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Research Paper

Anthropometric parameters and effect of bael (*Aegle marmelos* L.) on mineral content of type 2 diabetics

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■ **ABSTRACT :** 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 g 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. There was a significant decrease ($p \leq 0.01$) in calcium, phosphorus, magnesium and significant increase ($p \leq 0.05$) of zinc and iron ($p \leq 0.01$) by the subjects of group II, III and IV.

■ **KEY WORDS:** Bael, Mineral content, Type 2 diabetics

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The prevalence of diabetes has dramatically increased in the latter half of the the 20th century, largely due to ready availability of large quantities of calorie rich foods and the technology driven reduction in routine daily exercise (Birnbaum, 2005). Obesity and physical inactivity independently contribute to the development of type 2 diabetes. However, magnitude of risk contributed by obesity is much greater than that imparted by lack of physical activity (Rana *et al.*, 2007).

Bael (*Aegle marmelos* L.) is an important medicinal plant of India. Biochemical compounds of bael leaves, fruits and seeds have been used in several diseases like diabetes, cardio-vascular and anti-inflammatory (Maity *et al.*, 2009). The most important ingredients present in plants are alkaloids, terpenoids, steriods, phenols glycosides and tannins (Venkatesan *et al.*, 2009). Keeping in view the beneficial effects of *Aegle marmelos* leaves, fruit and seeds in the management of diabetes present study was planned to check the anthropometric parameter and mineral content of diet of diabetic people.

■ RESEARCH METHODS

The patients were selected from Punjab Agricultural University Hospital and Civil hospital of Ludhiana. Newly detected, male non-insulin dependent diabetic mellitus subjects who were not taking any medicine, aged between 35-65 years, free from serious complication were selected. On the basis of the above mentioned criteria, a sample of one hundred twenty male

diabetic subjects were selected and divided into four groups *viz.*, group I, group II, group III and group IV having thirty subjects each. Various anthropometric parameters *viz*., height, weight, Body Mass Index (BMI) mid upper arm circumference and triceps skin fold thickness were recorded using standard method given by Jellife (1966). The techniques applied were practiced and standardized on ten preliminary diabetic subjects. An open ended preliminary interview schedule was drafted to elicit information pertaining to food habits, dietary intake of the subjects. It was divided into three sections. A multiple choice questionnaire was designed to test the knowledge regarding diabetes and bael (*Aegle marmelos* L.). There were three parts of the questionnaire. Part I included questions related to knowledge, Part II consisted of questions related to attitude and Part III was on aspect of practices. The preliminary interview schedule was pre tested on fifteen diabetic subjects so as to test the validity and suitability of the interview schedule. Data were collected personally by interviewing the subjects and filled accordingly in the interview schedule. Information pertaining to food preferences, food avoidances was recorded. Dietary intake of subjects was recorded for three consecutive days by 24 hours recall cum weighment method, using standardized containers, both before and after the experimental period. The average daily nutrient intake of diet was calculated by using MSU nutriguide computer programmer (Song *et al.*, 1992). The average raw amounts in grams of each and every item of food consumed for three consecutive days for each subject was fed in the software and nutritive value of the diets was recorded and compared with RDA (ICMR, 2010). From the day of selection each subject was followed for a period of one month without imparting nutrition intervention. The already designed and pre-tested, knowledge questionnaire was used to pre test, the knowledge they have regarding diet, its importance, diabetes and its management. After the pre-testing, the subjects in group II, III and IV were imparted nutrition counseling via charts, discussion and demonstration by individual and in group contact for a period of three months at 15 days interval. Lectures on diabetes, dietary treatment, and sample menu of 1280 kcal diet were given to the subjects. A booklet containing all the information regarding diabetes and diet along with food exchange lists, eating pattern, menus of different caloric value, beneficial effects of bael (*Aegle marmelos* L.) consumption were given to the subjects. The data on all the parameters *viz*., mineral intake were analyzed statistically. The mean standard error, percentages, paired t- test and their statistical significance was ascertained using a computer programmed package (Cheema and Singh, 1990).

■ RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Anthropometric parameters of the subjects before and after bael (*Aegle marmelos* L .) supplementation and nutrition intervention :

Anthropometric profile of the subjects is given in Table 1.

Height :

The mean heights of the subjects were 168.2±0.24, 172.5±0.60, 170.1±0.16 and 169.6±0.17 cm of the subjects in group I, II, III and IV, respectively. The increase in height was statistically insignificant.

Weight :

The initial mean weight recorded were 77.5±0.31, 82.1±0.72, 80.9±0.66 and 81.1±0.65 kg of the subjects in group I, II, III and IV, respectively. After nutrition intervention the figure were 78.8±0.34, 78.1±0.38 and 79.0±0.52 kg of the subjects in group II, III and IV, respectively. The per cent reduction was less *i.e.* 4.0, 3.5 and 2.6 in the subjects of group II, III and IV, respectively. The decrease in the weight of the subjects in group II, III and IV could be due to the impact of nutrition education where they were taught to decrease the intake of refined foods and increase intake of fibre rich foods. They were explained the beneficial effect of exercise and motivate to do the same. There was a significant decrease ($p \leq 0.01$) in the weight of the subjects in group II, III and IV, respectively and a non-significant decrease ($p \leq 0.01$) in the weight of the subjects in group I after study. Balagopal *et al.* (2008) and Choudhary (2010) reported that education intervention was useful in reducing obesity.

Body mass index (BMI) :

The initial mean values of BMI were 27.5±0.15,

27.7±0.14, 27.9±0.15 and 28.6±0.19 kg/m^2 of the subjects in group I, II, III and IV, respectively. After nutrition intervention the corresponding values recorded were 26.6±0.34, 27.0±0.26 and 27.6±0.30 kg/m^2 of the subjects in group II, III and IV, respectively. The decrease in BMI of the subjects in group II, III and IV could be due to the impact of nutrition education. There was a significant reduction ($p \leq 0.01$) in the mean values of BMI of the subjects in group II, III and IV after study and a non-significant reduction ($p \leq 0.01$) in the BMI of the subjects of group I. Heydari *et al.* (2006) and Anuradha and Vidhya (2001) also found that dietary counseling was effective in reducing BMI in diabetic patients.

Mid upper arm circumference (MUAC) :

The initial mean value mid upper arm circumference of the subjects in group I, II, III and IV were 28.1±0.13, 29.4±0.22, 30.1±0.29 and 28.9±0.18 cm, respectively. After nutrition intervention the corresponding values recorded were 27.8±0.23, 27.6±0.37, 27.3±0.39 and 27.1±0.40 cm of the subjects in group I, II, III and IV. The decrease in MUAC of the subjects in group II, III and IV could be due to the impact of nutrition education. The per cent reduction in the mid upper arm circumference of the subjects in group II, III and IV were 6.1, 9.3 and 6.2, respectively. There was a significant reduction ($p \leq 0.01$) in the mean values of mid upper arm circumference of the subjects in group II, III and IV and a non- significant reduction ($p \leq 0.01$) in the mean value of mid upper arm circumference of the subjects in group I after study. The similar results were also reported by Choudhary (2010).

Table 1 : Anthropometric measurements of the subjects before and after supplementation of bael *(Aegle marmelos* L.*)* leaf, pulp and seed powder and nutrition intervention

Variables	Before	After	% Change		Paired t-value		Suggested value
1	2 SB	3 NI	Between 1 and 2	Between 1 and 3	Between 1 and 2		Between 1 and 3
			3 months		6 months		
Group I							
Height (cm)	168.2±0.24	168.2±0.24	168.2±0.24	-	-	-	-
Weight (kg)	77.5±0.31	77.4±0.49	76.8±0.45	0.1	0.9	0.79 NS	1.91 NS	68#
BMI (kg/m^2)	27.5±0.15	27.4±0.14	27.2±0.25	0.4	1.1	1.43 NS	1.81NS	18.5-24.99●
MUAC (cm)	28.1±0.13	27.9±0.17	27.8±0.23	0.7	1.3	1.79 NS	2.02*	29.31
TSFT (mm)	11.9±0.13	11.8±0.13	11.8±0.15	0.6	0.8	1.81 NS	1.74NS	12.51
Group II							
Height (cm)	172.5±0.60	172.5±0.60	172.5±0.60	-	-	-	-	-
Weight (kg)	82.1±0.72	79.8±0.40	78.8±0.34	2.8	4.0	3.13**	6.00**	72#
BMI (kg/m^2)	27.7±0.14	26.9±0.32	26.6±0.34	2.9	3.9	2.96**	3.56**	18.5-24.99●
MUAC (cm)	29.4±0.22	27.7±0.35	27.6±0.37	5.8	6.1	3.65**	5.88**	29.31
TSFT (mm)	12.3±0.12	12.0±0.14	11.7±0.23	2.4	4.9	2.80**	3.07**	12.51
Group III							
Height (cm)	170.13±0.16	170.13±0.16	170.13±0.16	-	-	-	-	-
Weight (kg)	80.9±0.66	79.8±0.53	78.1±0.38	1.4	3.5	2.43*	4.28**	70#
BMI (kg/m^2)	27.9±0.15	27.6±0.21	27.0±0.26	1.1	3.2	1.98*	2.87**	18.5-24.99●
MUAC (cm)	30.1±0.29	28.1±0.32	27.3±0.39	6.6	9.3	2.88**	4.02**	29.31
TSFT (mm)	12.4±0.15	12.1±0.13	11.9±0.19	2.4	4.8	2.29*	3.17**	12.51
Group IV							
Height (cm)	169.6±0.17	169.6±0.17	169.6±0.17	-	-	-	-	-
Weight (kg)	81.1±0.65	80.1±0.61	79.0±0.52	1.2	2.6	2.16*	3.53**	69#
BMI (kg/m^2)	28.6±0.19	28.0±0.22	27.6±0.30	2.1	3.5	2.68**	3.94*	18.5-24.99●
MUAC (cm)	28.9±0.18	28.2±0.22	27.1±0.40	2.4	6.2	2.90**	4.28**	29.31
TSFT (mm)	12.5±0.16	12.1±0.14	11.6±0.26	3.2	7.2	2.58**	3.43**	12.51

Values represent Mean±SE

* and ** indicate significance of values at P=0.05 and 0.01, respectively # ICMR (2010) ● Anonymous (2005); Jellife (1966)

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

Triceps skin fold thickness (TSFT) :

The Initial mean triceps skin fold thickness values recorded were 11.9±0.13, 12.3±0.12, 12.4±0.15 and 12.5±0.16 mm of the subjects in group I, II, III and IV, respectively. After nutrition intervention the corresponding values were 11.7±0.23, 11.9±0.19 and 11.6±0.26 mm of the subjects in group II, III and IV, respectively after study. There was a significant decrease ($p \leq 0.01$) in the mean triceps skin fold thickness values of the subjects of group II, III and IV after study and a non-significant reduction ($p \leq 0.01$) in the mean triceps skinfold thickness values of the subjects in group I. The per cent reduction in the triceps skin fold thickness in the subjects of group II, III and IV were 4.9, 4.8 and 7.2, respectively. The similar results were also reported by Choudhary (2010).

Distribution of the subjects according to their body mass index (BMI) before and after the study :

It was seen that maximum of the subjects lied in the BMI range 25.00-29.99 and 30.00-34.99 before nutrition counseling. But after nutrition counseling the number of subjects decreased in the BMI range of 30.00-34.99 and increased in 25.00-29.99 BMI range in group II, III and IV (Table 2).

Minerals :

The mean daily intake of vitamins is given in Table 3.

Calcium :

The average daily intakes of calcium before the study were 699.1±1.59, 661.2±3.40, 692.2±6.20 and 664.9±0.22 mg/day by the subjects of group I, II, III and IV, respectively. The corresponding intakes after nutrition intervention were 646.7±9.05, 668.2±11.92 and 636.9±11.28 mg/day by the subjects of group II, III and IV, respectively. The significant decrease ($p \leq 0.01$) in calcium intake after nutrition intervention could be due to the nutrition counseling given to the subjects of group II, III and IV and non-significant decrease in the subjects of group I after study. It was observed that the calcium intake both before and after the study was much higher as compared to the RDA of 600 mg/day given by ICMR (2010). The calcium intakes were reduced by 2.2, 3.5 and 4.2 per cent by the subjects of group II, III and IV, respectively. The reduction in calcium intake could be due to nutrition education given to the subjects as they were taught to consume balanced diet. Similar results were also reported by Choudhary (2010).

Phosphorus :

The average daily intakes of phosphorus before the study were 1664.2±10.1, 1723.9±8.98, 1680.7±21.4 and 1629.3±9.00 mg/day by the subjects of group I, II, III and IV, respectively. There was a significant decrease ($p \leq 0.01$) in phosphorus intakes which were 1697.9±15.4, 1610.6±35.5 and 1578.3±24.4 mg/day by the subjects of group II, III and IV after nutrition intervention. The reduction in phosphorus may be due to nutrition education given to the subjects. However the intake was still higher when compared to the RDA of 600 mg/day given by ICMR (2010). There was high intake of phosphorus before and after nutrition education which can be due to cereals. The phosphorus intakes were reduced by 1.5, 4.2 and 3.1 per cent in the subjects of group II, III and IV, respectively. Higher intake of phosphorus among diabetics in Brazil was also reported by Gross *et al.* (2002) and Choudhary (2010).

Table 2 : Distribution of the subjects according to their BMI before and after bael *(Aegle marmelos* L.) leaf, pulp and seed powder supplementation and nutrition intervention

BMI (kg/m^2)*	Group I				Group II		Group III			Group IV		
Before	After		Before	After			Before	After		Before	After	
3 months	6 months		SB	NI			SB	NI		SB	NI	
18.5-24.99	4 (13.3)	4 (13.3)	4 (13.3)	3 (10.0)	3 (10.0)	4 (13.3)	5 (16.7)	5 (16.7)	5 (16.7)	4 (13.3)	4 (13.3)	4 (13.3)
25.00-29.99	24 (80.0)	24 (80.0)	24 (80.0)	21 (70.0)	21 (70.0)	22 (73.3)	23 (76.7)	23 (76.7)	24 (80.0)	23 (76.7)	23 (76.7)	25 (83.3)
30.00-34.99	2 (6.7)	2 (6.7)	2 (6.7)	6 (20.0)	6 (20.0)	4 (13.3)	2 (6.7)	2 (6.7)	1 (3.3)	3 (10.0)	3 (10.0)	1 (3.3)
35.00-39.99	-	-	-	-	-	-	-	-	-	-	-	-
≥40.00	-	-	-	-	-	-	-	-	-	-	-	-

Figures in parenthesis are percentage *Anonymous (2005) 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

Magnesium :

The mean daily intake of magnesium before the study were 504.4±5.85, 476.8±2.42, 535.3±7.72 and 628.9±7.15 mg/day by the subjects of group I, II, III and IV, respectively and after nutrition intervention the corresponding figures were 456.1±8.15, 504.5±15.44 and 601.1±12.23 mg/day by the subjects of group II, III and IV, respectively. However, there was a significant decrease ($p \leq 0.01$) in magnesium intake after the study by the subjects of group II, III and IV. However, the magnesium intake of all the four groups both before and after the study was more as compared to the RDA of 340 mg/day given by ICMR (2010). Similarly, Rob *et al.* (2006) reported that a diet high in magnesium foods, particularly whole grains is associated with a substantially lower risk of type 2 diabetes in U.S black women. Magnesium taurate in diabetes improves insulin sensitivity and also may lower the risk of micro and macro vascular complication in diabetes as reported by McCarty (1996). The decrease in magnesium intake could be due to nutrition education given to the subjects to consume balanced diets. Similar results were also reported by Aggarwal (2003).

Zinc :

The mean daily intakes of zinc before the study were 11.4±0.48, 9.9±0.28, 11.1±0.28 and 10.2±0.16 mg/day by the subjects of group I, II, III and IV, respectively. After nutrition intervention the corresponding zinc intake recorded were 11.6±0.49, 10.1±0.28, 11.8±0.28 and 10.9±0.86 mg/day by the subjects of group I, II, III and IV, respectively. The mean intake was less both before and after study as compared to the RDA of 12 mg/day given by ICMR (2010). There was a significant increase

Table 3 : Mean daily intake of minerals in the subjects before and after bael *(Aegle marmelos* L.*)* leaf, pulp and seed powder supplementation and nutrition intervention

Minerals (mg/day)	Before 1		After	% Change		Paired t-Value		Suggested intake (mg/day)
2	3		Between 1 and 2	Between 1 and 3		Between 1 and 2		Between 1 and 3
Control								
Group I				3 months			6 months	
Calcium	699.1±1.59	696.5±2.55	695.8±4.12	0.4	0.5	1.80NS	1.76 NS	600●
Phosphorus	1664.2±10.1	1638.6±20.5	1634.2±22.5	1.5	1.8	1.79 NS	1.81 NS	600●
Magnesium	504.4±5.85	493.7±9.77	483.3±12.21	2.1	4.2	1.81 NS	2.42*	340●
Zinc	11.4±0.48	11.5±0.50	11.6±0.49	0.9	1.8	1.55NS	1.64 NS	12●
Iron	20.4±0.30	20.4±0.29	20.6±0.31	0.1	0.9	1.43 NS	1.74 NS	17●
Experimental				SB			NI	
Group II								
Calcium	661.2±3.40	650.0±8.49	646.7±9.05	1.7	2.2	1.76 NS	2.03**	600●
Phosphorus	1723.9±8.98	1713.5±10.0	1697.9±15.4	0.6	1.5	1.850 NS	2.40*	600●
Magnesium	476.8±2.42	458.2±8.18	456.1±8.15	3.9	4.6	2.37*	2.61**	340●
Zinc	9.9±0.28	10.0±0.27	10.1±0.28	1.7	2.4	1.78 NS	2.09*	12●
Iron	22.9±0.19	23.1±0.21	24.3±0.53	0.9	5.8	2.13*	2.85**	17●
Group III								
Calcium	692.2±6.20	679.7±6.33	668.2±11.92	1.8	3.5	2.16*	2.31*	600●
Phosphorus	1680.7±21.4	1647.5±31.0	1610.6±35.2	1.9	4.2	1.95*	2.50*	600●
Magnesium	535.3±7.72	520.0±13.21	504.5±15.44	2.9	5.6	2.06*	2.59**	340●
Zinc	11.1±0.28	11.4±0.25	11.8±0.28	2.7	3.6	2.64*	3.37**	12●
Iron	19.1±0.15	19.8±0.52	20.1±0.47	3.8	5.0	1.75 NS	2.37*	17●
Group IV								
Calcium	664.9±0.22	655.4±5.35	636.9±11.28	1.4	4.2	2.08*	2.72**	600●
Phosphorus	1629.3±9.0	1600.5±19.9	1578.3±24.4	1.8	3.1	1.93 NS	2.52**	600●
Magnesium	628.9±7.15	621.2±7.80	601.1±12.23	1.2	4.4	2.08*	2.72**	340●
Zinc	10.2±0.16	10.3±0.17	10.9±0.86	0.9	6.9	1.24NS	4.06**	12●
Iron	20.9±0.55	21.6±0.71	22.3±0.86	2.9	6.5	1.64 NS	2.11*	17●

Values represent Mean±SE * and ** indicate significance of values at P=0.05 and 0.01, respectively ●ICMR (2010) 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

($p \leq 0.05$) in zinc intake by the subjects of group II and significant increase in zinc intake by the subjects of group III and IV after study. Similar results were also reported by Choudhary (2010) and Tailor *et al*. (2015). According to Chausmer (1998) zinc plays a role in the synthesis, storage and secretion of insulin as well as conformational integrity of insulin in the hexameric form which has the ability of the islet cell to produce and secrete insulin, particularly in Type 2 diabetes. Another study showed that zinc has antioxidant properties which may be useful in warding off heart disease in people with Type 2 diabetes reported by Campell (2007). The patients were encouraged to consume diet rich in zinc like roasted pumkin seed, sesame seed and cashew nuts.

Iron :

The mean daily intakes of iron before study were 20.4±0.30, 22.9±0.19, 19.1±0.15 and 20.9±0.55 mg/day by the subjects of group I, II, III and IV, respectively. After nutrition intervention the corresponding mean iron intake recorded were 24.3±0.53, 20.1±0.47 and 22.3±0.86 mg/day by the subjects of group I, II, III and IV, respectively. There was increase in iron intake by 5.8, 5.0 and 6.5 per cent in the subjects of group II, III and IV, respectively. There was a significant increase ($p \leq 0.01$) of iron intake by the subjects of group II, III and IV after the study and non-significant increase in iron intake by the subjects of group I. The increase of iron by the subjects of group II, III and IV could be due to nutrition education given to the subjects to consume more green leafy vegetables which are a good source of iron. However, the values were fairly good as compared to the RDA of 17 mg given by ICMR (2010). The present study inline with Choudhary (2010); Singh and Saha (2015) and Choudhary and Sachan (2015) also reported the similar results.

Conclusion :

It was seen that significant decrease ($p \leq 0.01$) in calcium, phosphorus, magnesium and significant increase ($p \leq 0.05$) of zinc and iron ($p \leq 0.01$) by the subjects of group II, III and IV. The reduction in calcium,phosphorus and magnesium intake could be due to nutrition education given to the subjects as they were taught to consume balanced diet. The patients were encouraged to consume diet rich in zinc like roasted pumkin seed, sesame seed and cashew nuts.

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