CHAPTER-VIII

SUMMARY AND CONCLUSION

The present study titled “Assessment of Nutritional and Pharmacological Properties of Pisonia grandis R.Br leaves (Nyctanginacea) and its effect on Type 2 Diabetes” progressed with the following objectives.

OBJECTIVES

Field Study:
- To delineate the socio demographic, anthropometric, dietary and health profile of the of type 2 diabetic subjects.
- To evolve a conceptual model highlighting the socio economic & health attributes leading to prevalence of T2D

Experimental Studies:
- To study the nutritional & pharmacological properties of Pisonia grandis R.Br. leaves.
- In vivo study to analyze the anti-diabetic activity of Pisonia grandis R.Br. leaves.
- To develop the recipes using Pisonia grandis R.Br leaves and evaluate organoleptically the standardized recipes.
- To assess the insulin secretion in a normal subject after administering Pisonia grandis R.Br. leaf soup – A Case Study.

The study was conducted by adopting the multi-methodological procedure i.e. both Experimental and Survey method. The study was conducted over a period of two years i.e from the April, 2013 to December 2014. The study was done in four phases under the following heads:
Chapter III: Survey Methodology – to elicit the Socio-demographic profile, health related information of Type 2 Diabetic subjects and to evolve a conceptual model highlighting the socio economic & health attributes leading to prevalence of T2D.

Chapter IV: Experimental design 1 – to study the Nutritional and Pharmacological properties of *Pisonia grandis R.Br.* leaves.

Chapter V: Experimental design 2 – to analyze acute toxicity and the anti-diabetic activity of *Pisonia grandis R.Br.* leaves.

Chapter VI: Experimental design 3 – to standardize the recipe by incorporating the *Pisonia grandis R.Br.* leaves.

Chapter VII: Experimental design 4 – to analyze the insulin secretion in a normal subject after administering 200 ml of Pg leaves soup with 35 gms of Pg leaves.

The following methodology was designed to fulfill the needs of the objectives:

Chapter III – Survey Methodology – To elicit the Socio-demographic profile, health related information of Type 2 Diabetic subjects and to evolve a conceptual model highlighting the socio economic & health attributes leading to prevalence of T2D.

Puducherry region was selected for the study. Ten Government Primary Health Centres comprising both rural and urban areas of Puducherry were included for collecting the samples for the study. Multistage proportionate stratified random sampling method was used for picking up the samples. Samples were selected from the above 10 urban & rural Primary Health Centres and during the special diabetic camps conducted by Health Department, Government of Puducherry. The duration of study period was from April, 2013 to December 2014.
As on the date of study, 4887 samples both male and female were enrolled at the survey period. Out of total 4887 general population, 874 found to be diabetic. Of total 874 diabetic samples, 400 samples were taken as a sub-sample for analyzing the Body Composition Analysis (BCA) and Food Frequency Questionnaire (FFQ). The diabetic samples were included for the study based on the Diagnostic criteria given by American Diabetes Association (ADA) standards used for random/casual blood sugar (RBS) greater than or equal to 200 mg/dl, the age of the sample was between 30 – 80 years and those who gave consent to participate at the time of study. Exclusion criteria used for the present study was those who do not fall in the inclusive criteria and those who do not extend their consent. Interview schedule was used for collecting the data and a well constructed schedule was used to elicit information related to diabetes viz. socio-demographic, health related questions and food frequency. To assess the core parameters of the study, following instrument was used. For assessing the body composition, Tanita SC (n=400) was used. To measure height and waist circumference, Stadiometer & flexible inch tape was used (n=400). Biochemical test-blood glucose test, blood pressure and HbA1c were assessed (n=4887).

Chapter IV - Experimental design 1 - To study the Nutritional and Pharmacological properties of Pisonia grandis R.br leaves.

The leaf of Pisonia grandis R. Br. and Cassia auriculata flower were selected for the present study. The plant species were collected from the vegetable market of Puducherry. The petals of the Cassia auriculata species was used to overcome the bitterness of Pisonia grandis R. Br. leaf powder. Leaves of Pisonia grandis R.Br. and the petals of Cassia auriculata were shade dried at room temperature for 45 days. Then the shade dried leaves and petals were pulverized to coarse powder. These coarse and fine powders were used for further studies. To know the nutritional properties of Pisonia grandis R. Br. leaves, the fresh leaf was analyzed by way of sauteing (shell frying, 5
min), blanching (open blanch 5min), steaming (10min) to find the moisture, vitamin-C, polyphenel, total carotene, CHO, iron and antioxidant properties. The nutritional analysis was also done both in fresh and dried leaf powder. The analysis has been done by adopting standard procedure of Association of Analytical Chemistry (AOAC). Further, the leaf powder was tested to know the active phyto compounds present in the leaf. The sequential soxhlet apparatus was used for the study, in which the dried powder of *Pisonia grandis R. Br.* leaves was done with Chloroform (S), Ethanol (S), Methanol (S) and Petroleum ether. The extracts were concentrated, residues designated as PGSX1, PGSX2, PGSX3, PGSX4 and PGSX5 respectively. Further, the organic compound present in the ethanolic extract of *Pisonia grandis R.Br* leaf powder was tested at M/s. Bureau Veritas Consumer Products Services (I) Pvt. Ltd., Ekkattuthangal, Guindy, Chennai – 32 using GC MS 5975 C Agilent. The molecular weight, molecular formula and structure of the compound were ascertained using NIST library.

**Chapter V - Experimental design 2 – To analyze the acute toxicity and anti-diabetic activity of *Pisonia grandis R. Br* leaves.**

The anti-diabetic activity of *Pisonia grandis R.Br.* leaves was tested against Streptozotocin (STZ) induced diabetes mellitus in rats. The male and female rats weighing 180–240g and 134-166g were used in the study. The selected animals were housed and maintained under laboratory conditions at a temperature of 18-24°C, relative humidity of 55-75(%), with a 12h light and 12h dark cycles with standard diet and water *ad libitum*. The study was conducted after obtaining the ethical clearance i.e. CPCSEA approval. The oral acute toxicity of the extract was carried out in female wistar rats using up and down procedure (OECD, 2001). This method was carried out with six female rats (three animals per step). The test item was administered as a single oral dose to overnight fasted (16-18 hours) rats at the dose volume of 10 ml/kg b.wt. Mortality, clinical observations, body weights and gross necropsy
findings were evaluated. At the end of the observation period the rats were sacrificed using diethyl ether anaesthesia and subjected to detailed gross necropsy studies.

The powdered material was subjected to cold maceration using sufficient quantity of ethanol and distilled water (1:1) for 10 days with intermittent shaking in a round bottom flask. On 10th day, it was strained and marc was pressed. The pressed liquid was added to the strained liquid and the combined liquid was clarified by filtration and the filtrate was subjected to distillation at temperature 60°C for removing ethanol and water. The extract was dried in a desiccator and it was referred to as PgEE. It was diluted with 2% carboxy methyl cellulose to desired concentrations and used for the experiments.

The 30 male Wistar rats (which are previously treated with STZ and selected) was divided into 5 groups of 6 each. Group 1 was served as normal and Group 2 was serve as control, Group 3 were administered PgEE (250 mg/kg b.w/d) and Group IV was administered PgEE (500mg/kg b.w/d) respectively. Group 5 receive glibenclamide (10 mg, kg, p.o.). All the rats were given the above assigned treatment for a period of 14 days and fasting blood glucose was measured on day 0, 7 and 14.

To analyze the effect of *Pisonia grandis* *R. Br. leaves* in Type II Diabetic patients. Ten newly diagnosed male & female diabetic samples were randomly selected from Puducherry region between the age group of 30-50 years. The samples were included based on their age, blood glucose level >200mg/dl and free from major illness. The samples who have not met the inclusion criteria were excluded from the study. In compliance of the ethical consideration, the patients (samples) were explained of the need, scope and the nature of the study and a consent letter was obtained from them.
The selected 10 samples were administered 5g of Pg Powder and 2g cassia aculeate petal powder three doses /day for one month as specified below:-

(a) Morning dosage taken immediately after breakfast with 200ml of warm water.

(b) Afternoon dosage taken at the start of lunch (ie) the powder must be mixed with a ball of raw rice and swallowed.

(c) Night dosage taken immediately after dinner with 200 ml of warm water.

Before administering the leaf powder, the subjects were asked to maintain their habitual diet and the level of physical activity. The Fasting and Post prandial glucose level were measured once in 15 days before, during and after administering the leaf powder (ie. 3 times) during the course of administration of Pg powder.

Chapter VI- Experimental design 3 – to standardize the recipe by incorporating the Pisonia grandis R. Br. leaves.

Enough care was taken to decide on the recipe. A primary list of recipes was prepared. Accordingly, Soup, Chappathi, Sambar, Kozhukattai, Poriyal, Masiyal, Adai and Bread-sandwich were tried out. The recipe was prepared considering the diabetic population.

Then the outcome of the prepared items was evaluated for taste, consistency, flavor, mouth feel, colour and appearance. Suggestions and hints given to improvise the dish by the experts were taken into consideration and the final study was carried out. Each dish was prepared for 15 servings and then values were calculated for one serving.

The essential nutrients like calories, protein, fat, fibre, carbohydrates, iron, calcium, vitamin-A and vitamin-C were calculated using the book Nutritive Value of Indian Foods, published by National Institute of Nutrition. The cost of all the ingredients used for preparing each
dish was noted and the cost for one serving was worked out. The panel members were selected in the age of 30 to 35 years and they were free from health disorder and especially free from cold and cough. The 30 selected panel members were asked to evaluate the prepared items for taste, flavour, mouth feel, colour and appearance on 4-point hedonic scale.

The four point hedonic rating scale was used to evaluate the selected recipes. The rating was fixed to Excellent, Good, Fair and Poor and the scores were given to each category of rating scale was 4, 3, 2 and 1 respectively. Panel members were briefed about the *Pisonia grandis* R. Br. leaves and its applications and then were asked to fill the evaluation form.

The data were represented as mean ± S.D. The minimum level of significance was set at p<0.05. The SPSS 20 was adhered to compare various sets of dependent variables and independent variables. Odds ratio was used to measure risk factors between the variables. Results were analyzed statistically by one-way ANOVA followed by Dunnett’s multiple comparison tests using Prism software (Version 4).

**Chapter VII: Experimental design 4 –To assess the insulin secretion in a normal subject after administering *Pisonia grandis* R.Br. leaf soup – A Case Study**

Mrs. X a 28 year old married female subject with 2 children aged 5 years and 3 year. Enough care was taken to pick the study subject who fulfilled the standards prescribed for an Indian reference woman by ICMR (2010).

The selected subject was advised to have a habitual day to day activity along with normal south Indian diet. Mrs. X was advised not to consume concentrated sweets and bakery foods so as to avoid the interaction with the serum insulin level. Further, the test was
conducted after 15 days of her menstruation cycle, to avoid fluctuation on insulin levels.

**SUMMARY OF THE RESULTS OBTAINED FROM THE STUDY ARE DISCUSSED BELOW**

**Chapter III:** The summary of this phase of the study is to discuss the results related to socio demographic, family history, biochemical, anthropometric and dietary profile of the respondents. Further, the study used the Odds Ratio and multiple logistic regressions to find the risk factor of the diabetic samples.

To delineate the socio demographic, anthropometric, dietary and health profile of the of type 2 diabetic subjects and to evolve a conceptual model highlighting the socio economic & health attributes leading to prevalence of T2D

The study revealed that out of 4870 enrolled 1112 (22.83%) samples were found to be diabetic and pre-diabetic samples. From 1112, nearly 261 female and 156 male were found to be pre-diabetic and 365 females and 330 males were observed to be diabetic. To find the diabetic and pre-diabetics, the standard values of HbA1c was used as per the recommendations of American Diabetic Association (ADA).

It was observed that mean height, weight, waist circumference (WC), waist hip ratio (WHR), blood pressure [such as diastolic (DBP) and systolic (SBP)] and random blood sugar (RBS) of the male respondent was towering than the female respondent, even though the female subjects had lower mean values than male mean values. All the mean values of the both respondents were high when compared to standards of diabetics and pre-diabetic.

**Socio-demographic profile of the Diabetic and Pre-diabetic samples**

From the selected age group, it was observed that almost more than 50 percent of pre-diabetic male and female were between 30 - 49 years
and almost 40 percent of the diabetic male and female population between the age group of 30 – 49 years. Unfortunately, it was found that pre-diabetic was more prevalent among the younger adults.

Regarding sex distribution, 62 percent of participants were females and 38 percent were males. In the educational qualification, illiteracy was found to be high in the female population than the male population.

Regarding the economic status, 24 percent of the female and 25 percent of the male pre-diabetic samples were found to be economically weaker. On analysing the diabetic samples, nearly 29 percent female and 20 percent male subjects were found to be economically weaker.

Almost 35 to 43 percent of the pre-diabetic and diabetic from both sexes belonged to the Low Income Group (LIG). About 8 to 10 percent of the male and female pre-diabetic populations were from High Income Group (HIG). Undesirably, more prevalence was found in Low income and economically weaker sections.

In caste wise distribution, nearly 80 percent of the entire categories (normal, diabetic and pre-diabetic) were from backward communities. About 90 percent of the respondents belonged to Hindu religion.

On studying the occupational classification, nearly 90 of pre-diabetic and diabetic female population were homemakers or retired staff. Only 1 percent and 13 percent of the pre-diabetic female and male belonged to professionals.
Health Attributes of the selected respondents:

Of the total 417 pre-diabetic and 695 diabetic samples, almost 70 percent of the female pre-diabetic and diabetic samples revealed that they were not in the habit of doing physical exercise.

Nearly 44 to 54 percent of the male diabetic and pre-diabetic samples informed that they were not doing physical exercise.

It was observed that the more number of the female population expressed that they were not doing physical exercise when compared to male population.

Moreover, nearly 61 percent from the total 1112 diabetic and pre-diabetic informed that they will say “No” to physical exercise due to lack of time, work pressure and joint pains.

Out of 1112 total diabetic and pre-diabetic samples, sharply 48.9 percent of them were unaware of prevalence of T2D and were of the opinion that they had normal levels of blood glucose.

Unexpectedly, the result of the present study showed that nearly 79 percent of the pre-diabetic samples didn’t know that they were having HbA1C between 5.7 percent and 6.4 percent.

In the 695 diabetic populations, nearly 30.6 percent of the samples did not know that they were diabetic. Nearly, fifteen diabetic and pre-diabetic subjects revealed that they were ignorant of the knowledge of diabetes and its prevalence in them.

Regarding the family history of diabetes, only 2 to 5 percent of the pre-diabetic and diabetics reported that their siblings (First degree relation) had Type 2 diabetes.
Nearly, one-fourth of the diabetics and pre-diabetic samples informed that their mother had diabetes. Almost 32 of them reported that their father had either diabetes or pre-diabetes.

**Anthropometric assessment of diabetic and pre-diabetic respondents:**

Nearly 84 percent of the pre-diabetic and 88 percent of diabetic female population had waist circumference (WC) of 80 and above.

In waist to height ratio (WHtR) distribution, around 94.3 percent of the selected pre-diabetic female subjects were found to be overweight, very overweight and morbidly obese.

Of the total 261 pre-diabetic females, almost 58 percent was observed to be morbidly obese. While in diabetic females, around 62 percent of them were observed to morbidly obese, 10 percent found to overweight and 23 percent found to be very overweight.

From the total 261 pre-diabetic and 365 diabetic females, almost 90 percent of them had WHR of ≥ 0.80.

Undesirably, from the anthropometry assessment (WC, WHR, WHrT) of diabetic and pre-diabetic female subjects, it was observed that the prevalence of obesity, overweight and very over weight was very high among the diabetic and pre-diabetic subjects.

Out of 156 pre-diabetic and 330 diabetic male subjects, nearly 58 and 60 percent of pre-diabetic and diabetic men had their WC of 90cm and above.

It is inferred that almost 90 percent of the pre-diabetic and diabetic females were found to be overweight (23 to 27.5) and obese (above 27.5), using BMI as a criterion.
Nearly 82 and 83 percent from the pre-diabetic and diabetic male respondent had BMI of 23 - 27.5 (overweight) and above 27.5 (obese).

Chronic Energy Malnutrition (CED) was observed in 11 males and females of diabetic and pre-diabetic subjects.

**Biochemical analysis for the selected study population:**

It was observed that from the identified prediabetic samples, about 42 percent and 41 percent of female and male had the systolic pressure between 120 – 139 mm/Hg. (ie. prehypertensive).

Whereas in stage I and II hypertension, nearly 30 percent and 40 percent of the pre-diabetic female and male had systolic pressure between 140-159 and 160 and above.

Subsequently in diabetic female and male subjects, nearly 42 percent and 38 percent were found to be pre-hypertensive and around 40 percent and 60 percent had stage I and II hypertension.

From the present study, it was revealed that prevalence of hypertension was more among diabetic and pre-diabetic samples. And also alarmingly, male subjects had high systolic pressure than female subjects.

**Statistical Analysis for the total respondents (N=4887) with respect to RBS (Random Blood Sugar):**

It can be inferred that gender, physical exercise, diabetes and HbA1c were associated significantly to RBS group category (p-value <0.05).

Odds ratio (OR) reveals that females were having 0.778 times more risk than the males.

The subjects who were doing physical exercises were found to be lesser in number in both RBS categories.
The odds ratio reveals that the subjects having HbA1c >7 were highly susceptible to have above 200mg/dl RBS, which means that the subjects of above 7 HbA1c were prone to have 11.695 times risk when compare to their counter parts.

**Body composition assessment of the diabetic sub samples (n=400):**

It was observed that 53 percent of the respondents had high and very high body fat percentage.

Regarding visceral fat, it was found that nearly 31.5 percent of the diabetic subjects had more than the normal values ≤9.

Nearly 97 percent of the diabetic samples were identified as high and very high muscle mass.

On performing the odds ratio and multiple logistic regressions, the results show that Weight, Fat percentage and Visceral Fat Rating are the key factors to be observed in the female subjects.

**Food Frequency Questionnaire (FFQ):**

Cereals consumption among the selected respondent was observed that almost all the samples consumed rice daily and nearly 58 percent of population reported that they consumed ragi but 21 percent and 17 percent consumed weekly and monthly once.

While wheat consumption reported among the diabetic samples was 71 percent daily and 25 percent weekly.

The samples reported that they consumed wheat because doctor advised to take wheat instead of rice.

Around 96 percent revealed that they consumed maize whenever available or monthly once and in millets consumption only 16 percent
reported that they consume millet occasionally and many of them reported that they do not even know about the millets.

Regarding the pulses consumption, frequency was observed in selected subjects.

Around 98 percent was reported that they consume red gram dhal daily and almost all the population was reported that they use split dhal like Bengal gram, moong dhal and urad dhal frequently in a month in the form of sambar, idly and koottu etc.

But in whole grams consumption of the diabetic samples revealed that they occasionally consume grams.

With respect to vegetables consumption among the respondent revealed they consume vegetables like Onion, Tomato, Carrot, Beetroot, Potato, Beans, Brinjal frequently.

While in the gourd varieties like Bottle gourd and Snake gourd consumed occasionally by the diabetic population due to the myths. Other gourd varieties like bitter gourd & ridge gourd consumed weekly once and monthly.

Green leafy vegetable consumption frequency identified as almost all the respondent reported that they include drumstick leaves, amaranth leaves weekly, but 50 percent of them consume leafy vegetables occasionally due to indigestion.

Almost all the respondents reported they use refined sunflower oil and gingelly oil was consumed occasionally due to cost of the oil. But other oil like olive, bran, and safflower oil was used occasionally by the respondent, other like ghee was used during festival seasons and butter used occasionally whenever available.
Fruit consumption of the diabetic population nearly 80 percent of population reported that they eating fruits occasionally because fear to raising the blood sugar.

While consumption in frequency of nuts and dry fruits almost all population consumed occasionally (i.e) especially in festivals.

**Chapter IV:** This Chapter of the study summarize the results related to analysis of soil salinity, nutritional and phytoconstituent present in the *Pisonia grandis* R. Br. leaves. Further, the study used the Odds Ratio and multiple logistic regressions to find the risk factor of the diabetic samples.

To study the Nutritional and Pharmacological properties of *Pisonia grandis* R.Br. leaves.

Nutritional and Phyto-constituent properties of *Pisonia grandis* R.Br:

**Soil salinity:**

From the results it was observed that the Ph of soil was normal, EC was also normal and other nutrients like zn, cu, mn and Fe were also sufficient when compared to the standards of the soil in Puducherry.

It was observed that the moisture content of the Pg leaves varies according to the treatments while in the drying method is reduced upto 2 times when compared to the fresh leaves.

But the other method does not produce much difference in moisture content.

The carbohydrates content of the selected plant species was observed from six to eight g/100 g of the leaf from fresh, steaming, sautéing, drying and followed by blanching.
And in the total carotenoid content of the *Pisonia grandis* R. Br. leaves in different cooking method varied from 15540 to 16820 µg/100g.

In the present study, *Pisonia grandis* R.Br. leaves enhances the availability of Antioxidant and Vitamin C content during steam cooking method.

The effect of drying results on retention of carotene and vitamin C is observed in the present study due to shrikage of plant materials.

Iron content of the dried leaf powder was observed that the 38 g per 100 g of dry leaf powder and other method of cooking revealed that the 37 g per 100g of samples.

The calcium content of the *Pisonia grandis* R. Br. leaves provides 80 percent from the daily requirements of male sedentary workers and half percent from adolescents requirements followed by one third from its requirement of the pregnant and lactating mothers.

In the phytochemical screening of crude ethanolic extract of the Pg leaves, in which many active compounds were identified and it shows positive activity against disease.

**Chapter V:** The present study is summarised under the following headings;

**Acute oral toxicity study:**

There were no toxic signs and pre-terminal deaths observed in all the treated animals.

The present study also identified scientifically that the ethanolic extract of *Pisonia grandis* leaves does not produce any mortality upto 2000mg/kg of body weight.

The induction of experimental diabetes in the rat using chemicals such as Streptozotocin (STZ) which selectively destroy pancreatic β cells is very convenient and simple to use.

The STZ treated animal’s shows the increased blood glucose level of 271 mg% on Day 0 which was further increased to 289 mg% on Day 14.

In the dose of 250 mg/kg of ethanolic extract reduced the blood glucose level from 253 mg% to 239 and 242 mg% at 7th and 14th days respectively.

And also the dose of 500 mg/kg of ethanolic extract reduced the blood glucose level from 279 mg% to 233 & 220 mg% at 7th and 14th days respectively which was significant when compared to control (p>0.05)

The results of the extract was comparable to that of 10 mg/kg of Glibenclimide (p>0.05).

**Result of anti-diabetic activity of the *Pisonia grandis R. Br.* leaves in human subjects:**

Those who freshly as diagnosed Diabetic Mellitus patients with the age limit of 40 – 60 years were selected for the study.

The PGCA powder steadily decreases the FBS and PPBS in day 15 and day 30 when compared to first day (i.e. before administration of powder).
Chapter VI: In this phase results summarised about the selection of recipes and panel members, methods and procedures of cooking, nutritive value evaluation and mainly organoleptic evaluation of the recipes using hedonic rating scale.

Standardizing the Recipes incorporating Pisonia grandis R. Br. leaves:

The results obtained from organoleptic evaluation of foods using Pisonia grandis leaves reported by the panel members were excellent. Sambar and soup scored 4 and 3 for consistency, taste, appearance, and flavour. The other recipes also score 3 but the dumplings scored 1 due to hardness of the recipe.

Calculation of nutrient content of the selected recipes:

Among the prepared recipes, soup provides very less amount of energy and fat content, but it provides good amount of calcium and Iron in 200 ml.

Regarding the nutritive value calculation, it was observed that the Sambar and Adai provides more amount of energy when compared to other recipes, but iron and calcium content of selected recipes was observed adequate for per servings.

The other recipes like Masiyal, Chappathi and Poriyal provides good amount of the calculated nutrients and the selected recipes were economically feasible.

Adai provides 16 percent of energy from the Recommended Dietary Allowances (RDA) of sedentary male workers and Chappathi provides 7 percent of energy from the day’s requirements of sedentary male workers.
The Chappathi and Poriyal gives 83 percent of the iron from the day’s requirement.

Ninety-nine percent of calcium provided by adai from the day’s requirements.

**A Case Study on Insulin secretion in a normal subject after Administering 200ml of *Pisonia grandis* R.Br. leaf Soup**

Initial insulin values were very low because of overnight fasting. After consuming the Pg leaves soup the serum insulin values increased steadily till the 75\(^{th}\) minutes.

After the 75\(^{th}\) minute there was a gradual decline in insulin levels. The values started to normalize i.e. 0 -17\(\mu\)U/mL at the 165\(^{th}\) minute.

Besides this, the difference was found between the initial and final insulin values of the normal subject and was found to be 5.8, 1.6 and 7.3(\(\mu\)U/mL).

**IMPLICATIONS OF THE STUDY**

- In the total of 4870 enrolled, about 1112 (22.83%) samples were found to be diabetic and pre-diabetic samples.

- Among this 1112, nearly 261 female and 156 male were found to be pre-diabetic and 365 females and 330 males were observed to be diabetic.

- Most of the samples belonged to economically weaker section and low income group, but the prevalence was observed more in the age of 41-50 years.

- More number of female population were pre-diabetic when compared to male pre-diabetic population in same above mentioned age group.
Those who had less physical exercise were prone to diabetes.

Nearly 50 percent of the diabetic and pre-diabetic found to be undiagnosed and they were not aware about diabetes.

The BMI was high in pre-diabetic and diabetes subjects.

It can also be inferred that gender, physical exercise, diabetes and HbA1c are associated significantly to RBS group category (p-value < 0.05).

Weight, Fat percentage and Visceral Fat Rating are the key factors to be observed in the female subjects.

The dietary habits of diabetes patients reported that the intake of protective foods like vegetables and fruits was very less due to fear of increasing blood glucose level and economic status of individual.

The nutritive value of the *Pisonia grandis* R.Br. leaves shows that the Iron and Vitamin C content of leaves increased while steaming.

In the phytoconstituent analysis, the leaf contains many active principles which possess the positive effect on health.

In animal study the ethanolic extract of *Pisonia grandis* reduced when compared to that of 10 mg/kg of Glibenclimide (p>0.05).

In human subjects the PGCA powder steadily decreases the FBS and PPBS in day 15 and day 30 when compared to first day (i.e. before administration of powder).

In organo-leptic evaluation of foods using *Pisonia grandis* R.Br. leaves reported by the panel members were excellent. Sambar and soup scored 4 and 3 for consistency, taste, appearance, and flavour. The other recipes also score 3 but the dumplings scored 1 due to hardness of the recipe.
The insulin levels of *Pisonia grandis* R. Br. leaf soup in the normal individuals, it shows after consumption of the Pg leaves soup the serum insulin values was increased steadily till the 75th minutes.

The prevalence of the diabetes and pre-diabetes are more in Puducherry and most of them were undiagnosed and belongs to economically weaker sections.

*Pisonia grandis* R.Br. leaves are rich in iron and calcium which helps to eradicate the malnutrition like Iron deficiency & Osteoporosis, the present study recommends the prospect of more aggressive introduction and utilization of *Pisonia grandis* R.Br. leaves by the food sector.

It implies that it may be worthwhile for industry to take up the production of *Pisonia grandis* leaf powder. Such promotion of *Pisonia grandis* leaf incorporating into the diet will go a long way towards not only alleviating micro nutrient deficiencies, but also towards the development of functional foods for several chronic degenerative disorders like diabetics, rheumatoid arthritis and diuretics.

**SUGGESTIONS FOR FUTURE RESEARCH**

The present study has opened up a new direction for future large scale clinical research to find an inexpensive herbal formulation for the Non Insulin Dependent Diabetes Mellitus (NIDDM) persons.

The researchers can isolate the pure compounds present in the same leaves and study the exact mechanism of action to reduce the hyperglycemia in NIDDM persons.
Further, the study was limited to only one person for analysing the insulin levels due to financial constraints. The researcher can make in-depth analysis of insulin levels with more number of subjects.

**SUGGESTIONS FOR POLICY MAKERS**

- The present study found that diabetic and pre-diabetic was more among young adults and most of them had their BMI and WHtR more than that of standards.

- Added to this WHO also reports that gestational and juvenile diabetes was high among the world population due to the lifestyle changes, physical inactivity and food faddisms.

- So, to strengthen the future India, the policy makers should advocate the effective polices both in terms of nutrition and education sectors.

- In education sectors, the schools should hold on selling the junk foods in canteens. Awareness to be created to both teachers and parents about usefulness of fruits, vegetables, millets and pulses so that it will help them to teach the kids.

- The policy makers should include physical education as part of school curriculum and promote them to make the students to actively participate in outdoor games.

- It may be imparted from preschool levels to college levels for physical and mental well being of all students.

- In food sector, it is important to teach the parents and teacher to encourage the kids to have right choice of foods.
➢ To create awareness among the community population about the traditional local herbs and its therapeutic efficacy, emphasize be made that this is economically feasible and easily available and with added focus to the effective use of herbs by way of food as well as medicine.

➢ However, it is significant that the health workers, researchers, policy makers and teachers need to tread this path with care. Further, the development of healthy perceptions is an important part of an individual so that healthy citizens are groomed from childhood.