CHAPTER-6

SUMMARY AND CONCLUSION
(http://www.allrecipes.com) sweet taste and colour cinnamon enhanced the taste and colour of cake.

In Idli cinnamon incorporated varieties were accepted. In this Idli incorporated with 3% *G. sylvestre* was most accepted. In baked papad 3% cinnamon and *M. koenigii* products were more accepted.

Only Dhokla was the product, where 3% *G. sylvestre* incorporation level was most accepted. *G. sylvestre* is bitter in taste with pleasant aromatic odour (Soneja et al., 2010). Because of taste and color food products incorporated with *G. sylvestre* were a trifle less accepted.

In a summarized way it can be said that water extracts of all three plant parts were effective on nearly all parameters. Their effectiveness found to be varied in different parameters and doses. But in mixture form nearly consistent effects were observed in all parameters so a mixture of these can be recommended for the use by diabetic subjects. Food products prepared found to be liked moderately to very much by the diabetics there for products can also be recommended to the diabetes patients.
India is a country with highest number of type2 diabetes patients and of late the disease has begun to adversely affect the quality of life of people even at a much young age. In fact, diabetes is not a single aberration but a syndrome associated with multiple complications. It is the main etiological factor for the deaths occurring due to End Stage Renal Disease (ESRD) and Cardio Vascular Diseases (CVD’s). Several biochemical processes at cellular level are responsible for the generation of such complications in diabetics. It has been realized that diabetes should be managed or treated in multiple ways to control dyslipidemia, hyperlipidemia, oxidative stress and glycated hemoglobin along with all pervasive hyperglycemia. Plants containing various bioactive compounds can contribute in this direction. The present study is a systematic scientific effort to explore the efficacy of *C. verum* bark, *G. sylvestre* leaves and *M. koenigii* stem bark water extracts in treating diabetes. In essence, the study has been undertaken with the following objectives:

- To evaluate the antidiabetic, hypolipidemic and oxidative stress lowering effects of *C. verum, G. sylvestre, M. koenigii* individually as well as equiproportional blends in both, experimental animals and human diabetic subjects.
- To develop food products incorporating *C. verum, G. sylvestre* and *M. koenigii* in appropriate proportions into other relevant food stuffs to develop products and to undertake their acceptability evaluation studies.

The study was conducted in three phases, first phase comprising the proximate and biochemical analysis of three plant products. Water extracts in powdered form were prepared from the plant parts in this phase. Second phase involved the selection and supplementation to diabetic experimental rat models and type2 diabetic patients followed by estimation of different biochemical parameters in the biological samples drawn from them. In the last phase, three plant parts were incorporated in different food products in different concentration.

*C. verum* bark, *G. sylvestre* leaves and *M. koenigii* bark were acquired from the authentic sources. Proximate principles- carbohydrate, protein, fat and crude fiber as well as mineral ash were estimated in the plant parts. Qualitative analysis of phytochemicals; tannins, saponins, alkaloids, phenols, glycosides and sterols was
also undertaken. To prepare the plant extracts, plant products were dipped in water, leached and concentrated in standardized conditions to make them into powdered forms.

Ten groups of rats (n-6 in each group) were selected for the supplementation of plant extracts. Nine groups were made diabetic with streptozotocin. Eight groups of diabetic animals were supplemented with plant extracts at two levels; 50 and 75mg/kg BW/day of *C. verum*, *G. sylvestre*, *M. koenigii* and equipropotion mixture of the three for 60 days, while rest two groups served as controls. Different parameters, glycemic and lipid profile, oxidative stress, serum transaminases and serum uric acid were estimated before and after supplementation. 100 type 2 diabetes patients enrolled for the study and randomly divided into five groups. Four out of five groups of human subjects were supplemented with the water extracts of three plant products (1g/day) individually and in mixture form for 60 days. Biochemical parameters similar to those assessed in animal experimentation were analysed for human subjects.

To incorporate the three plant products in food products, a total of nine recipes were selected, powders of plant products incorporated in 3% and 5% concentration individually and mixture form. Acceptability of products was assessed using nine point hedonic scale by a panel of diabetic patients. To sum up focus of the study was to explore the potential of these plant parts as a remedy of diabetes or is there any synergistic impact they have. Following conclusions have been drawn from the study-

- All three plant products were rich in carbohydrate and crude fiber. *G. sylvestre* leaves and *M. koenigii* were also found to be abundant in mineral ash. Moisture, fat and protein content were found to be low in plant products.
- Tannins, phenols, glycosides, sterols and alkaloids phytochemicals were present in *C. verum* bark. *M. koenigii* bark was found to contain tannins, saponins, alkaloids and phenols. *G. sylvestre* leaves were found to have tannins, saponins, alkaloids. Glycosides and sterols.
Summary and Conclusions

- Plant extracts supplementation was able to maintain the body weight of diabetic rats normal while a substantial body weight loss was observed in diabetic animals not given any treatment.

- A significant hypoglycemic effect of the water extract of all three plant products was observed both in diabetic rats and human subjects. Impact of 75 mg/kg BW dose of \( G. \) sylvestre (33.70 %) was the highest on FBG followed by \( C. \) verum (32.94%) and mixture (29.63%) of plant extracts in rats. Further and both the doses of \( C. \) verum and mixture were equally effective to reduce hyperglycemia but the 75mg/ kg BW doses of \( G. \) sylvestre and \( M. \) koenigii were more effective than 50mg/kg BW. In human subjects effect of mixture (9.19%) of extracts was highest on FBG.

- All three plant extracts significantly reduced the level of HbA1c except 50mg/kg BW dose of \( M. \) koenigii in diabetic rats. Mixture (28.10 - 25.78 %) of plant extracts was most effective to reduce the level of HbA1c. In diabetic subjects also, the mixture (822%) of extracts was found to be most effective to reduce HbA1c.

- Plant extracts were found to reduce the level of total TG, total-C, LDL-C and to increase the level of HDL-C both in diabetic rats and human subjects. Mixture of extracts (21.67 -16.78%) was observed to be most effective to reduce serum TG in rats but in diabetic subjects extract of \( C. \) verum was found more effective than others.

- Serum total-C was most effectively reduced by \( G. \) sylvestre extract (43.72 - 26.41%) in rats. However in human subjects, \( C. \) verum (6.90%) extract was found most effective followed by \( M. \) koenigi (6.22%) and \( G. \) sylvestre (6.02%).

- \( C. \) verum and \( G. \) sylvestre extracts were found most effective to increasing the serum HDL-C both in diabetic animals and T2DM patients and LDL-C was most effectively reduced by mixture of extracts (21.67 – 16.78 %) in rats and by \( G. \) sylvestre (10.40%) in the humans.

- All three plant extracts were found to reduce the oxidative stress effectively. In diabetic rats \( C. \) verum extract was most effective to reduce serum TBARS and that of \( G. \) sylvestre to reduce tissue TBARS levels. These two products
were found to most effective to increase the level of tissue an serum GSH vice-versa. *M. koenigii* bark was the product found to be most effective to reduce the activity of SOD and CAT in rats. GSH-px activity was most affected by the *C. verum* extract.

- In diabetic subjects, mixture of extracts and that of *C. verum* were found to be most effective to reduce serum TBARS and to increase GSH respectively.
- Serum uric acid level was most effectively reduced by the extract of *C. verum* in rats but in human subjects mixture was found to cause the most effect.
- Serum transaminases’ levels were most effectively reduced by *G. sylvestre* and *C. verum* extracts in rats, although no tangible effect of supplementation was observed in human subjects.
- Among the food products, those developed with the incorporation of 3% of plant products were found to be more acceptable than those developed with the incorporation of 5% level. Products- Sev, carrot soup, cake, cold coffee, baked papad and stuffed idli prepared with incorporation of *C. verum* bark powder were more accepted than those made with the others incorporation. Dal samosa, crunchy triangles and baked papads incorporated with *M. koenigii* bark were accepted more. *G. sylvestre* leaves were least preferred in food products.

It can be stated in nut shell that water extracts of all three plant products were effective in regulating various aberrations in biochemical parameters associated with the condition of diabetes mellitus. The same three plant products were found to act in mixture form in a more pronounced manner by building up a kind of synergy in to enhance their efficacy.