISCUSSION

Initially, ninety non-insulin dependent diabetic male subjects were identified and divided into three groups. General information of the subjects showed that majority of the subjects belonged to the age group of 40-60 years and were educated only up to high school (Table. 1). Most of them had their own business. Majority of the subjects belonged to sikh religion and had joint family of size 5-6 members.The most common reason for diabetes among the selected subjects was obesity as depicted in Table.2. Obesity among the subjects was due to faulty eating habits, sedentary lifestyle and lack of physical exercise. Signs and symptoms of the disease showed that majority of the subjects in group I, II and III suffered from polydypsia along with other symptoms like polyurea, tiredness, loss of weight and nocturea (Table 3). The physical activity pattern of the subjects showed that majority of the subjects were not doing any kind of physical exercise.After nutrition intervention, 73.3 and 76.7 per cent of the subjects in group II and III started some kind of physical exercise while there was no change in group I (Table 4).Majority of the subjects in group I, II

Table 1: General information of the subjects

Characteristics	Group I	Group II	Group III
Age (years)			
40-50	14(46.7)	17(56.7)	15(50.0)
50-60	16(53.3)	13(43.3)	15(50.0)
56-65	5(16.7)	6(20.0)	4(13.3)
Religion			
Hindu	12(40.0)	16(53.3)	11(36.7)
Sikh	18(60.0)	14(46.7)	19(63.3)
Education			
Illiterate	1(3.3)	2(6.7)	2(6.7)
High School	22(73.3)	17(56.6)	21(70.0)
Higher Secondary	5(16.7)	3(10.0)	5(16.7)
Graduate	2(6.7)	8(26.7)	2(6.7)
Occupation			
Business	26(86.6)	20(66.7)	27(90.0)
Service	4(13.3)	10(33.3)	3(10.0)
Marital Status			
Married	30(100.0)	30(100.0)	30(100.0)
Type of family			
Nuclear	10(33.3)	12(40.0)	8(26.7)
Joint	20(66.7)	18(60.0)	22(73.3)
Family size			
2-4	7(23.4)	10(33.4)	8(26.7)
5-6	18(60.0)	12(40.0)	20(66.7)
7-8	5(16.7)	8(26.7)	2(6.7)

Figures in parenthesis are percentages

Table 2 :Etiology of disease of the subjects

S.No.	Factors	Group I	Group II	Group III
1.	Heredity	10(33.3)	12(40.0)	7(23.4)
2.	Obesity	18(60.0)	15(50.0)	21(70.0)
3	Others	2(6.7)	3(10.0)	2(6.7)

Figures in parenthesis are percentages

Table 3: Physical activity pattern of the subjects

	Group I		Group II		Group III	
	Before	After NI	Before	After	Before	After NI
Physical Exercise						
Yes	5(16.7)	6(20.0)	7(23.3)	22(73.3)	9(30.0)	23(76.7)
No	25(83.3)	24(80.0)	23(76.7)	8(26.7)	21(70.0)	7(23.3)
Type of Exercise						
Walking	4(13.3)	5(16.7)	5(16.7)	18(60.0)	7(16.7)	20(66.7)
Yoga	1(3.3)	1(3.3)	2(6.7)	2(6.7)	2(6.7)	3(10.0)
Sleeping Pattern						
Disturbed Sleep (5-6 hrs)	18(60.0)	18(60.0)	19(63.3)	21(70.0)	20(66.7)	22(73.3)
Sound Sleep (7-8 hrs)	12(40.0)	12(40.0)	11(36.7)	9(30.0)	10(33.3)	8(26.7)

Figures in parenthesis are percentages; BFP Broccoli floret powder ; BLP- Broccoli leaf powder
Nutrition intervention (NI)-Supplementation of BFP & BLP and counselling

Table 4: Signs and symptoms before and after nutrition intervention

S.No.	Signs and symptoms	Group I		Group II		Group III	
		Before	After	Before	After NI	Before	After NI
1.	Polydipsia	18(60.0)	18(60.0)	16(53.3)	14(46.7)	17(56.7)	12(40.0)
2.	Polyurea	16(53.4)	16(53.4)	14(46.7)	12(40.0)	15(50.0)	9(30.0)
3.	Tiredness	12(40.0)	12(40.0)	10(33.4)	9(30.0)	11(36.7)	7(23.3)
4.	Loss of weight	14(46.7)	7(23.3)	7(23.3)	4(13.4)	8(26.7)	5(16.7)
5.	Nocturea	10(33.4)	6(20.0)	6(20.0)	4(13.4)	7(23.3)	6(20.0)
6.	Polyphagia	15(50.0)	15(50.0)	12(40.0)	8(26.7)	10(33.4)	8(26.7)
7.	Hypertension	8(26.7)	8(26.7)	9(30.0)	7(23.3)	5(16.7)	3(10.0)
8.	Excessive sweating	4(13.4)	4(13.4)	5(16.7)	3(10.0)	6(20.0)	4(13.4)
9.	Itching	3(10.0)	3(10.0)	7(23.3)	4(13.4)	4(13.4)	2(6.7)
10.	Delayed healing	2(6.7)	2(6.7)	1(3.33)	0(0.0)	3(10.0)	1(3.33)

Figures in parenthesis are percentages; BFP Broccoli floret powder ; BLP- Broccoli leaf powder
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and III were vegetarians and had craving for sweet foods (Table 5).

At the end of 3 months of supplementation with broccoli floret and leaf powder in the rotis, the subjects of group II and III showed a significant($p<0.01$) reduction in fasting and postprandial blood glucose levels with an improvement in lipid profile. Similar findings with a significant reduction in blood glucose level was observed after 4-weeks supplementation with high sulforaphane-concentration broccoli sprouts powder (BSP) was found to reduce inflammatory markers in group A (dose 10 g/d) by Bahadoran *et al*. (2012a). Since the sub-clinical inflammation and increased inflammatory cytokines are centralmediators of inflammatory reactions and development of insulin resistance and diabetes complications, so observed effects of BSP as supplementary treatment in type 2 diabetic patients may be clinically valuable (Spranger *et al*., 2003). Significant reduction ($p<0.01$) was observed in blood pressure like

Table 5: Food habits of the selected diabetics

S.No.	Food habits	Group I	Group II	Group III
1.	**Vegetarian/ non vegetarian**			
	Vegetarian	22(73.3)	14(46.7)	10(33.3)
	Ova/Non -Vegetarian	8(26.6)	16(53.3)	20(66.7)
2.	**Food likes and dislikes**			
	Sweet food			
	Liked	16(53.3)	22(73.3)	23(76.6)
	Disliked	14(46.7)	8(26.6)	7(23.3)
	Salty food			
	Liked	25(83.4)	23(76.7)	20(66.7)
	Disliked	5(16.7)	7(23.4)	10(33.3)
	Fried food			
	Liked	18(60.0)	19(63.3)	17(56.7)
	Disliked	12(40.0)	11(36.7)	13(43.3)
	Fast food			
	Liked	25(83.4)	24(80.0)	21(70.0)
	Disliked	5(16.7)	6(20.0)	9(30.0)

Figures in parenthesis are percentages

systolic blood pressure (134.20 to 127.57mmHg and 140.67 to 135.20 mmHg) and diastolic blood pressure (89.60 to 82.93 mmHg 88.36 to 83.30 mmHg) in the subjects of group II and III (Table 6). Studies on male and female spontaneously hypertensive rats on a glucoraphanin-enriched diet (equivalent to 27.3 μmol sulforaphane per g dried sprouts) showed decreased oxidative stress, lower blood pressure, and less renal and central nervous system inflammation in kidney and spinal cord tissue when compared to animals on glucoraphanin-free diets(Noyan-Ashraf *et al*.,2006 and Wu *et al*.,2004).

Supplementation of 10 g of broccoli floret powder (BFP) and broccoli leaf powder (BLP) significantly ($p<0.01$) reduced the fasting blood glucose FBS (122.20 to 101.01 mg/dl and 123.63 to109.23 mg/dl) and post prandial blood glucose (181.07 to 155.57 mg/dl and 180.8 to 159.53 mg/dl) in the subjects of group II and III respectively as shown in Table 7. Other bioactive components such as phenolic compounds, carotenoids, antioxidant vitamins and selenium may contribute to these beneficial effects. Both TNF-a and IL-6, the Pro-inflammatory cytokines, increase in diabetic condition and have important role in development of diabetes and

Table 6: Mean fasting and post prandial blood glucose levels of the subjects before and after nutrition intervention

Blood glucose level (mg/dl)	Before 1	After 2	% Change	t - value	Normal range (mg/dl)
			Between 1 and 2	Between 1 and 2	
Group I Control					
Fasting	118.50±1.60	117.20±0.89	1.09	1.01 ^{NS}	70-110$^{\#}$
Post prandial	176.67±1.32	175.51±1.49	0.62	0.63 ^{NS}	120-140$^{\#}$
Experimental					
GroupII (BFP+NI)					
Fasting	122.20±0.76	101.01±3.47	17.20	5.92$^{\bullet}$	70-110$^{\#}$
Post prandial	181.07±1.02	155.57±1.26	14.13	18.58$^{\bullet}$	120-140$^{\#}$
Group III (BLP+NI)					
Fasting	123.63±1.05	109.20±4.50	11.74	3.04$^{\bullet}$	70-110$^{\#}$
Post prandial	180.80±0.98	159.23±0.96	11.94	13.73$^{\bullet}$	120-140$^{\#}$

Values represent Mean±SE ● Significant 1% NS Non significant
BFP Broccoli floret powder ; BLP- Broccoli leaf powder ; Nutrition intervention(NI)- Supplementation of BFP & BLP and counseling;#Raghuram *et al*.,(2012)

Table 7: Mean blood pressure of the subjects before and after nutrition intervention

Variables (mm Hg)	Before 1	After 2	% Change	t - value	Normal range (mm Hg)
			Between 1 and 2	Between 1 and 2	
Group I Control					
Systolic BP	139.33±0.55	138.23±0.54	0.7	0.12 ^{NS}	120$^{\#}$
Diastolic BP	87.60±0.28	86.50±0.27	1.2	1.08 ^{NS}	80$^{\#}$
Experimental		NI			
GroupII (BFP+NI)					
Systolic BP	134.20±0.66	127.57±0.97	4.94	6.05•	120$^{\#}$
Diastolic BP	89.60±1.26	82.93±0.32	7.44	9.50•	80$^{\#}$
GroupIII (BLP+NI)					
Systolic BP	140.67±0.53	135.20±1.19	3.88	7.41•	120$^{\#}$
Diastolic BP	88.36±0.34	83.30±0.69	5.72	6.90•	80$^{\#}$

Values represent Mean±SE ● Significant 1% NS Non significant
BFP Broccoli floret powder ; BLP- Broccoli leaf powder ;Nutrition intervention (NI)- Supplementation of BFP & BLP and counseling #Raghuram *et al*.,(2012)

cardiovascular complications (Herder *et al*.,2011). Effects of sulforaphane on inflammatory pathways were previously have been reported in in vitro models; sulforaphane inhibited cytokine production include interluekine-8, interluekin-1b, through the activation of nrf-2 pathway and consequently induction of NAD(P)H: quinone oxidoreductase 1 (NQO1), an antioxidant phase II protein (Ritz *et al*., 2007). Sulforaphane also inhibits production of inflammatory mediators and cytokines including TNF-a, IL-6, IL-1b, prostaglandins and nitric oxide through inhibition of NF-κB transcriptional activity, as a key modulator of pro-inflammatory processes (Cheung, Khor, & Kong, 2009 Heiss *et al*., 2001, Prawan *et al*., 2009). Sulforaphane is an activator of transcription factor NF-E2related factor-2 (nrf2) that regulates gene expression through the promoter antioxidant response element (ARE). Nrf2 regulates the transcription of a battery of protective and metabolic enzymes. Cruciferous vegetable consumption and synthetic activators of nrf2 are expected to decrease the risk of vascular disease in diabetes (Xue *et al*., 2008).

Farahmandi *et al*. (2013) observed that diabetic rats could be treated with broccoli leaves extract and showed a significant decrease in blood glucose level ($p<0.05$). Broccoli leaves extract was used to increase anti-oxidative defense and to control damages caused as a result of oxidative stresses and the presence of flavonoids as an essential factor in extract structure and the proanthocyanidin compounds existing in broccoli leaves extract are among effective factors in incidence of anti-oxidative properties. Broccoli is beneficial for diabetics by Bahadoran and Tohidi *et al*. (2012). Eun Young Ko *et al.* (2010) investigated hypoglycemic effects of Broccoli in hyperglycemic rats for prevention of type-2 diabetes. According to results from this research, consumption of antioxidants existing in broccoli leaves contributes to decrease damages to cells and accelerates restoration of pancreatic cells and subsequently increases insulin and decreases blood glucose.

Significant reduction in total cholesterol (TC) (206.5 to 189.0 mg/dl and 211.2 to 198.0 mg/dl), total triglycerides (TG) (173.5 to 154.8 mg/dl and 160.6 to 145.4 mg/dl), LDL (140.7 to125.04 mg/dl and 143.4 to 131.9 mg/dl), VLDL (34.6 to 30.9 mg/dl and 32.1 to 29.2 mg/dl) and increase in (HDL-C 31.2 to 33.5 mg/dl and 35.7 to 37.0 mg/dl) was observed. A significant reduction ($p<0.01$) in the ratio of total cholesterol to HDL-C(6.73 to 5.64 and 5.91 to 5.35), LDL-C to HDL-C (4.50 to 3.73 and 4.01 to 3.56) was also noticed in the subjects of group II and III (Table 8). Salem *et al*. (2013) revealed groups of rats fed on animal fat diet with cauliflower or broccoli at levels of intake (5%) had significant decrease in total cholesterol, triglycerides, HDL, LDL-C and VLDL-C as well as serum level of creatinine and uric acid. In addition, a significant increase in liver function (AST and ALT) and urea concentrations was also observed. These changes may be related to the phenolic compounds in cauliflower or broccoli and its properties as antioxidant activity. These results were clarified by Maria *et al*. (2011) who reported that phenolic compounds was

Table 8: Lipid profile of the subjects before and after Nutrition intervention

Variables	Before 1	After 2	% Change	t - value	Normal range (mg/dl)
			Between 1 and 2	Between 1 and 2	
Group I Control					
Total Cholesterol(mg/dl)	212.4±0.81	211.8±1.1	0.3	0.66 ^{NS}	<200*
Triglycerides(mg/dl)	166.6±1.20	166.0±0.55	0.2	0.03 ^{NS}	<150*
HDL-C(mg/dl)	32.0±0.36	32.50±0.39	1.5	0.85 ^{NS}	>50*
LDL-C(mg/dl)	146.8±0.21	146.2±0.13	0.4	0.69 ^{NS}	<130*
VLDL-C(mg/dl)	33.6±0.12	33.0±0.06	1.5	4.55	<30*
Total cholesterol/HDL-C	6.63±0.01	6.51±0.01	1.8	4.98	<4$^{\#}$
LDLC/HDL-C	4.55±0.02	4.04±0.02	2.8	3.50	<3$^{\#}$
Experimetal		NI			
Group II (BFP+NI)					
Total Cholesterol(mg/dl)	206.5±1.36	189.0± 1.10	8.4	16.73•	<200*
Triglycerides(mg/dl)	173.5±1.28	154.8±1.12	10.7	9.85•	<150*
HDL-C(mg/dl)	31.2±0.40	33.5±0.35	7.3	4.79•	>50*
LDL-C(mg/dl)	140.7±0.68	125.04±0.30	11.1	19.31•	<130*
VLDL-C(mg/dl)	34.6±0.25	30.9±0.38	10.5	12.02•	<30*
Total cholesterol/HDL-C	6.73±0.01	5.64±0.10	14.6	9.20•	<4$^{\#}$
LDLC/HDL-C	4.50±0.01	3.73±0.03	16.6	19.95•	<3$^{\#}$
Group III (BFP+NI)					
Total Cholesterol(mg/dl)	211.2±1.10	198.0±0.66	9.58	15.48•	<200*
Triglycerides(mg/dl)	160.6±0.95	145.4±1.13	6.25	10.28•	<150*
HDL-C(mg/dl)	35.7±0.60	37.0±0.79	3.64	1.46•	>50*
LDL-C(mg/dl)	143.4±0.48	131.9±0.46	8.00	18.48•	<130*
VLDL-C(mg/dl)	32.1±0.05	29.2±0.22	9.40	12.47•	<30*
Total cholesterol/HDL-C	5.91±0.07	5.35±0.01	9.47	6.42•	<4$^{\#}$
LDLC/HDL-C	4.01±0.02	3.56±0.01	11.25	16.30•	<3$^{\#}$

Values represent Mean±SE • Significant 1% NS Non significant NI- Supplementation of Broccoli floret and leaf Nutrition counselling HDL-C High density lipoprotein cholesterol, LDL_C Low density lipoprotein cholesterol, VLDL-C Very low density lipoprotein cholesterol
*Ghafoorunissa and Krishnamurthy (2007) # American Heart Association(2004)

higher in Brassica vegetables in which flavonols were always the major compounds. In addition consumption of Brassica vegetables has been related to human health due to their phytochemicals, such as glucosinolates and phenolic compounds that induce a variety of physiological functions including antioxidant activity, enzymes regulation and apoptosis control and the cell cycle. Bahadoran et al.(2012b) studied BSP in dose of 10 g/d, significantly decreased serum triglycerides, OX-LDL/LDL ratio and AIP $p < 0.05$ for treatment effect). HDL-C concentration was significantly higher ($p<0.01$) in group A. BSP as supplementary treatment in type 2 diabetes could have favorable effects on lipid profiles and OX-LDL/LDL ratio, as risk factors for cardiovascular disease. The mechanism effect of broccoli sprout on lipid metabolism is not exactly clear; but in vitro study showed that phytonutrient compounds in broccoli such as isothiocyanates, bind with bile acids and reduce fat absorption (Kahlon *et al*., 2007). Broccoli sprouts extract also inhibited lipoprotein lipase activity in adipose tissue (Lee *et al*., 2009). In vitro and animal studies demonstrated that indol-3-carbinol, which is produced by the breakdown of the glucosinolate glucobrassicin in broccoli, decreased gene expression and activity key lipogenic enzymes including diacylglycerol acyltransferases, fatty acid synthase, and acyl-CoA-cholesterol acyltransferase (Dunn and LeBlanc *et al*.,1994). In addition, indol glucosinolates reduced apolipoprotein B secretion as a primary apolipoprotein of low-density lipoproteins (Maiyoh *et al*., 2007).

The hypolipidemic activity of Brassica oleracea may be attributed due to the presence of flavonoids, ascorbic acid etc (Magdy et al.,2010). Flavonoids are known for their diverse biological activities including hypolipidemic activity resulting from their antioxidant

Table 9: Percent reduction in blood glucose, lipid profile and blood pressure of the subjects of group I, group II and III before and after Nutrition intervention

	Group I 3 months	Group II 3 months	Group III 3 months
Blood glucose level (mg/dl)			
Fasting	1.0	17.2	11.7
post prandial	0.6	14.1	11.9
Lipid Profile(mg/dl)			
Total Cholesterol	0.3	8.4	9.58
Triglycerides	0.9	10.7	6.25
HDL-Cholesterol	1.5	7.3	3.74
LDL- Cholesterol	0.6	11.1	8.00
VLDL- Cholesterol	2.0	10.5	9.40
Total cholesterol/HDL-C	1.8	14.6	9.47
LDLC/HDL-C	2.8	16.6	11.25
Blood pressure(mm Hg)			
Systolic BP	0.7	4.9	3.8
Diastolic BP	1.1	7.4	5.7

activity (Afanas'ev *et al*.,1995). Broccoli is rich in dietary fiber which can lower levels of LDL, cholesterol. Its effectiveness in lowering of cholesterol helps protect the arteries and prevents the onset of heart disease. High fibre foods such as broccoli also help with weight loss, an important factor in controlling diabetes as it decreases insulin resistance. The less resistant cells are to insulin, the more effective it is in keeping blood sugar levels under check by Bahadoran and Tohidi *et al*. (2012). Farahmandi *et al*. (2013) studied high level of anti-oxidative substances existing in extract of broccoli leaves, which can induce desirable metabolic changes associated to hepatic enzymes as to improve undesirable changes blood glucose and lipid levels.

CONCLUSION

Diabetes was more prevalent in the subjects of 40-60 years, more prosperous, economically sound literate Punjabi subjects. Family history of the disease was also observed in most of the subjects. Supplementation of 10 g of Broccoli (*Brassica oleracea l var italica plenca*) floret and leaf powder in *missi roti* along with nutrition counseling significantly ($P \leq 0.01$) reduced the fasting blood glucose by 17.2 and 11.7 per cent, post prandial glucose level by 14.1 and 11.9 per cent in the subjects of group II, and III respectively whereas non significant changes were observed in the subjects of group I .

Significant ($p \leq 0.01$) reduction in total cholesterol 8.4 and 9.5 per cent, triglycerides 10.7 and 6.2 per cent, LDL-C 11.1 and 8.0 per cent, VLDL-C 10.5 and 9.4 per cent, and an increase in HDL-C 6.8 and 3.7 percent along with a reduction in the ratio of total cholesterol to HDL-C and LDL- C to HDL-C in the subjects of group II, and III was observed after supplementation of broccoli floret and leaf powder along with nutrition counseling respectively. Supplementation of 10 g of Broccoli (Brassica oleracea l var italica plenca) floret and leaf powder significantly reduced the systolic as well as diastolic blood pressure in the subjects of group II and III respectively. No significant changes were observed in the subjects of group I. Hence it can be inferred from the results that supplementation of Broccoli floret and leaf powder along with nutrition counseling significantly improved the nutritional status of the diabetic patients with no side effects.

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