JPR INFO.com
Journal of Pharma Research

Journal of Pharma Research
Available online through
www.jprinfo.com

Research Article
ISSN: 2319-5622

Effect of supplementation of bael (*Aegle marmelos* L.) and nutrition counseling on blood glucose, lipid profile and blood pressure of non-insulin dependent diabetics

Uttara Singh[1*] and Anita Kochhar[2]
[1]*B.D College, Dr. Ram Manohar Lohia Avadh University, Faizabad, Uttar Pradesh,* India.
[2]*Department of Food and Nutrition, Punjab Agricultural University, Ludhiana, Punjab,* India.

Received on: 02-09-2012; Revised on: 02-09-2012; Accepted on: 06-09-2012

ABSTRACT

One hundred twenty non-insulin dependent diabetic subjects were selected from Punjab Agricultural University and Civil Hospital of Ludhiana. The selected subjects were divided into four groups viz. group I, II, III and IV having thirty subjects each. The subjects of group I was not given any treatment. The subjects of group II, III and IV were supplemented with 2 gm of bael (Aegle marmelos L.) leaf, pulp and seed powder respectively for a period of three month and supplementation was continued along with nutrition counseling for the next three months. The nutrition education was given for three months after fifteen days interval to the subjects of group II, III and IV through individual and group contact and gain in nutrition knowledge was assessed after the study. General information, diabetic information and dietary pattern of the subjects were recorded. The blood glucose and lipid profile were analyzed. It was found that there was significant reduction (P≤0.01) in fasting blood glucose level by 16.1, 10.8 and 11.4% and post prandial blood glucose level 11.5, 27.3 and 13.0% in the subjects of group II, III and IV respectively after the study and a non-significant reduction (P≤0.01) was seen in the subjects of group I. It was observed that significant reduction (P≤0.01) in total cholesterol 7.8, 9.3 and 5.0%, triglycerides 10.9, 8.5 and 6.6%, LDL-C 14.4, 17.0 and 8.0%, VLDL-C 11.0, 8.6 and 6.7% and an increase in HDL-C 17.0, 19.4 and 4.8% in the subjects of group II, III and IV respectively. The ratio of total cholesterol to HDL-C reduced from 5.3 to 4.2, 5.8 to 4.4 and 5.5 to 4.9 mg/dl and LDL-C to HDL-C were reduced from 3.6 to 2.7, 3.8 to 2.9 and 3.6 to 3.1 mg/dl in the subjects of group II, III and IV respectively after the study. There were also a significant decrease (P≤0.01) in the blood pressure of the subjects in group II, III and IV and a non-significant decrease (P≤0.01) were seen in the subjects of group I.

Keywords: *Bael (Aegle marmelos L.) leaf, pulp and seed powder, blood glucose, lipid profile, anthropometric measurements, nutrition counseling.*

INTRODUCTION

Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces [40]. Diabetes is fast becoming a leading cause of morbidity, mortality and disability across the world. Diabetes mellitus is a global metabolic epidemic affecting essential biochemical activities in almost every age group [8].

According to International Diabetic Federation the estimated diabetes prevalence for 2010 has risen to 285 million, representing 6.4% of the world's adult population, with a prediction that by 2030 the number of people with diabetes will have risen to 438 million corresponding to 7.8% of the adult population [10].

India has been declared as the "Diabetic capital of world". By 2030 there would be 366 million diabetics throughout the world and 79.44 million diabetics in India alone [38]. It is estimated that by the year 2030, diabetes is likely to be the seventh leading cause of death accounting 3.3 per cent of total deaths in the world [39].

According to International Diabetic Federation 70% of the current cases of diabetes occur in low and middle income countries. With an estimated 50.8 million people living with diabetes, India has the world's largest diabetes population, followed by China with 43.2 million. The largest age group currently affected by diabetes is between 40-59 years. By 2030 this "record" is expected to move to the 60-79 age groups with 196 million cases. Diabetes is one of the major causes of premature illness and death worldwide. Non-communicable diseases including diabetes account for 60% of all deaths worldwide. Type 2diabetes is responsible for 85-95% of all diabetes in high income countries and may account for an even higher percentage in low and middle income countries. Eighty per cent of type 2 diabetes is preventable by changing diet, increasing physical activity and improving the living environment. Yet, without effective prevention and control programmes, the incidence of diabetes is likely to continue rising globally [8].

Aegle marmelos family rutaceae is highly reputed medicinal tree commonly known as the bael. It is medium sized tree growing throughout the forest of India of altitude 1200 meter. It is found all over India, from sub-Himalayan forest, Bengal, central and south India. The different parts of this plant contain number of coumarins, alkaloids, sterols and essential oils. Various parts of this plant such as leaves, fruit and seed possess hypoglycaemic, hypolipidemic and blood pressure lowering property [16]. The peel of the fruit which is a very hard shell and green to brown in color depends on ripening stage. The appearance of yellow or orange edible pulp is like a boiled pumpkin, possesses a slightly sweet taste and a characteristic floral, terpene-like aroma, very fragrant and pleasantly flavored. Seeds are surrounded by slimy transparent mucilage [33].

Bael (*Aegle marmelos*) is an important medicinal plant of India. Biochemical compounds of bael leaves, fruits and seeds have been used in several diseases like diabetes, cardiovascular and anti-inflammatory [20]. The most important ingredients present in plants are alkaloids, terpenoids, steriods, phenols glycosides and tannins. The bael leaf contain seven monotorpene hydrocarbons (90.7%), three oxygenated monoterpenes (2.9%), four sesquiterpene hydrocarbons (3.1%) and one phenolic compound (0.2%). Limonene (82.4%) was the main constituent of bael (Kaur et al 2006). *Aegle marmelos* leaf extract (200 mg/dl for 35 days) significantly affect the activity of lipid peroxidase, lipoprotein and antioxidant enzymes in isoproterenol treated rats [25].

Leaf extract of *Aegle marmelos* (Bilva) was effective in restoring blood glucose, body weight to normal values and significantly reversed the altered (histological and ultra structural) parameters in tissues of streptozotocin induced diabetic rats seen by light and electron microscopy to near normal and improved the functional state of pancreatic beta cells. The hypoglycemic effects of this plant drug appear to be mediated through regeneration of damaged pancreas [3]. Bael leaf enhances ability to utilize the external glucose load in the body by stimulation of glucose uptake similar to insulin. Bael extract significantly lowers blood urea, reduction in lipid peroxidation and cholesterol and increased levels of super dioxide dismutase, catalase, glutathione peroxidase and glutathione level in serum as well as in liver in experimental diabetic animals [31].

***Corresponding author:**
Uttara Singh
B.D College, Dr. Ram Manohar Lohia Avadh University,
Faizabad, Uttar Pradesh, India.
**E-Mail: usuttarasingh@gmail.com*

DOI: https://doi.org/10.5281/zenodo.1098649

MATERIALS AND METHODS

One hundred twenty non-insulin dependent diabetic subjects were selected from Punjab Agricultural University and Civil Hospital of Ludhiana. The selected subjects were divided into four groups viz. Group I, II, III and IV having thirty subjects each. The subjects of Group I was not given any treatment. The subjects of Group II, III and IV were supplemented with 2 gm of bael (*Aegle marmelos* L.) leaf, pulp and seed powder respectively for a period of three month and supplementation was continued along with nutrition counseling for the next three months.

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 was recorded for all the subjects through questionnaire schedule. Blood pressure was recorded with sphygmomanometer [19]. Blood analysis was done for glucose [34], serum total cholesterol (TC) [26], triglycerides (TG) [5], high density lipoprotein cholesterol (HDL-C) [18], low density lipoprotein cholesterol (LDL-C) [6] and very low density lipoprotein cholesterol (VLDL-C) (Triglycerides/5). Ratio of total cholesterol to HDL-C and LDL-C to HDL-C was also calculated.

Statistical analysis: The data on all the blood parameters was analyzed statistically. The mean standard error, percentages, paired t- test and their statistical significance was ascertained using a computer programme package.

RESULTS AND DISCUSSIONS

The selected 120 male patients suffering from non insulin dependent diabetes mellitus (NIDDM) were in the age group of 35-65 years. Majority of the subjects were Sikhs and rest were Hindu in group I, II, III and IV respectively with maximum numbers of the subjects were studied up to high school. Majority of the subjects had their own business and maximum of them belong to joint family with family size of 5-6 members.

At the end of three months with supplementation of bael (*Aegle marmelos* L.) leaf, pulp and seed powder, the subjects of group II, III and IV showed a significant ($p \leq 0.01$) reduction in fasting and post prandial blood glucose levels with an improvement in lipid profile.

After three months of bael (*Aegle marmelos* L.) leaf powder supplementation the values of fasting and post prandial glucose levels of the subjects in group II was 120.6±0.86 mg/dl and 179.3±1.70 mg/dl and after nutrition intervention the glucose level further reduced to 112.3±0.64 mg/dl and 168.1±1.83 mg/dl. Reduction in blood glucose level is may be due to presence of active component, aegelin 2 and scopoletin in leaf [20-22]. Similarily, supplementation of 2 g *Aegle marmelos* leaf powder for 2 months reduced fasting (135-105 mg/dl), post prandial (195 mg/dl) blood glucose levels and urine sugar level in NIDDM patients [12, 29]. It was observed that methanolic leaf extract of *Aegle marmelos* reduced blood sugar level by 54 per cent on 12th day after continuous administration and aqueous leaf extract (100 mg/kg) of *Aegle marmelos* significantly reduced plasma glucose level (156.87 to 96.11 mg/dl) and plasma urea (26.37 to 17.11 mg/dl) in diabetic rats after 4 weeks of administration [27, 35]. After three months of bael (*Aegle marmelos* L.) pulp powder supplementation the values of fasting and post prandial glucose levels of the subjects in group III was 121.2±0.56 mg/dl and 157.7±1.86 mg/dl and after nutrition intervention the glucose level further reduced to 116.6±0.46 mg/dl and 143.2±1.67 mg/dl. Blood glucose reduction possibly due to presence of active component, coumarin in fruit extract which potentiate insulin secretion from β-cells of the Islets of Langerhans and umbelliferone in fruit pulp [11]. Similarly, *Aegle marmelos* fruit extract (250 mg/kg) when given twice daily for a period of 30 days significantly decreased blood glucose level in STZ induced diabetic rats [11, 25] and the values of fasting and post prandial glucose levels of the subjects in group IV was 123.9±0.84 mg/dl and 172.4±1.62 mg/dl after three months of bael (*Aegle marmelos* L.) seed powder supplementation. After nutrition intervention the values of fasting and post prandial glucose levels of the subjects in group IV further reduced to 120.2±0.87 mg/dl and 162.2±1.62 mg/dl. Blood glucose reduction in the subjects of group IV possibly due to presence of active component, luvangetin and β-sitosterol present in bael seed [20]. Similarly [14], observed that treatment of severely diabetic rats for 14 days with aqueous extract (250 mg/kg, orally) of *Aegle marmelos* seeds reduced the fasting blood glucose by 60.84 per cent and urine sugar by 75 per cent (**Table 1**).

Even trace elements play an important role in the formation of active constituents in bael (*Aegle marmelos* L) leaf, pulp and seed. Diabetes mellitus has been shown to be associated with abnormalities in the metabolism of zinc, chromium. It may play a role in the release of insulin. Hyun-Mee Oh and Jin-Sook Yoon (2008) reported that Zn supplementation for a short-term period (4 week) may improve glycemic control in diabetic patients with higher HbA1c levels and marginal zinc status [9]. Guerrero-Romero and Rodrı´guez-Mora´n (2005) studied that chromium exert a positive effect on glucose and insulin levels of type 2 diabetic subjects [7]. After nutrition intervention, there was further decrease in blood glucose levels. This reduction could be due to the nutrition counseling imparted to the subjects in group II, III and IV [32].

Table No. 1: Mean fasting and post prandial blood glucose levels of the subjects before and after bael (*Aegle marmelos* L.) leaf, pulp and seed powder supplementation and Nutrition intervention

Blood glucose level (mg/dl)	Before	After		% Change		Paired t – value		Normal range (mg/dl)
	1	2	3	Between 1 and 2	Between 1 and 3	Between 1 and 2	Between 1 and 3	
Control		**3 months**	**6 months**					
			Group I					
Fasting	123.9±0.19	123.7±0.23	123.6±0.23	0.1	0.3	2.06^{NS}	1.20^{NS}	70-110#
Post prandial	186.6±1.28	186.2±1.49	185.8±1.28	0.2	0.4	0.93^{NS}	1.40^{NS}	120-140#
Experimental		**SB**	**NI**					
			Group II					
Fasting	133.8±0.59	120.6±0.86	112.3±0.64	9.8	16.1	12.56**	24.15**	70-110#
Post prandial	189.9±1.25	179.3±1.70	168.1±1.83	5.6	11.5	10.17**	26.89**	120-140#
			Group III					
Fasting	130.8±0.63	121.2±0.56	116.6±0.46	7.3	10.8	13.50**	19.08**	70-110#
Post prandial	196.9±3.04	157.7±1.86	143.2±1.67	20.0	27.3	12.16**	13.69**	120-140#
			Group IV					
Fasting	135.6±0.84	123.9±0.84	120.2±0.87	8.6	11.4	10.44**	13.39**	70-110#
Post prandial	186.4±0.80	172.4±1.62	162.2±1.62	7.5	12.9	8.56**	13.54**	120-140#

Values represent Mean±SE, ** Significant 1%, *Significant 5%, NS – Non significant, #Raghuram *et al* (2007), SB-Supplementation of Bael (*Aegle marmelos* L.) leaf, pulp and seed powder, NI- Supplementation of Bael (*Aegle marmelos* L.) leaf. Pulp and seed powder + Nutrition counseling.

After three months of bael (*Aegle marmelos* L.) leaf powder supplementation reported that the nutrition education was an effective tool in the management of diabetes with the development of a trusting relationship. Lim et al (2009) showed that individualized nutrition education was effective in adherence to diet recommendation and in improving glycemic control and lipid concentrations [17]. Reduction in blood glucose levels after nutrition counseling was also reported [2, 28]. Aggarwal et al (2007) reported 13.68 per cent reduction in fasting and 9.85 reduction in post prandial blood glucose level was observed which can be attributed to nutrition education [1]. Pimentela et al (2010) showed a significant reduction in fasting and post prandial blood glucose level by 14.0 and 21.0 per cent respectively after nutrition education [23].

Significant reduction in total cholesterol after three months of bael (*Aegle marmelos* L.) leaf powder supplementation the corresponding figure was 192.3±0.74 mg/dl and after nutrition intervention the value of serum total cholesterol decreased to 185.7±0.45 mg/dl in the subjects of group II respectively. Aegline 2, active component present in bael leaf was found to regulate lipid level [21]. A decrease in total cholesterol levels from 260.20 to 251.47 mg/dl after *vilvai* (*Aegle marmelos* L.) leaf supplementation on NIDDM patients

for 90 days was also reported [24]. After three months of bael (*Aegle marmelos* L.) pulp powder supplementation the corresponding figure of serum total cholesterol was 196.1±0.42 mg/dl and after nutrition intervention the corresponding value decreased to 189.1±0.87 mg/dl in the subjects of group III respectively. The reduction in total cholesterol may be due to presence of marmelosin and umbelliferon, active component in bael pulp. Similarly, oral administration of aqueous fruit extract at dose of 250 mg/kg to diabetic rats significantly lowered serum and tissue lipid profile [11] and after three months of bael (*Aegle marmelos* L.) seed powder supplementation the corresponding figure of serum total cholesterol was 204.8±0.31 mg/dl and after nutrition intervention the corresponding value decreased to 199.4±0.25 mg/dl in the subjects of group IV respectively. The percent reduction in total cholesterol could be due to beta-sitosterol present in bael (*Aegle marmelos* L.) which is structurally similar to cholesterol helps in reducing serum concentration of cholesterol by reducing the absorption of cholesterol from the gut by competing for the limited space for cholesterol in mixed micelles. Similarly, Kesari et al (2006) reported that bael seed aqueous extract at dose of 250 mg/kg to diabetic rats significantly reduced serum total cholesterol by 25.49 percent [14]. Farshchi et al (2010) reported that *Aegle marmelos* seed have hypolipidemic effect [4].

Significant reduction triglycerides after three months of bael (*Aegle marmelos* L.) leaf supplementation the corresponding figure was found to be 163.2±0.38 mg/dl and after nutrition intervention the values further decreased to 154.9±1.33 mg/dl in the subjects of group II. Similarily, Narender et al (2007) reported at dose of 50 mg/kg of bael leaf extract reduced triglycerides by 55 percent [21]. Vijaya et al (2009) reported that bael leaf extract at dose of 125 and 250 mg/kg reduced triglycerides in diabetic rats by 17.7 and 39.01 per cent respectively [37]. After three month of bael (*Aegle marmelos* L.) pulp supplementation the corresponding figure was found to be 160.4±0.43 mg/dl and after nutrition intervention values of triglycerides further decreased to 155.1±0.22 mg/dl in the subjects of group III. Krushna et al (2009) reported diabetic rats treated with *Aegle marmelos* fruit extract (150 mg/kg, for 45 days) showed significant ($p < 0.05$) decrease in triglycerides by 37.55 per cent and after bael (*Aegle marmelos* L.) seed supplementation the corresponding figure was found to be 164.9±0.26 mg/dl and after nutrition intervention values of triglycerides further decreased to 159.2±0.42 mg/dl in the subjects of group IV [15]. Kesari et al (2006) reported that bael seed aqueous extract at dose of 250 mg/kg to diabetic rats significantly reduced triglycerides by 45.77 percent [14].

After three months of bael (*Aegle marmelos* L.) leaf supplementation the corresponding figure was observed 118.2±0.99 mg/dl and after nutrition intervention values of LDL-C further decreased to 110.1±1.88 mg/dl in the subjects of group II. Vijaya et al (2009) reported that bael leaf extract at dose of 125 and 250 mg/kg showed significant reduction in LDL-C due to intensive conversion of LDL-C to HDL-C and clearance of circulatory lipids in diabetic rats [37].

Significant reduction in VLDL-C after three months of bael (*Aegle marmelos* L.) leaf supplementation the corresponding figure was found 32.6±0.32 mg/dl and after nutrition intervention values of VLDL-C further decreased to 30.9±0.14 mg/dl in the subjects of group II. Devi et al (2010) reported that bael leaf extract at dose of 450 mg/kg showed significant reduction in VLDL-C by 37.93 per cent in diabetic albino rats. After three months of bael (*Aegle marmelos* L.) pulp supplementation to the subjects, the corresponding figure was found 32.1±0.22 mg/dl and after nutrition intervention values of VLDL-C further decreased to 31.0±0.36 mg/dl in the subjects of group III. Krushna et al (2009) reported diabetic rats treated with *Aegle marmelos* fruit extract (150 mg/kg, for 45 days) showed significant ($p<0.05$) reduction in VLDL-C by 37.67 per cent and after three months of bael (*Aegle marmelos* L.) seed supplementation to the subjects, the corresponding figure was found 32.9±0.38 mg/dl and after nutrition intervention values of VLDL-C further decreased to 31.8±0.66 in the subjects of group IV [15]. Maity et al (2009) showed aqueous extract of bael seed at dose of 250 mg/kg to diabetic rats significantly lowered serum lipid level [20].

Reduction in value of total cholesterol/HDL-C after three months of bael (*Aegle marmelos* L.) leaf supplementation the corresponding figure reduced to be 4.6±0.12 mg/dl and after nutrition intervention values further decreased to 4.2±0.12 mg/dl in the subjects of group II. Similarly, Narender et al (2007) reported at dose of 50 mg/kg of bael leaf extract increased total cholesterol/HDL-C ratio by 66 per cent in diabetic rats. After three months of bael (*Aegle marmelos* L.) pulp supplementation the corresponding figures reduced to be 5.2±0.15 mg/dl and after nutrition intervention values of total cholesterol/HDL-C further decreased to 4.4±0.18 mg/dl in the subjects of group III and bael (*Aegle marmelos* L.) seed supplementation to the subjects, the corresponding figures reduced to be 5.2±0.19 mg/dl and after nutrition intervention values of total cholesterol/HDL-C further decreased to 4.9±0.27 mg/dl in the subjects of group IV [21].

After three months of bael (*Aegle marmelos* L.) leaf supplementation the corresponding figure reduced to be 3.1±0.11 mg/dl and after nutrition intervention value of ratio of LDL-C to HDL-C further decreased to 2.7±0.12 mg/dl in the subjects of group II. After three months of bael (*Aegle marmelos* L.) pulp supplementation the corresponding figures reduced to be 3.4±0.19 mg/dl and after nutrition intervention values of ratio of LDL-C to HDL-C further decreased to 2.9±0.21 mg/dl in the subjects of group III and after bael (*Aegle marmelos* L.) seed supplementation the corresponding figures reduced to be 3.4±0.14 mg/dl and after nutrition intervention values of ratio of LDL-C to HDL-C further decreased to 3.1±0.18 mg/dl in the subjects of group IV.

Significant increase in HDL-C after three months of bael (*Aegle marmelos* L.) leaf supplementation the corresponding figure was found to be 41.5±1.20 mg/dl and after nutrition intervention the values further increased to 44.6±1.48 mg/dl in the subjects of group II. Similarly, Narender et al (2007) reported at dose of 50 mg/kg of bael leaf extract increased HDL-C by 28 per cent. After three months of bael (*Aegle marmelos* L.) pulp supplementation to the subjects, the corresponding figure was found to be 37.5±0.38 mg/dl and after nutrition intervention the values of HDL-C further increased to 42.8±1.61 mg/dl in the subjects of group III [21]. The increase in HDL-C may be due to marmelosin and umbelliferon, active component present in bael pulp. Krushna et al (2009) reported diabetic rats treated with *Aegle marmelos* fruit extract (150 mg/kg, for 45 days) showed significant ($p<0.05$) increase in HDL-C by 64.32 per cent and after three months of bael (*Aegle marmelos* L.) seed supplementation to the subjects, the corresponding figure was found to be 39.1±0.09 mg/dl and after nutrition intervention the values of HDL-C further increased to 41.0±1.00 mg/dl in the subjects of group IV [15]. Kesari et al (2006) reported that bael seed aqueous extract at dose of 250 mg/kg to diabetic rats significantly ($p<0.05$) increased HDL-C by 33.43 percent (**Table 2**) [14].

Table No. 2: Lipid profile of the subjects before and after bael (*Aegle marmelos* L.) leaf, pulp and seed powder supplementation and nutrition intervention

Variables	Before	After		% Change		Paired t - value		Normal range (mg/dl)
	1	2	3	Between 1 and 2	Between 1 and 3	Between 1 and 2	Between 1 and 3	
Control		**3 months**	**6 months**					
			Group I					
Total Cholesterol	215.3±0.46	214.3±0.71	214.1±0.91	0.5	0.6	1.95^{NS}	1.69^{NS}	<200$^{\bullet}$
Triglycerides	167.9±0.48	167.6±0.61	166.5±0.93	0.2	0.8	1.37^{NS}	1.86^{NS}	<150$^{\bullet}$
HDL-C	30.2±0.86	31.9±0.45	32.2±0.67	5.5	6.3	2.17*	2.20*	>50$^{\bullet}$
LDL-C	151.5±3.59	48.9±3.51	148.6±3.59	1.7	1.8	1.17^{NS}	1.04^{NS}	<130$^{\bullet}$
VLDL-C	33.6±0.57	33.5±0.77	33.3±0.74	0.3	0.8	0.74^{NS}	0.85^{NS}	<30$^{\bullet}$
Total cholesterol/HDL-C	7.1±0.20	6.7±0.28	6.7±0.34	5.8	6.5	1.65^{NS}	1.48^{NS}	<4$^{\#}$
LDLC/HDL-C	4.6±0.26	4.4±0.45	4.3±0.28	5.8	6.9	1.20^{NS}	1.37^{NS}	<3$^{\#}$
Experimental		**SB**	**NI**					

Group II								
Total Cholesterol	201.5±0.99	192.3±0.74	185.7±0.45	4.5	7.8	7.73**	14.60**	<200•
Triglycerides	174.1±0.48	163.2±0.38	154.9±1.33	6.2	10.9	17.51**	12.79**	<150•
HDL-C	38.1±0.96	41.5±1.20	44.6±1.48	8.9	16.9	2.91**	3.92**	>50•
LDL-C	128.6±1.49	118.2±0.99	110.1±1.88	8.1	14.4	9.11**	12.63**	<130•
VLDL-C	34.8±0.17	32.6±0.32	30.9±0.14	6.2	10.9	2.28*	4.17**	<30•
Total cholesterol/HDL-C	5.3±0.17	4.6±0.12	4.2±0.12	12.5	21.5	2.37*	3.25**	<4#
LDLC/HDL-C	3.6±0.08	3.1±0.11	2.7±0.12	15.0	23.7	2.27*	3.00*	<3#
Group III								
Total Cholesterol	208.7±0.20	196.1±0.42	189.1±0.87	6.0	9.3	31.61**	21.13**	<200•
Triglycerides	169.6±0.21	160.4±0.43	155.1±0.22	5.4	8.5	21.72**	42.36**	<150•
HDL-C	35.9±0.17	37.5±0.38	42.8±1.61	4.4	19.4	4.98**	4.42**	>50•
LDL-C	138.9±1.00	126.6±0.44	115.3±1.93	8.9	16.9	12.33**	9.12**	<130•
VLDL-C	33.9±0.13	32.1±0.22	31.0±0.36	5.5	8.6	2.29*	3.11*	<30•
Total cholesterol/HDL-C	5.8±0.13	5.2±0.15	4.4±0.18	10.1	24.1	2.74*	3.32**	<4#
LDLC/HDL-C	3.8±0.13	3.4±0.19	2.9±0.21	29.5	24.6	2.91*	2.36*	<3#
Group IV								
Total Cholesterol	209.9±0.26	204.8±0.31	199.4±0.25	2.4	5.0	26.96**	21.53**	<200•
Triglycerides	170.6±0.28	164.9±0.26	159.2±0.42	3.3	6.6	14.83**	40.42**	<150•
HDL-C	38.2±0.29	39.1±0.09	41.0±1.00	0.8	4.8	2.99*	3.45**	>50•
LDL-C	137.6±0.51	132.7±0.60	126.5±0.96	3.6	8.0	5.14**	8.41**	<130•
VLDL-C	34.1±0.48	32.9±0.38	31.8±0.66	3.3	6.7	2.77*	3.46**	<30•
Total Cholesterol/HDLC	5.5±0.17	5.2±0.19	4.9±0.27	4.7	11.5	2.15*	3.27**	<4#
LDL-C/HDL-C	3.6±0.11	3.4±0.14	3.1±0.18	4.8	12.9	4.32**	2.62**	<3#

Values represent Mean±SE, ** Significant 1% ,*Significant 5%, •Ghafoorunissa and Krishnamurthy (2007) , # American Heart Association (2004), NS – Non significant, SB-Supplementation of bael (*Aegle marmelos* L.) leaf, pulp and seed powder, NI- Supplementation of bael (*Aegle marmelos* L.) leaf, pulp and seed powder + Nutrition counseling

After three months of bael (*Aegle marmelos* L.) leaf powder supplementation to the subjects, the value of systolic and diastolic blood pressure were reduced to 125.3±0.44 and 83.3±0.20 mm Hg and after the nutrition intervention the value of systolic and diastolic blood pressure further reduced to 122.3±0.37 and 80.7±0.25 mm Hg in the subjects of group II. Rajadurai and Prince (2005) showed that the leaves of *Aegle marmelos* possess a "cardiotonic" effect and maintain blood pressure due to presence of phytochemicals such as flavonoid, maemesinin, lupeol and eugenol in leaves [20, 25]. Sharma and Asrani (2003) showed significant reduction in systolic and diastolic blood pressure from 162±5.5 to 138 ± 4.1 and 108±3.5 to 88.6±2.7 respectively at a dose of 1 gm of leaf extract for 4 weeks to mild to moderate hypertensive patients [30]. After three months of bael (*Aegle marmelos* L.) pulp powder supplementation to the subjects, the values of systolic and diastolic blood pressure were reduced to 131.4±0.44 and 85.8±0.43 mm Hg and after the nutrition intervention the values of systolic and diastolic blood pressure further reduced to 127.5±0.41 mm Hg and 82.9±0.21 mm Hg in the subjects of group III. Maity et al (2009) studied that aurapten, active component present in pulp inhibit the chronotrophic effects on cardiac tissue so it is useful in treatment of hypertension and after three months of bael (*Aegle marmelos* L.) seed powder supplementation to the subjects, the values of systolic and diastolic blood pressure were 136.1±0.38 and 85.2±0.66 mm Hg and after the nutrition intervention the values of systolic and diastolic blood pressure further reduced to 133.4±0.47 and 83.8±0.45 mm Hg in the subjects of group IV (**Table 3**) [20].

Table No. 3: Mean blood pressure of the subjects before and after bael (*Aegle marmelos* L.) leaf, pulp and seed powder supplementation and nutrition intervention

Variables	Before	After		% Change		Paired t - value		Normal range (mm Hg)
	1	2	3	Between 1 and 2	Between 1 and 3	Between 1 and 2	Between 1 and 3	
Control		3 months	6 months					
Group I								
Systolic BP	141.6±0.50	141.1±0.56	140.9±0.79	0.4	0.5	1.30^{NS}	1.36^{NS}	120#
Diastolic BP	90.2±0.59	90.1±0.64	89.5±0.67	0.1	0.7	0.82^{NS}	1.47^{NS}	80#
Experimental		SB	NI					
Group II								
Systolic BP	139.3±0.24	125.3±0.44	122.3±0.37	10.0	12.2	26.68**	43.59**	120#
Diastolic BP	86.6±0.38	83.3±0.20	80.7±0.25	3.8	6.8	9.01**	16.67**	80#
Group III								
Systolic BP	137.3±0.37	131.4±0.44	127.5±0.41	4.3	7.1	8.51**	17.97**	120#
Diastolic BP	88.1±0.66	85.8±0.43	82.9±0.21	2.6	5.9	3.79**	8.08**	80#
Group IV								
Systolic BP	138.1±0.31	136.1±0.38	133.4±0.47	1.4	3.4	4.62**	8.43**	120#
Diastolic BP	87.5±0.67	85.2±0.66	83.8±0.45	2.6	4.2	2.76**	4.05**	80#

Values represent Mean±SE, ** Significant 1%, *Significant 5%, # Raghuram *et al* (2007), NS – Non significant, SB-Supplementation of bael (*Aegle marmelos* L.) leaf, pulp and seed powder, NI- Supplementation of bael (*Aegle marmelos* L.) leaf, pulp and seed powder + Nutrition counseling

CONCLUSION

Supplementation of 2 g of bael *(Aegle marmelos* L.*)* leaf, pulp and seed powder significantly (P≤0.01) reduced the fasting blood glucose by 9.8, 7.3 and 8.5 percent, post prandial glucose level by 5.6, 20.0 and 7.5 percent in the subjects of group II, III and IV respectively. Supplementation along with nutrition counseling reduced the fasting blood glucose by 16.1, 10.8 and 11.4 percent, post prandial glucose level by 11.5, 27.3 and 12.9 percent in the subjects of group II, III and IV respectively. Significant (p≤0.01) reduction in total cholesterol 4.5, 6.0 and 2.0 percent, triglycerides 6.2, 5.4 and 3.3 percent, LDL-C 7.4, 6.2 and 2.4 percent, VLDL-C 11.0, 8.7 and 6.4 percent, and an increase in HDL-C 8.9, 4.4 and 0.80 percent in the subjects of group II, III and IV was observed after supplementation of bael *(Aegle marmelos* L.*)* leaf, pulp and seed powder respectively. The ratio of total cholesterol to HDL-C reduced from 5.3 to 4.6, 5.8 to 5.2 and 5.5.to 5.2 mg/dl and LDL- C to HDL-C from 3.6 to 3.1, 3.8 to 3.4 and 3.6 to 3.4 mg/dl in the subjects of group II, III and IV respectively. Supplementation along with nutrition counseling reduced total cholesterol by 7.8, 9.3 and 5.0 percent, triglycerides 10.9, 8.5 and 6.6 percent, LDL-C 10.7, 9.9 and 6.4 percent, VLDL-C 16.7, 12.4 and 10.4 percent and increased HDL-C 16.9, 19.4 and 4.8 percent in the subjects of group II, III and IV respectively. The ratio of total cholesterol to HDL-C reduced from 5.3 to 4.2, 5.8 to 4.4 and 5.5.to 4.9 mg/dl and LDL-C to HDL-C from 3.6 to 2.7, 3.8 to 2.9 and 3.6 to 3.1 mg/dl in the subjects of group II, III and IV respectively. Supplementation of 2 g of bael *(Aegle marmelos* L.*)* leaf, pulp and seed powder significantly reduced the systolic blood pressure by 10.2, 4.3 and 1.4 percent, and diastolic blood pressure by 3.8, 2.6 and 2.6 percent in the subjects of group II, III and IV respectively. Supplementation along with nutrition counseling reduced the systolic blood pressure by 12.2, 7.1 and 3.4 percent and diastolic blood pressure by 6.7, 5.9 and 4.2 percent in the subjects of group II, III and IV respectively. Hence it can be inferred from the results that supplementation of bael *(Aegle marmelos* L.*)* leaf, pulp and seed powder along with nutrition counseling significantly improved the nutritional status of the diabetic patients.

REFERENCES:

1. Aggarwal R, Nagi M and Kochhar A. Effect of Nutrition Education on Blood Glucose and Lipid Profile of Non Insulin Dependent Female Diabetics. J. Hum. Ecol., **2007**: 22(4); 323-326.
2. Balagopal P, Kamalamma N, Patel GT and Misra R. A Community Based Diabetes Prevention and Management Education Program in a Rural Village in India. Diabetes Care, **2008**: (74).
3. Dahanukar SA, Kulkarni RA, Rege NN. Pharmacology of Medicinal Plants and Natural Products. Ind. J. Pharm., **2000**: 32; S81-S118.
4. Farshchi A, Ghiasi G, Farshchi S and Ghobadi AT. The Effect of Chronic Administration of Aegle Marmelos Seed Extract on Learning and Memory in Diabetic Rats, Iranian J. Basic Medical Sci., **2010**: 14(1); 42-48.
5. Fossati P and Principle L. Qualitative determination of triglycerides in serum or plasma by enzymatic DHBC colorimetric method. Clin. Chem., **1982**: 28; 2077.
6. Frieldwalds WT, Levy RI and Friedrickson DS. Estimation of plasma or serum low density lipoprotein cholesterol concentration without use of preparaline ultracentrifuge. Clin. Chem., **1972**: 18; 499.
7. Guerrero-Romero F and Rodrı´guez-Mora´n M. Complementary Therapies for Diabetes: The Case for Chromium, Magnesium and Antioxidants. Archives of Medical Research, **2005**: 36; 250-257.
8. Gupta R, Bajpai KG, John S and Saxena AM. An: overview of Indian novel traditional medicinal plants with antidiabetic potentials. African J. Trod. Comp. Alt. Med., **2008**: 5(1); 1-17.
9. Hyun-Mee Oh and Jin-Sook Yoon. Glycemic control of type 2 diabetic patients after short-term zinc supplementation. Nutrition Research and Practice, **2008**: 2(4); 283-288.
10. IDF (**2011**) Diabetes Atlas. 4th edition. (http://www.diabetesatlas.org/content/foreword-0).
11. Kamalakkannan N and Prince PS. The effect of Aegle marmelos fruit extract in streptozotocin diabetes: A histopathological study. J. Herb. Pharmacotherapy, **2005**: 5(3); 87-98.
12. Kar A, Choudhary BK, and Bandyopadhyay NG. Comparative evaluation of hypoglycaemic activity of some Indian medicinal plants in alloxan diabetic rats. J. Ethnopharmacol., **2003**: 84; 105-108.
13. Kaur HP, Garg SN, Sashidhara KV and Yadav A. Chemical Composition of the Essential Oil of the Twigs and Leaves of Aegle marmelos (L.) Correa. J. Essential Oil Research, **2006**. (http://findarticles.com/p/articles/mi_qa4091/is_200605/ai_n17175095/).
14. Kesari AN, Gupta RK, Singh SK, Diwakar S and Watal G. Hypoglycemic and antihyperglycemic activity of Aegle marmelos seed extract in normal and diabetic rats. J. Ethnopharmacol., **2006**: 107(3); 374-79.
15. Krushna G, Kareem MA and Devi KL. Antidyslipidaemic effect of Aegle marmelos Linn. fruit on isoproterenol induced myocardial injury in rats. The Internet J. Pharm., **2009**: 6(2).
16. Lmbole VB, Murti K, Kumar U, Bhatt SP and Gajera V. Phytopharmacological Properties of Aegle Marmelos as a Potential Medicinal Tree: An Overview. Int. J. Pharmaceutical Sci. Review and Res., **2010**: 5(2); Article-014.
17. Lim H, Park J, Choi Y, Huh KB and Kim WY. Individualized diabetes nutrition education improves compliance with diet prescription. Nutrition Research and Practice, **2009**: 3(4); 315-322.
18. Lopes- Virella MF, Stone P, Ellis S and Cohwel JA. Qualitative determination of HDL-Cholesterol in serum or plasma by phospotungstate method. Clin. Chem., **1977**: 23; 882.
19. Maclead J. Daviosons principles and practice of medicine. 14th ed ELBS/Churchill Living Stone, **1984**.
20. Maity P, Hansda D, Bandyopadhyay and Mishra DK. Biological Activity of crude extracts and chemical constituents of bael, Aegle marmelos (L.) Corr., Ind. J. Experimental Biology, **2009**: 47; 849-861.
21. Narender T, Shweta S, Tiwari P, Papi RK, Khaliq T, Prathipati P, Puri A, Srivastava A, Chander R, Agarwal SC and Raj K. Antihyperglycemic and antidyslipidemic agent from Aegle marmelos. Bioorg. Med. Chem. Letter, **2007**: 17(6); 1808-11.
22. Panda S and Kar A. Evaluation of the antithyriod, antioxidative and antihyperglycemic activity of scopoletin from Aegle marmelos leaves in hyperthyroid rats. Phytotherapy Res., **2006**: 20(12); 103-05.
23. Pimentela GD, Portero-Mclellanbc KC, Oliveirac EP, Spadac AM, Oshiiwad M, Zemdegsa JCS, Barbalhod SM. Long-term nutrition education reduces several risk factors for type 2 diabetes mellitus in Brazilians with impaired glucose tolerance. Nutrition Research, **2010**: 30(3); 186-190.
24. Radha R and Amirthaveni M. Hypoglycemic effect of vilvai leaf (Aegle marmelos) powder on type II diabetics. Indian J. Nutr. Dietet., **2007**: 44(11); 515-21.
25. Rajadurai M and Prince PSM. Comparative effects of Aegle marmelos extract and alpha-tocopherol on serum lipids, lipid peroxides and cardiac enzyme levels in rats with isoproterenol-induced myocardial infarction. Singapore Med. J., **2005**: 46(2); 7881.
26. Richmond W. Qualitative determination of cholesterol in serum or plama by enzymatic method. Clin. Chem., **1973**: 19; 1350.
27. Sabu MC and Kuttan R. Antidiabetic activity of Aegle marmelos and its relationship with its antioxidant properties. Ind. J. Physiology and Pharmacology, **2004**: 48; 81-88.
28. Sakineh S, Batoul F and Mousavi A. Effects of clinical nutrition education on glycemic control outcomes in type 2 diabetes. Internal J. of Diab. in Deve. Count., **2006**: 26; 156-9.
29. Shankhala A and Sharma S. Efficacy of herbal extract of bael patra (Aegle Marmelos) in the management of hyperglycemia In: IX Asian Congress of Nutrition (Abstract) New Delhi, India, **2003**; 308p.
30. Sharma RS and Asrani D. Aegle Marmelos (BEL) Leaves Extract (Extractum Belae Fructus Liquidum) in The Management of Essential Hypertension. JAPI, **2003**: 51; 1252-1256. (http://www.japi.org/december2003/Poster/Hypertension_Poster.pdf).
31. Sharma PC, Bhatia V, Bansal N and Sharma A. A Review on Bael Tree. Natural Product Radiance, **2007**: 6(2); 171-178.
32. Smart C, Aslander-van Vliet E and Waldron S. Nutritional management in children and adolescents with diabetes. Pediatric Diabetes, **2009**: 10(12); 100-117.
33. Suvimol C and Pranee A. Bioactive compounds and volatile compounds of Thai bael fruit (Aegle marmelos (L.) Correa) as a valuable source for functional food ingredients. Inter. Food Research J., **2008**: 15(3); 1-9.
34. Trinder P. Practical Clinical Biochemistry. Vol X, 5th ed William Heinnemann Medical Books Limited, New York; **1969**.
35. Upadhya SA, Shanbhay KK, Suneetha G, Balachandra NM and Upadhya S. A study of hypoglycemic and antioxidant activity of Aegle marmelos in alloxan induced diabetic rats. Indian J. Physiol. Pharmacol., **2004**: 48(4); 476-80.
36. Vasanthamani G and Savita D. Hypoglycemic and Hypocholesterolemic effects of selected Herbal Powders. The Indian J. Nutr. Diet., **2001**: 38; 419-27.
37. Vijaya C, Ramanathan M and Suresh B. Lipid lowering activity of ethanolic extract of leaves of Aegle marmelos (Linn.) in hyperlipidaemic models of Wistar albino rats. Indian J. Exp. Biol., **2009**: 47(3); 182-5.

38. WHO **2007**. Diabetes Programme. (http://www.who.int/diabetes/facts/world figure/en/).
39. WHO **2008**. World health Statistics. (http://www.who.int/whosis /whostat /2008 /en/).
40. WHO **2009**. Fact Sheet No. 312: What is Diabetes? (http://www.who.int/mediacentre/factsheets/fs312/en/-).

Source of support: Nil, Conflict of interest: None Declared