RESULTS AND DISCUSSION

The results and discussion chapter is divided into 3 parts:

Part 1: In-depth antioxidant profile, proximate composition, trace elements and heavy metals in the cultivated ('*Gomayasi*') and wild variety of *Aegle Marmelos (L.) Correa* leaves

Part 2: Knowledge, practice and use (KPU) of *Aegle Marmelos (L.) Correa* leaves with practitioners of Ayurveda and Naturopathy.

Part 3: Impact of *Aegle Marmelos (L.) Correa* (Bael) leaf juice supplementation on blood sugar levels, lipid profile, liver and kidney functions of type II diabetes subjects.

PHASE-I

In-depth antioxidant profile, proximate composition, trace elements and heavy metals in the cultivated ('*Gomayasi*') and wild variety of *Aegle Marmelos (L.) Correa* leaves.

RESULTS

Proximate composition of Aegle Marmelos (L.) Correa leaf

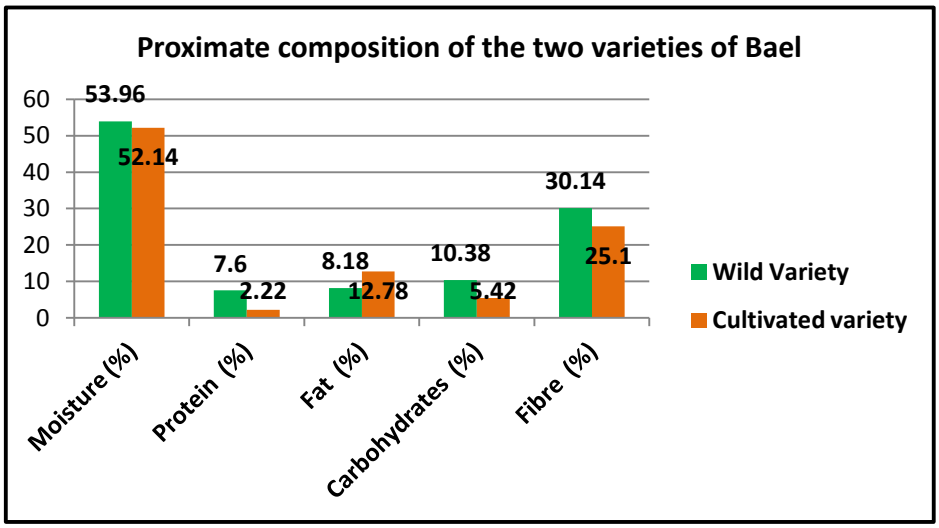
The wild and the cultivated variety of *Aegle Marmelos (L.) Correa* leaves were analyzed for ash, moisture, protein, carbohydrates, fat, fibre, total phenols, minerals and heavy metals. The ash, moisture, protein, carbohydrate, fat and crude fibre content of wild variety of Gir and cultivated variety called *Gomayasi* were 6.5% and 6%; 53.96% and 52.14%; 7.6% and 2.22% ; 10.38% and 5.42%; 8.18% and 12.78% and 30.14% and 25.10% respectively. Table 4.1 and Fig 4.1 depicts results of proximate analysis of the *Aegle Marmelos (L.) Correa* leaves of both the varieties.

TABLE 4.1: PROXIMATE COMPOSITION OF AEGLE MARMELOS (L.) CORREA LEAF

Sr. No	Parameter	Wild variety of *Aegle Marmelos (L.) Correa* Leaf (%)	Cultivated variety of *Aegle Marmelos (L.) Correa* Leaf *'Gomayasi'* (%)
1	Total Ash	6.5	6.0
2	Moisture	53.96	52.14
3	Protein	7.60	2.22
4	Carbohydrate	10.38	5.42
5	Fat	8.18	12.78
6	Fibre	30.14	25.10

(Proximate composition carried out at Food Testing Lab, Junagadh Agricultural University)

FIG 4.1: COMPARISON OF THE PROXIMATE PRINCIPLES OF THE TWO VARIETIES OF *AEGLE MARMELOS (L.) CORREA* LEAF



Mineral content of Aegle Marmelos (L.) Correa leaf

It is known that certain inorganic trace elements such as vanadium zinc, chromium, copper, iron, potassium, sodium, and nickel play an important role in the maintenance of normoglycemia by activating the β-cells of the pancreas. In the present study, the elemental composition in the leaves of two varieties of *Aegle Marmelos (L.) Correa*, traditional medicinal plant- wild variety and cultivated variety called *"Gomayasi"* were studied. Various trace metals found during the analysis are shown in the Table 4.2 and Table 4.3.

The levels of magnesium for wild variety and cultivated variety were 6.3% and 6.5% respectively; silicon 3.9% and 4.03% respectively; chlorine 4.0% and 5.68% respectively; potassium 2.70% and 2.46% respectively; calcium 7.9% and 7.6% respectively; titanium 0.057% and 0.099% respectively; vanadium 0.043% and in cultivated variety it was not respectively detected. chromium content for the wild and cultivated variety was 0.067% and 0.026%; nickel 0.14% and 0.049% respectively; bromium 0.374% and 0.547% respectively; strontium 0.693% and 0.719% respectively; barium 0.24% and 0.25% respectively; rhenium 0.04% for both the varieties. Aurum (Gold) content was also detected for both the varieties (0.11% and 0.095% for wild and cultivated variety respectively). Trace elements in both the varieties are given in Table 4.3.

TABLE 4.2: MINERAL CONTENT OF AEGLE MARMELOS (L.) CORREA LEAF

Sr. No	**Minerals**	**wild variety of *Aegle Marmelos (L.) Correa* Leaf (ppm)**	**Cultivated variety of *Aegle Marmelos (L.) Correa* Leaf (*Gomayasi*) (ppm)**
1	Copper	12	11
2	Iron	181	165
3	Manganese	62	56
4	Zinc	49	38

(Elemental analysis by Atomic Absorption Spectroscopy)

TABLE 4.3 : MINERAL COMPOSITION IN THE WILD AND CULTIVATED VARIETY OF AEGLE MARMELOS (L.) CORREA LEAF USING X-RAY FLUROSCENCE

Sr. No.	Element	% Mass by XRF (Wild variety)	% Mass by XRF (Cultivated variety)
1	Manganese	6.3	6.5
2	Silicon	3.9	4.03
3	Strontium	0.92	1.51
4	Chlorine	4.0	5.68
5	Potassium	2.7	2.46
6	Calcium	79.3	76.9
7	Titanium	0.05	0.09
8	Vanadium	0.04	-
9	Chromium	0.06	0.02
10	Magnesium	0.49	0.07
11	Iron	0.88	0.79
12	Nickel	0.14	0.04
13	Copper	0.02	0.17

(Qualitative % mass analysis by XRF)

Heavy metal analysis of Aegle Marmelos (L.) Correa leaf

Aegle Marmelos (L.) Correa is an important traditional medicinal plant. The ash value, heavy metals, pesticide residue is important to check contamination and toxicity. Heavy metals were analyzed through Atomic Absorption Spectrophotometer (AAS). The results shows that none of the metals like Cadmium, Arsenic, Lead and Mercury were detected in our study for both the varieties. The heavy metal analysis of the two varieties is given in table 4.4.

TABLE 4.4: HEAVY METAL CONTENT OF THE TWO VARIETIES AEGLE MARMELOS (L.) CORREA LEAVES

Sr. No	Heavy Metals	Wild variety of *Aegle Marmelos (L.) Correa* Leaf (%)	Cultivated variety of *Aegle Marmelos (L.) Correa* 'Gomayasi' (%)
1	Cadmium	Nil	Nil
2	Arsenic	Nil	Nil
3	Lead	Nil	Nil
4	Mercury	Nil	Nil

(Heavy Metal Analysis done by Atomic Absorption Spectroscopy)

Antioxidant Capacity of Aegle Marmelos (L.) Correa Leaf

a) FRAP Assay

Antioxidants can reduce the access of oxidants and other deleterious molecules due to their ability to scavenge oxygen nitrogen-derived free radicals by donating hydrogen atom or an electron, chelating metal catalysts, activating antioxidant enzymes, and inhibiting oxidases (Ames et al., 2001).

Antioxidant potential Ferric Reducing Antioxidant Potential (FRAP) of wild and cultivated variety (Gomayasi) of *Aegle Marmelos (L.) Correa* leaves is presented in Table 4.5 and Table 4.6. The standard curve for FRAP assay is given in Fig: 4.2. FRAP values for wild and cultivated variety of *Aegle Marmelos (L.) Correa* leaves were 14.65 µmol/l and 11.80 µmol/l. Wild variety showed slightly higher reducing power (FRAP) as compared to cultivated variety.

FIG 4.2: STD CURVE FOR FRAP ASSAY

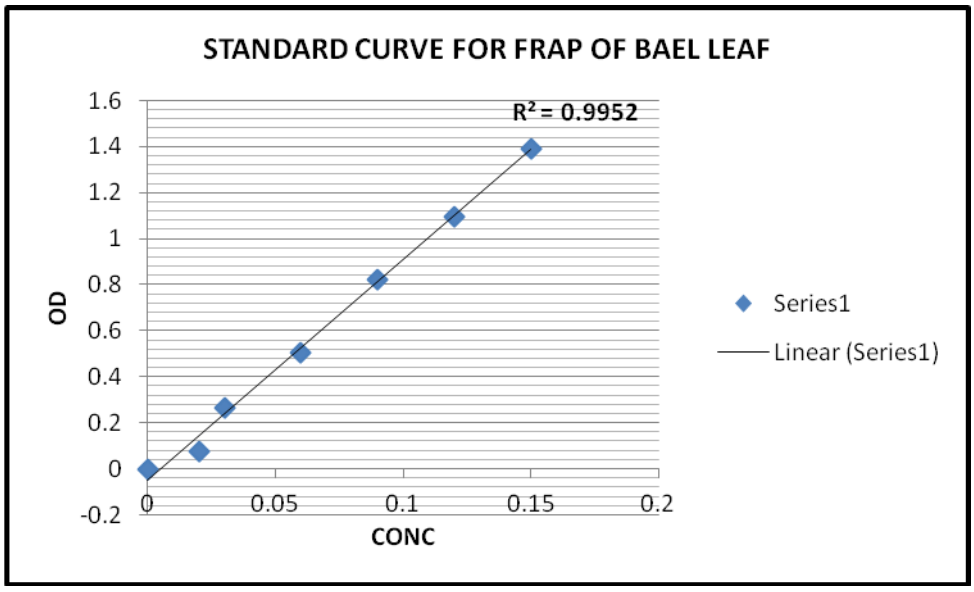


TABLE 4.5 : ANTIOXIDANT ACTIVITY (FRAP) OF WILD AND CULTIVATED VARIETY OF AEGLE MARMELOS (L.) CORREA LEAVES

Type of variety	**FRAP (µM/L)**
Cultivated variety of AM	11.87
Wild variety of AM	14.65

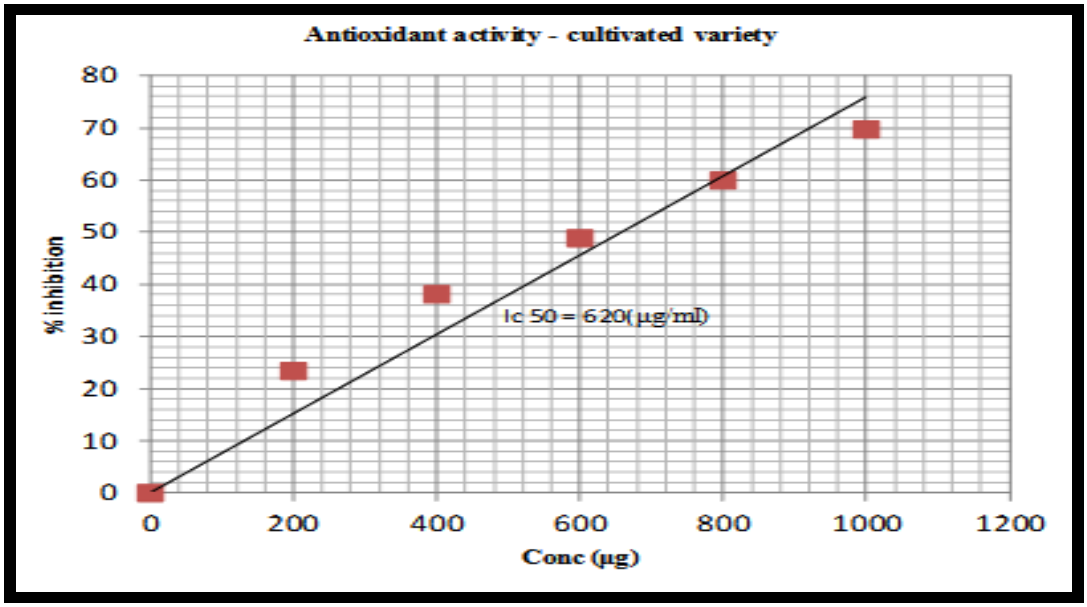
b) DPPH Assay

Total antioxidant capacity of *Aegle Marmelos (L.) Correa* leaf using 1,1 Diphenylpicryl Hydrazine (DPPH) method was reported as IC_{50} values. The IC_{50} values for wild and cultivated variety was 437 µg/ml and 620 µg/ml respectively. Wild variety showed slightly higher IC_{50} values (µg/ml DPPH) as compared to cultivated variety. The lower the IC_{50} value, higher is the antioxidant capacity of the sample. As can be seen from the Table 4.6 and Table 4.7, the wild variety is having more antioxidant capacity than the cultivated one (IC_{50} : 437 µg/ml<620µg/ml).

Fig: 4.3 and Fig: 4.4 indicates std curve for DPPH assay for wild and cultivated variety of *Aegle Marmelos (L.) Correa* leaves. Table 4.10 shows total antioxidant content, TPC and phenol composition of the wild and cultivated varieties of *Aegle*

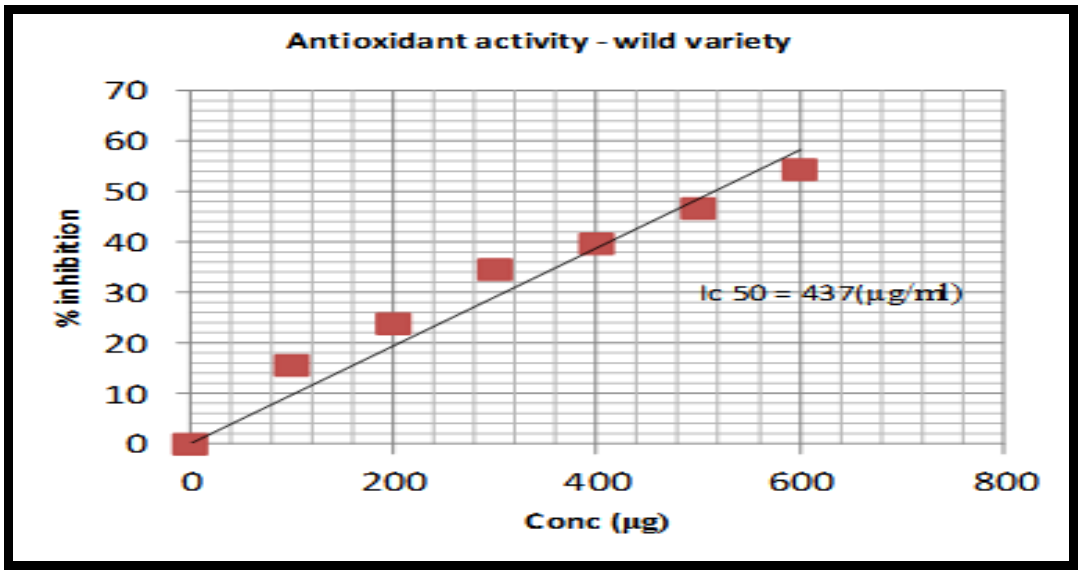
Marmelos (L.) Correa leaves. Table 4.11 shows perfect corelation between Total antioxidant capacity (FRAP) and DPPH and total phenol content of *Aegle Marmelos (L.) Correa* leaves (r=1).

FIG 4.3: GRAPH ON IC_{50} VALUE OF CULTIVATED VARIETY



From graph IC_{50} value= 620µg/ml

FIG 4.4: GRAPH ON IC_{50} OF WILD VARIETY



From graph IC_{50} value= 437µg/ml

TABLE 4.6: ANTIOXIDANT ACTIVITY (DPPH) OF CULTIVATED VARIETY OF AEGLE MARMELOS (L.) CORREA LEAVES

Aliquot	Concentration (µg)	Reading at 517nm	Control	% Inhibition
0.2	200	0.835	1.090	23.39
0.4	400	0.675	1.090	38.07
0.6	600	0.558	1.090	48.84
0.8	800	0.437	1.090	`59.91
1.0	1000	0.330	1.090	69.72

% Inhibition= Control Reading-Sample Reading/Control Reading*100

TABLE 4.7: ANTIOXIDANT ACTIVITY (DPPH) OF WILD VARIETY OF AEGLE MARMELOS (L.) CORREA LEAVES

Aliquot	Concentration (µg)	Reading at 517nm	Control	% Inhibition
0.1	100	0.920	1.090	15.60
0.2	200	0.830	1.090	23.85
0.3	300	0.713	1.090	34.59
0.4	400	0.658	1.090	`39.69
0.5	500	0.581	1.090	46.70
0.6	600	0.497	1.090	54.40

% Inhibition= Control Reading-Sample Reading/Control Reading*100

FIG 4.5 GRAPH OF TOTAL PHENOL CONTENT AND TOTAL ANTIOXIDANT CAPACITY USING FRAP AND DPPH OF WILD AND CULTIVATED VARIETY OF *AEGLE MARMELOS (L.) CORREA* LEAVES

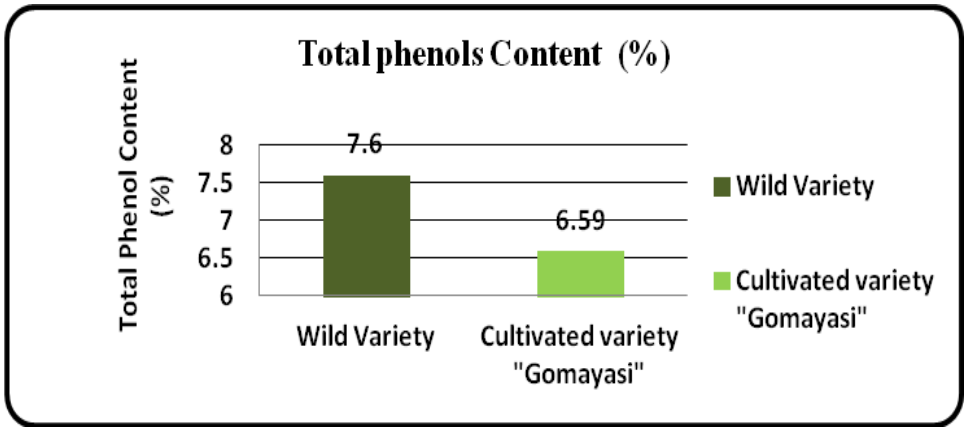


FIG 4.6: GRAPH OF ANTIOXIDANT ACTIVITY (FRAP) OF WILD AND CULTIVATED VARIETY OF *AEGLE MARMELOS (L.) CORREA* LEAVES

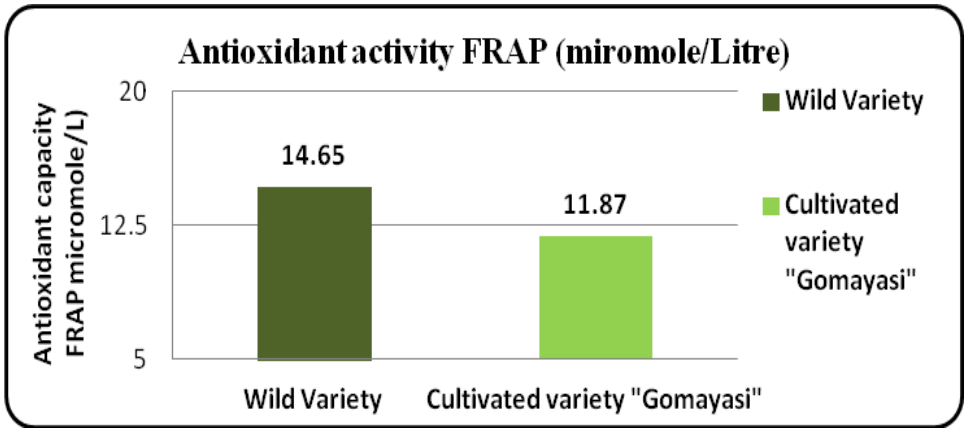
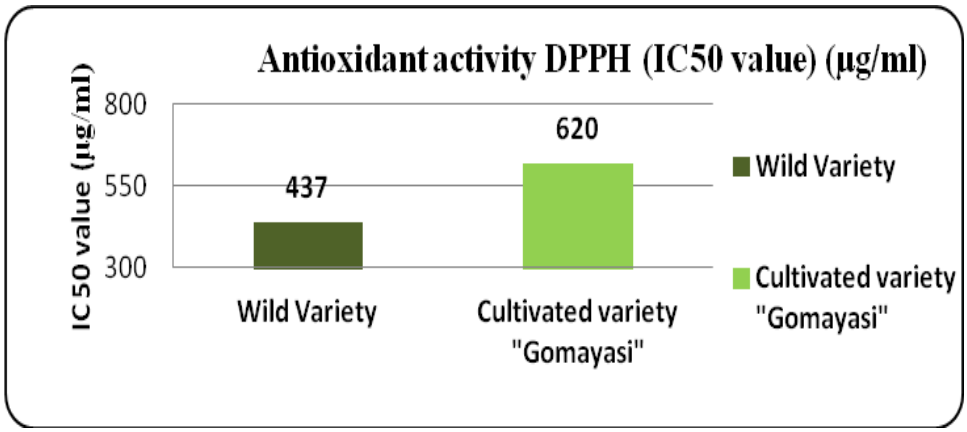


FIG 4.7: GRAPH OF ANTIOXIDANT ACTIVITY (DPPH) OF WILD AND CULTIVATED VARIETY OF *AEGLE MARMELOS (L.) CORREA* LEAVES



Phenol Content

a) Total Phenol Content of *Aegle Marmelos (L.) Correa* Leaf

Results for Total Phenol Content (TPC) of wild and cultivated *Aegle Marmelos (L.) Correa* leaf samples were 76 mg GAE/g and 65 mg GAE/g of dry extract (7.6% and 6.56%) respectively (Table 4.10). Fig: 4.8 and Fig: 4.9 shows standard curve for TPC of wild and cultivated variety. TPC of wild variety was more than cultivated variety. A perfect positive correlation of 1 was seen between TPC and DPPH (IC_{50} Value), TPC and FRAP and between DPPH and FRAP as shown in table 4.11. Table 4.10 presents TAC of both the types of *Aegle Marmelos (L.) Correa* leaves.

FIG 4.8 STD CURVE FOR TOTAL PHENOL CONTENT OF WILD VARIETY

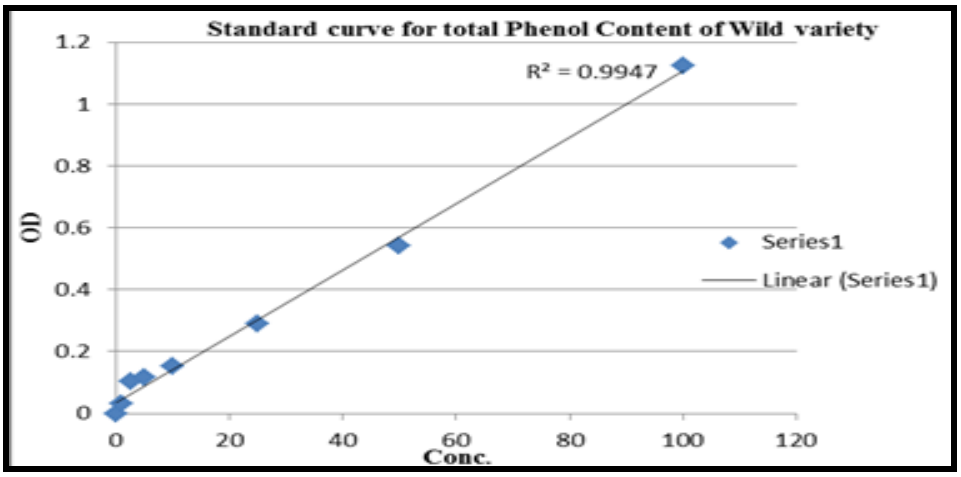
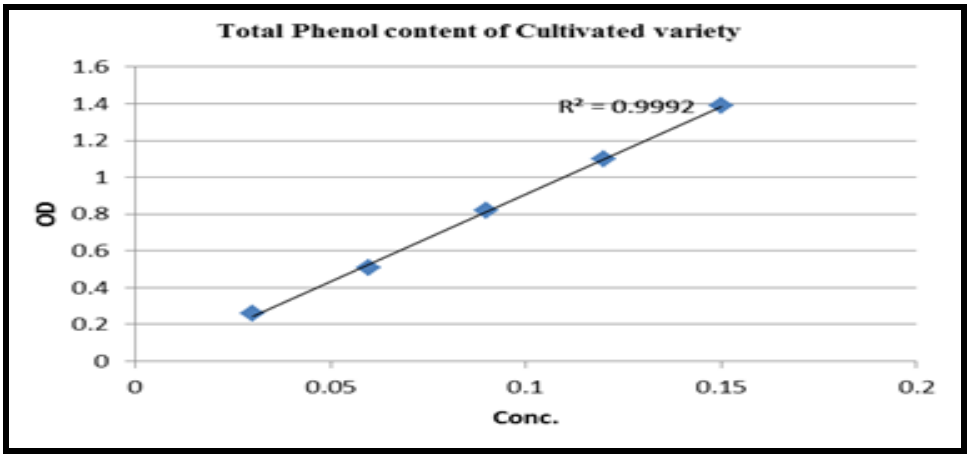


FIG 4.9 STD CURVE FOR TOTAL PHENOL CONTENT OF CULTIVATED VARIETY



b) Individual phenolic compounds

HPLC analysis for quantification of individual phenolic compounds revealed the presence of Gallic acid, Chlorogenic acid and Ferullic acid in wild variety whereas Gallic acid, Ferullic acid and Pyrocatechol was found in cultivated variety. Fig 4.10 and Fig 4.11 describes the HPLC analysis chromatograms and details of the HPLC analysis of wild and cultivated *Aegle Marmelos (L.) Correa* leaf samples is given in Table 4.8 and Table 4.9.

TABLE 4.8: DETAILS OF THE HPLC ANALYSIS FOR CULTIVATED VARIETY (GOMAYASI)

Sr. No.	Name	Retention time (min)	Area (μV^2Sec)	%Area	Height (μV)	Peak type	Start time (min.)	End time (min.)
1		2.558	649790	1.68	46084	Unknown	2.316	2.766
2	Gallic acid	2.766	399234	1.03	31553	Found	2.766	3.083
3		3.169	380073	0.98	15262	Unknown	3.083	3.533
4		3.942	1362501	3.53	36395	Unknown	3.533	4.516
5	Pyrocatechol	4.910	1353254	3.50	27835	Found	4.516	5.600
6	Ferullic acid	6.911	8212852	21.27	200343	Found	5.600	7.083
7		7.162	26262563	68.00	193876	Unknown	7.083	16.032

HPLC-High Pressure liquid chromatography

TABLE 4.9: DETAILS OF THE HPLC ANALYSIS FOR WILD VARIETY

Sr. No.	Name	Retention time (min)	Area (μV^2Sec)	% Area	Height (μV)	Peak type	Start time (min)	End time (min)
1		2.556	514409	1.42	54434	Unknown	2.367	2.650
2	Gallic acid	2.701	936002	2.59	50008	Found	2.650	3.267
3	Chlorogenic acid	3.628	1079902	2.99	24867	Found	3.267	4.183
4		4.418	1042240	2.88	20375	Unknown	4.183	5.467
5	Ferullic acid	6.900	6351894	17.58	150326	Found	5.967	7.050
6		7.161	9868229	27.31	150050	Unknown	7.050	8.417
7		8.485	16341919	45.23	99437	Unknown	8.417	17.233

HPLC-High Pressure liquid chromatography

FIG 4.10: CHROMATOGRAM FOR THE CULTIVATED VARIETY

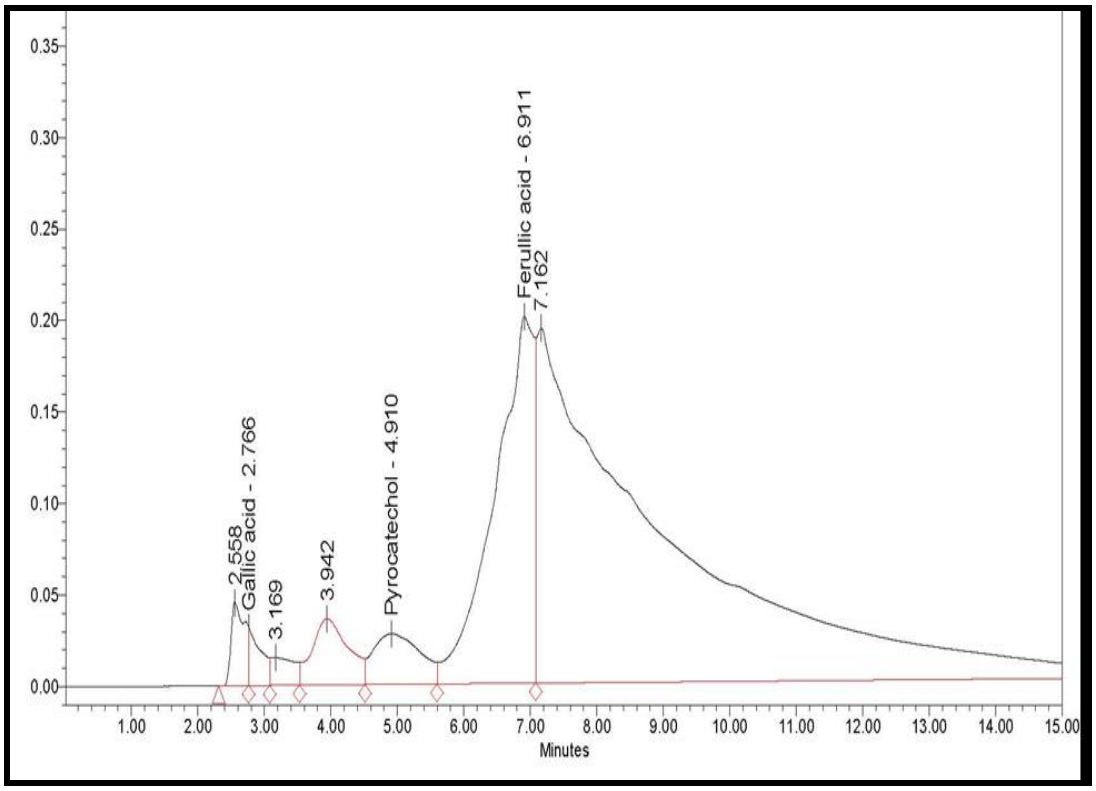


FIG 4.11: CHROMATOGRAM FOR THE WILD VARIETY

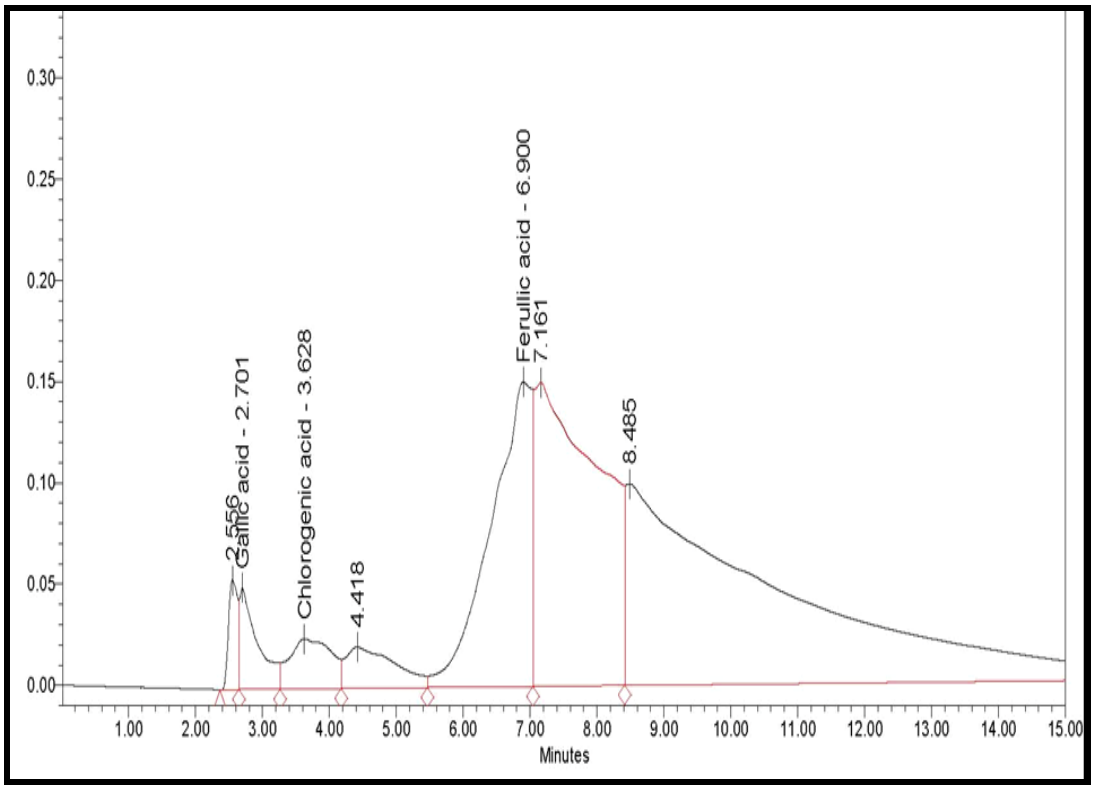


TABLE 4.10: RESULTS OF THE TOTAL PHENOL, INDIVIDUAL PHENOL AND TOTAL ANTIOXIDANT ACTIVITY OF AEGLE MARMELOS (L.) CORREA LEAVES

Sample	Total Phenol Content (mgGAE/g)	Polyphenol composition	Antioxidant Capacity	
			FRAP (µmol/L)	DPPH (IC_{50} value µg/ml)
Wild variety bael leaves	76	Gallic acid, Chlorogenic acid, Ferullic acid	14.65	437
Cultivated variety bael leaves	65	Gallic acid, Pyrocatechol, Ferullic acid	11.80	620

TABLE 4.11: CORRELATION BETWEEN TPC, FRAP AND DPPH

Parameters	Correlation
TPC & IC50	1
TPC & FRAP	1
IC50 & FRAP	1

Discussion

Proximate composition of the Aegle Marmelos (L.) Correa leaves

The wild and the cultivated variety of *Aegle Marmelos (L.) Correa* leaves were analysed for ash, moisture, protein, carbohydrates, fat, fibre total phenols, minerals and heavy metals. Ash usually represents the inorganic part of the plant (Vermani et al., 2010). The ash, moisture, protein, carbohydrate, fat and crude fiber content of wild variety of Gir and cultivated variety were 6.5% and 6%; 53.96% and 52.14%; 7.6% and 2.22% ; 10.38% and 5.42%; 8.18% and 12.78% and 30.14% and 25.10% respectively. On comparison with various studies, it is seen that ash and carbohydrate content is in the range given on table 4.12. But both the varieties of *Aegle Marmelos (L.) Correa* leaves in our study were having higher content of protein, fat and fibre.

The difference in the values may be due to the various reasons like age of the plant, the amount and composition of ash remaining after combustion of plant material, geographical locations, environment changes and various methods or treatment applied.

TABLE 4.12: COMPARISON OF PROXIMATE COMPOSITION OF AEGLE MARMELOS (L.) CORREA LEAVES WITH OTHER STUDIES

Sr. No	Parameter	Wild variety of leaf (%)	Cultivated variety *'Gomayasi'* (%)	Other studies	Range (%)
1	Total Ash	6.5	6.0	8.6% [b], 6.5% [d], 9.2% [a], 10.3% [c]	6.0-10.3
2	Moisture	53.96	52.14	65% [b], 66.5 [a], 67% [c]	52.1-67.0
3	Protein	7.60	2.22	6.2% [b], 5.9% [a]	2.22-7.6
4	Carbohydrate	10.38	5.42	4.3 [a], 10.5% [c]	4.3-10.5
5	Fat	8.18	12.78	1.7% [b], 1.8% [a]	1.8-12.8
6	Fibre	30.14	25.10	14.8 [a], 18 [c]	14.8-30.1

[a] Singh et al., 2012; [b] Dandapat et al., 2013, [c] Narendhirakannan, 2005; [d] Umadevi et al., 2012

Mineral content in Aegle Marmelos (L.) Correa leaves

Quantitative analysis of minerals in *Aegle Marmelos (L.) Correa* leaves were compared with other medicinal plants in Table 4.13, it was found that copper, iron and zinc were in the range given but lower than values given in other studies (Table 4.14).

X-ray Fluorescence being one of the most reliable and accurate, as well as consistent and non-destructive qualitative method for analysis of major and trace elements using a single pressed pellet. On comparison with the leaves of *Aegle Marmelos (L.) Correa* growing in semi-arid region of Kachchh district using XRF (Ram et al., 2015), it was seen that our variety had higher values for all the elements. Cobalt, arsenic, hafnium, vanadium, platinum, titanium, chromium and tantalum elements which were not detected in this study were present in our sample of *Aegle Marmelos (L.) Correa* (Table 4.15). Chromium and vanadium are essential for normal glucose homeostatis.

Implications of minerals present in Aegle Marmelos (L.) Correa leaves in health and disease especially in diabetes

Aegle Marmelos (L.) Correa leaf is good source of copper (11.5 ppm), iron (173 ppm), manganese (59 ppm) and zinc (43.5 ppm). *Aegle Marmelos (L.) Correa* leaf juice (20g/day) will provide 3.3 mg iron, 0.11 mg manganese, 0.076 mg zinc and 0.022 mg zinc which will add to health and improve normal carbohydrate and lipid metabolism and immunity system.

Sium et al., (2016) analyzed the levels of trace elements and their therapeutic role in the management of diabetes from selected medicinal plants such as *Aloe camperi*, *Meriandra dianthera*, *Lepidium sativum*, *Brassica nigra*, and *Nigella sativa*. These plants have been traditionally used for the treatment of diabetes and other ailments in Eritrea using inductively coupled plasma optical emission spectrometry (ICP-OES) and flame atomic absorption spectroscopy (FAAS) techniques. Mineral content in our samples are compared with the other medicinal plants in Table 4.13

TABLE 4.13: COMPARISON OF MINERAL CONTENT OF AEGLE MARMELOS (L.) CORREA WITH OTHER MEDICINAL PLANTS

Mineral	Range (ppm) Other medicinal plants*	Range (ppm) Present study	RDA[a]	UL[b]
Zinc	25-52	43.5	7-9mg	25mg
Manganese	18-80	59	3mg	11mg
Vanadium	1-9	4	10-20µg	1.8mg
Selenium	2.25-7.5	-	-	-
Magnesium	2000-11000	0.49%	280-350mg	350mg
Iron	117.32	178	9-15mg	25mg

Aloe camperi, Meriandra dianthera, Lepidium sativum, Brassica nigra,* and *Nigella sativa-Sium et al., 2016

[a-] RDA: recommended daily dietary allowance per day for adults; (WHO, 2011; WHO, 2007)

[b] UL: tolerable upper intake level per day for adults

Zinc plays a crucial role in the storage and secretion of insulin, which subsequently increases the uptake of glucose (Li, 2014). Vanadium affects various aspects of carbohydrate metabolism including glucose transport, glycolysis, and glucose oxidation and glycogen synthesis (Thompson, 2006). Manganese is also required for normal insulin synthesis, its secretion, and an alteration in its metabolism has been implicated in diabetes development (Kazi, 2008). It was demonstrated that magnesium deficiency might lead to a decrease in insulin mediated glucose uptake and has been associated with the development of insulin resistance (Viktorinova, 2009).

Selenium is constituent of glutathione peroxidase and other enzymes and has antioxidant property. Arsenic takes a role in metabolism of methyl compounds and the deficiency of it will lead to impairment of growth reproduction and heart function. The function of titanium is not known yet. It is harmless to our body. Normal potassium concentration is necessary for optimal insulin secretion, and deficiency of potassium causes diabetic acidosis. Potassium depletion can result in impaired glucose tolerance. (Anderon, 1998).

TABLE 4.14: COMPARISON OF MINERALS IN AEGLE MARMELOS (L.) CORREA LEAVES WITH OTHER STUDIES

Sr. No	Minerals	Wild variety of Leaf ppm/mg/ 100g (Present study)	Cultivated variety ppm/mg/ 100g (Present study)	Average value ppm	Other studies [a] (mg/ 100g)	Range (mg/ 100g)
1	Copper	12 /0.12	11/0.11	11.5	0.17 [b], 0.3 [a]	0.11-0.3
2	Iron	181/18.1	165/16.5	173	22.5 [a], 0.26 [b], 2.67 μg [c]	0.26-22.5
3	Manganese	62 /0.62	56/0.56	59	-	0.56-0.62
4	Zinc	49 /0.49	38/0.38	43.5	6.5 [a], 0.001 [b], 0.14 μg [c]	0.001-6.5

[a] Singh et al., 2012; [b] Dandapat et al., 2013, [c] Narendhirakannan et al., 2005

TABLE 4.15: COMPARISON OF TRACE ELEMENTS IN AEGLE MARMELOS (L.) CORREA LEAVES WITH OTHER STUDIES

Sr. No.	Element	% Mass by XRF (Wild variety)	% Mass by XRF (Cultivated variety)	% Mass by XRF (Ram et al, 2015)
1	Manganese	0.0062	0.0056	0.0037
2	Zinc (ppm)	0.0049	0.0038	0.0012
3	Magnesium	6.3	6.5	0.082
4	Silicon	3.9	4.03	0.586
5	Sulphur	0.92	1.51	0.503
6	Chlorine	4.0	5.68	3.51
7	Potassium	2.7	2.46	0.910
8	Calcium	79.3	76.9	6.61
9	Titanium	0.057	0.099	ND
10	Vanadium	0.043	0	ND
11	Chromium	0.067	0.027	ND
12	Magnesium	0.492	0.07	0.082
13	Iron	0.88	0.795	0.0657
14	Nickel	0.14	0.049	0.0030
15	Copper	0.025	0.17	0.0013

Heavy metals in Aegle Marmelos (L.) Correa leaves

In this study, the elemental composition in the leaves of *Aegle Marmelos (L.) Correa* widely used in the treatment of diabetes-related metabolic disorders has been studied using atomic absorption spectroscopy. As seen from the Table 4.15, the levels of Cu, Ni, Zn, K, Na Fe, Cr, and V were found to be in trace amounts. In the present study heavy metals like arsenic, mercury, lead and mercury were not detected but arsenic and lead were detected within permissible limits while mercury and arsenic and total pesticide residues were not detectable (ND) in *Aegle Marmelos (L.) Correa* leaf sample in a the study by Janarthanan et al (2012) (Table 4.16).

Various locations of the sample found was one of the reason for these variation in mineral level. It was shown that the same species of medicinal plants, growing in

different environments, accumulates different levels of heavy metals (Khan, Ahmad and Mohatir, 2006).

The carrier substances assure the delivery of trace elements to their specific sites of action. The action of trace element is specific to their specific sites of action and is dependent on properties such as valence state, redox potential, ionic radius, coordination number, coordination geometry, spin state (high slow spin transition), and rate of ligand exchange (Speck, 1949).

Some of the daily requirement of these elements are as follows; Iron 100mg per day for male, 15mg for female per day; Zinc 15mg/day, Mn 2.5-5mg/day, copper 2-3mg/day; chromium and Selenium -9.95,0.2mg/day.

The non-detection of heavy metals in *Aegle Marmelos (L.) Correa* leads to the fact that these plants are grown in pollution free areas of such elements and elemental uptake by these plants depends on soil characteristics and climatic condition. It is also an important environmental protector as *Aegle Marmelos (L.) Correa* leaves act as a sink by absorbing dust and foul and poisonous gases from surrounding atmosphere and makes them clean (Agarwal, 1997).

TABLE 4.16: COMPARISON OF HEAVY METALS IN AEGLE MARMELOS (L.) CORREA LEAVES WITH OTHER STUDIES

Sr. No.	**Heavy Metals**	**wild variety of *Aegle Marmelos (L.) Correa* Leaf (%)**	**Cultivated variety of *Aegle Marmelos (L.) Correa* 'Gomayasi' (%)**	**Heavy metals in other Study (Janarthanan et al., 2012)**
1	Cadmium	Nil	Nil	0.09
2	Arsenic	Nil	Nil	-
3	Lead	Nil	Nil	2.86
4	Mercury	Nil	Nil	-

Antioxidant capacity of Aegle Marmelos (L.) Correa leaves

Antioxidants which are immensely present in wild leaves or green leafy vegetables work by significantly slowing or preventing the oxidative or damage from oxygen process caused by free radicals such as superoxide radical (O_2), Hydroxyl radical (OH) and non-free radical species such as H_2O_2 and singlet oxygen (O_2) is associated with cellular and metabolic injury, accelerating aging, cancer, cardio-vascular diseases, neurodegenerative diseases and inflammation.

Comparison of Antioxidant Capacity of *Aegle Marmelos (L.) Correa* leaves with various other studies

The results of our study were compared with various other studies which reported TPC of *Aegle Marmelos (L.) Correa* leaf using spectrophotometric method. Our samples exhibited higher phenol content (Range 0.001 % - 7.6 %) and IC_{50} values in the range given in Table 4.17 (Range: 2.76 µg/ml - 1000 µg/ml) when compared with other studies.

These differences might be due to different samples used, various geographical locations of the plants and the methods used to evaluate antioxidant potency.

A direct correlation between DPPH radical scavenging assay (RSA) values and total phenol levels has been established suggesting that phenol compounds were likely to be contributing to the radical scavenging assay of these extracts (Miliauskas et al., 2004).

Bhatti et al., (2013) indicated presence of imperatorin, which is well documented for anticancer activity during HPTLC of ethanol fraction of *Aegle Marmelos (L.) Correa* leaf. The antiproliferative activity of imperatonin may be attributed to the presence of imperatorin and is mediated through multiple mechanisms and target sites including induction of apoptosis, antioxidant effect and inhibition of oncogenes (Bhatti et al., 2013).

TABLE 4.17: COMPARISON OF TPC AND ANTIOXIDANT ACTIVITY OF PRESENT STUDY WITH OTHER STUDIES

Variable	Wild variety of AM	Cultivated variety of AM	Other Studies	Range
Total Phenol Content (%)	7.6%	6.5%	0.009% [a], 0.81% [b], 2.4% [c], 0.001% [d]	0.001-7.6 %
IC_{50} values (µg/ml)	437	620	2.096 [a], 1000 [e]	2.096-1000 (µg/ml)

[a] Siddique et al., 2011; [b] Dandapani and Sabna, 2008; [c] Reddi et al 2012; [d] Sathya et al 2013; [e] Badam et al, 2002

Comparison of TPC with other medicinal plants

Different methanolic plant extracts were screened for their total phenol content by Veeru et al (2009). The TPC content of methanolic extracts expressed in gallic acid equivalents (GAE) varied between 10.47 ± 0.34 and 33.22 ± 1.28 mg/g . The TPC values of our samples were higher than these values (Table 4.1.14). Comparing our samples with this study (Table 4.18 and Table 4.19) it is seen that *Aegle Marmelos (L.) Correa* leaves has higher phenol content than these plants samples.

Many studies have shown that many polyphenols contribute significantly to the antioxidant activity and act as highly effective free radical scavengers which is mainly due to their redox properties, which can play an important role in adsorbing and neutralizing free radicals, quenching singlet and triplet oxygen or decomposing peroxides.

Comparison of Antioxidant property (FRAP) of *Aegle Marmelos (L.) Correa* leaves with other studies

Table 4.18 shows FRAP values in various extracts of medicinal plants samples. The FRAP values were in the range of 1.07±0.15- 3.70±0.11 mmol Fe/100 g of fresh weight. Our samples were analysed in dry powdered form and showed high FRAP values. Calculating for fresh weight (Moisture content-53%) the FRAP values turned

out to be 28.75 mmol Fe/100 g of fresh weight of wild variety and 23.16 mmol Fe/100 g of fresh weight of cultivated leaf sample (Table 4.18)

TABLE 4.18: TOTAL PHENOL CONTENT AND ANTIOXIDANT CAPACITY IN VARIOUS EXTRACTS OF SELECTED HERBS

Botanical name	Common name	Total antioxidant power (mmol Fe/100 g of fresh weight)	Total phenolics (mg of GAE/g of fresh weight)
Rosmarinus officinalis	Rosemary	3.70±0.11	33.22±1.28
Lavandula angustifolia	Lavander	2.87±0.29	13.31±2.15
Mentha aquatica	Orange mint	3.68±0.12	11.26±0.99
Mentha piperita	Peppermint	2.50±0.06	19.46±0.35
Mentha spicata	Spearmint	3.35±0.53	22.49±1.99
Ocimum basilicum	Sweet basil	2.52±0.37	25.69±2.41
Chicorium	chicory (leaf) common	1.07±0.15	10.47±0.34
Aegle Marmelos (L.) Correa leaf-wild variety	Bael (present study)	14.65 μmol/l	76.0
Aegle Marmelos (L.) Correa leaf-Cultivated variety	Bael (present study)	11. 80 μmol/l	65.0

Comparison of IC_{50} values in comparison with other studies

The methanolic crude extracts of some commonly used medicinal plants were screened for their free radical scavenging properties using 1, 1-diphenyl-2-picrylhydrazyl (DPPH) and ascorbic acid as standard antioxidant in a study by Khalaf et al (2008). The IC_{50} of the methanolic extracts ranged between 6.7 ± 0.1 and 681.5 ± 8.4 μg/ml and that of ascorbic acid was 8.9 ± 0.1 μg/ml. The antioxidant value of wild variety of our sample can be compared to *Trigonella foenum graecum* (Methi) (Table 4.19).

TABLE 4.19: COMPARISON OF ANTIOXIDANT PROPERTY OF AEGLE MARMELOS (L.) CORREA LEAF WITH OTHER MEDICINAL PLANTS

Plant extracts	**DPPH (IC_{50}) (**μg/ml)
Green tea	6.7±0.1
Black tea (*Camellia sinensis Linn*)	9.7±0.1
Eugenia caryophyllus (Spreng)	9.9±0.2
Piper cubeba (Linn.), Pipli	65.1±1.7
Bullock and Harrison	11.3±0.3
Trigonella foenum graecum (Methi)	444.1±5.5
Zingiber officinale Roscoe	144.1±2.2
Piper nigrum (Linn)	
Ascorbic acid	8.9±0.1
Aegle Marmelos (L.) Correa wild variety (present study)	437 μg/ml
Cultivated variety (present study)	620 μg/ml
Aegle Marmelos (L.) Correa leaves [a]	1000 μg/ml

(Souces: Khalaf et al, 2008), [a] Badam et al., 2002

Antioxidant property of different phenotypic traits of *Aegle Marmelos (L.) Correa* leaves using DPPH and FRAP methods was studied by Ariharan and Prasad (2008). The antioxidant property of the water and methanolic leaf extracts of 3 different traits at four different concentrations were studied. Out of the three different traits studied the traditional small 3 leaves showed maximum DPPH activity and Iron chelating activity (FRAP) in all concentrations.

Since *Aegle Marmelos (L.) Correa* is rich in antioxidant, it can be used as food additives to delay the oxidative deterioration of foods and as neutraceutical in medicinal formulation against degenerative diseases. *Aegle Marmelos (L.) Correa* can be used as a natural antioxidant, antipyretic, antibiotic and immunomodulatory drug (Panaskar et al., 2013). It can also be used as a remedy for diabetes as it contains aegelinnosides A and B isolated from *Aegle Marmelos (L.) Correa* leaves as alpha-glycosidase inhibitors. Of the compounds isolated, anhydroaegeline revealed the most

potent inhibitory effect against alpha-glycosidase with IC_{50} value of 35.8 mM (Phuwapraisirisan, 2008). This result support ethno pharmacological use of A. marmelos as a remedy for diabetes mellitus.

Individual phenols

HPLC analysis for quantification of individual phenolics compounds revealed the presence of gallic acid, Chlorogenic acid and Ferullic acid in wild variety whereas gallic acid, Ferullic acid and Pyrocatechol in cultivated variety.

A large number of these phytomolecules viz. Quercetin, gallic acid, Chlorogenic acid, quercetin-3-O-glucopyranoside, kaempferol, rutin are well known to possess potent antioxidant activities (Khanduja *et al*., 2006; Prakash *et al*., 2007). From the results, it is clear that gallic acid present in appreciable quantities in *Aegle Marmelos (L.) Correa* might be responsible for its efficient *in vitro* antioxidant property. Gallic acid has been shown to inhibit cell proliferation in prostate cancer cells. Chlorogenic acid contains anti-cancer, antimicrobial, anti-LDL (bad cholesterol) and antiviral properties.

Warrier et al., (2012) reported the following compounds with Retention Values (Rf) values in *Aegle Marmelos (L.) Correa* leaves -1) 0.076 flavonoid glycoside 2) 0.150 pyrocatechuic acid 3) 0.225 gallic acid 4) 0.270 flavonoid glycoside 5) 0.316 rutin 6) 0.359 umbelliferone 7) 0.385 ellagic acid 8) 0.416 psoralen 9) 0.449 Marmelosin 10) 0.450 Quercetin glycoside 11) 0.505 Chlorogenic acid 12) 0.674 hyperoside 13) 0.754 catharanthine 14) 0.815 isoquercetin 15) 0.846 vindoline 16) 0.960 Quercetin 17) 0.985 vanillin acid.

In a study by Karawya et al. (1980), the major constituents of the *Aegle Marmelos (L.) Correa* leaf extract were identified to be tannins, Skimmianine, essential oil (mainly caryophyllene, cineole, citral, eugenol), sterols and or triterpenoids, including lupeol, β- and γ-sitosterol, α- and β –amyrin, flavonoids (mainly rutin) and coumarins, including Aegelin, marmesin and umbelliferone (Karawya et al., 1980). *Aegle Marmelos (L.) Correa* showed alkaloids as the major compounds, characterized by its Rf values. *Aegle Marmelos (L.) Correa* has been a major component of many

medicinal preparations which might be due to the presence of higher alkaloid content; phenols which comprise of tannins were also high in it.

Aegle Marmelos (L.) Correa is a good chelator, and this might contribute, at least in part, to these observed antioxidant properties effects (Baliga et al., 2010). A perfect correlation (r=1) was seen between total phenol content and antioxidant property using FRAP and DPPH assay (Table 4.11).

Conclusions

In this phase of present study, an attempt has been made to investigate *Aegle Marmelos (L.) Correa*, a traditional medicinal plant for proximate principles, trace elements, heavy metals and total antioxidant capacity of the wild and cultivated variety of leaves.

From the results, it can be concluded that *Aegle Marmelos (L.) Correa* leaves which are widely used in folk medicine in the Indian traditional system of medicine can be considered a good sources of protein, carbohydrates and fibre. It is also rich in mineral elements and non-toxic (free of heavy metals) and rich source of antioxidants.

Aegle Marmelos (L.) Correa leaves have exhibited high phenol content, rich polyphenol profile and strong antioxidant capacity. When compared to the other commonly consumed herbs and medicinal plants, it has come out as a potent antioxidant. The antioxidant potential is attributed to its polyphenol content. These phenols also provide myriad protective actions. Further human intervention trials are warranted as to study the beneficial effects on humans, for knowledge about molecular basis of these effects animal and cell model studies are required.

Based on above results, wild variety of *Aegle Marmelos (L.) Correa* leaves was found to be superior to the cultivated variety and was selected for supplementation to the Experimental group during clinical trial phase.

HIGHLIGHTS OF THE SECTION

- The proximate composition of the wild and cultivated varieties of *Aegle Marmelos (L.) Correa* leaves indicated that it is good source of protein (7.6%; 2.22%), carbohydrates (10.38%; 5.42%), fat (8.18%;12.78%) and fibre (30.14%; 25.10%).
- The trace elements (copper, iron, manganese and iron) were present in both the varieties of *Aegle Marmelos (L.) Correa* leaves and they were found to be good source of minerals.
- None of the heavy metals like lead, cadmium, arsenic and mercury were detected in both the varieties of *Aegle Marmelos (L.) Correa* leaves and were free of contamination and toxicity.
- Both the varieties of *Aegle Marmelos (L.) Correa* leaves were found to be rich source of antioxidant (FRAP: 14.65μmo;/L ,11.80 μmol/L) (IC_{50}: 437μg/ml, 620 μg/ml) However wild variety was superior to cultivated one with respect to FRAP and DPPH values:
- TPC of wild variety (7.6%) was more than cultivated variety (6.5%).
- HPLC analysis for quantification of individual polyphenol revealed the presence of Gallic acid, Chlorogenic acid and Ferullic acid in wild variety whereas Gallic acid, Ferullic acid and Pyrocatechol in cultivated variety.
- Based on above results, wild variety of *Aegle Marmelos (L.) Correa* leaves were selected for supplementation to the experimental group during clinical trial phase.

PHASE II

Knowledge, practice and use (KPU) of *Aegle Marmelos (L.) Correa* leaves with practitioners of Ayurveda and Naturopathy.

RESULTS

Results of desk reviews of Ayurvedic formulations of Aegle Marmelos (L.) Correa for general health and disease as reported in the literature

Various university library visits and desk reviews on commercial formulations of *Aegle Marmelos (L.) Correa* available in the online market revealed that various therapeutic uses of *Aegle Marmelos (L.) Correa* leaves were available in Ayurveda such as its potency as anti-inflammatory activity, uses in insect bites, fever, for headache, use in diarrhea, pain reliever, etc. However all the drug formulations consisted of several ingredients containing *Aegle Marmelos (L.) Correa* leaves as one of them. These poly herbal formulation of *Aegle Marmelos (L.) Correa* leaves were available commercially in the registered Ayurveda pharmacies (Table 4.20).

Other Ayurveda formulations such as Dasmula-taila, Amritarista, Chyavana-prasa, Mahanarayana taila, Dhanya Panchaka Kvatha, Pusyanuga churna, Vatsakadi Kvatha. are mentioned in Ayurvedic Pharmacoepia of India part I (API, 1990)

TABLE 4.20 : VARIOUS AYURVEDIC FORMULATIONS OF AEGLE MARMELOS (L.) CORREA AVAILABLE COMMERCIALLY FOR GENERAL HEALTH AND DISEASE AS REPORTED IN THE LITERATURE

Name of the	Formulations (PHF)	Claims

Company		
Baidyanath	Dashmool (Roots)	Decoction of the root are to be taken to relieve palpitation of the heart
	Bilva Taila (Leaf)	oil prepared with bael root is used in ear diseases
	Vilwadi Gulika (Leaf)	used in insect bites, fever
	Astapatra taila (Leaf)	treatment of headache
	Kutajavaleha and Brihat Gangadhara Churna (Fruit)	useful in diarrhoea and dysentery
	Divya-Pidantaka Rasa (Leaf)	useful in joint pain, arthritis, lumbar pain, cervical spondylitis and sciatica
	Divya-Pidantaka Taila (Leaf)	relieves pain of lumbar region, knee-joints, cervical spondylitis, oedema & inflammation.
Himalaya	Chyawanprash (Fruit)	Used for digestive disorder and immunity

Result of desk reviews of the use of Ayurvedic poly herbal formulation (PHF) of Aegle Marmelos (L.) Correa available commercially to control blood sugar reported in the literature

Desk review reveals that various Ayurvedic poly herbal formulations (PHF) were available containing various parts of *Aegle Marmelos (L.) Correa* such as leaves, fruits, stem bark and roots. Also there were mixtures of other medicinal plants such as *Murraya koenigii, Aloe vera, Pongamia pinnata and Elaeodendron glaucum, Ficus benghalensis, Catharanthus roseus, Bambusa arundinaceae, Salacia reticulata and Szygium cumini* and '*Eruca sativa.'etc.* were mentioned in review of literature.

Some of the different polyherbal formulation that have been confirmed by scientific investigation, which appear to be most effective, relatively nontoxic and have substantial documentation of efficacy having *Aegle Marmelos (L.) Correa* leaves are given in Table 4.21 and their ingredients involved with their claims are given in Table 4.22.

TABLE 4.21 : AYURVEDIC POLY HERBAL FORMULATIONS OF AEGLE MARMELOS (L.) CORREA TO CONTROL BLOOD SUGAR LEVELS AVAILABLE COMMERCIALLY

Formulations	Type (Single/ PHF)	Constituents	Dosage
Bilvadi Leha, Brithatgangadhara churna	PHF	Bael dry leaf powder	3-6g in powdered form
Pancrease Tonic (Hsia et al., 2004)	PHF	It is herbal mixture of 10 herbal extracts contains 30-40% bael leaf	2 tsp 2 times daily
ESF/AY/500 (Sajeeth et al., 2010)	PHF	Composed of bael leaf as one out of 8 medicinal plants	Capsules 500 mg
5 EPHF (Lanjhiyana et al., 2007)	PHF	Composed of bael leaf as one out of 5 medicinal plants	200mg/kg
Divya Madhunasini vati (Himalayan healthcare system)	PHF	500 mg tablet containing 15 mg bael leaf	1-2 tablets twice a day with warm water or milk one hour before breakfast or dinner
DIABAC Patanjali Ayurved products	PHF	Each tablet contains 100mg bael leaves in 1 capsule	2 tablets twice a day after meals

TABLE 4.22: CONSTITUENTS OF THESE POLY HERBAL FORMULATION AND THEIR CLAIMS

Name of poly herbal	Constituents/ingredients	Claims

formulation		
Madhumehantak churna (Malaviya, 2013)	Saptarangi, vijaysar, Bilvapatra, Gurmar Gymnema, Giloy and Daru haldi	1-2 teaspoonfuls of this powder consumed twice in a day either with apple juice, sugarless iced tea or plain water controls blood sugar
Pancrease tonic/ (Hsia et al., 2004)	*Pterocarpus marsupium , Syzigium cumini, Momordica charantia, Gymnema sylvestre, Trigonella foenum graecum, Azadirachta indica, Ficus racemosa, Tinospora cordifolia, Cinnamum tamala*	Therapy with Pancreas Tonic 2 capsule 3 times a day for 3 month significantly lowered HbA1c in those type 2 diabetic subject with a baseline HbA1c level between 10.0 to 12.0%.
ESF/AY/500-PHF (Sajeeth et al., 2010)	*Ficus benghalensis, Catharanthus roseus, Bambusa arundinaceae, Salacia reticulata and Szygium cumini* and '*Eruca sativa.'*	The ethanolic extract of ESF/AY/500 exhibited significant antioxidant activity showing increased levels of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), and reduced glutathione(GSH) and decreased level of lipid peroxidation
5EPHF (Lanzhiana et al., 2007)	*Aegle Marmelos (L.) Correa , Murraya koenigii, Aloe vera, Pongamia pinnata and Elaeodendron glaucum*	A dose 200 mg/kg to diabetic rats resulted in significant reduction of BS,TC,TG,LDL, creatinine and urea and improved antioxidant enzymes in alloxanized rats
Diabeta (*Narayana and Subhose, 2005*	*Gymnema sylvestre* (leaves) *Tinospora cordifolia* (stems), *Azadirachta indica* (leaves), *Phyllanthus emblica* (fruits), *Curcuma longa* (roots) and *Aegle Marmelos (L.) Correa* (leaves) 15%	4 gm of mixed powder, twice a day with water controls blood sugar
DIABAC	Gurmar, shilajeet, *Aegle Marmelos (L.)Correa*, Jamun mingi, Nyagrodha	2 tablets twice a day regenerates β cells of pancreas, relieves symptoms like thirst and frequent urination

These Ayurvedic poly herbal formulations as traditional Ayurvedic remedy for diabetes work as under-

- Helps support the pancreatic function to regulate insulin secretion
- Helps the liver to regulate the carbohydrate metabolism
- Helps to recover from the weakness and body aches.
- Regulates the body weight
- Helps in preventing the complications of diabetes like diabetic neuropathy, nephropathy, myopathy

Some of the marketed formulations of *Aegle Marmelos (L.) Correa* produced by different companies in tablets, capsules and syrups form, are listed in Table 4.23

TABLE 4.23: VARIOUS AYURVEDIC FORMULATIONS OF AEGLE MARMELOS (L.) CORREA USING LEAF, FRUIT, ROOT AND STEM BARK

Sr. No.	Marketed formulations	Company name
1	Chyawanprash	Himalaya
2	Entrostat Syrup Ambika, Kof-Rid Syrup Ambika Medico	Ambika Medico
4	*Aegle Marmelos (L.) Correa* Capsules	La-Medicca (India) Pvt. Limited
5	Leucare capsules Shrey	Shrey Nutraceuticals & Herbals
6	Pregeight	Sydler Remedies Pvt. Ltd.
7	Ojamin Tates Remedies	Tates Remedies
8	Manasamithravatakram, Pushyanugam gulika, Pushyanugam gulika, Vilwadi gulika Oushadhi	Oushadhi
11	Glucomap	Maharishi Ayurveda
12	UlcoBliss Tablets	Bliss ayurveda
13	Capsule Bilv Giri	Ayurvedic Sanjivani
14	R-Qunol Syrup	Vatsal Ayurvedic Products (P) Ltd

(Malaviya et al., 2012)

Desk reviews revealed many commercial uses of *Aegle Marmelos (L.) Correa*. The Fig: 4.12 shows various brands consisting of *Aegle Marmelos (L.) Correa* available commercially in the market.

FIG 4.12: VARIOUS BRANDED AYURVEDIC FORMULATIONS OF *AEGLE MARMELOS (L.) CORREA* (DABUR, BAIDYANATH, PATANJALI, DIVYA AND HIMALAYA PHARMACY)

Use of Aegle Marmelos (L.) Correa in various Naturopathic preparations available commercially to control blood sugar reported in the literature

Naturopathy or naturopathic medicine is a form of alternative medicine employing a wide array of pseudoscientific modalities that are branded as "natural," including homeopathy, herbalism, and acupuncture, in addition to diet and lifestyle counseling (http://www.indianmedicine.nic.in/). Naturopaths believed in the principle of removal of toxins from the body which is the root cause of all the diseases. They relied on the fresh form of dose for the instant effect. So there were no commercial preparations available for blood sugar control.

Conclusions

From the several pharmacological activities and various poly herbal formulation narrated above, it is concluded that *Aegle Marmelos (L.) Correa* (Bael) is a plant of multiple medicinal properties. This plant has been used in traditional system of medicine for the treatment of various diseases. Studies in the desk review easily predict the fact that whole plant of *Aegle Marmelos (L.) Correa* has sufficient medicinal value.

Desk reviews revealed that *Aegle Marmelos (L.) Correa* leaves were being recognized as a remedy for the treatment of diabetes in both Ayurveda and Naturopathy. Many Ayurvedic formulations were available commercially in the market of various reputed brands such as Dabur, Himalaya, Oshidhi, Patanjali etc. which contained *Aegle Marmelos (L.) Correa* leaves in the form of various powder, tablets, capsules, etc. These formulations were selling the products and drugs in poly herbal formulations (PHF) rather than single drug.

Naturopathy did not contain any commercial brands of *Aegle Marmelos (L.) Correa* leaves as it believes in fresh doses of the plant.

Results of Key informant interviews of Ayurvedic and Naturopathic practitioners (ten each) are as given below

General information regarding the practitioners

The mean age of the Ayurveda practitioners enrolled for the study was 54.1 years (range of 35-70y). They all were qualified with either Bachelor of Ayurvedic - Medicine and Surgery (B.A.M.S) or Bachelor of Surgery and Ayurvedic Medicine (B.S.A.M), M.D. (Ayurveda) degrees and were giving treatment through *panchkarma.* The mean age of the naturopathic practitioners was 47.5 years (age range of 33-55 years) and all had a degrees such as Diploma in Naturopathy and Yoga (N.D.D.Y)., M.B.B.S., Diploma in Child Health (D.C.H), Diploma in Alternative Medicine, Naturopathy and Yoga (A.D.N.Y) and running a *Nisargopchar Kendra.* The mean age of Ayurveda practitioners was 54.1 years (age range of 40-70 years). Ninety five percent of them were qualified to practice Indian Medicine in any part of India (Table 4.24).

TABLE 4.24: GENERAL INFORMATION REGARDING PRACTITIONERS

Type of Practitioners	Mean Age (Years)	Range (years)	Degree of profession
Ayurveda (n=10)	54.1	40-70	B.A.M.S or B.S.A.M
Naturopathy (n=10)	47.5	35-60	N.D.D.Y, M.B.B.S

Comparison of Ayurveda and Naturopathic practitioners

As can be seen from Table 4.25, both the types of practitioners had good knowledge regarding beneficial use of *Aegle Marmelos (L.) Correa* (AM), plant as a whole and leaves in particular. Seventy two percent of Ayurveda practitioners were using Bael in various forms for the treatment of various diseases such as diarrhoea, dysentery acidity, gastric ulcer, diabetes, cough cholestrolemia, oedema, fever, ophthalmic, arthritis, jaundice, food poisoning, removal of toxins, skin allergy, back-pain, loose motion, conjunctivitis etc.

All the practitioners were aware of the medicinal properties of *Aegle Marmelos (L.) Correa* . Regarding the various parts of bael that were most beneficial in the treatment

of various diseases, leaves and fruits are more important-raw fruit is used for the treatment of diarrhoea and ripe fruit is used for the treatment of acidity and gastric ulcer.

Naturopathic practitioners knew about the medicinal properties of this plant. It was used mainly in oedema, diarrhoea and other digestive disorders. Among various parts of this plant like root, fruit, stem, leaf etc., roots and fruits were used in acidity (*vaat na rogo*), all types of pains, nervous disorders, cytica, and muscular disorders. (Table: 4.25). Few also reported that tender new leaves are effective in not only diabetes but also constipation (dosage-15-20 triplet or trifoliate leaves- "*Akhandpaan*"). Bael fruit is used in the treatment of diarrhoea. Ripe fruit sherbet is used for the prevention of heat wave "loo". Some reported that *Aegle Marmelos (L.) Correa* is used in powdered form for the treatment of diabetes and oedema. One of them said that leaves contain an alkaloid rutacin which is hypoglycaemic. 'two leaves before breakfast' is said to keep diabetes under control.

TABLE 4.25: COMPARISON OF KNOWLEDGE REGARDING DISEASES IN WHICH AEGLE MARMELOS (L.) CORREA WAS USED BY AYURVEDA AND NATUROPATHY PRACTITIONERS

Types of practitioners	**Use of AM in diabetes**	**Diseases in which *Aegle Marmelos (L.) Correa* is used**
Ayurveda	72%	Diarrhoea, Dysentery acidity, gastric ulcer, Diabetes, cough, cholestrolemia, oedema, fever, opthalmia, arthritis, jaundice, conjunctivitis etc.
Naturopathy	40%	Food poisoning, diabetes, removal of toxins, skin allergy, back-pain, loose motion etc.

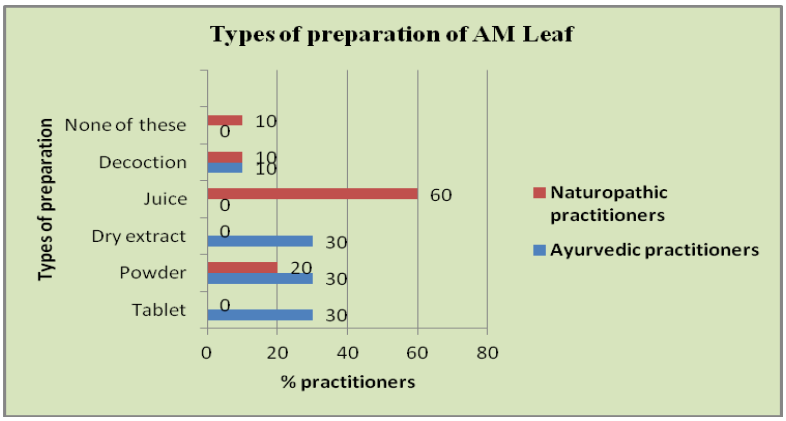
Comparison between Ayurveda and Naturopathic practitioners for the types of preparation of *Aegle Marmelos (L.) Correa* leaves in various treatment

Ayurvedic practitioners used various forms of preparation of leaves like tablet, powder, dry extract and decoction. Mostly powdered form of *Aegle Marmelos (L.) Correa* leaves is used more as juice is inconvenient to be given to the patients. It can be given in powdered form or raw form. Kerala Ayurvedic centre reported that *Aegle Marmelos (L.) Correa* can be used for external applications for removal of skin allergies in the form of goli, chawanprash leham or decoction. Whereas naturopathic practitioners preferred raw intake of the leaves in the form of paste or juice (Table 4.26 and Fig: 4.13). The most preferred form of preparations among Ayurveda practitioners were tablet, powder and dry extract (30% each) whereas fresh juice of *Aegle Marmelos (L.) Correa* was the most preferred recommendation by Naturopathic practitioners (60%).

TABLE 4.26: COMPARISON BETWEEN THE TYPES OF PREPARATION OF AEGLE MARMELOS (L.) CORREA LEAVES USED BY AYURVEDA AND NATUROPATHIC PRACTITIONERS

Types of Practitioners	**Types of Preparation**					
	Tablet	Powder	Dry extract	Juice	Decoction	None of these
Ayurvedic	30%	30%	30%	_	10%	_
Naturopathic	_	20%	_	60%	10%	10%

FIG 4.13: TYPES OF PREPARATION OF AM LEAF



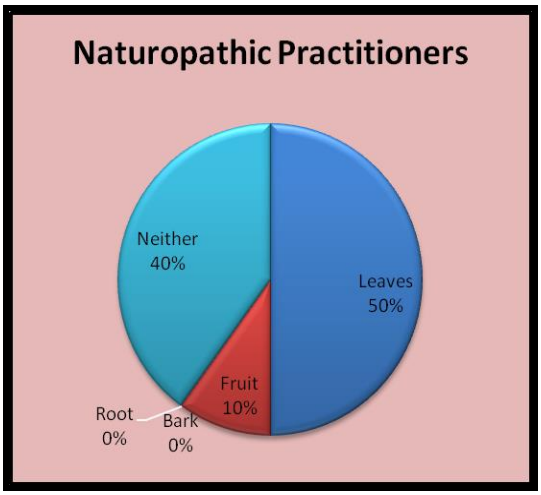
Parts of *Aegle Marmelos (L.) Correa* plant used in various treatment according to various practitioners

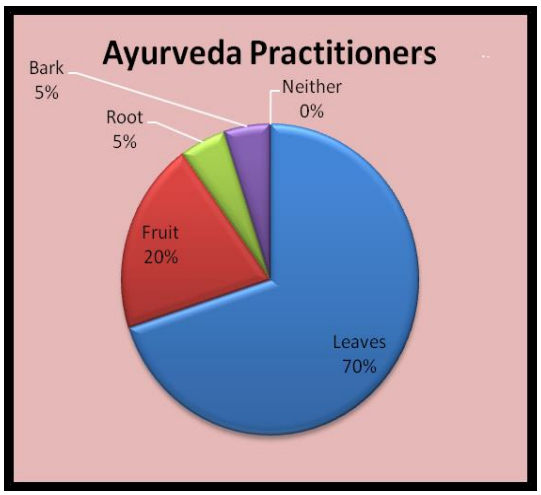
As seen from the Table 4.27 and Fig: 4.14 ; Fig: 4.15, leaf is the maximum part of the plant utilized for medicinal purpose in comparison to fruit, root, bark and stem. Out of various parts, Ayurveda practitioners used 70% leaf in comparison to other parts whereas naturopathic practitioners used 50% leaves for the treatment of various diseases. This finding is similar to the result of Chanda and Dave (2009) who screened out various medicinal plants for their antioxidant potential and concluded that generally, any part of the plant can be used for antioxidant studies but most commonly used part is leaf followed by fruit which is generally used for treating gastrointestinal disorders.

TABLE 4.27: PARTS OF AEGLE MARMELOS (L.) CORREA LEAVES USED IN VARIOUS TREATMENT ACCORDING TO VARIOUS PRACTITIONERS

Types of Practitioners	Leaves	Fruit	Root	Bark	Neither
Ayurveda	70%	20%	5%	5%	_
Naturopathic	50%	10%	_	_	40%

FIG: 4.14 AND FIG: 4.15: USE OF PLANT PARTS BY THE NATUROPATHIC PRACTITIONERS AND AYURVEDIC PRACTITIONERS





Forms of preparation:

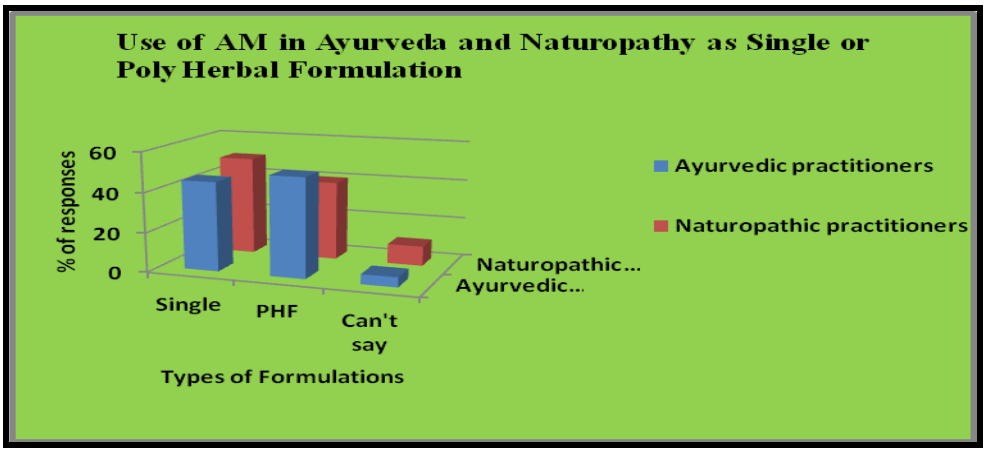
Many different plants have been used individually or in poly herbal formulations for treatment of diabetes and its complications. One of the major problems with this herbal formulation is that the active ingredients are not well defined. It is important to know the active component and their molecular interaction, which will help to analyze therapeutic efficacy of the product and also to standardize the product. As can be seen from Table 4.28, *Aegle Marmelos (L.) Correa* was utilized for the medicinal purpose either singly or in combination. The Ayurveda practitioners used 45% *Aegle Marmelos (L.) Correa* leaves in single and 50% in combination whereas Naturopathic practitioners used 50% *Aegle Marmelos (L.) Correa* leaves singly and 40% in combination.

TABLE 4.28: COMPARISON BETWEEN FORMS OF THE PREPARATION

Types of Practitioner	Single	PHF	%	Type of combination	Can't Say
Ayurveda	45%	50%	30%	(AM+ Curcumin longa (Haldi) + pterocarpus Marsupium (Vijaysar)	5%
			20%	(AM+Azadirachta indica (neem) + Curcumin longa	
Naturopathic	50%	40%	20%	(AM +piper nigrum)	10%
			20%	(AM + Azadirachta indica + Curcumin longa)	

PHF-Poly Herbal Formulations

FIG 4.16: PERCENT RESPONSE OF AYURVEDA AND NATUROPATHY PRACTITIONERS ON THE USE OF *AEGLE MARMELOS (L.) CORREA* AS SINGLE AND PHF



Dosage of *Aegle Marmelos (L.) Correa* given in diabetes

Dosage of *Aegle Marmelos (L.) Correa* leaves regarding treatment for diabetes was not fixed. Twenty percent told that depending upon the body weight maximum 2 grams twice a day (1g-4 tablets each of 250 mg of *Aegle Marmelos (L.) Correa* leaves) was sufficient. However the duration depended upon the severity of the diabetic condition but maximum 45 days supplementation was sufficient for reversal to the normal condition. Practitioners from Kerala Ayurvedic Centre did not make use of the AM in the treatment of diabetes but recommended standard drug like Diarid, Glysokit and Nishakathakaadi Kasayam Kwath which did not include *Aegle Marmelos (L.) Correa* . No single drug or component were used but compounds were mixed in polyherbal formulation and decoction was advised.

There was no standardized dosage formulation agreed upon by all the practitioners. 50% of the Naturopathic practitioners were of the opinion that *Aegle Marmelos (L.) Correa* leaf in fresh form alone is sufficient to control high blood sugar. According to them, juice of 22-40g fresh leaves made to a final volume of 100ml with water could be given to patient every day in the morning empty stomach. Duration varied from 45-60 days for significant reduction in blood sugar levels.

However 40% were in favour of poly-herbal formulation. Forty percent Naturopathic practitioners were of the opinion that *Aegle Marmelos (L.) Correa* alone is not effective enough. Twenty percent said that *Aegle Marmelos (L.) Correa* should be

combined with other herbs like Neem and Curcumin (Haldi). So according to them, one tsp of dry *Aegle Marmelos (L.) Correa* leaf powder with half teaspoon of Neem and Curcumin (haldi) in the form of polyherbal formulation twice a day is very effective treatment for uncontrolled diabetes.

Twenty percent Naturopathic practitioners said that 10-20 green leaves of *Aegle Marmelos (L.) Correa* crushed with 5-7 piper nigericum (*kali mirch*) and taken early morning helped in maintaining normal sugar levels. Ten percent could not agree upon form and dosage. Also they insisted upon inclusion of green leafy vegetables and fruits to form part of their daily diet. Raw diet was important part of treatment along with drug therapy. Forty percent of the Naturopaths did not use either leaf or fruit of *Aegle Marmelos (L.) Correa* since their line of treatment is based on detoxification of body and its self healing, so they used less of medicinal herbs and that too common culinary items like Bitter-gourd (karela) and Fenugreek (methi) were used by them in the treatment of diabetes.

Forty five percent Ayurveda practitioners agreed that treatment with *Aegle Marmelos (L.) Correa* leaves only is enough to control high blood sugar. According to them one tsp dry *Aegle Marmelos (L.) Correa* leaf powder can be given with warm water twice a day to control high blood sugar levels. Fifty percent Ayurveda practitioners believed that *Aegle Marmelos (L.) Correa* leaves are not sufficient to cause change in high insulin levels and combined therapy in the form of polyherbal formulation is more effective. Other herbs and spices like curcumin, Azadirachta indica (neem) and pterocarpus Marsupium (Vijaysar) could be combined with *Aegle Marmelos (L.) Correa* in dry powdered form twice a day. The duration varied from 2-3 months. However 5% of Ayurveda doctors could not agree upon any fixed dosage and form of therapy.

Various Ayurvedic pharmacopeia preparations involving *Aegle Marmelos (L.) Correa* leaf

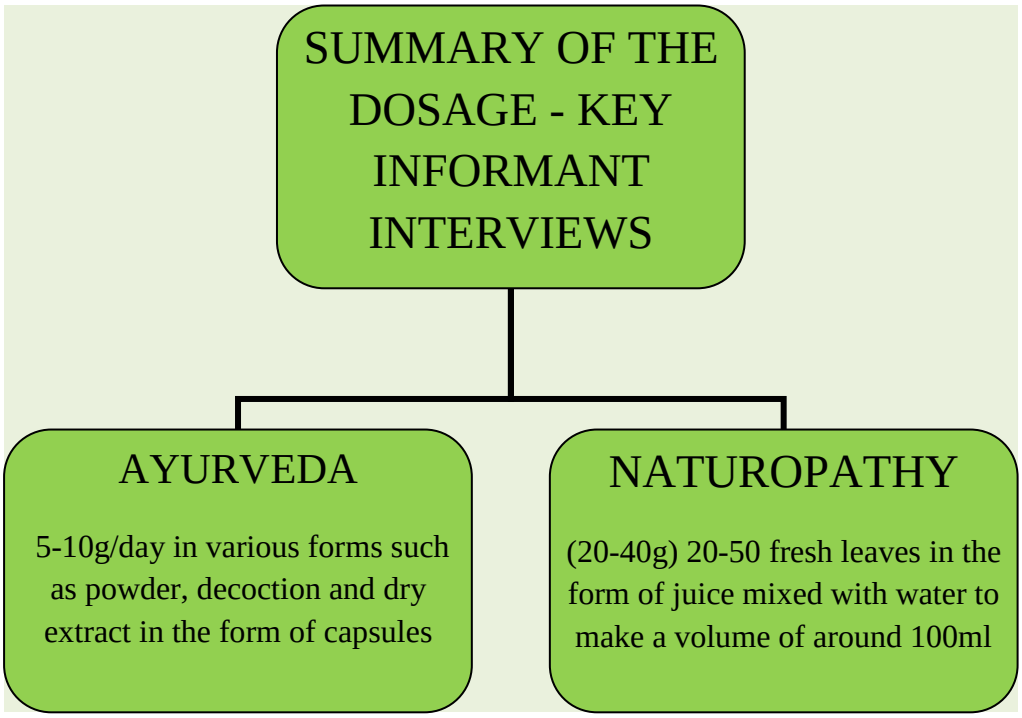
According to Ayurvedic practitioners, various Ayurvedic pharmacopeia preparations like Bilvadi tablets, Bilvadi Ras, Bilvadi ghanvati, Bilvadi churna, bilvadi taila, bilvamuladi gutika, Lakshmana louh (Bhaishajyaratnavali), jeera kabilwadi leha, dashmularishta, murraba, sherbet (of fruit) made from *Aegle Marmelos (L.) Correa*

were the specific formulations being prescribed for the treatments. Others reported that both single or PHF can be given.

Ayurveda practitioners used *Aegle Marmelos (L.) Correa* leaves for the treatment of diabetes. Dosage for the treatment ranged from 5-10g/day in various forms such as powder, decoction and dry extract in the form of capsules (1 capsule contains 0.5mg of extract which is equivalent to 5mg of leaf powder)

Naturopathic practitioners used the *Aegle Marmelos (L.) Correa* leaves for the treatment of diabetes and the dosage ranged from 20-40g fresh leaves in the form of juice mixed with water to make a volume of around 100ml (Fig 4.17)

FIG 4.17: SUMMARY OF DOSAGE RECOMMENDED BY THE PRACTITIONERS



Discussion

Phase II involving Knowledge, practice and use of *Aegle Marmelos (L.) Correa* and its desk reviews focused on an overall use of plant *Aegle Marmelos (L.) Correa* leaves used in Ayurveda and its future prospects for the further scientific investigation. It also helped to throw some light on dose formulation for its supplementation in clinical trial.

Ayurvedic practitioners gave 5-10g/day in various forms such as powder, decoction and dry extract in the form of capsules whereas Naturopathic practitioners recommended 20-40 fresh *Aegle Marmelos (L.) Correa* leaves for the treatment of diabetes in the form of juice mixed with water to make a volume of around 100ml. Several branded Ayurveda poly herbal formulation of *Aegle Marmelos (L.) Correa* leaves were available in many pharmacies but *Aegle Marmelos (L.) Correa* leaves were not available as a single drug.

From the results of Phase II, 10-30 g of fresh *Aegle Marmelos (L.) Correa* leaves were selected for the standardization of various doses prepared using 10g, 20g and 30g leaves used in making 100ml juice which were subjected to sensory evaluation to type II diabetic subjects.

HIGHLIGHTS OF PHASE II

- Ayurvedic practitioners were of the opinion that *Aegle Marmelos (L.) Correa* can be given for the treatment and dosage ranged from 5-10g/day in various forms such as powder, decoction and dry extract in the form of capsules (1 capsule contains 0.5mg of extract which is equivalent to 5mg of leaf powder)
- Naturopathic practitioners recommended *Aegle Marmelos (L.) Correa* leaves for the treatment of diabetes and the dosage ranged from 20-40 g fresh leaves in the form of juice mixed with water to make a volume of around 100ml.
- Desk reviews also revealed that several herbal medicines are already available in the commercial markets claiming the use of *Aegle Marmelos (L.) Correa* leaves in many diseases specially diabetes
- Based on the results of Phase II, 10-30 g of fresh *Aegle Marmelos (L.) Correa* leaves were selected for the standardization of various doses prepared using 10g, 20g and 30g leaves used in making 100ml juice which were subjected to sensory evaluation to type II diabetic subjects, since availability of fresh bael leaves was not a problem for the clinical trial.

PHASE III

Impact of *Aegle Marmelos (L.) Correa* leaf juice supplementation on blood sugar levels, lipid profile, liver and kidney functions of type II diabetes subjects.

RESULTS

Baseline information of the Type II diabetic subjects

The mean age of study population is given in Table 4.29. The mean age of the subjects was around 51 years (Mean ± SD: 51.35 ± 9.13). The socioeconomic status of the subjects is depicted in Table 4.30. The table depicts the following trend:

- Mean age: The mean age of study population was 51.35 ± 9.13 (male: 50.8 ± 11.14 and female: 51.7 ± 7.52).
- Gender: Around 40% were males and 60% were females
- Religion: Almost all (94%) subjects were following Hindu religion (M- 100%, F-88.7%). However 5% females were Muslims and 1 % female was Christian.
- Marital Status: Eighty eight percent male and 83% female subjects were married whereas 8% males and 4% females were unmarried.
- Family type: Of all the subjects, 56.67% lived in joint families and 38.34% in nuclear families.
- Educational status: Thirty percent of the total subjects were illiterate. 45.41% females and 8 % males were illiterate. 36% of the males as well as females with total 30% subjects received primary education. 20% subjects received secondary education. Only 6.67% had studied up to graduation level comprising of 4% males and 8.57% females.
- Occupation: Thirty six percent males and 5.71% females with total of 18.34% were employed outside whereas same number of subjects was having their own business. 51.67% females subjects were house wives. 10% of the subjects were retired.
- Family size: The average family size of all the subjects was found to be 5-6 members.
- Family income: Majority of the subjects (81.67%) were having average monthly family income between Rs. 3000-25000 followed by 10 % of the subjects having income between Rs. 26000-48000 monthly.

- Per capita income: Sixty six percent of the subjects had per capita income less than 5000 Rupees.
- Mean age of duration: The mean duration from the first diagnosis of diabetes for the study patients was 6.6 ± 5.31 years.
- Diagnosis: Around 53.34% were diagnosed as diabetics in first five years. Around, 30 % were diabetics since 6-10 years and about 16.67 % of subjects had DM since >10 years.

TABLE 4.29: QUARTILE VALUES OF AGE OF THE TYPE II DIABETIC SUBJECTS

Sex	Minimum	25%ile	Median	75%ile	Maximum	mode	Mean ± SD
Male	25	44	54	59	69	60	50.80 ± 11.14
Female	35	47	52	58	68	50	51.74 ± 7.52
Total	25	45	52	58	69		51.35 ± 9.13

TABLE 4.30: BASELINE INFORMATION OF TYPE II DIABETIC SUBJECTS

Variable	**Total Sample N (%)**					
	Male N (%)		**Female N (%)**		**Total N (%)**	
Frequency, (%)	25 (41.67)		35 (58.33)		60 (100)	
Age (Mean±SD) (years**)**	50.8±11.14		51.74±7.52		51.35±9.13	
Marital Status						
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
Single	2	3.33	2	3.33	4	6.6667
Married	22	88	29	82.85	51	85
Separated/Divorcee)	1	1.67	4	6.67	5	8.34
Religion						
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
Hindu	25	41.67	31	51.67	56	93.34
Muslim	0	0	3	5	3	5
Christian	0	0	1	1.67	1	1.67
Educational Qualification						
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
Illiterate	2	3.33	16	26.67	18	30
Primary Education	9	15	9	15	18	30
Secondary	6	10	6	10	12	20
Higher Secondary	3	5	0	0	3	5
Graduate	1	1.67	3	5	4	6.67
Post graduate	3	5	1	1.67	4	6.67
Technical degree	1	1.67	0	0	1	1.67
Occupation						
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
Service	9	15	2	3.33	11	18.34
Home maker	0	0	31	51.67	31	51.67
Retired	5	8.33	1	1.67	6	10
Business	10	16.67	1	1.67	11	18.34
Unemployed	1	1.67	0	0	1	1.66
Family Type						
Single	1	1.67	2	3.33	3	5
Nuclear	8	13.33	15	25	23	38.33
Joint/Extended	16	26.67	18	30	34	56.66
Total Family Income (Rs)						
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
3000-25000	20	80	29	82.85	49	81.67
26001-48000	1	4	5	14.28	6	10
>48001	4	16	1	2.85	5	8.34

Anthropometric profile of the subjects with respect to gender and age

The mean Body mass index (BMI) of the male was 24.89±4.20 kg/m^2 and for female subjects it was 28.85±4.98 kg/m^2 respectively as given in Table 4.31. There was a significant difference between the BMI of males and females ($p<0.01$). Table 4.32 shows that BMI differed greatly between males and females of < 45 years and > 45 years ($p<0.01$). However the females had higher BMI than males in age < 45 years.

The prevalence of overweight and obesity among type 2 diabetic subjects is given in Table 4.33. It was found that there were around 31 % female subjects who were obese (BMI>30kg/m^2) and 45 % were pre-obese (BMI 25-29.9). There were almost equal number of overweight males and females. It was also observed that prevalence of obesity was higher in females as compared to male subjects (Table 4.33)

TABLE 4.31: ANTHROPOMETRIC PROFILE OF TYPE II DIABETIC SUBJECTS

Variable	Male	Female	Total	t value	p value
Age (Years)	50.80 ± 11.41	51.74 ± 7.52	51.27±9.32	0.3915	0.6968
Weight (Kg)	69.24±12.59	68.36±11.11	68.73±11.65	0.284	0.776
BMI (Kg/m^2)	24.89±4.203	28.85±4.98	27.20±5.03	3.227**	0.0021**

Significantly different at p<0.05, ** significantly different at p<0.01, ***significantly different at p<0.0001

TABLE 4.32: ANTHROPOMETRIC PROFILE OF TYPE II DIABETIC SUBJECTS ACCORDING TO AGE (Mean ± SD)

Variable	Male < 45 yrs	Female < 45 yrs	p value	Male ≥ 45 yrs	Female ≥ 45yrs.	p value
Weight (Kg)	71.5±18.78	80.9±14.1	0.33	67.19±10.62	68.36±11.11	0.51
BMI	24.01±5.23	32.72±6.68	0.02*	25.24±6.59	28.85±4.78	0.02*

Significantly different at p<0.05, ** significantly different at p<0.01, ***significantly different at p<0.0001

TABLE 4.33: BODY MASS INDEX (BMI) OF TYPE II DIABETES SUBJECTS ACCORDING TO GENDER

Variable	Male		Female		Total	
BMI	N	%	N	%	N	%
Normal BMI (18.5-22.5)	9	36	4	11.42	13	21.67
Overweight (≥23-24)	3	12	4	11.42	7	11.66
Pre-obese (25-29.9)	9	36	16	45.71	25	41.67
Obese (≥30)	4	16	11	31.42	15	25

(Source: Asia Pacific Classification)

Biophysical profile

Body fat

There was a significant difference ($p<0.0001$) between the body fat of males and females (23.54±6.81; 40.60±8.76) as shown in Table 4.34. The body fat differed greatly between male and female of < 45 years and > 45 years ($p<0.0001$). The mean body fat of males and females ≤ 45years was 21.56±7.43 and 40.84±5.50 whereas for age group above 45 years it was 24.31±6.59 and 39.37±8.81 respectively (Table 4.35).

TABLE 4.34: BODY FAT COMPOSITION OF TYPE II DIABETIC SUBJECTS

Variable	Male	Female	Total	t value	p value
Body fat (%)	23.54±6.81	40.60±8.76	32.07±11.62	8.127***	0.0001***

****Significantly different at p<0.05, ** significantly different at p<0.01, ***significantly different at p<0.0001***

TABLE 4.35: BODY FAT COMPOSITION OF TYPE II DIABETIC SUBJECTS ACCORDING TO AGE (Mean ± SD)

Variable	Male < 45 yrs	Female < 45 yrs	p value	Male ≥ 45 yrs	Female ≥ 45yrs.	p value
Body Fat (%)	21.56±7.48	40.84±5.50	<0.0001***	24.31±6.59	39.37±8.81	<0.0001***

****Significantly different at p<0.05, ** significantly different at p<0.01, ***significantly different at p<0.0001***

Prevalence of hypertension

Blood pressure rises with each heartbeat and falls when the heart relaxes between beats. While BP can change from minute to minute with changes in posture, exercise, stress or sleep, it should normally be less than 120/80 mm Hg (less than 120 systolic and less than 80 diastolic) for an adult of age 20 or over. Twenty five percent of the adults in the world suffer from hypertension.

The mean blood pressure of the subjects was found to be at border

4line. Systolic blood pressure (SBP: 131.9 ± 18.76 mmHg; DBP: 83.69 ± 9.71 mmHg). As seen from the Table 4.36, there were 31.67 % subjects who had systolic blood pressure ≥ 140mmg and 25% subjects with Diastolic blood pressure ≥ 90 mmHg.

When the prevalence of hypertension and pre-hypertension was correlated with BMI, it was found that 55% of the obese diabetic subjects were pre hypertensive and 17.5% were hypertensive (Table 4.37).

TABLE 4.36: MEAN SYSTOLIC AND DIASTOLIC BLOOD PRESSURE OF TYPE II DIABETIC SUBJECTS

BP (mmHg)	Male (N=25)	Female (N=35)	Total (N=60)	t value	p value
SBP	132±15.85	131.9±20.82	131.9±18.76	0.02814	0.9776
DBP	86.29±10.16	81.83±9.07	83.69±9.71	1.787	0.0792

SBP-Systolic Blood Pressure, DBP-Diastolic Blood Pressure

TABLE 4.37: PREVALENCE OF PRE-HYPERTENSION AND HYPERTENSION IN RELATION TO BMI IN TYPE II DIABETIC SUBJECTS

BMI (Kg/m^2)	Normal	Pre HTN (mmHg)	HTN (mmHg)
	(N, %)	**(N, %)**	**(N, %)**
18.5-22.9	2(25)	5(62.5)	1(12.5)
≥23-24.9	5(50)	2(20)	3(30)
≥25	11(27.5)	22(55)	7(17.5)

Values in parenthesis indicate percentage
HTN- Hypertension
BMI- Body Mass Index

Personal habits, practices and physical activity

The assessment of the personal habits and practices in Table 4.38 revealed that 75% of the subjects had no addiction pattern. However 3.34% consumed alcohol, 10% chewed tobacco, 1.67% were addicted to smoking, 6.67% had the habit of eating mava and 3.34% of the subjects were addicted to all the three.

Physical activity is strongly associated with incidence of type 2 diabetes (Amanda et al, 2009). It was categorized as sedentary (sitting, standing, and driving for most of the day, cooking, light cleaning, light yard work, slow walking, and other major activities that involve sitting), moderate (an occupation that includes lifting, lots of walking, or other activities that keep you moving for several hours qualified as moderately active), and heavy (heavy manual labour, a very active lifestyle, dancer, or very active sports played for several hours almost daily, an elite athlete in training, or an extremely active lifestyle—both at work and at play and sport or activity last for several hours, almost daily.

In the present study the physical activity data was collected and calculated using questionnaire. The physical activity pattern indicates that 21.67% of the subjects led a sedentary life and while 55% did moderate activity. 23.34% were following heavy physical activity pattern (Table 4.39).

TABLE 4.38: ADDICTION PATTERN OF TYPE II DIABETIC SUBJECTS

Variable	Male (N, %)	Female (N, %)	Total (N, %)
Alcohol	**2 (6.67)**	**-**	**2 (3.34)**
Cigarette	**1 (3.33)**	**-**	**1 (1.67)**
Tobacco	**6 (20)**	**-**	**6 (10)**
Mava	**4 (13.34)**	**-**	**4 (6.67)**
All	**2 (6.67)**	**-**	**2 (3.4)**

Values in parenthesis indicate percentage

TABLE 4.39: PHYSICAL ACTIVITY PATTERN OF TYPE II DIABETIC SUBJECTS

Variable	Male (N, %)	Female (N, %)	Total (N, %)
Heavy	**6 (10)**	**7 (11.67)**	**13 (21.67)**
Moderate	**14 (23.3)**	**19 (31.6)**	**33 (55)**
Sedentary	**6 (10)**	**8 (13.3)**	**14 (23.34)**

Values in parenthesis indicate percentage

Medical and family history

Various clinical signs and symptoms were observed and recorded while screening the Type II diabetic subjects. Prevalence of various clinical conditions based on medical history of subjects is given in Table 4.40. About 56.67% subjects had pale conjunctiva, 40% complained of other symptoms like fatigue, 28.34% of breathlessness, 23.34% of increased palpitations of heart, 21.67% of dizziness, 25% of frequent headache, 38.34% complained of insomnia and 43.34% showed numbness in fingers and toes.

TABLE 4.40: CLINICAL SIGNS AND SYMPTOMS PREVALENT IN TYPE II DIABETIC SUBJECTS

Clinical signs and symptoms	N (%)
Eyes / Pale conjunctiva	34 (56.67)
Eyelid light pink	3 (5)
Angular stomatitis	-
Tongue / glossaries	3 (5)
Spoon shaped nails	1(1.67)
Fatigue	24 (40)
Breathlessness	17 (28.34)
Palpitations	14 (23.34)
Dizziness	13(21.67)
Headache	15 (25)
Insomnia	23 (38.34)
Numbness in fingers and toes	26 (43.34)

Values in parenthesis indicate percentage

Morbidity profile of the screened subjects

The morbidity profile of the subjects screened given in Table 4.41 showed that 10% had mouth ulcers while 23.34% had dental caries. 36.67% had gastric disorders. 15% had asthma and 16.67% had recurrent cold.

TABLE 4.41: MORBIDITY PROFILE OF TYPE II DIABETIC SUBJECTS

Problems	**N (%)**
Mouth Ulcers	6 (10)
Inflammation of tongue	1 (1.67)
Dental Caries	14 (23.34)
Problems of gastrointestinal tract	
Ulcerative Colitis	-
Dysentery	2 (3.34)
Pneumonia	-
Asthma	9 (15)
Recurrent cold	10 (16.67)
Tonsillitis	1(1.67)
Jaundice	1(1.67)

Values in parenthesis indicate percentage

Medicines taken by Type II diabetic subjects

All the subjects were following conventional treatment and were taking oral hypoglycemic drugs as given in Table 4.42. However 65% subjects took metformin medicine either single dose or double dose per day depending upon their blood sugar values. The percentage of subjects taking other medicines such as Glibomet (11.67%), Glucomet (3.33%), Voglibose (6.67%), Novonorm (1.67%), Glipizide (3.33%), Glynase MF (3.33%) and Diaform (5%).

TABLE 4.42: MEDICINES TAKEN BY TYPE II DIABETIC SUBJECTS

Name of the medicines	Experimental Group (N, %)	Control Group (N, %)	Total (N, %)
Metformin	22 (73.34)	17 (56.7)	39 (65)
Glibomet	2 (6.67)	5 (16.67)	7 (11.67)
Glucomet	-	2 (6.67)	2 (3.33)
Voglibose	2 (6.67)	2 (6.67)	4 (6.67)
Novonorm	-	1 (3.3)	1 (1.67)
Glipizide	2 (6.67)	-	2 (3.33)
Glynase MF	2 (6.67)	-	2 (3.33)
Diaform	-	3 (10)	3 (5)

Values in parenthesis indicate percentage

General Medical history of Type II diabetic subjects

Diabetes being risk factor of cardiovascular diseases serve as the platform for various co-morbidities. Table 4.43 shows general medical history of the enrolled subjects. It shows that 40% of diabetic subjects had strong family history of diabetes mellitus. Most of the subjects had either of the parents having diabetes. Thirty percent of the diabetic subjects had hypertension. Fifty percent of the subjects had dyslipidemia. Also 11.42 % females had hyperthyroidism. These results indicate considerable number of subjects had hypertension and dyslipidemia which constitute the most common risk factor for coronary heart disease. These results are in line with other studies which have shown that diabetes co-exists with other morbidities which if uncontrolled can lead to the development of coronary heart disease (ADA, 2015) (Table 4.43).

TABLE 4.43: GENERAL MEDICAL HISTORY OF TYPE II DIABETIC SUBJECTS (N, %)

Parameters	Male (N=25)	Female (N=35)	Total (N=60)
Diabetes + HTN (≥140/90)	6(24)	6(17.14)	12(20)
DM + Dyslipidemia	16(64)	14(40)	30(50)
Diabetes + Obesity (BMI ≥ 30)	3(5)	11(18.33)	14 (23.3)
DM + Hyperthyroidism	-	4(11.42)	4(6.67)

Values in parenthesis indicate percentage

Monitoring of blood sugar levels in type II diabetic subjects

Regular monitoring of the sugar levels of the subjects was also recorded. It was observed that 45% of the subjects monitored the blood sugar levels once in a month and 18.34% subjects monitored once a fortnight. However 21.67% monitored blood sugar once in 3 months but there was 6.67% of the subjects who did not go for monitoring their blood sugar levels at all (Table 4.44).

TABLE 4.44: MONITORING OF BLOOD SUGAR LEVELS IN TYPE II DIABETIC SUBJECTS

Monitoring of blood sugar	**N,(%)**
Once a Week	4(6.67)
Once a Fortnight	11(18.34)
Once a Month	27(45)
Once in 3 months	13(21.67)
Once in 6 months	1(1.67)
Once in an Year	0
Never	4(6.67)

Values in parenthesis indicate percentage

Results of quality of life of diabetic subjects

a) Overall health status of the subjects

The subjects were asked to fill up a questionnaire having five-sections assessing their health status scoring on a Likert scale ranging from 1(excellent) to 5 (poor). Questions regarding how they felt during the past 4 weeks about their behaviour whether they were calm, downhearted and angry were scored on a Likert scale ranging from 1(all of the time) to 5 (none of the time).

The (Mean±SD) scores obtained for the perception of subjects regarding their general health status were 3.3±0.72 which ranged from good to fair (51.7% felt it was good and 36.7% felt it was poor).

b) Monitoring of their understanding regarding various aspects of diabetes

This section assessed their understanding regarding *1*) diet, *2*) insulin, *3*) exercise, *4*) foot care, and *5*) blood glucose monitoring (identified by the American Diabetes Association as critical for good metabolic control) and overall diabetes care. Each behavior was scored on a Likert scale ranging from 1 (poor) to 5 (excellent).

Their overall mean score of this section of their understanding regarding various aspects of diabetes was 2.48±1.01 ranging from poor to fair. It included role of exercise in the control of blood sugar (1.95±1.35), coping up with stress during diabetes (2.26±1.26), diet for blood sugar control (2.55±1.22), using results of blood sugar monitoring (2.31±1.20), effect of diet, exercise and medicine on blood sugar levels (2.53±1.29), prevention and treatment of high and low blood sugar (2.5±1.23), prevention of long term complications of diabetes (2.66±1.23) and benefits of improving blood sugar control (2.58±1.56).

c) Monitoring parameters and understanding of various parameters listed below

This section dealt with monitoring parameters and understanding on the number of days in a week when they had been told to test their urine sugar and blood sugar. Also

their opinion on whether they had ever received diabetes education was also elicited. They were also told to rate their understanding of diet and blood sugar control, 2) weight management, 3) complications of diabetes, 4) eye care, 5) combining diabetes medication with other medications and 6) alcohol use and diabetes. The scoring for this on a Likert scale ranged from 1 (poor) to 5 (excellent).

Their overall mean score regarding monitoring parameters and understanding on various aspects of diabetes was 2.48±1.01 ranging from good to fair.

d) Regarding ease of the various activities carried out by the subjects during a day

This section dealt with the activities that they might be doing during a day like vigorous activities, moderate activities, lifting or carrying, climbing the stairs, bending, kneeling, stooping, walking and bathing or dressing themselves. These answers were scored on a Likert scale ranging from 1(Limited a lot) to 3(Not Limited at all).

The average mean scores recorded for ease of the various activities carried out by them during a day was 1.32±0.57. It was recorded that all these activities were performed by them with a lot of limitation (Table 4.45).

Almost all the subjects (96.7%) had received the diabetes education before. They were also asked about whether they had filled up such form in the past or for the first time.

Diabetes Care Profile Questionnaire- The instrument used in this study was based largely on instruments that have been widely used in diabetes research (Burroughs, Pontious, Santiago, 1993).

QOL is influenced by a range of other factors, such as the existence of other health problems, social relationships, marital status (Rubin and Peyrot, 1999; Parkerson, 1992), patient knowledge and perceived ability to control one's disease (Rubin and Peyrot, 1999).

TABLE 4.45: MEAN SCORES OBTAINED FOR QUALITY OF LIFE (QOL) OF TYPE II DIABETIC SUBJECTS

Section	Sub-section	(Mean±SD)
A	**Overall health Likert scale ranging from** 1(excellent) to 5 (poor).	**3.33±0.72**
	How do you feel during the last 4 weeks (Average of 1-3) Likert scale from 1 (All of the time to 5 (none of the time)	**2.83±1.92**
1	Have you felt calm and peaceful	2.21±1.83
2	Did you have a lot of energy?	2.35±1.84
3	Have you felt downhearted & angry?	3.95±2.09
B	**How do you rate your understanding of various aspects of diabetes (Average of 1-9)** Likert scale ranging from 1 (poor) to 5 (excellent).	**2.49±1.25**
1	Overall score of understanding regarding various aspects of diabetes	2.76±1.18
2	Role of exercise in control of blood sugar	1.95±1.35
3	Coping up with stress during diabetes	2.26±1.26
4	Diet for blood sugar control	2.55±1.22
5	Blood sugar monitoring	2.31±1.20
6	Effect of diet, exercise and medicne on blood sugar	2.53±1.29
7	Prevention of high and low blood sugar	2.51±1.23
8	Prevention of long term complications of diabetes	2.66±1.23
9	Benefits of improving blood sugar control	2.58±1.56
C	**Monitoring parameters and Understanding (Average of 1-9)** Likert scale ranging from 1 (poor) to 5 (excellent).	**2.15±1.10**
1	diet and blood sugar control	2.48±1.14
2	weight management	2.18±1.15
3	Exercise	1.85±1.11
4	use of insulin/pills	2.26±1.11
5	Sugar testing	2.41±1.07
6	complications of diabetes	2.2±1.16
7	combining diabetes medication with other medications	1.81±1.04
8	Eye care	2.06±1.11
9	Alcohol use and diabetes	2.18±1.04
D	**Physical Activities (Average of 1-8)** Likert scale ranging from 1(Limited a lot) to 3(Not Limited at all)	**1.32±0.57**
1	Vigorous activities, such as running, lifting heavy objects,	1.65±0.77
2	Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling	1.53±0.72
3	Lifting or carrying groceries	1.56±0.69
4	Climbing several flights of stairs?	1.48±0.65
5	Bending, kneeling, or stooping	1.48±0.59
6	Walking several blocks	1.43±0.64
7	Walking one block	1.35±0.54
8	Bathing or dressing yourself	1.41±0.61
	Total mean score (Section I to Section IV)	2.42±1.11

Dietary pattern

The dietary data was collected with respect to the 24 hour dietary recall method and food frequency method.

The dietary practices of the type II subjects showed that 68.34% of the subjects were vegetarian and 31.67% of the study population had non-vegetarian food habits. An important consideration for diabetics is the number and frequency of meals they consume in a day as it influences the hyperglycemic and hypoglycaemic states. It was observed that nearly 40% of the subjects had 3 meals /day and 22% subjects had only 2 meals/day with tea or milk as breakfast and 38% had 4 meals/day as far as frequency of meals was concerned.

24- Hour dietary recall

Dietary information obtained from 24 hour dietary recall as given in Table 4.46 revealed that there was no significant difference in the mean macronutrients like energy, fat, carbohydrate and proteins and micronutrients like minerals and vitamins intake of the male and female subjects.

The percent of calories coming from macronutrients is shown in Fig: 4.18. The calories coming from carbohydrates, protein and fat was found to be 53.75%, 12% and 34.5% respectively. There was no significant difference between the male and female of study population regarding percent of calories from macronutrients (total calorie, carbohydrate and protein intake).

Fats

The average fat intake in males and females contributed to about 34% of the total calories. Diets were high in fat in both the genders exceeding % RDA for fat. Females had higher exceed (45% more than RDA) than males (21% more than RDA). There was no difference among males and females in their fat intake.

Energy

Total subjects consumed 1917±500 kcal. Male subjects consumed 1914 Kcal and females consumed 1919 Kcal (Table 4.46).

Carbohydrate

The mean carbohydrate intake was 242g (51% Energy) for the male and female subjects of the total study population. Both the genders met about 84% of RDA for total calories for carbohydrate intake (Table 4.46).

Protein

Table 4.47 gives the % RDA met by the subjects and the % energy distribution for macronutrients. Total mean protein intake ranged from 55% to 56% of total calories. Female subjects met 102 % of the RDA and male subjects met 92% of the RDA for protein intake.

Fiber

Total dietary fibre intake was 23.09g for male (135.82% of RDA) and 22.85g for females (108.80% of RDA) respectively and total diabetic subjects met 121.21% RDA for total dietary fibre (Table 4.48).

Vitamin

The mean vitamin intake and % RDA of antioxidant vitamins met by the diabetic subjects is depicted in Table 4.46 and 4.49.

β carotene-

There was no significant difference in the mean β carotene intake of male and female subjects ($p>0.05$). The mean β carotene intake for the diabetic subjects was 1539.71±1451.15µg (32.07% of the RDA) and male subjects (32.28 % of RDA) and female subjects (31.87 % of RDA) which shows poor intake (Table 4.49).

Vitamin A

Mean vitamin A intake was 121.09±96.16µg (20.18% of RDA) for the diabetic subjects (Males-20.42% of RDA; females- 20.09% of RDA). It reflected poor intake of Vitamin A (Table 4.49).

Vitamin C

There was no significant difference in the mean Vitamin C intake amongst the gender ($p>0.05$). However the diabetic subjects were able to meet almost double the RDA for Vitamin C. The diabetic subjects had mean vitamin C intake of 73.64±43.88mg (184.1% of RDA) (Table 4.49).

Minerals

The mean mineral intake and % RDA met by the diabetic subjects is given in Table 4.50. It was found that the male diabetics met around 145.23% of RDA for iron intake which was more in relation to females who met 116.95% of the RDA. Around 74% of RDA for zinc was met by the subjects which is not good.

Iron, calcium and copper intake in both the genders exceeded the RDA. There was no significant difference in the zinc intake, potassium intake, copper and calcium intake of males and females.

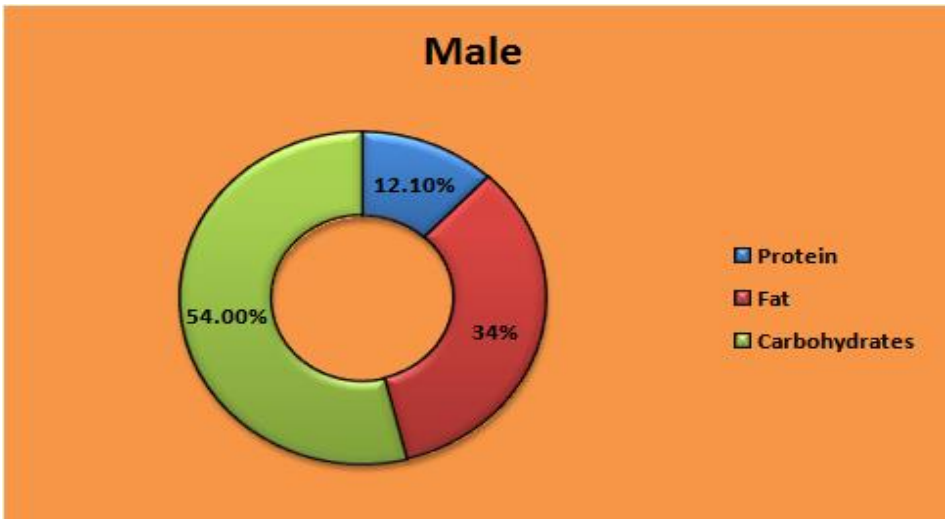
Overall the diet of the diabetic subjects did not show significant difference in the intake of major and minor nutrients between the males and females. It was seen that the diet of the subjects was high in macronutrients like fat and total dietary fiber, vitamin C, minerals like iron, calcium and copper intake and poor in Vitamin A, β carotene, minerals like zinc and potassium which may make the diabetics vulnerable to poor antioxidant defence mechanism (Table 4.46).

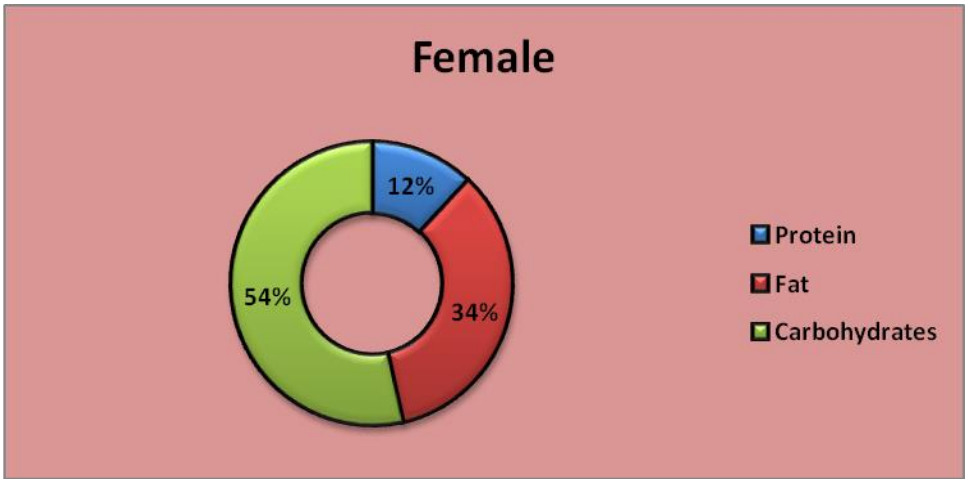
TABLE 4.46: NUTRIENT INTAKE OF TYPE II DIABETIC SUBJECTS

Nutrients	Male (mean±SD)	Female (mean±SD)	Total (mean±SD)	'P' value	't' value
N	25	35	60		
Macronutrients					
Energy (K Cals)	1914±503	1919±499	1917±500	0.85	0.18
Protein (g)	55.08±9.73	56.30±9.03	55.69±9.38	0.59	0.53
Fats (g)	72.74±23.29	72.90±23.24	72.82±23.09	0.89	0.13
Carbohydrates (g)	242.69±81.30	243.25±80.77	242.97±80.97	0.68	0.41
Total Dietary Fibre (g)	23.09±9.00	22.85±8.90	23.03±8.93	0.08	1.78
Minerals					
Iron (mg)	24.69±5.95	24.56±6.17	24.62±6.06	0.18	1.35
Calcium (mg)	955.34±276.61	956.29±276.59	955.83±274.26	0.26	1.12
Phosphorus (mg)	1488.46±354.70	1495.14±350.42	1488.10±351.70	0.72	0.35
Zinc (mg)	8.88±2.54	8.84±2.54	8.85±2.52	0.61	0.50
Copper (mg)	2.25±0.63	2.25±0.63	2.25±0.63	0.29	1.06
Chromium (mg)	0.07±0.03	0.07±0.03	0.07±0.03	0.27	1.10
Vitamins					
Vitamin A (µg)	122.56±96.96	120.56±76.96	121.09±96.16	0.47	0.72
Vitamin C (mg)	72.07±43.58	75.23±44.18	73.64±43.88	0.42	0.80
B Carotene (µg)	1549.55±1459.59	1529.87±1463.24	1539.71±1451.15	0.97	0.03*

***Significantly different at p<0.05**

FIG 4.18: PERCENT CALORIES FROM MACRONUTRIENTS IN TYPE 2 DIABETIC SUBJECTS





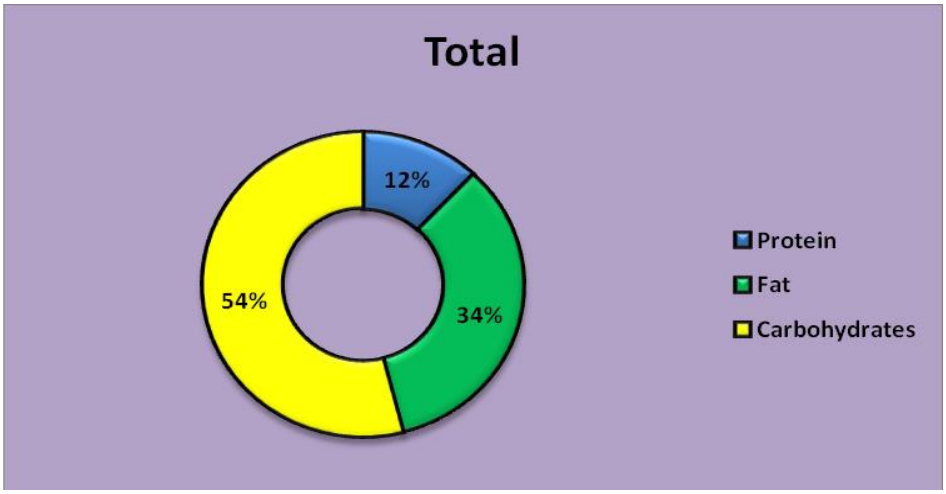


TABLE 4.47: PERCENT RDA MET FOR MACRONUTRIENTS BY DIABETIC SUBJECTS

Macronutrients	Males (N=25)		Females (N=35)	
	Mean±SD	% RDA*	Mean±SD	% RDA
Energy (kcal)	1914±503	82.54	1919±499	86
CHO (g)	242.69±81.30	84	243.25±80.77	81.5
Protein (g)	55.08±9.73	91.8	56.30±9.03	102.36
Fat (g)	72.74±23.29	121.24	72.90±23.24	145.8

RDA (NIN ICMR, 2011)

TABLE 4.48: PERCENT RDA OF TOTAL DIETARY FIBRE MET BY THE DIABETIC SUBJECTS

GENDER	(g) (Mean±SD)	% RDA
Male	23.09±9.00	135.82
Female	22.85±8.90	108.80
Total	23.03±8.93	121.21

TABLE 4.49: PERCENT RDA OF ANTIOXIDANT VITAMINS MET BY THE DIABETIC SUBJECTS

Vitamins	Male (Mean±SD)	% RDA	Female (Mean±SD)	% RDA	Total (Mean±SD)	% RDA
B carotene (µg)	1549.55± 1459.59	32.28	1529.87± 1463.24	31.87	1539.71±1451.15	32.07
Vitamin A (mg)	122.56± 96.96	20.42	120.56± 76.96	20.09	121.09± 96.16	20.18
Vitamin C (mg)	72.06± 43.58	180.15	75.23± 44.18	188.07	73.64± 43.88	184.1

TABLE 4.50: PERCENT RDA OF MINERALS MET BY TYPE II DIABETIC SUBJECTS

Minerals	Male (Mean±SD)	% RDA	Female (Mean±SD)	% RDA	Total (Mean±SD)	% RDA
Iron (g)	20.69±5.95	116.23	16.56±6.17	96.95	18.62±6.06	104.47
Calcium (mg)	955.34±276.61	159.22	956.29±276.59	159.38	955.83±274.26	159.30
Zinc (mg)	8.88±2.54	74	8.84±2.54	73.66	8.85±2.52	73.75
Copper (mg)	2.43±0.77	179.9	2.54±0.78	188.04	2.48±0.77	183.59
Potassium (mg)	1627.55±535.1	50.40	1688.02±553.16	52.27	1657.78±544.13	51.33

RDA (NIN ICMR, 2011)

Food Frequency

The information on frequency of various food items among the diabetic subjects as reported by the subjects themselves through Food frequency questionnaire is given in Table 4.51. The frequency of various food items consumed daily were Bajra (97%), Wheat (83.4%), Rice (55%), pulses (55%), fruits (18%), GLV (13.4%), other vegetables 87%), milk (38.4%), fish (17%), tea (87%), coffee (1.7%) and carbonated beverages (8.4%). The consumption pattern of fruits and GLV was very poor. About 53.3% subjects consumed GLV once in a week while 13.4% subjects consumed GLV on a daily basis. Other vegetables were the most frequently consumed (87% subjects consumed daily) followed by Roots and Tubers (52% consumed 2-3 times a week).

Only 12% of the diabetic subjects consumed sweet fruits on a daily basis (Fig: 4.19) and Fig: 4.20 and Table 4.52). The mean intake of the fruits was once in a week (45%) which was not encouraging for diabetics (The sweet fruits included sapota, papaya, water melon, Musk melon, banana and citrus fruits were Orange, Apple, Amala, Mango, Blue berries, Mosambi etc).

Thus the frequency of consumption of fruits and vegetables reflected poor intake of protective foods. The consumption of fruit and vegetables is low worldwide, particularly in low income countries, and this is associated with low affordability.

Policies worldwide should enhance the availability and affordability of fruits and vegetables (Miller et al., 2016).

TABLE 4.51 : FREQUENCY OF CONSUMPTION OF FRUITS AND VEGETABLES AS REPORTED BY TYPE II DIABETIC SUBJECTS (N,%)

Frequency	Citrus Fruits	Sweet fruits	GLVs	Other Veg.
Daily	7(12%)	7(12%)	8(13.5%)	52(87%)
2-3 times/week	4(7%)	4(7%)	12(20%)	12(20%)
Weekly	27(45%)	27(45%)	32(54%)	4(7%)
Fortnightly	5(8.5%)	5(8.5%)	4(7%)	0
Monthly	2(3.5%)	2(3.5%)	0	0
Occasionally	7(12%)	12(20%)	4(7%)	1(1.7%)
Never	0	3(5%)	0	1(1.7%)

FIG: 4.19: FOOD HABITS OF THE TYPE II DIABETIC SUBJECTS ACCORDING TO FOOD GROUPS

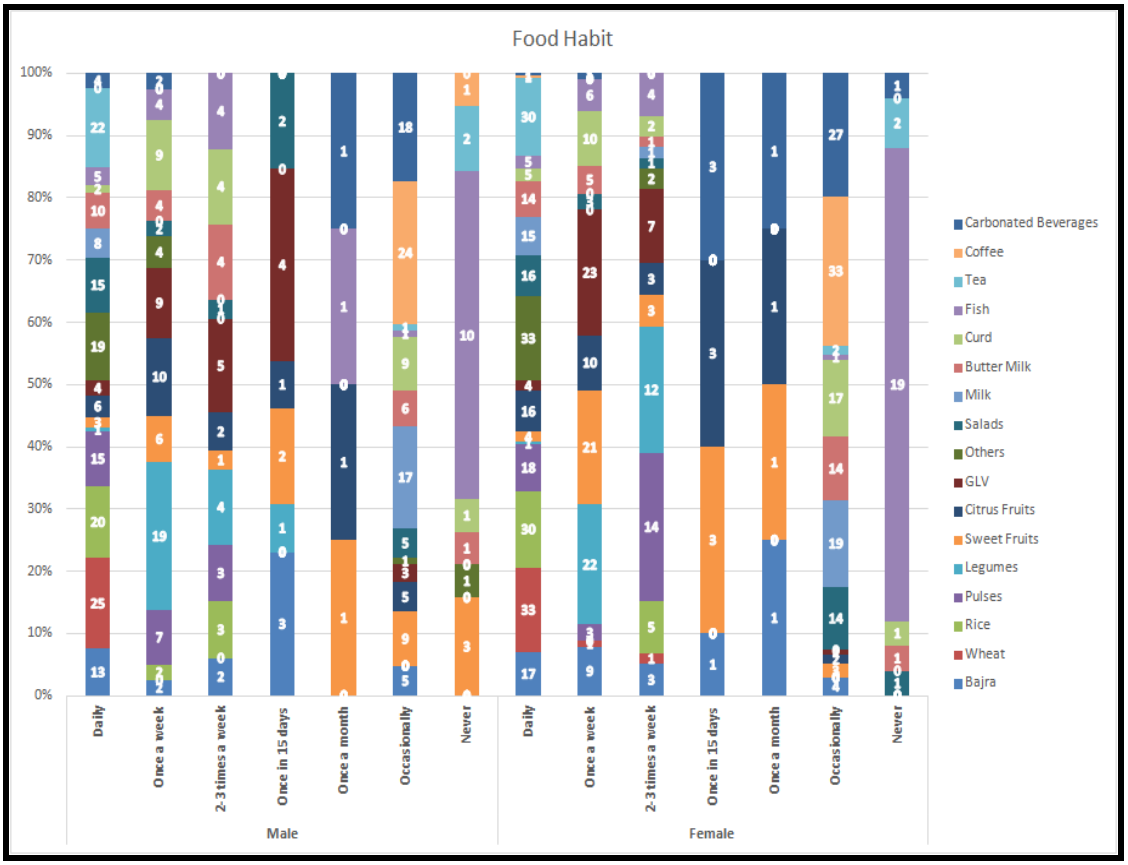
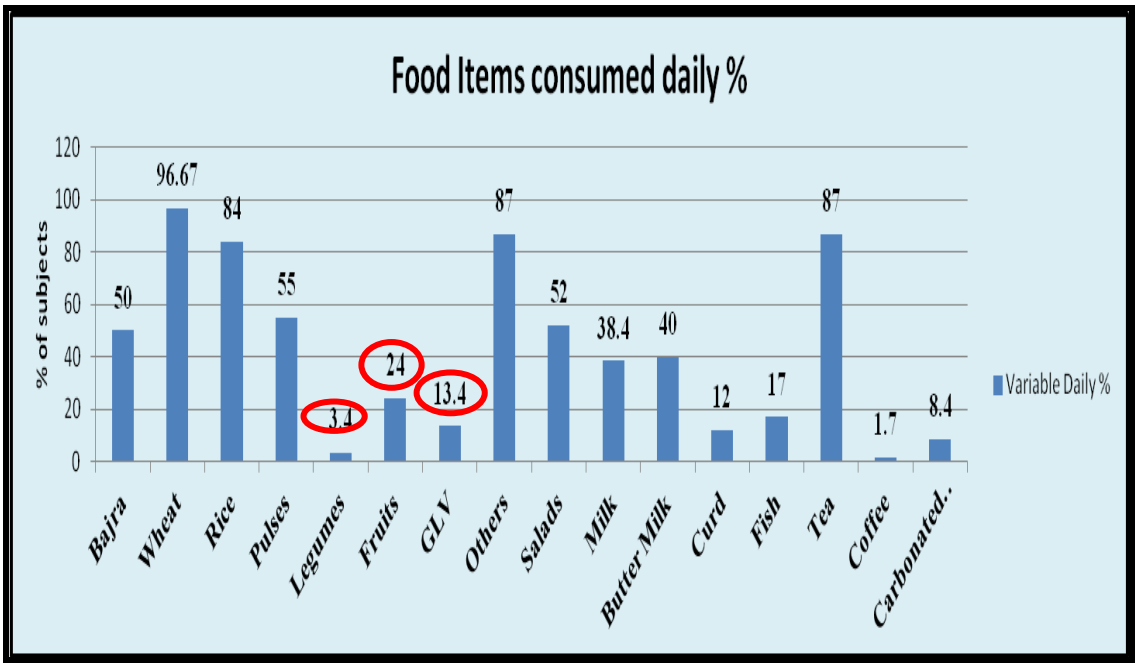


TABLE 4.52: FREQUENCY DISTRIBUTION WITH RESPECT TO THE FOOD HABIT OF THE WHOLE GROUP (N,%)

Variable	Male (N = 25) (N, %)							Female (N = 35)						
	Daily	Once a week	2-3 times a week	Once in 15 days	Once a month	Occasionally	Never	Daily	Once a week	2-3 times a week	Once in 15 days	Once a month	Occasionally	Never
Bajra	13 (52%)	2 (8%)	2 (8%)	3 (12%)	0 (0%)	5 (20%)	0 (0%)	17 (48.57%)	9 (25.71%)	3 (8.57%)	1 (2.86%)	1 (2.86%)	4 (11.43%)	0 (0%)
Wheat	25 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	33 (94.29%)	1 (2.86%)	1 (2.86%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Rice	20 (80%)	2 (8%)	3 (12%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	30 (85.71%)	0 (0%)	5 (14.29%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Pulses (dal)	15 (60%)	7 (28%)	3 (12%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	18 (51.43%)	3 (8.57%)	14 (40%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Whole pulses	1 (4%)	19 (76%)	4 (16%)	1 (4%)	0 (0%)	0 (0%)	0 (0%)	1 (2.86%)	22 (62.86%)	12 (34.29%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Sweet Fruits	3 (12%)	6 (24%)	1 (4%)	2 (8%)	1 (4%)	9 (36%)	3 (12%)	4 (11.43%)	21 (60%)	3 (8.57%)	3 (8.57%)	1 (2.86%)	3 (8.57%)	0 (0%)
Citrus Fruits	6 (24%)	10 (40%)	2 (8%)	1 (4%)	1 (4%)	5 (20%)	0 (0%)	16 (45.71%)	10 (28.57%)	3 (8.57%)	3 (8.57%)	1 (2.86%)	2 (5.71%)	0 (0%)
GLV	4 (16%)	9 (36%)	5 (20%)	4 (16%)	0 (0%)	3 (12%)	0 (0%)	4 (11.43%)	23 (65.71%)	7 (20%)	0 (0%)	0 (0%)	1 (2.86%)	0 (0%)
Others	19 (76%)	4 (16%)	0 (0%)	0 (0%)	0 (0%)	1 (4%)	1 (4%)	33 (94.29%)	0 (0%)	2 (5.71%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Milk	8 (32%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	17 (68%)	0 (0%)	15 (42.86%)	0 (0%)	1 (2.86%)	0 (0%)	0 (0%)	19 (54.29%)	0 (0%)
Butter Milk	10 (40%)	4 (16%)	4 (16%)	0 (0%)	0 (0%)	6 (24%)	1 (4%)	14 (40%)	5 (14.29%)	1 (2.86%)	0 (0%)	0 (0%)	14 (40%)	1 (2.86%)
Fish	5 (20%)	4 (16%)	4 (16%)	0 (0%)	1 (4%)	1 (4%)	10 (40%)	5 (14.29%)	6 (17.14%)	4 (11.43%)	0 (0%)	0 (0%)	1 (2.86%)	19 (54.29%)
Tea	22 (88%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (4%)	2 (8%)	30 (85.71%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (5.71%)	2 (5.71%)
Coffee	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	24 (96%)	1 (4%)	1 (2.86%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	33 (94.29%)	0 (0%)
Carbonated Beverages	4 (16%)	2 (8%)	0 (0%)	0 (0%)	1 (4%)	18 (72%)	0 (0%)	1 (2.86%)	1 (2.86%)	0 (0%)	3 (8.57%)	1 (2.86%)	27 (77.14%)	1 (2.86%)

FIG 4.20: AVERAGE DAILY INTAKE OF FOOD ITEMS BY TYPE II DIABETIC SUBJECTS



Biochemical Estimation

Glycemic profile and lipid profile of the subjects

The mean fasting blood sugar values of total enrolled type II diabetic subjects were 171.5 mg/dl (M: 174 mg/dl; F: 169.6 mg/dl). The mean glycosylated heamoglobin **(**HbA1c) values were 9.21% (M: 9.11%; F: 9.28%). There was no significant difference in the HbA1c mean value (9.11% and 9.28% for males and females respectively). The mean post prandial blood sugar (PPBS) value for total population was 217.5mg/dl (M: 221.7mg/dl; F:214.5 mg/dl). There was no significant difference ($p > 0.05$) in the mean FBS, HbA1c and PPBS values between the males and females in the study population. The subjects showed poor control of glycemic parameters.

The total cholesterol (TC) value for the total population was 207.0 mg/dl (range 139-336 mg/dl) with (M: 201.4 mg/dl; F: 210.9 mg/dl). The subjects were diagnosed to be at borderline for hypercholestrolimea (TC ≥ 200g/dl). Despite high TC levels, the HDL-C values for females were almost same as that of males (40.25mg/dl; 39.17 mg/dl). The HDL-C levels were 19.41% and 19.08% of TC in males and females respectively. The mean TG values were 154.6 mg/dl (M: 152.4 mg/dl; F: 156.1 mg/dl) (range 86.7-251.1 mg/dl). Mean TG value was more than the recommended values (TG < 150 mg/dl) indicating that these subjects (25-69 y) were at-risk for the development of CDDs. The total subjects had a mean LDL –C values of 134.6 mg/dl (M: 129.8 mg/dl; F: 138.0) (range 77.1-245.2 mg/dl). The mean VLDL values were 30.87 mg/dl (range 14-74 mg/dl). In all they had poor lipid profile (Table 4.3.25).

Glycemic profile in relation to the age (< 45 years and > 45 years) revealed that overall FBS and HbA1c values were almost same for both age group where as PPBS values were higher for < 45 years of age (227.5±29.6; 214.7±41.87mg/dl). Gender wise in older age group ≥45 years, mean FBS and PPBS values were higher in males than females whereas HbA1c values were little more in females (8.95% ± 1.44 in males; 9.30% ± 1.36). In younger age group < 45 years, mean values for both FBS and PPBS were higher in females than males whereas HbA1c values were almost same in both sex (9.28%± 3.56 in F; 9.52% ± 1.55 in M) (Table 4.53).

Table 4.53 shows that overall, the females had higher values for lipid profile than the males in both the age groups. When the lipid values were analyzed according to age i.e, <45 years and ≥ 45 years, all the lipid parameters monitored were more in < 45 years age group and these values decreased with age. The HDL-C values remained the same in both the sexes in both the age groups.

On comparing lipid profile of the normal subjects with hyperlipidemics, only 21.6% were normal (had TC < 200 mg/dl and TG < 150 mg/dl) (M-13.5%; F- 8%), 32% were hyperlipidemics, with both the TC>200 mg/dl and TG>150 mg/dl (M- 21%; F-11%), 46% subjects were having either a high total cholesterol (TC >200 mg/dl) or a high triglyceride value (TG >150 mg/dl). The females no matter normal or hyperlipidemics had higher TC, TG, HDL and VLDL as compared to the lipid values of the male subjects.

TABLE 4.53 : GLYCAEMIC AND LIPID PROFILE OF TYPE II DIABETIC SUBJECTS (25-69 YEARS)

Variable	Males (Mean ± S.D)	Females (Mean ± S.D)	Total (Mean ± S.D)	P value	t value
N	25	35	60		
FBS (mg/dl)	↑ 174.0±40.54	169.6±38.20	171.5±38.95	0.76	0.30
HbA1c (%)	9.11±1.47	↑ 9.28±1.31	9.21±1.37	0.64	0.46
PPBS (mg/dl)	↑ 221.7±40.17	214.5±38.05	217.5±39.01	0.48	0.70
TC (mg/dl)	201.4±48.25	↑ 210.9±34.33	207±40.61	0.37	0.89
TG (mg/dl)	152.4±44.26	156±39.68	154.6±41.32	0.73	0.34
HDL-C (mg/dl)	39.17±5.128	40.25±6.91	39.8±6.20	0.51	0.65
LDL - C (mg/dl)	129.8±40.43	↑ 138.0±30.60	134.6±34.95	0.37	0.89
TC/HDL ratio	5.14±1.07	5.36±1.22	5.27±1.15	0.48	0.70
LDL/HDL ratio	3.36±0.95	3.56±1.06	3.48±1.01	0.46	0.72
VLDL - C (mg/dl)	30.03±8.779	↑ 31.47±6.30	30.87±8.46	0.52	0.64

**** Significantly different at p < 0.05***

TABLE 4.54: GLYCAEMIC AND LIPID PROFILE OF THE HYPERLIPIDEMIC SUBJECTS ACCORDING TO THEIR AGE (MEAN ± SD)

Variable	Subjects < 45 years			Subjects ≥ 45 years		
	Male	Female	p value	Male	Female	p value
FBS	165.8±35.36	190.6±38.11	0.24	177.2±42.89	168.7±39.17	0.48
HbA1c	9.52±1.55	9.28±3.56	0.75	8.95±1.44	9.30±1.36	0.39
PPBS	228.8±24.34	237.7±38.58	0.62	219.0±46.85	212.1±34.41	0.58
TC	209±64.62	230.7±26.14	0.46	198.5±42.19	208.9±36.19	0.39
TG	161.8±51.99	184.3±47.17	0.43	148.8±41.87	156.5±42.10	0.53
HDL-C	39.30±4.87	38.15±9.24	0.77	39.12±5.36	39.98±6.74	0.65
LDL-C	137.3±57.49	146.9±23.21	0.71	126.9±33.30	135.3±32.48	0.39
VLDL-C	32.35±10.39	38.2±10.56	0.33	29.13±8.22	31.59±8.84	0.34
TC/HDL	5.31±1.48	6.27±1.66	0.29	5.08±0.90	5.33±1.29	0.47
LDL/HDL	3.48±1.34	4.31±1.34	0.29	3.32±0.99	3.52±1.13	0.50

Other bio-chemical parameters of screened type II diabetic subjects

The Mean±SD value for liver functions such as the SGPT values for the Type II diabetic subjects were 27.43±8.45 (M: 27.06±9.95; F: 27.7±7.34) and SGOT values 29.59±9.84 (M:29.54±2.17;F:29.72±9.20) respectively which was in the reference range of 0-42 IU/L. There was no gender difference in the mean values.

The mean values for the serum Creatinine was 1.2±0.3 mg/dl (M 1.3±0.3 mg/dl ; F 1.2±0.3mg/dl) which was in the normal range of 0.7-1.4mg/dl and there was no gender difference in the mean values between males and females.

The total mean serum HsCRP value of the subjects was 3.46±1.52 IU/ml; (M: 3.45±1.86; F: 3.47±1.24 IU/ml). There was no significant difference in the HsCRP values between males and females. As per AHA/CDC all the subjects were at high risk for CVD (≥3IU/ml).

The Mean±SD total protein value was 6.50±0.5 g/dl (M 6.50±0.5 g/dl ; F 6.40±0.6 g/dl). The total protein values were in the normal reference range of 6.0-8.3g/dl. Mean total albumin, total globulin and A/G ratio were 4.32±0.40 g/dl, 2.16±0.49g/dl, 2.11±0.55 respectively (Table 4.55).

TABLE 4.55 : SGOT, SGPT (LIVER FUNCTIONS), SERUM CREATININE (KIDNEY FUCTIONS), HSCRP (ANTI-INFLAMMATORY STATUS) AND TOTAL PROTEIN QUARTILE VALUES OF T2DM SUBJECTS

Parameter	Minimum value			Median value			Mean±SD		
Category	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
SGPT (IU/L)	13.5	10.9	10.9	27.5	28.4	28.25	27.06±9.95	27.7±7.34	27.43±8.45
SGOT (IU/L)	14.4	12.96	12.96	32.95	29.1	28.25	29.54±2.17	29.72±9.20	29.59±9.84
Creatinine (mg/dl)	0.82	0.82	0.82	1.27	1.08	1.55	1.34±0.36	1.21±0.37	1.27±0.37
HsCRP (IU/ml)	1.08	1.33	1.08	3	3.66	3.10	3.45±1.86	3.47±1.24	3.46±1.42
Total proteins (g/dl)	5.40	4.90	4.20	6.70	6.50	6.50	6.59±0.52	6.46±0.63	6.51±0.58
Total Albumin (g/dl)	4.00	3.30	3.30	4.50	4.27	4.32	4.48±0.41	4.32±0.40	4.39±0.41
Total Globulin (g/dl)	1.24	1.30	1.24	2.15	2.10	2.11	2.07±0.41	2.16±0.49	2.12±0.46
A/G Ratio	1.43	0.92	0.92	2.05	2.04	2.04	2.25±0.63	2.11±0.55	2.17±0.59

Serum Ferric Reducing Antioxidant Potential (FRAP)

The serum FRAP value of all the subjects was 1.34±0.44 Mmol/TE/L (M: 1.32±0.30 Mmol/TE/L; F: 1.36±0.53 Mmol/TE/L). There was no significant difference between the males and females ($p \geq 0.05$) for antioxidant capacity analyzed through serum FRAP. The serum FRAP values for the enrolled subjects was in the range of healthy adults which is around 0.5 to 2.0 Mmol/TE/L (Table 4.56).

TABLE 4.56: SERUM FRAP QUARTILE VALUES OF TYPE II DIABETIC SUBJECTS

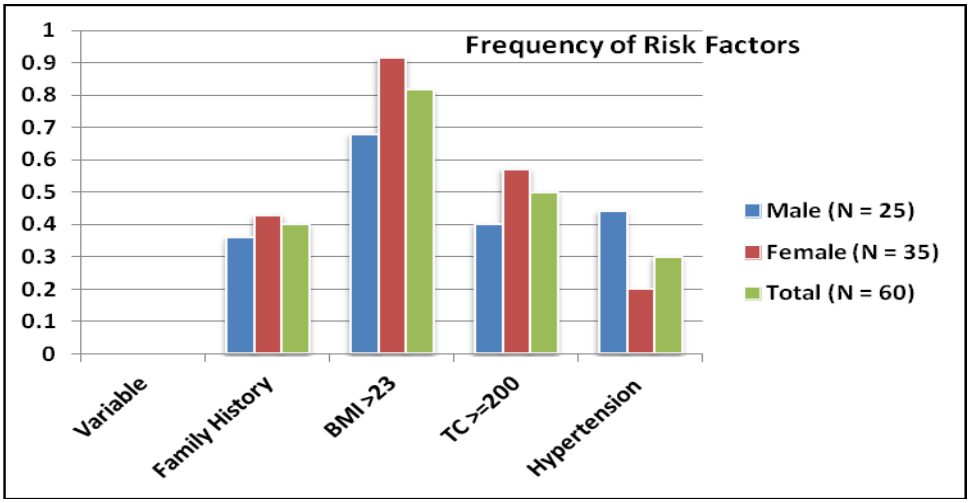
Serum FRAP (Mmol/TE/L)	Minimum value	25% percentile	Median value	75% percentile	Mean±SD	Maximum value
Male	0.96	1.07	1.22	1.61	1.32±0.30	2.02
Female	0.84	1.07	1.23	1.45	1.36±0.53	3.24
Total	0.84	1.07	1.22	1.46	1.34±0.44	3.24

TABLE 4.57: FREQUENCY DISTRIBUTION WITH RESPECT TO THE RISK FACTORS OF THE WHOLE GROUP (N, %)

Variable	Male (N = 25)	Female (N = 35)	Total (N = 60)
Family History	9 (36%)	15 (42.86%)	24 (40%)
BMI >23	17(68%)	32(91.43)	49(81.67)
TC >=200	10(40%)	20 (57.14%)	30 (50%)
Hypertension	11 (44%)	7 (20%)	18 (30%)

Values in parenthesis indicate percentage

FIG 4.21: FREQUENCY OF RISK FACTORS IN TYPE II DIABETIC SUBJECTS



HIGHLIGHTS OF BASELINE DATA

From the results of pre-data, the following salient observations can be stated.

General background

- The mean age of the subjects was 51 years (M-50.80±9.13y; F-51.74±7.52y)
- Religion and marital status: - Ninety four percent were Hindus (M- 100%, F-88.7%) and 80% were married.
- Education: Thirty percent of the total subjects were illiterate.
- Occupation: Eighteen percent were employed outside (M-36%; F-5.7%)
- Family size: The average family size was 5.6 members.
- Income : Sixty seven percent subjects had per capita income less than Rs 5000
- Family History: Forty percent had family history of either of parent having diabetes.
- Food habits: Almost 31.67% had non-vegetarian food habits.
- Low consumption of fruits and green leafy vegetables.
- Hypertension: Twenty percent had hypertension
- Dyslipidemia: Fifty percent had dyslipidemia which constitute most common risk factor for coronary heart disease.

Bio-chemical

- There was no significant difference among males and females ($p>0.05$) in the baseline mean values for all the biochemical parameters of the enrolled subjects.
- Their hyperglycemic parameters were poorly controlled (Mean ± SD - HbA1c≥ 9.21±1.37) along with hypertension or pre hypertension.
- Many factors, such as obesity, family history of diabetes, dyslipidemia, uncontrolled glycemic status, sedentary lifestyles and hypertension were prevalent among the Type II diabetic subjects.

Results of impact of Aegle Marmelos (L.) Correa leaf juice supplementation (Post-data)

Impact on dietary intake (24 Hr dietary recall method)

The 24 hour dietary recall of the Experimental and Control group diabetic subjects is given in Table 4.58.

Macronutrients

Dietary information obtained from 24 hour dietary recall of pre and post supplementation diet of Experimental subjects revealed that the mean energy, protein, fat, carbohydrate and fibre intake was less compared to the pre-diet intake. However there was no significant statistical difference ($p>0.05$) in their pre and post supplementation. (Table 4.58).

Micronutrients

Dietary information obtained from 24 hour dietary recall of pre and post supplementation diet of Experimental subjects revealed that the mean mineral intake such as iron, calcium, zinc, copper, phosphorus etc was less compared to the pre-diet intake. Mean Vitamin intake for vitamin A, C and B-carotene also showed no statistical difference ($p>0.05$) between the pre and post diet intake (Table 4.58).

In Control group there was significant difference ($p< 0.05$) in the mean intake of macronutrients such as energy, proteins, fat and carbohydrate of the male and female subjects post supplementation of 2 months. However there was no statistical difference ($p>0.05$) in the mean vitamin and mineral content post supplementation.

TABLE 4.58: MEAN NUTRIENT INTAKE OF EXPERIMENTAL GROUP AND CONTROL GROUP

VARIABLE	EXPERIMENT GROUP			CONTROL GROUP		
	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL
ENERGY (K cal)						
Pre Diet	1803±216	1760±269	1781±242	1806±298	1872±452	1881±401
Post Diet	1545±408	1766±218	1655±313	2065±342	2055±243	2040±500
T Value (P Value)	2.75(0.02)*	0.94(0.92)NS	1.58(0.12)NS	2.73(0.01*)	2.99(0.01*)	1.98(0.05)*
PROTEIN (g)						
Pre Diet	55.78±12.48	54.47±9.40	54.95±10.44	57.56±13.76	60.28±14.27	58.96±13.86
Post Diet	50.84±12.75	56.30±9.03	52.72±8.47	65.52±12.28	69.12±11.88	67.44±11.98
T Value (P Value)	1.14(0.28)NS	0.29(0.77)NS	1.05(0.30)NS	0.69(0.4)	2.99(0.01*)	4.47(0.01)*
FATS (g)						
Pre Diet	66.11±15.91	63.39±12.20	64.39±13.47	67.83±9.71	74.6±6.97	71.44±8.90
Post Diet	53.86±10.60	65.49±13.07	61.23±13.31	73.33±11.88	78.5±7.97	76.09±11.04
T Value (P Value)	2.22(0.05)*	0.55(0.6)NS	0.98(0.33)NS	2.94(0.01*)	2.92(0.01*)	2.17(0.01)*
CARBOHYDRATES (g)						
Pre Diet	236.9±58.87	226.95±46.83	230.60±50.80	204.8±41.1	200.1±46.25	208.1±47.59
Post Diet	201.6±80.99	218.46±41.45	212.13±	245.2±32.05	263.9±50.03	262.0±53.21
T Value (P Value)	1.80(0.10)NS	0.88(0.39)NS	1.92(0.06)NS	5.04(0.02**)	2.78(0.01*)	3.52(0.002)**
IRON (mg)						
Pre Diet	14.05±5.06	14.69±	14.38±3.29	16.47±4.10	17.23±2.47	16.87±3.29
Post Diet	15.06±5.50	15.56±6.17	15.31±5.50	17.21±2.82	17.77±3.36	17.51±3.08
T Value (P Value)	1.78(0.20)NS	1.23(0.45)NS	1.28(0.20)NS	1.02(0.32)NS	0.70(0.48)NS	1.21(0.23)NS
CALCIUM (mg)						
Pre Diet	853.51±202.8	955.34±276.61	904.42±295	731.1±91.06	743.8±113	737.9±86.34
Post Diet	873.5±134.1	956.29±276.59	914.89±272.15	749.3±79.78	780.2±176.2	765.8±99.06
T Value (P Value)	0.54(0.77)NS	0.81(0.42)NS	1.93(0.06)NS	5.04(0.02**)	2.11(0.058)NS	1.93(0.06)NS
PHOSPHORUS (mg)						
Pre Diet	1470±301	1488.46±354.70	1479.23±327.5	1536±420.8	1538.46±417.6	1537±411.8
Post Diet	1381.6±370	1495.14±350.42	1430.37±360.21	1610±436.9	1610±379.4	1610±400.1
T Value (P Value)	1.35(0.20)NS	0.82(0.22)NS	0.94(0.69)NS	0.61(0.54)NS	0.69(0.49)NS	0.94(0.35)NS
ZINC (mg)						
Pre Diet	8.07±2.31	8.88±2.54	8.47±2.42	9.81±2.48	8.88±3.07	9.33±2.80
Post Diet	7.84±2.08	8.84±2.54	8.34±2.31	9.16±2.68	9.51±2.75	9.33±2.80
T Value (P Value)	1.33(0.21)NS	0.50(0.31)NS	0.03(0.97)NS	0.87(0.39)NS	0.48(0.72)NS	0.03(0.97)NS

VARIABLE	EXPERIMENT GROUP			CONTROL GROUP		
	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL
COPPER (mg)						
Pre Diet	2.14±0.58	2.25±0.63	2.19±0.60	2.50±0.73	2.27±0.70	2.38±0.71
Post Diet	1.92±0.48	2.25±0.63	2.08±0.55	2.53±0.84	2.43±0.87	2.48±0.84
T Value (P Value)	1.89(0.22)NS	1.06(0.28)NS	0.31(0.95)NS	0.09(0.92)NS	0.54(0.61)NS	0.55(0.58)NS
CHROMIUM (mg)						
Pre Diet	0.06±0.02	0.07±0.03	0.06±0.02	0.09±0.02	0.06±0.02	0.08±0.03
Post Diet	0.05±0.02	0.07±0.03	0.06±0.02	0.08±0.02	0.07±0.03	0.07±0.02
T Value (P Value)	0.74(0.34)NS	1.10(0.0)NS	0.27(0.78)NS	0.48(0.63)NS	0.92(0.09)NS	0.80(0.24)NS
VITAMIN A (µg)						
Pre Diet	101.56±38.32	99.50±55.36	100.53±46.84	158±58.5	133.5±97.52	144.9±27.8
Post Diet	80.17±37.33	112.05±45.65	96.11±41.49	168.4±88.9	118.56±76.96	140.0±26.3
T Value (P Value)	1.66(0.13)NS	0.78(0.44)NS	0.59(0.53)NS	0.08(0.93)NS	1.50(0.15)NS	0.53(0.59)NS
VITAMIN C (mg)						
Pre Diet	62.07±23.58	60.36±24.53	61.21±24.05	50.8±17.88	49.36±18.71	1530±400.8
Post Diet	56.03±23.42	59.21±23.5	57.62±23.21	52.35±11.59	61.08±20.52	1757±415.3
T Value (P Value)	1.02(0.16)NS	0.02(0.09)	1.60(0.11)NS	0.30(0.76)NS	1.74(0.10)NS	0.39(0.69)NS
B CAROTENE (µg)						
Pre Diet	1549.55±400.8	1459.97±1165.16	1504.76±412.08	1407.55±391.6	1637±379.4	1530±400.8
Post Diet	1434.80±415.3	1470.16±426.02	1452.48±420.65	1616±420.8	1796±391.3	1757±415.3
T Value (P Value)	1.20(0.33)NS	0.81(0.42)NS	0.39(0.69)NS	0.58(0.57)NS	0.10(0.91)NS	0.39(0.69)NS
TOTAL DIETARY FIBER (g)						
Pre Diet	14.14±2.84	15.50±5.90	14.82±4.35	18.03±3.39	17.79±2.76	16.90±3.02
Post Diet	12.46±4.96	15.85±8.90	14.15±6.93	19.34±3.24	19.34±3.24	17.68±2.90
T Value (P Value)	0.92(0.37)NS		1.12(0.26)NS	2.11(0.058)NS	2.11(0.058)NS	2.12(0.06)

Results of the impact of *Aegle Marmelos (L.) Correa* leaf juice supplementation on the anthropometric profile of Experimental And Control Group

The body weight, height and BMI were recorded at the baseline and at the end of supplementation period i.e. 60th day. The mean BMI of the subjects decreased from 26.57 kg to 25.66 kg. There was significant decrease in weight ($p<0.05$) and BMI ($p<0.05$) of the subjects in experimental group. Whereas no such trend was recorded in control group (Table 4.59). There was improvement in nutiritonal status of Experimental group. Post supplementation, obese subjects decreased from 20% to 16% whereas normal subjects increased from 13% before supplementation to 20% after 2 months in Experimental group (Table 4.60).

TABLE 4.59: RESULTS OF THE ANTHROPOMETRIC PROFILE OF EXPERIMENTAL AND CONTROL GROUP

Experimental Group			Control Group			
Weight (Kg)						
	Male	Female	Total	Male	Female	Total
Basal	67.89±8.01	67.43±9.89	67.60±9.11	70.63±16.14	68.94±13.09	69.73±14.35
Final	67.09±7.75	66.72±10.44	66.85±9.41	70.29±15.51	69.47±12.64	69.85±13.81
't' value	1.92 NS	1.72 NS	2.49*	1.02 NS	1.47 NS	0.37 NS
BMI						
Basal	24.39±2.63	28.76±4.79	26.57±4.61	25.29±5.19	28.95±5.35	27.12±5.51
Final	24.10±2.56	27.73±4.97	25.66±4.71	25.19±5.07	29.18±5.15	27.32±5.41
't' value	2.17	1.81	2.57*	0.90	1.51	0.30

TABLE 4.60: NUTRITIONAL STATUS OF EXPERIMENTAL AND CONTROL GROUP

(N=30)	**Experiment Group (N, %)**		**Control Group (N, %)**	
BMI/Nutritional Grade	**Pre data**	**Post data**	**Pre data**	**Post data**
Underweight < 18.5	-	-	1(3.33)	1 (3.33)
Normal 18.5-22.9	4 (13.33)	6 (20)	5 (16.67)	5 (16.67)
Overweight 23-24.9	5 (16.67)	6 (20)	5 (16.67)	5 (16.67)
Pre-obese 25-29.9	15 (50)	13 (43.3)	9 (20)	10 (3.33)
Obese > 30	6 (20)	5 (16.67)	10 (3.33)	9 (20)

(WHO, 2010)

Impact of *Aegle Marmelos (L.) Correa* leaf juice supplementation on bio-physical profile of the Experimental and Control group

Impact on Body Fat

A significant decrease was recorded in the body fat percent among females ($p<0.01$) and ($p<0.001$) total subjects in the experimental group whereas no such alteration was recorded in control group (Table 4.61).

TABLE 4.61: BODY FAT COMPOSITION OF EXPERIMENT AND CONTROL GROUP

	Experimental Group			Control Group		
	Male (%)	**Female (%)**	**Total (%)**	**Male (%)**	**Female (%)**	**Total (%)**
Basal	22.84±4.66	39.58±9.71	31.21±11.55	24.67±7.67	39.65±8.81	32.16±11.87
Final	21.50±4.91	38.43±9.16	29.96±11.37	24.09±8.25	39.30±8.40	31.69±11.97
't' value	1.69	3.06**	3.48**	1.26	0.37	0.20

significant difference at p<0.05; ** Significant difference at p<0.01

Impact of *Aegle Marmelos (L.) Correa* leaf juice supplementation on blood-pressure of the Experimental and Control group

Hypertension defined as a blood pressure (≥140/90mmHg) is an extremely common co-morbid condition in diabetes.

Overall *Aegle Marmelos (L.) Correa* leaf juice supplementation was effective in altering the BP measurements. Around 5-6 % significant decrease was seen in SBP in both the groups (Pre-post Expt. / Control Group SBP values: 138.8±19.1mmHg-129.8±19.0mmHg / 134.3±20.2-127.1±18.0).

There was significant ($p<0.05$) drop (5.3%) in DBP values in Expt. group post supplementation for all the subjects (Pre-post DBP mean±SD values: 86.6±10.0mmHg/82.0±11.6 mmHg). However in control group, there was no significant difference in DBP values in the total subjects (pre-post DBP values-82.4±9.3mmHg/81.5±10.1).

There was significant difference (decrease) ($p<0.001$) in the systolic BP of females and moderately significant drop in the total systolic BP ($p<0.01$) in the experimental group as seen in Table 4.62 . In control group significant decrease ($p<0.05$) was seen only in total systolic BP.

TABLE 4.62: IMPACT OF AEGLE MARMELOS (L.) CORREA LEAF JUICE SUPPLEMENTATION ON MEAN BLOOD PRESSURE OF EXPERIMENTAL AND CONTROL GROUP (MEAN±SD)

Experimental Group			**Control Group**	
Male (N=11)			**Male (N=14)**	
BP(mmHg)	**Basal**	**Final**	**Basal**	**Final**
Male SBP	139.23±18.11	136.21±21.99	127.3±18.76	121.9±18.04
T value	0.64		2.07	
DBP	88.65±8.81	↓ 85.52±13.65	79.23±8.30	79.5±9.21
T value	0.69		1.60	
Female (N=19)			**Female (N=16)**	
Female SBP	138.39±20.24	↓ 123.50±16.20	138.9±21.38	132.9±16.21
T value	4.48***		1.28	
DBP	84.62±11.20	79.56±9.68	84.3±6.57	84.3±11.5
T value	1.90		0.22	
Total (N=30)			**Total (N=30)**	
Total SBP	138.81±19.17	↓ 129.85±19.09	133.13±20.96	127.10±18.02
T value	2.68*		2.36*	
DBP	86.63±10.00	82.54±11.66	81.76±9.32	81.91±10.11
	2.01*		0.63	

**** Significantly different at p<0.05*** ***SBP-Systolic Blood Pressure***
******highly significant at p<0.001*** ***DBP-Diastolic Blood Pressure***

Result of impact of *Aegle Marmelos (L.) Correa leaf* juice supplementation on the glycemic and lipemic profile of the Type II diabetic subjects

In the present study, the estimation of FBS, HbA1c and PPBS was carried out. *Aegle Marmelos (L.) Correa* leaf juice supplementation caused highly significant decrease in mean FBS, HbA1c and PPBS values in males, females and total subjects of Experimental group ($p<0.0001$) in comparison to Control group post supplementation.

The impact of the *Aegle Marmelos (L.) Correa* leaf juice supplementation on HbA1c revealed high significant reduction for males, females and total group ($p<0.0001$) in Experimental group post supplementation. It was also observed that percent fall in the initial HbA1c and FBS was more pronounced in the female subjects (Table 4.63). But the percent fall in the initial PPBS was more pronounced in the male subjects in comparison to female subjects (Table 4.63). These results indicate the beneficial role of *Aegle Marmelos (L.) Correa* leaf juice supplementation in Experimental group.

Hypertriglyceridemia is a common finding in T2DM subjects and is responsible for vascular complications. In present study *Aegle Marmelos (L.) Correa* leaf juice supplementation for two months to experimental group observed significant decrease in serum cholesterol in all the subjects ($p<0.01$) and females ($p<0.001$) but there was significant rise in serum TC levels in total group ($p<0.0001$) and males and females ($p<0.01$) in Control group. There was significant fall in serum TG levels in all the subjects ($p<0.01$) and in females ($p<0.05$) in the intervened group whereas there was significant rise in serum TG levels in all the subjects ($p<0.000$), females ($p<0.001$) and males ($p<0.01$) in Control group. There was significant drop in mean serum LDL values in all the subjects ($p<0.01$) and significant rise ($p<0.05$) in serum LDL values in total subjects of Control group. There was significant drop in VLDL in total subjects ($p<0.05$) in Experimental group but there was significant rise in VLDL levels in total subjects ($p<0.0001$) in Control group.

TABLE 4.63: IMPACT OF AEGLE MARMELOS (L.) CORREA LEAF JUICE SUPPLEMENTATION ON GLYCEMIC AND LIPID PROFILE OF EXPERIMENTAL AND CONTROL GROUP

	Experimental Group			Control Group		
Fasting Blood Sugar (mg/dl)						
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
Basal	177.70±37.46	172.99±43.82	174.72±50.06	171.11±43.98	165.75±31.73	168.25±37.25
Final	↓ 134.18±40.81	↓ 143.48±50.06	↓ 140.07±46.37	201.20±49.65	187.01±33.04	193.66±41.50
't' value	7.06***	5.37***	7.14***	7.40***	3.00**	5.45***
Post Prandial Blood Sugar (mg/dl)						
Basal	221.19±39.17	207.32±42.08	212.40±40.92	220.11±42.55	223.00±31.84	222.59±36.98
Final	↓ 186.98±54.60	↓ 175.37±48.12	↓ 179.63±49.98	↑ 240.53±44.54	↑ 243.29±28.46	↑ 242.3±36.67
't' value	4.11**	5.10***	6.64***	12.73***	7.80***	9.54**
Glycosylated Hemoglobin (HbA1c) (%)						
Basal	9.80±1.33	9.93±1.24	9.88±1.25	8.57±1.38	8.51±0.96	8.54±1.15
Final	↓ 7.93±1.03	↓ 7.97±1.17	7.96±1.10	↑ 9.21±1.23	↑ 9.08±1.03	9.14±1.11
't' value	6.06***	8.90***	10.92***	6.28***	3.90**	5.90***
Serum Cholesterol (mg/dl)						
Basal	203.8±63.84	212.9±38.49	209.64±48.43	190.54±36.10	191.79±35.87	191.21±35.36
Final	↓ 194.0±46.21	↓ 190.86±44.30	↓ 192.03±44.24	199.47±33.97	208.54±29.71	204.31±31.54
't' value	1.07	3.96***	3.58**	3.10**	3.78**	4.73***
Serum Triglycerides (mg/dl)						
Basal	154.86±47.84	151.64±43.90	152.80±44.59	136.47±40.46	152.27±41.09	144.90±40.88
Final	↓ 142.00±49.19	↓ 134.61±38.87	↓ 137.40±42.27	↑ 150.45±42.98	↑ 166.23±39.40	158.87±41.17
't' value	1.47	2.19*	2.67*	2.96*	4.5***	5.17***
Serum HDL (mg/dl)						
Basal	38.35±4.62	41.03±7.41	40.05±6.57	38.41±6.11	40.49±4.27	39.52±5.22
Final	↑ 43.50±6.04	↑ 42.28±5.79	42.73±5.81	39.82±5.58	39.32±6.38	39.55±5.92
't' value	3.59**	0.58	1.80	1.37	0.59	0.02
Serum LDL (mg/dl)						
Basal	134.50±52.65	144.20±35.43	140.7±41.93	121.41±26.81	119.8±37.42	120.6±32.36
Final	118.50±32.56	↓ 120.4±36.79	↓ 119.7±34.74	↓ 126.10±29.18	↑ 132.8±28.09	↑ 129.7±28.31
't' value	1.61	4.54***	4.29***	1.60	2.18*	2.61*
Serum VLDL (mg/dl)						
Basal	30.97±9.56	30.97±9.57	31.01±10.0	26.43±7.76	30.21±8.36	28.45±8.17
Final	↓ 27.45±9.74	27.45±9.75	↓ 27.23±8.30	↑ 29.29±8.39	↑ 33.73±8.56	↑ 31.66±8.63
't' value	1.49	2.05	2.58*	3.05**	4.00**	5.08***

Significantly different at p<0.05, **Significantly different at p<0.001, ***Significantly different at p<0.0001

Atherogenic Index of Plasma (AIP)

The Atherogenic Index of Plasma (AIP) defined as log (TG/HDL-C), has been proposed as marker of plasma atherogenicity because it is increased in people at a high risk for coronary heart disease and is inversely correlated with LDL-C particle size. Mean±SD AIP values for Experiment and Control group were 0.56±0.13 and 0.55±0.15. Almost all the subjects fell in to the high risk category (>0.21). Thus a high prevalence of dyslipidemia was observed among the subjects and the subjects were at greater risk for CHD as indicated by AIP levels.

As can be seen from the Table 4.64, AIP decreased significantly among the total subjects ($p<0.01$) (0.56±0.13; 0.49±0.13), and moderately among male subjects ($p<0.05$) (0.59±0.11; 0.48±0.13) in the Experimental group. There was increase in AIP in the Control group subjects ($p<0.01$).

TABLE 4.64: IMPACT OF AEGLE MARMELOS (L.) CORREA LEAF JUICE ON THE AIP OF EXPERIMENTAL AND CONTROL GROUP

Experimental Group				**Control Group**		
Atherogenic Index of Plasma (AIP)						
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
Basal	0.59±0.11	0.55±0.14	0.56±0.13	0.54±0.15	0.56±0.15	0.55±0.15
Final	0.48±0.13	0.49±0.13	0.49±0.13	0.56±0.16	0.62±0.14	0.59±0.15
'p' value	0.005**	0.06	0.003**	0.01*	0.01*	0.002**

Significantly different at p<0.05 ; **Significantly different at p<0.01

Impact of *Aegle Marmelos (L.) Correa* leaf juice supplementation on other bio-chemical parameters of Experimental and Control group

Aegle Marmelos (L.) Correa leaf juice supplementation caused significant decrease in mean SGPT values ($p<0.001$) (25.02±7.8; 21.79±5.7) and mean SGOT values ($p<0.01$) of all the subjects (29.03±9.9; 23.32±8.6) in the Experimental group after supplementation of 2 months (Table 4.65). However in Control group there was significant rise in SGPT values ($p<0.0001$) and SGOT values ($p<0.0001$) in total subjects. Overall there was 13% fall in SGPT and 19% fall in SGOT in Experimental group and 15% increase in these parameters in Control group. As can be seen from the Table 4.65, there was no alteration in serum Creatinine values ($p>0.05$) in Experimental group post intervention. However there was significant rise in mean serum Creatinine values in males ($p<0.01$) of Control group. (Pre values 1.34±0.37; Post values 1.47±0.36 mg/dl). These values were found to be in normal range of 0.7-1.4mg/dl. There was no significant difference in serum HsCRP values in Experimental group. However, all the subjects who were at risk (pre mean serum HsCRP values > 0.3 mg/dl) came in the normal range (post mean serum HsCRP values < 3 mg/dl) after *Aegle Marmelos (L.) Correa* leaf juice supplementation. In Control group only males showed significant increase in HsCRP values after two months ($p<0.05$) (Pre values: 3.23±2.11 mg/dl; Post values: 3.70±2.21 mg/dl) (Table4.3.37). There was no significant alteration in the total protein values and albumin levels in Experimental group post supplementation ($p>0.05$) but significant drop in the total globulin and A/G ratio levels in males of Experimental group ($p<0.05$). In Control group there was significant increase in total protein among males and females ($p<0.05$), and total group ($p<0.0001$). Same trend was seen in total albumin levels in males ($p<0.05$), females and total group ($p<0.001$) in Control group. There was no alteration in Globulin and A/G ratio in control group. But all the subjects were in the normal range of 6.0-8.3 g/dl.

TABLE 4.65: IMPACT ON OTHER BIO-CHEMICAL PARAMETERS OF EXPERIMENTAL AND CONTROL GROUP

	Experimental Group			Control Group		
SGPT (IU/L)						
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
Basal	21.97±7.99	26.80±7.34	25.02±7.81	26.81±10.09	25.19±8.04	25.94±8.93
Final	19.48±4.11	23.13±6.23	21.79±5.75	31.05±9.73	28.78±7.43	29.84±8.50
't' value	1.24	2.47*	2.75*	4.48***	4.17***	6.20***
SGOT (IU/L)						
Basal	29.81±11.59	28.58±9.23	29.03±9.98	25.93±8.48	26.77±7.78	26.38±7.98
Final	22.35±7.41	23.89±9.44	23.32±8.65	29.09±10.72	31.07±9.29	30.14±9.86
't' value	1.89	2.29*	2.97**	2.04	3.24**	3.77***
Serum Creatinine (mg/dl)						
Basal	1.19±0.32	1.11±0.22	1.14±0.26	1.34±0.37	1.22±0.44	1.27±0.40
Final	1.19±0.27	1.07±0.13	1.11±0.20	1.47±0.36	1.34±0.47	1.40±0.42
't' value	0.048	0.79	0.75	3.93**	0.84	1.60
Serum HsCRP (mg/dl)						
Basal	3.14±1.35	3.28±1.18	3.23±1.23	3.23±2.11	4.40±4.73	3.85±3.73
Final	2.70±1.11	2.87±0.93	2.80±0.98	3.70±2.21	3.71±1.31	3.71±1.76
Total Proteins (g/dl)						
't' value	1.40	1.07	1.60	2.75*	0.53	0.21
Basal	6.34±0.49	6.16±0.47	6.23±0.48	6.45±0.49	6.34±0.65	6.39±0.58
Final	6.27±0.46	6.27±0.57	6.27±0.53	6.79±0.48	6.82±0.62	6.81±0.55
't' value	0.58	1.27	0.60	2.79*	5.03***	5.45***
Total Albumin (g/dl)						
Basal	4.24±0.21	4.14±0.29	4.17±0.26	4.26±0.32	4.28±0.42	4.27±0.37
Final	4.46±0.45	4.46±0.45	4.25±0.42	4.67±0.43	4.53±0.42	4.60±0.43
't' value	1.91	0.16	0.88	2.78*	2.19*	3.56**
Total Globulin (g/dl)						
Basal	2.08±0.46	2.08±0.51	2.08±0.48	2.18±0.30	2.13±0.54	2.16±0.44
Final	1.79±0.28	2.11±0.44	2.00±0.41	2.06±0.38	2.27±0.47	2.17±0.43
't' value	2.27*	0.41	1.05	0.94	1.20	0.16
A/G Ratio						
Basal	2.09±0.49	2.11±0.60	2.10±0.55	1.95±0.28	2.03±0.43	2.02±0.43
Final	2.53±0.52	2.02±0.46	2.21±0.53	2.38±0.72	2.24±0.63	2.23±0.62
't' value	2.61*	0.67	0.88	1.84	0.15	1.58

Significantly different at p<0.05, ** Significantly different at P<0.001, *** Significantly different at P<0.0001

Impact of *Aegle Marmelos (L.) Correa leaf juice* supplementation on the serum antioxidant profile of Experimental and Control group

There was significant rise (17.7%) in mean serum FRAP values ($p<0.0001$) and also in males and females (Table 4.66). However there was significant decrease ($p<0.0001$) in serum FRAP values (15%) in all the subjects of Control group ($p<0.0001$), males ($p<0.01$) and females ($p<0.05$).

TABLE 4.66: IMPACT OF AEGLE MARMELOS (L.) CORREA LEAF JUICE ON SERUM ANTIOXIDANT STATUS (S FRAP) OF EXPERIMENTAL AND CONTROL GROUP

	Experimental Group			**Control Group**		
	Serum FRAP (µmolTE/L)					
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
Basal	1.75±0.44	1.59±0.37	1.65±0.40	2.12±0.70	2.24±0.97	2.18±0.84
Final	↑ 2.04±0.39	↑ 1.87±0.39	↑ 1.93±0.39	↓ 1.66±0.36	↓ 2.00±0.90	↓ 1.84±0.71
't' value	3.49**	2.96**	4.27***	3.68**	2.74*	4.50***

****Significantly different at p<0.05, ** Significantly different at P<0.001, *** Significantly different at P<0.0001***

Summary of impact of Aegle Marmelos (L.) Correa leaf juice supplementation on biochemical parameters of Experimental and Control group

Aegle Marmelos (L.) Correa juice supplementation resulted in remarkable reduction in the following biochemical parameters as seen in Table 4.67.

FBS 20 % (Expt. group: Mean pre/post FBS values (mg/dl)- [174.7±41/140.1±46.3; Cont. group (15% increase): 168.3±37.3/193.7±41.5], **HbA1c 20%** [Expt. group: Mean pre/post HbA1c values (%)- 9.8±1.2/7.9±1.1; Cont. group (7% increase): 8.5±1.1/9.1±1.1], **LDL 15%** [Expt. group: Mean pre/post LDL values(mg/dl)- 140.7±41.9/119.7±34.7; Cont. group (7.5% increase): 120.6±32.3/129.7±28.3], **TG 10.9%** [Expt. group: Mean pre/post TG values mg/dl)- 152.8±44.5/137.4±42.2; Cont. group (9.6% increase): 144.9±4.8/158.9±41.1], **VLDL 12.6%** [Expt. group: Mean pre/post VLDL values mg/dl)- 31.0±10.0/27.2±8.3; Cont. group (11.2% increase): 28.4±8.1/31.6±8.6], **Serum FRAP 17.7% rise** [Expt. group: Mean pre/post serum FRAP values (µmolTE/L)- 1.6±0.3/1.9±0.3; Cont. group (15% drop): 168.3±37.3/193.7±41.5], **SGPT 13%** [Expt. group: Mean pre/post SGPT values (IU/L)- 25.3±7.8/21.7±5.7; Cont. group (15% increase): 25.9±8.9/29.8±8.5], **SGOT 19%** Expt. group: Mean pre/post SGOT values (IU/L)- 29.0±9.9/23.3±8.6; Cont. group (14.4% increase): 26.3±7.9/30.1±9.8].

Maximum difference was noted in Glycemic profile i.e. FBS, HbA1c, PPBS and serum antioxidant (Serum FRAP) values, lipid profile like TG, LDL and VLDL values and liver enzymes (SGPT and SGOT) while minimum difference was recorded in serum Creatinine and HsCRP values. There was no difference in total proteins values post supplementation.

TABLE 4.67 : SUMMARY OF THE IMPACT OF AEGLE MARMELOS (L.) CORREA LEAF JUICE SUPPLEMENTATION ON THE BIO-CHEMICAL PARAMETERS OF EXPERIMENTAL AND CONTROL GROUP (MEAN±SD)

Experimental Group						**Control Group**			
Fasting Blood Sugar (mg/dl)									
	Male	**Female**	**Total**	**Normal Range**	**% Decrease in total subjects**	**Male**	**Female**	**Total**	**% Increase in total subjects**
Basal	177.70±37.46	172.99±43.82	174.72±50.06	70-110mg/dl	20	171.11±43.98	165.75±31.73	168.25±37.25	↑ 15.1
Final	134.18±40.81	143.48±50.06	140.07±46.37			201.20±49.65	187.01±33.04	193.66±41.50	
't' value	7.06***	5.37***	7.14***			7.40***	3.00**	5.45***	
Post Prandial Blood Sugar (mg/dl)									
Basal	221.19±39.17	207.32±42.08	212.40±40.92	120-140mg/dl	↓ 15.5	221.11±42.55	223.00±31.84	222.59±36.98	↑ 8.85
Final	186.98±54.60	175.37±48.12	179.63±49.98			240.53±44.54	243.29±28.46	242.3±36.67	
't' value	4.11**	5.10***	6.64***			12.73***	7.80***	11.54***	
Glycosylated Haemoglobin (HbA1c) (%)									↑
Basal	9.80±1.33	9.93±1.24	9.88±1.25	<7%	↓ 20	8.57±1.38	8.51±0.96	8.54±1.15	↑ 7.02
Final	7.93±1.03	7.97±1.17	7.96±1.10			9.21±1.23	9.08±1.03	9.14±1.11	
't' value	6.06***	8.90***	10.92***			6.28***	3.90**	5.90***	
Total Cholesterol (mg/dl)									
Basal	203.8±63.84	212.9±38.49	209.64±48.43	<200 mg/dl	↓ 8.4	190.54±36.10	191.79±35.87	191.21±35.36	↑ 6.85
Final	194.0±46.21	190.86±44.30	192.03±44.24			199.47±33.97	208.54±29.71	204.31±31.54	
't' value	1.07	3.96***	3.58**			3.10**	3.78**	4.73***	

Variable	Male	Female	Total	Normal Range	% Decrease in total subjects	Male	Female	Total	% Increase in total subjects
Serum Triglycerides (mg/dl)									
Basal	154.86±47.84	151.64±43.90	152.80±44.59	<150mg/dl	10.9	136.47±40.46	152.27±41.09	144.90±40.88	9.64
Final	142.00±49.19	134.61±38.87	137.40±42.27			150.45±42.98	166.23±39.40	158.87±41.17	
't' value	1.47	2.19*	2.67*			2.96*	4.5***	5.17***	
Serum HDL (mg/dl)									
Basal	38.35±4.62	41.03±7.41	40.05±6.57	>50mg/dl	↑ 6.7	38.41±6.11	40.49±4.27	39.52±5.22	↑ 0.07
Final	43.50±6.04	42.28±5.79	42.73±5.81			39.82±5.58	39.32±6.38	39.55±5.92	
't' value	3.59**	0.58	1.80			1.37	0.59	0.02	
Serum LDL (mg/dl)									
Basal	134.50±52.65	144.20±35.43	140.7±41.93	<130mg/dl	15	121.41±26.81	119.8±37.42	120.6±32.36	7.54
Final	118.50±32.56	120.4±36.79	119.7±34.74			126.10±29.18	132.8±28.09	129.7±28.31	
't' value	1.61	4.54***	4.29***			1.60	2.18*	2.61*	
Serum VLDL (mg/dl)									
Basal	30.97±9.56	30.97±9.57	31.01±10.0	<30mg/dl	12.6	26.43±7.76	30.21±8.36	28.45±8.17	11.28
Final	27.45±9.74	27.45±9.75	27.23±8.30			29.29±8.39	33.73±8.56	31.66±8.63	
't' value	1.49	2.05	2.58*			3.05**	4.00**	5.08***	
Serum FRAP (Mmol TE/L)									
Basal	1.75±0.44	1.59±0.37	1.65±0.40	0.5-2.0mmol/L	↑ 17.7	2.12±0.70	2.24±0.97	2.18±0.84	↓ 15.59
Final	2.04±0.39	1.87±0.39	1.93±0.39			1.66±0.36	2.00±0.90	1.84±0.71	
't' value	3.49**	2.96**	4.27***			3.68**	2.74*	4.50***	

Variable	Male	Female	Total	Normal Range	% Decrease in total subjects	Male	Female	Total	% Increase in total subjects
SGPT (IU/ml)									
Basal	21.97±7.99	26.80±7.34	25.02±7.81	0-48U/L	↓ 13	26.81±10.09	25.19±8.04	25.94±8.93	15.03
Final	19.48±4.11	23.13±6.23	21.79±5.75			31.05±9.73	28.78±7.43	29.84±8.50	
't' value	1.24	2.47*	2.75*			4.48***	4.17***	6.20***	
SGOT(IU/L)									
Basal	29.81±11.59	28.58±9.23	29.03±9.98	0-42U/L	↓ 19	25.93±8.48	26.77±7.78	26.38±7.98	14.25
Final	22.35±7.41	23.89±9.44	23.32±8.65			29.09±10.72	31.07±9.29	30.14±9.86	
't' value	1.89	2.29*	2.97**			2.04	3.24**	3.77***	
Serum Creatinine (mg/dl)									
Basal	1.19±0.32	1.11±0.22	1.14±0.26	0.7-1.4mg/dl	2.6	1.34±0.37	1.22±0.44	1.27±0.40	10.23
Final	1.19±0.27	1.07±0.13	1.11±0.20			1.47±0.36	1.34±0.47	1.40±0.42	
't' value	0.048	0.79	0.75			3.93**	0.84	1.60	
HsCRP (mg/dl)									
Basal	3.14±1.35	3.28±1.18	3.23±1.23	<3mg/L	1.3	3.23±2.11	4.40±4.73	3.85±3.73	↓ 3.63
Final	2.70±1.11	2.87±0.93	2.80±0.98			3.70±2.21	3.71±1.31	3.71±1.76	
't' value	1.40	1.07	1.60			2.75*	0.53	0.21	
Total Protein (g/dl)									
Basal	6.34±0.49	6.16±0.47	6.23±0.48	6.0-8.3g/dl	↑ 0.6	6.45±0.49	6.34±0.65	6.39±0.58	6.57
Final	6.27±0.46	6.27±0.57	6.27±0.53			6.79±0.48	6.82±0.62	6.81±0.55	
't' value	0.58	1.27	0.60			2.79*	5.03***	5.45***	

Discussion

Phase III was a clinical trial on- "the impact of *Aegle Marmelos (L.) Correa* leaf juice supplementation on blood sugar, lipid profile, liver and kidney function in Type II diabetes mellitus subjects".

In the present study 20g fresh *Aegle Marmelos (L.) Correa* leaf (100ml juice) was supplemented to 30 confirmed type II diabetic subjects for 2 months and significant difference was recorded in blood pressure (reduction: SBP-6.45%; DBP- 4.6%), glycemic profile (15-20%), lipid profile (8-15%), liver functions (13-19%), increase in antioxidant activity (18%) in the subjects of Experimental group post supplementation. *Aegle Marmelos (L.) Correa* leaf juice supplementation has played a positive impact on reducing blood sugar levels, lipid profile and liver functions in Type II diabetic subjects

No studies on fresh *Aegle Marmelos (L.) Correa* leaf juice for its anti-diabetic property has been reported up till now but couple of studies done using dry bael powder on human subjects were reported and the hypoglycaemic and hypolipidemic effect of the leaf was confirmed (Table 4.68). However the impact of the leaves on liver and kidney functions along with anti-inflammatory status, total proteins and antioxidant status of the subjects was not assessed in these studies.

Reduction in blood glucose level may be due to presence of active component, Aegelin 2 and scopoletin in leaf (Maity et al., 2009; Narender et al., 2007; Panda and Kar, 2006). Bael leaves produce hypoglycaemic effect probably by enhancing the peripheral utilization of glucose, correcting the impaired hepatic glycolysis and arresting its gluconeogenic formation similar to insulin (Yaheya and Ismail, 2009).

Reduction of serum lipids may be due to the decreased fat mobilization from the peripheral stores as well as their synthesis. *Aegle Marmelos* leaf extract activates hydrolysis of triglycerides and decreases circulatory level of blood cholesterol by decreasing fat mobilization from the peripheral adipose tissues (Maity et al., 2009). A lower level of circulatory fatty acid may favour the restoration of normal functioning

of Na+/K+-ATPase path, an essential pathway for proper burning of glucose at cellular level in diabetic animals (Bandopadhyay et al., 2002).

Another mechanism for reduction in lipid level proposed is that Aegline 2, active component present in bael leaf regulates lipid level (Narender et al., 2007). The reduction in total cholesterol could be due to beta-sitosterol present in *Aegle Marmelos (L.) Correa* which is structurally similar to cholesterol helps in reducing serum cholesterol concentration by reducing the absorption of cholesterol from the gut by competing for the limited space for cholesterol in mixed micelles (Maity et al., 2009).

The antioxidative phytochemicals such as flavonoids, alkaloids, sterols, tannins, phlobatannins, flavonoid glycosides present in the leaf extract possess this free radical scavenging activity.

TABLE 4.68 : STUDIES (HUMAN CLINICAL TRIALS) PROVING EFFICACY OF VARIOUS FUNCTIONAL FOODS USED IN THE MANAGEMENT OF TYPE II DIABETES

Investigators	Functional Food	Dose/Duration	Results
Iyer et al (2008)	Garden Cress Seeds	3g/d (28 days) on 41 NIDDM subjects	↓ HbA1c-4.7%;TG-71%;TC,LDL,HDL-NS
Khan et al (2003)	Cinnamon	1,3, 6g/day (40 days)-short term on 60 NIDDM subjects	↓ FBS-18-29%
Ziegenfguss et al (2006)	Cinnamon	500mg/d (90 days) long term	↓ 83% subjects showed FBS-8%
Srivastava et al., (1993)	Momordica charantia	Dried powder and aq. extract of 5g/d (1-3 times a day for 21 days	↓ extract-Av bl sugar-54% ↓ dry powder Av bl sugar-25%; HbA1c-27%
Iyer and Mani (1989)	Curry leaves	1g/d for 1 month on 30 NIDDM	Transient decrease in glycemic and other parameters
Rai et al (1997)	Ocimum Sanctum	1g/day for 1 month on 27 NIDDM	↓ FBS-21%, HbA1c- 11%,TC-11%,LDL-14%, VLDL-16%, TG-16%
Iyer and Desai (2008)	150ml Panchatantra drink (ingr: Amla, tulsi, mint, cumin & turmeric)	150ml/d for 45 days on 25 T2DM	↓ FBS-7%, HbA1c- 3%
Joshi and Iyer (2008)	Amla	35g/d for 60 days	↓ Gly. profile-no change, TC-5.8%, LDL-9.4%, non-HDL-8.3% ↑ HDL-5.5%
Venugopal and Iyer (2010)	Barley grass powder	1.2g/d(capsules) for 60 days on 23 NIDDM subjects	↓ FBS-10.8%, HbA1c- 5.2%
Venugopal and Iyer (2010)	Kodari seeds	40g/d for 28 days on 30 T2DM subjects	↓ HbA1c-1.2%, FBS-no change
Venugopal and Chug (2015)	Insulin plant leaf powder	1g/d (4 capsules) for 45 days on 27 T2DM subjects	↓ FBS-13.8%, HbA1c-5.13%, PPBS-12.3%, TG-16.2%, ↑ HDL-9.8%
Human studies on *Aegle Marmelos (L.) Correa* leaves			
Yaheya and Ismail (2009)	5g dry *Aegle Marmelos (L.) Correa* leaf powder along with OHD	10 subjects for 30 days	↓ PPBS-31% (201mg/dl-137 mg/dl) **Hypoglycemic effect**
Singh and Kochhar (2012)	2g dry *Aegle Marmelos (L.) Correa* leaf powder along with OHD	30 NIDDM subjects for 60 days	↑ FBS-9.8%, PPBS-5.6%, TC-4.5%, TG-6.2%, LDL-8.1% ↑ HDL-8.9% **Hypoglycemic effect**
Present study	100ml Fresh juice containing 20 g fresh *Aegle Marmelos (L.) Correa* leaves along with OHD	30 Type II subjects for 60 days	↓ FBS-20%, HbA1c- 20% ,PPBS-15.5%, TC-8.4%, TG-10.9%, LDL-15%, VLDL-12.6%, SGPT-13%, SGOT-19% ↑ HDL-6.7%, Serum antioxidant value(Serum FRAP)-17.7% **Hypoglycemic effect**

Possible Mechanism of Action

Given below is the possible mechanism of action based on animal model clinical trial studies-

A. *Aegle Marmelos (L.) Correa* increases utilization of glucose, either by direct stimulation of glucose uptake or through the mediation of enhanced insulin secretion (Upadhya, 2004).

B. It decreases oxidative stress which indirectly simulates protein glycation and inactivation of enzymes (Sabu and Kuttan, 2004).

C. *Aegle Marmelos (L.) Correa* stimulates the β cells to increase insulin secretion. It increases the receptor responsiveness of the insulin receptors (Sevugan, 2008).

D. *Aegle Marmelos (L.) Correa* may also contain some bio molecules that may sensitize the insulin receptor to insulin or stimulates the β-cells of islets of Langerhans to release insulin which finally lead to improvement of carbohydrate metabolizing enzymes and re-establishes normal blood glucose level. (Khan et al., 2012).

E. It modulates the activity of enzymic and non-enzymic antioxidants and enhances the defence against ROS-generated damage in diabetic rats (Behera and Yadav, 2013).

F. It works like an insulin sensitizer which can be used in the treatment of diabetes. It improves the glycemic control by enhancing the insulin sensitivity in liver and muscle (Murlidharan, 2014).

Possible antidiabetic, Antihyperlipidaemic and antioxidant activities of *Aegle Marmelos (L.) Correa* leaf as reported by Maity et al (2009) is depicted in Table 4.69.

TABLE 4.69: POSSIBLE ANTIDIABETIC, ANTIHYPERLIPIDEMIC AND ANTIOXIDANT ACTIVITIES OF AEGLE MARMELOS (L.) CORREA LEAF

Bael Extract		
Anti diabetic activity	**Antihyperlipidaemic activity**	**Antioxidant activity**
↑ Insulin release	↓ Blood or serum Triglyceride	↑ Catalase
↓ Blood glucose level	↓ Fat mobilization	↑ Glutathione (GSH) peroxidase
↑ Glycogenesis	↓ Blood cholesterol	↑ GSH reductase
		↑ superoxide dismutase (SOD)

(Maity et al., 2009)

Cost of available commercial formulations of Aegle Marmelos (L.) Correa versus cost of fresh juice

Aegle Marmelos (L.) Correa (Bael) is one of the top 10 highly traded medicinal plants in India and it has huge demand in foreign markets (Bhattacharya et al., 2014). However Aegle Marmelos (L.) Correa leaf powder available commercially costs around Rs. 200 per 100 g as shown in Fig: 24 and Fig: 25 (Rs. 2000/kg). In comparison to this our fresh leaf juice costs only around Rs. 40-80 per Kg.

The cost effectiveness of fresh *Aegle Marmelos (L.) Correa* leaf juice can be very important factor particularly for low and middle income group and tribal belts of India which do not have an access to western costly system of medicine and herbal supplements available commercially in India and abroad.

FIG 24: BAEL LEAF POWDER COST RS. 204/100G NATURMED

FIG25: BAEL LEAF POWDER COST RS. 195/100G NATURE HERBAL PRODUCTS

Diabetes a Public health problem and Aegle Marmelos (L.) Correa juice

Diabetes mellitus is a growing public health problem in both developed and developing countries. According to the report of World Health Organization (2011), 346 million people have diabetes worldwide. It is also estimated that 3.4 million patients died from diabetes-related complications in 2004. Without urgent action, this number is likely to double by 2030.

Conventional treatment comprises of oral hypoglycemic drugs like including insulin sensitizers (biguanides, thiazolidinediones), insulin secretagogues (sulfonylurea, meglitinides), α-glucosidase inhibitors, incretin agonists and dipeptidyl peptidase-4 inhibitors (Lorenzati *et al.*, 2010). These are costly, having unpleasant side effects and inaccessible in remote areas.

This study focused on *Aegle Marmelos (L.) Correa* herb, the hypoglycemic actions of which have been supported by clinical trial.

Medicinal plants have always been an important source for finding new remedies for human health problems. Traditionally, numerous herbs have been recommended for treatment of diabetes. Also, antidiabetic effects of so many plants have been reported

by many researchers. In most cases, however, these reports are confirmed by animal models and even *in vitro* studies and limited evidence exists about their clinical usefulness.

Aegle Marmelos (L.) Correa, a plant indigenous to India has been used by the inhabitants of the Indian subcontinent for over 5000 years. The leaves, bark, roots, fruits and seeds are used extensively in the Indian traditional system of medicine, Ayurveda and in various folk medicine to treat number of ailments (Baliga et al., 2010). Bael has an important place in the traditional Ayurvedic system of medicine (Parmar & Kaushal, 1982).

In present study beneficial hypoglycemic effect of *Aegle Marmelos (L.) Correa* was clinically evaluated in type II diabetes subjects and improvement in blood sugar levels along with lipid profile helps to confirm the efficacy of fresh leaf juice for the same.

Bael leaves produce hypoglycemic effect probably by enhancing. the peripheral utilization of glucose, correcting the impaired hepatic glycolysis and limiting its gluconeogenic formation similar to insulin (Das et al., 1996, Bhavpriya and Govindswamy, 2000, Bannerji and Nigam, 1984).

This juice can be prepared at home. One can easily manage the leaves from local sources like Shiva temples, local market and adjoining gardens. One can easily grow *Aegle Marmelos (L.) Correa* plant in one's own house as it a plant of arid horticulture. It can be grown in any soil. It is a cheap domestic technology which will help the diabetic individuals control their blood sugar. It avoids tedious preparations such as extract formation, decoction etc. and can be taught to even illiterate also. *Aegle Marmelos (L.) Correa* leaf juice can be used to combat this public health problem.

Conclusions

It can be concluded that supplementation of 20 g *Aegle Marmelos (L.) Correa* leaf juice had beneficial impact on blood sugar values and lipid profile along with liver functions significantly improved the nutritional status of the diabetic patients. This effect can be attributed to the synergistic effect of good nutrient and phytochemicals profile of *Aegle Marmelos (L.) Correa* leaves. It can be supplemented along with oral hypoglycemic drugs to keep the above parameters in control.