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In the present study, three plant products \textit{Cinnamomum verum} (CV) bark, \textit{Gymnema sylvestre} leaves (GS) and \textit{Murraya koenigi} (MK) bark were studied for their effectiveness in controlling diabetes and its associated biochemical symptoms. In the first step, proximate principles of these plant products were assessed and the presence of phytochemicals was also screened. Water extract powders of the plant products were decided to supplement to the diabetic models. Plant extracts were supplemented to the 10 groups of diabetic rats individually and in mixture form. Groups CVI, GSI, MKI, MIXI were supplemented with 50mg kg$^{-1}$ body wt. day$^{-1}$ extracts of \textit{C. verum}, \textit{G. sylvestre}, \textit{M. koenigii} and mixture of three respectively and CVII, GSII, MKII, MIXII groups were provided with 75 mg kg$^{-1}$ body wt. extracts in a day in the same manner. Mean values of different parameters compared with the mean values of CD (control diabetic) or CND (control non diabetic) groups. Animal supplementation was followed by supplementation of extracts to human subjects, the type2 DM patients. Supplementation period was 60 days in both cases.

Last phase of the study involved development of food products with the incorporation of plant products to check their assimilability and acceptability and efficacy as a part of food products.

\subsection*{4.1 NUTRITIONAL AND CHEMICAL EVALUATION}

\subsubsection*{4.1.1 Proximate Principles}

Fig 4.1.1 shows proximate composition of plant products. The mean moisture content of CV bark, GS leaves and MK bark estimated stood at 6.78 ± 0.52, 8.13 ± 0.86 , and 7.66 ± 0.15 g/100g respectively. Mineral ash content was found to be the highest in GS leaves (10.43 ± 0.75 g/100g) followed by MK (7.99 ± 0.57 g/100g) and CV (2.43 ± 0.15 g/100g) barks. Mean Protein, fat, fiber and carbohydrate content estimated in CV bark were 4.66 ± 0.89, 3.95 ± 0.34, 37.66 ± 0.47 and 45.16 ± 1.82 g/100g respectively. Mean Protein, fat, fiber and carbohydrate content of GS leaves was noted 4.55 ± 0.22, 5.60 0.27, 41.76 ± 1.35, 33.65 ± 2.29 (g/100g) respectively. In MK bark, mean protein, fat, fiber and carbohydrate content was estimated to be 3.43 ± 0.14, 1.4 ± 0.08, 22.60 ± 0.93, 52.35 ± 5.47 g/100 mg respectively. All three plant parts were seen rich in fiber and carbohydrate but low in fat and protein. Ash content of GS leaves and MK bark was also found to be sizeable.
4.4.1 Mean values of proximate principles in CV bark, GS leaves, MK bark

4.1.2 Phytochemicals

Table 4.1.1 depicts the qualitative presence or absence of phytochemicals in CV bark, GS leaves and MK leaves. Whereas tannins, alkaloids, phenols, glycosides and sterols were found to be present in CV bark, saponins were found absent. In GS leaves, phenols were absent while other phytochemicals i.e. tannins, saponins, alkaloids, glycosides and sterols were present. Analysis of MK bark, revealed the presence of tannins, saponins, alkaloids and phenols. Glycosides and sterols were absent in MK bark.

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<th>Phytochemicals</th>
<th>CV</th>
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Table 4.1.1

Qualitative Presence of Phytochemicals in CV, GS and MK barks/leaves
4.2 ANIMAL EXPERIMENTATION

4.2.1 Body Weight

Fig. 4.2.1 (a,b) shows the mean body weight of ten experimental groups of six rats each during the periods of experimentation. Before supplementation mean body weights of all groups were between 100.83 g – 112.33 g there was no significant ($F <0.05$) difference in body weight of all groups. At the commencement of experiment mean body weight of control CND group was 106.33 ± 5.64 g and at culmination, it was observed to be 191.16 ± 17.67 g. The mean body weight (BW) of CD groups was 110.16 ± 12.43 and 107.50 ± 10.63 g at the starting and end of experiment respectively. During experimentation BW of CD group was significantly reduced ($p <0.01$) than that of CND group. Even at the end of 30 days, BW of CD group was reduced significantly ($p <.01$). At the end 60 days’, mean BW of CD group was found 43.66% lower than that of CND group.

Mean body weights of CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II were observed to be 195.33 ± 11.09, 200.00 ± 7.53, 199.16 ± 6.49, 189.66 ± 5.27, 192.33 ± 8.93, 197.33 ± 15.27, 182 ± 6.84, 205 ± 10.09 g. respectively at the of experimentation period. Mean body weights of all supplemented groups were significantly ($p < 0.01$) higher than those of CD group and there was no significant difference in the BW of CND group and the supplemented groups at the end of supplementation period.

4.2.2 Fasting Blood Glucose (FBG)

Fig. 4.2.2 displays the mean fasting glucose level of all experimental groups during experimentation at fortnightly intervals. Whereas mean FBG level of CND group was in normal range (83.37 – 86.00mg/dL) during the whole supplementation period, mean FBG levels of all other groups induced diabetes with streptozotocin were higher than 200 mg/dL and there was no significant difference between the blood glucose levels of these groups at beginning of supplementation with plant extracts. At the end of 15 days of supplementation, the mean FBG level of CD group stood at 213.84 ± 9.17 mg/dL. However MIX I, MIX II groups had significantly ($p <0.01$) lower levels of FBG, but FBG of CV I (227.83 ± 5.07), CV II (228.16 ±
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12.60) were significantly higher than that of CD group. After 30 days of supplementation CV I (193.00 ± 12.94 mg/dL), CV II (195.83 ± 17.74 mg/dL), GS I (261.16±7.49 mg/dL), GS II (187.83 ± 4.07 mg/dL), MIX I (188.50 ± 5.75 mg/dL), MIX II (193.00 ± 7.37 mg/dL) groups registered a significant decrease in the fasting glucose level as compared to the group CD (227.67 ± 11.05mg/dL).

After 45 day of supplementation, mean FBG levels of all supplemented groups were observed to be significantly lower FBG than that of the CD group. At the end of experimentation, mean FBG level of all groups stood at 86.00 ± 5.91 (CND), 241.84 ± 7.09 (CD), 172.00 ± 9.79 (CVI), 162.17 ± 7.3 (CV II), 201.17 ± 8.83 (GS I), 160.00 ± 6.83 (GS II), 212.33 ± 11.79 (MK I), 192.17 ± 18.09 (MK II), 176.67 ± 6.50 (MIX I), 170.17 ± 6.67 (MIX II) mg/dL.

After 60 days, highest impact of supplementation on FBG level was seen in group GS II (33.70% lower) as compared to that in CD group. In other groups, hypoglycemic effect of plant extracts in decreasing order had this sequence - CV II (32.94%) >MIX II (29.63%) >CV I (28.87%) > MIX I (26.94%) >MK II (20.94%) > GS I (16.81%) > MK I (12.51%).

The FBG level of GS II group was significantly lower ($p < 0.05$) than all other groups at end of the study. Interestingly there was no significant difference among the FBG of MIX I, CV I, MIX II and CV II groups. FBG of MK I and GS I was significantly higher than that of all other supplemented groups.

There was no significant difference between the FBG levels of CV I, CV II and MIX II groups at the end of the study. However significant difference was seen FBG of GS I and GS II. In MK I and MK II groups.

4.2.3 Glycated Hemoglobin (HbA1c)

Fig.4.2.3 shows the mean HbA1c before and after supplementation. At the starting of supplementation mean HbA1c of all groups was 4.91– 5.23% and there was no significant difference ($F < 0.05$) between the HbA1c levels of different groups.
Mean HbA1c of CD group increased to 13.65 ± 0.65% and this was significantly higher \((p < 0.01)\) than that of all supplemented groups except MK I (13.00 ± 0.51%). Mean HbA1c levels of other supplemented groups CV I, CV II, GS I, GS II, MK II, MIX I and MIX II were – 11.83 ± 0.60 %, 9.06 ± 0.58%, 10.98 ± 0.53%, 9.06 ± 0.58%, 11.96 ± 0.62%, 10.13 ± 0.53%, 9.81 ± 0.67% respectively and significantly lower than that of CD group. Maximum effect on HbA1c was seen in group GS II, a 33.62% lower than that of HbA1c of CD group. Effect of supplementation in controlling HbA1c in comparison with CD, in decreasing order was MIX II (28.1%) > MIX I (25.78%) > GS I (19.56%) > CV II (17.58%) > CV I (13.33%) > MK II (12.38%) in other groups. MIX II and GS II groups had no significant difference in HbA1c level but their FBG was significantly lower than the other supplemented groups. CV I and CV II, MIX I and MIX II had no significant difference with each other in their effect on HbA1c, but in groups GS and MK’s 75mg/kg doses were significantly more effective than 50mg/kg BW.

4.2.4 Lipid Profile

4.2.4.1 Total Triglycerides (TG)

Fig 4.2.4.1 depicts the effect of supplementation on the total serum TG level. Before the supplementation mean serum TG levels of all groups were between 81.08 – 89.23mg/dL. After supplementation mean TG levels of CD and CND group were 189.00 ± 4.87 and 86.30 ± 2.37 mg/dL respectively.

Groups supplemented with water extracts of plant products had significantly higher TG level than CND but significantly lower \((p < 0.05)\) than CD group. Mean serum total TG level of groups, CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II was 181.00 ± 4.87, 167.81 ± 3.90, 165.63 ± 3.99, 127.30 ± 6.52, 172.90 ± 7.96, 166.46 ± 7.33, 157.31 ± 8.95, 148.11 ± 6.09 mg/dL respectively at the end of treatment period. Serum TG levels of CV I and CV II were 4.27% and 11.25% lower that group CD respectively after supplementation. TG level of CV II, was significantly \((p<0.01)\) lower than CV I group.
Serum TG levels of GS I, GS II, MK I, MK II, MIX I, MIX II were observed 12.37, 37.65, 8.53, 11.97, 16.78 and 21.67% respectively lower than that of CD group. A significant difference (p<0.01) was seen in the serum total TG levels of groups GS I and GS II although there was no significant difference between the levels of MK I and MK II, MIX I and MIX II.

Hypolipidemic impact of supplementation observed in different groups in increasing order was CV I < MK I< CV II < MK II < GS I < MIX I < MIX II < GS II.

**4.2.4.2 Total Cholesterol (TC)**

Serum total cholesterol levels of all ten experimental groups estimated during the study shown in Fig. 4.2.4.2, it was between 80.33 – 84.16 mg/dL in all groups before the supplementation. After supplementation of 60 days mean TC level of CND and CD groups estimated 83.10 ± 3.12 and 168.51 ± 3.79 mg/dL respectively. Mean serum TC levels all supplemented groups were significantly lower than the level of CD group except MK I (167.35 ± 3.24mg/dL).

Serum TC levels of CV I (136.60±6.43 mg/dL), CV II (131.01±4.15 mg/dL), GS I (124.90±5.01 mg/dL), GS II (94.83±4.50 mg/dL), MK II (153.60±5.61 mg/dL), MIX I (150.01±3.45 mg/dL), MIX II (145.05±3.12 mg/dL) were 18.93%, 22.2%, 26.41%, 43.72%, 8.8%, 10.97% and 13.92% lower respectively as compared to the mean TC level of CD group. There was no significant difference between the mean serum TC levels of CV I and CV II groups but significant difference observed between GS I and GS II, MK I and MK II, MIX I and MIX II groups. Thus the hypocholesterolemic effect of supplementation observed in different supplemented groups in increasing order was MK I < MK II < MIX I < MIX II < CV I < CV II < GS I < GS II.

**4.2.4.3 HDL-Cholesterol (HDL-C)**

Fig 4.2.4.3 illustrates the pre and post supplementation levels of serum HDL–C of experimental groups. At the starting of supplementation mean serum HDL-C level of all experimental groups was between 39.66 to 41.26 mg/dL. After
supplementation mean serum HDL–C levels of CD and CND groups observed 32.76 ± 1.88 mg/dL and 39.48 ± 0.79 mg/dL respectively. The mean serum HDL–C levels of CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II groups observed after supplementation were 39.13±1.31, 40.80±0.98, 38.42±0.93, 40.75±1.58, 40.70±1.25, 38.25±0.92, 38.53±1.84, 38.91±1.65 mg/dL respectively.

Mean HDL–C levels of all supplemented groups were significantly (p<0.01) higher than that of CD group. The mean HDL–C levels of CV I, GS I, GS II, MK I, MIX I, MIX II groups was not significantly different from that in CND group. The mean HDL–C of CV II group was found to be significantly higher than that of CND group after supplementation but HDL–C level of MKII group was significantly lower than CND group. As compared to HDL-C level CD group, effect of supplementation on the same of other groups in increasing order was MK II (16.75%) < GS I (17.27%) < MIX I (17.61%) < MIX II (18.77%) < CV I (19.44%) < MK I (24.23%) < GS II (24.38%) <CV II (24.54%). There was no significant difference between the serum HDL–C of MK I, GS II and CV II groups and no significant difference observed in HDL–C level of MK II, MIX I, MIX II and CV I after supplementation. HDL–C levels of CV I and CV II, GS I and GS II, MK I and MK II were significantly different from each other but no significant difference was observed between MIX I and MIX II groups.

4.2.4.4 LDL-Cholesterol (LDL-C)

Fig 4.2.4.4 depicts the mean serum LDL–C levels of experimental groups before and after supplementation. The mean LDL-levels of experimental groups at the starting of supplementation were 45.36–47.71 mg/dL. At the end of supplementation mean LDL–C of CD and CND groups were 122.43±4.29 and 65.98±2.55 mg/dL respectively. LDL–C levels of all supplemented groups were significantly higher than CND group and significantly lower than CD except CV I group. The mean LDL–C level of CV I and CV II group was estimated as 118.45 ± 5.4 and 115.70 ± 2.79 mg/dL respectively and it was 3.25% and 5.49% lower than that of the CD group. Although there was no significant difference between the mean LDL–C levels of CV I and CV II groups. GS I (108.78 ± 1.93mg/dL) and GS
II (105.8±3.33mg/dL) were found to have 11.19% and 13.58% lower LDL–C levels respectively than CD group. There was no significant difference between LDL–C of GS I and GS II group at the end of supplementation.

Mean LDL–C of MK I and MK II groups were 112.25 ± 5.03, 114.45 ± 1.62 mg/dL respectively, the levels being 8.53% and 11.97% lower than mean LDL-C level of CD group. However, the LDL–C level of these was not significantly different from each other. The LDL–C of MIX I (104.83 ± 1.70mg/dL) and MIX II (100.95 ± 1.85mg/dL) groups were 16.78% and 21.67% lower respectively than that of CD group. Effectiveness of different plant extracts to arrest the LDL-C in increasing order has been CV I < CV II < MK II < MK I < GS I < GS II < MIX I < MIX II.

4.2.5 Oxidative Stress

4.2.5.1 TBARS

Fig. 4.2.5.1.a exhibits serum TBARS levels in the groups of experimental animals. Mean serum TBARS levels of all ten groups were between 3.24–3.50 nmol/mL before the supplementation. At the end of study period serum TBARS level of CD group evaluated 6.79±0.40 nmol/mL. TBARS level of all supplemented groups were significantly higher than that of CD group but significantly lower than that of CND group. The mean TBARS levels of CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II were 5.71 ± 0.41, 4.41 ± 0.15, 5.98 ± 0.25, 5.79 ± 0.25, 5.45 ± 0.27, 5.27 ± 0.17 n mol/mL respectively. Serum TBARS levels of CV I and CV II were significantly (p<0.01) different from each other and no significant difference was found between the TBARS levels of GS I and GS II, MK I and MK II groups, yet the mean TBARS levels of MIX I and MIX II were significantly different (p<0.01) from each other.

As compared to CD group, the maximum impact was observed in CV II (35.05% lower than CD group) and least in GS I group. Other supplemented groups were also observed to have low TBARS levels in comparison to CD group as follows- GS I (11.92%) < GS II (14.72%) < CV I (15.90%) < MK I (19.73%) < MK
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II (22.38%) < MIX I (23.41%) < MIX II (33.13%) < CV II (35.05%). There was no significant difference between the mean serum TBARS levels of CV I, GS I, GS II groups, MIX I, MK I and MK II groups and also between MIX II and CV II groups.

Liver Tissue TBARS (Fig. 4.2.5.1.b) level of CND and CD group was estimated as $0.511 \pm 0.014$ and $1.721 \pm 0.118$ nmol/mg protein respectively. TBARS level of CD group was significantly higher than CND group. The tissue TBARS levels of groups CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II were $0.85 \pm 0.042$, $0.770 \pm 0.045$, $0.640 \pm 0.040$, $0.633 \pm 0.035$, $0.753 \pm 0.038$, $0.723 \pm 0.040$, $0.838 \pm 0.033$, $0.770 \pm 0.037$ nmol/mg protein respectively. Tissue TBARS level of supplemented groups was significantly higher ($p<0.01$) than that of CND group and significantly lower than CD ($p<0.01$) group.

Effectiveness of plant extract supplementation to control oxidative stress in liver tissue in ascending order has been CV I (50.58%) < MIX I (51.74%) < CV II (55.23%), MIX II (55.23%) < MK I (56.39%) < MK II (58.13%) < GS I (62.79%) < GS II (63.37%). No significant difference was observed in the tissue TBARS levels of groups C I and MIX I, supplemented with 50 mg/kg BW extracts of C. verum and G. sylvestre. Groups supplemented with 75 mg/kg BW doses of C. verum, M. koenigii extracts and mixture produced the same impact on TBARS. Both doses (50mg, 75mg/kg BW) of M. koenigii and G. sylvestre found to cause same impact (no significant difference) on TBARS.

4.2.5.2 Reduced Glutathione (GSH)

Figs 4.2.5.2 a and b depict the mean serum and tissue reduced glutathione levels in experimental groups of rats. With supplementation on mean serum GSH levels of all groups were in the range 20.60 – 21.72 nmol/mL. After 60 days of treatment GSH level of CD group was $12.61 \pm 1.27$ nmol/mL while GSH level of group CND was $19.96 \pm 1.01$ nmol/mL. GSH levels of groups supplemented with plant extracts were significantly higher than CD group. Serum GSH levels of CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II were $16.23 \pm 0.64$, $18.20 \pm 0.65$, $19.76 \pm 0.60$, $19.38 \pm 0.66$, $18.72 \pm 0.51$, $15.47 \pm 0.82$, $16.50 \pm 0.94$, $18.30 \pm 0.48$ nmol/mL.
Results

56 mol/mL respectively. Whereas GSH levels of groups GS I and GS II became equal to GSH levels of CND group, there was no significant difference between them shows. No significant difference was estimated between serum GSH levels of groups GS I and GS II but significant difference was observed between CV I and CV II, MK I and MK II, MIX I and MIX II groups. GSH level of MK I group was 22.68% higher than the level of CD group. As compared to CD reduced glutathione levels of groups CV I, MIX I, CV II, MIX II, MK I, GS II, GS I were 28.70, 30.84, 44.32, 45.12, 48.45, 53.68, 56.70 % higher respectively. There was no significant difference observed between serum GSH levels of MK II and CV I, CV II, MIX II and MK I.

Mean tissue GSH level of CND group estimated 1.72±0.05 nmol/mg protein but the level of CD group was 0.98 ± 0.11 nmol/mg protein, significantly lower than CND group. Tissue GSH level of plant extract treated groups CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II observed 1.17 ± 0.04, 1.69 ± 0.05, 1.19 ± 0.05, 1.33 ± 0.31, 1.40 ± 0.04, 1.59 ± 0.05, 1.20 ± 0.04, 1.62 ± 0.03 n mol/mg protein respectively. Tissue GSH level of treated groups was significantly (p<0.05) higher than CND. After supplementation GSH level of CND and CV II group had no significant difference. To assess the impact of supplementation tissue GSH levels of treated groups were compared with GSH level of CD group. GSH levels of CV I, GS I, MIX I, GS II, MK I, MK II, MIX II, CV II groups were 19.38, 21.4, 22.44, 35.71, 42.85, 62.44, 65.30, 72.44% respectively higher than the mean GSH level of CD group. There was no significant difference between the tissue GSH levels of CV I, GS I, MIX I and GS II groups. There was also no significant difference between the levels of MK II and MIX II.

4.2.5.3 Superoxide Dismutase (SOD) Activity

Fig 4.2.5.3 displays the mean activity of superoxide dismutase (SOD) enzyme in liver tissue of experimental groups.

Mean SOD activity of CND group observed 11.57 ± 0.86 units/mg protein but the activity of CD group was significantly increased, this was 17.65 ± 0.63 u/mg
protein. All supplemented groups showed a significant low level of SOD activity as compared to the values of CD group. As compared to CD group, low activity of SOD enzyme 18.79, 21.68, 23.68, 29.57, 31.38, 31.95, 38.86, 42.58% lower of groups MIX I, MIX II, CV I, GS I, CV II, GS II, MK I and MK II respectively. In this way *M. koenigii* extract was most effective and mixture of extracts was least effective to control peroxides formation. There was no significant difference between the activities of MIX I and MIX II, MK I and MK II, GS I and GS II. SOD activities of CV I and CV II groups were significantly different from each other.

### 4.2.5.4 Catalase Activity

Mean CAT activities of experimental groups are summarized in Fig 4.2.5.4. Mean catalase activity of CD (23.10 ± 1.29 units/mg protein) group was significantly lower than the CAT activity CND (12.40 ± 1.04 units/mg protein) group. There was a significant low activity of CAT observed in groups received doses of plant extracts.

As compared to CD group CAT activity of different groups was lower in ascending order as GS I (26.70%) < CV I (31.12%) < MIX I (43.63%) < MK I (43.71%) < GS II (44.15%) < CV II (49.65%) < MIX II (52.12%) < MK II (52.42%). There was a significant lower activity of CAT was observed in groups those received higher dose of plant extracts. There was no significant difference in the tissue CAT activity of MK II, MIX I and CV II.

### 4.2.5.5 Glutathione–Peroxidase (GSH-Px) Activity

Fig 4.2.5.5 exhibits the mean liver tissue GSH–P<sub>x</sub> activity of different groups of diabetic rats at the end of supplementation period. GSH–P<sub>x</sub> activities of CND, CD, CV I, CV II, GS I, GS II, MK I, MK II, MIX I and MIX II estimated 0.22 ± 0.021, 0.38 ± 0.030, 0.29 ± 0.021, 0.25 ± 0.029, 0.34 ± 0.021, 0.30 ± 0.32, 0.29 ± 0.024, 0.27 ± 0.046, 0.33 ± 0.025, 0.30 ± 0.031 μmol/min/mg protein respectively. GSH-P<sub>x</sub> activities of treated groups were significantly higher than CND group but significantly lower than CD group. Effectiveness of plant extracts to control the oxidative stress as compared to CD group in increasing order was GS I (10.52%) <
MIX I (13.15%) < MIX II (21.05%), GS II (21.05%), < MK II (22.36%), < MK I (23.68%), CV I (23.68%) < CV II (34.21%) in terms of GSH-px activity. No significant difference was observed in the effect of GS I and MIX I, MIX II, GS II, MK II, MK I and CV I. When groups received two doses of one plant extract compared, it was found that there was no significant difference in groups GS I and GS II, MK I and MK II, MIX I and MIX II but GSH–P<sub>x</sub> activity of CV II significantly (P<0.001) lower than CV I group.

4.2.6 Uric acid

Fig 4.2.6 displays the mean serum uric acid levels of experimental groups. Mean serum uric acid levels of all groups estimated were 4.43 – 4.98 mg/dL on the day supplementation started. After supplementation uric acid levels of CND and CD groups were 4.44 ± 0.47, 10.36 ± 0.68 mg/dL, respectively. Mean serum uric acid of CD group was significantly higher than the level of CND group. Serum uric acid conc. of CV I, CV II, GS I, GS II, MK II and MIX II were found to be significantly lower than CD group, but there was no significant difference in uric acid level of MK I and MIX I groups as compared to CD group. Dose related differences were also observed because there was a significant difference in the serum uric acid levels of CV I and CV II, GS I and GS II, MK I and MK II, MIX I and MIX II groups. To analyze the impact of supplementation to control the level of serum uric acid, it was compared with the uric acid level of CD group and impact in increasing order was MK II (13.8%) < GS I (16.98%) < Mix II (21.13%), < CV I (24.32%), < GS II (25.09%), < CV II (31.27%).

4.2.7 Transaminases -

Serum ALT and AST activity of experimental groups before and after supplementation is summarized in Fig 4.2.7. a and b Before supplementation serum ALT and AST activities of all groups were normal and there was no significant difference between the values of different groups. After the period of two months AST and ALT activities of group CD were 16.05±0.55 and 88.01±6.84 U/L respectively, significantly higher than CND group. Activities of these enzymes in
plants’ extract supplemented groups were significantly \((p<0.01)\) lower than the level in CD group but significantly \((p<0.01)\) higher than CND group.

Mean serum ALT activities of CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II groups at the end of supplemented period were 76.07 ± 4.09, 45.06 ± 2.84, 45.35 ± 3.30, 35.73 ± 2.55, 62.25 ± 5.78, 63.58 ± 7.08, 74.43 ± 3.93, 70.31 ± 4.31 U/L respectively. As compared to CND (26.79 ± 4.36 U/L) group, ALT activities of CD, CV I, CV II, GS I, GS II, MK I, MK II, MIX I, MIX II groups were 228.51, 183.93, 68.13, 69.27, 33.37, 132.36, 137.36, 177.82, 162.44 % higher than CND. Effectiveness of plant extracts to control the liver damage in different groups in ascending order was CV I < MIX I < MIX II < MK II < MK I < GS I < CV II < GS II. There was no significant difference ALT levels of MK I and MK II, MIX I and MIX II groups but significant difference was observed between CV I and CV II, GS I, and GS II groups.

Serum AST levels (Fig.4.2.7.b) of plant treated groups were also significantly lower than the level of CD group. As compared to CND group serum AST levels of CD, CVI, CVII, GS I, GS II, MK I, MK II, MIX I, MIX II were 61.4, 39.25, 7.93, 38.05, 8.23, 29.14, 29.91, 26.70 and 11.14 % higher respectively.

Effectiveness of plant extract in controlling the liver damage in different groups was in following order – CV I < MK II < MK I < MIX I < MIX II < GS I < GS II < CV II. There was no significant difference in the serum AST levels of MK I, MK II and MIX I groups. But the AST level was significantly different in CV I and CV II, GS I and GS II, MIX I and MIX II groups.
4.2.1 (a) : Time courses changes in the mean FBG levels of diabetic rats supplemented with plant extracts

CND : control Non diabetic,  CD : control diabetic, CVI : supplemented with 50 mg/kg BW/day *C. verum* extract, CVII : supplemented with 75 mg/kg BW/day *C. verum* extract, GS : supplemented with 50 mg/kg BW/day *G. sylvestre* extract, GSII : supplemented with 75 mg/kg BW/day *G. sylvestre* extract, MKI : supplemented with 50 mg/kg BW/day *M. koenigii* extract, MKII : supplemented with 75 mg/kg BW/day *M. koenigii* extract, MIX I : supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIX II : supplemented with 75 mg/kg BW/day Mixture of plant extracts
4.2.1 (b) Mean body weights of diabetic rats supplemented with plant extracts

4.2.2 (a) Mean FBG levels of diabetic rats supplemented with plant extracts

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day C. verum extract, CVII: supplemented with 75 mg/kg BW/day C. verum extract, GS I: supplemented with 50 mg/kg BW/day G. sylvestre extract, GSII: supplemented with 75 mg/kg BW/day G. sylvestre extract, MKI: supplemented with 50 mg/kg BW/day M. koenigii extract, MKII: supplemented with 75 mg/kg BW/day M. koenigii extract, MIX I: supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIX II: supplemented with 75 mg/kg BW/day Mixture of plant extracts
4.2.2 (b) : Time courses changes in the mean FBG levels of diabetic rats supplemented with plant extracts

CND : control Non diabetic, CD : control diabetic, CVI : supplemented with 50 mg/kg BW/day *C. verum* extract, CVII : supplemented with 75 mg/kg BW/day *C. verum* extract, GS1 : supplemented with 50 mg/kg BW/day *G. sylvestre* extract, GSII : supplemented with 75 mg/kg BW/day *G. sylvestre* extract, MKI : supplemented with 50 mg/kg BW/day *M. koenigii* extract, MKII : supplemented with 75 mg/kg BW/day *M. koenigii* extract, MIX I : supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIX II : supplemented with 75 mg/kg BW/day Mixture of plant extracts
4.2.3 Mean HbA1c levels of diabetic rats supplemented with plant extracts

4.2.4.1 Mean serum total TG levels of diabetic rats supplemented with plant extracts

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day C. verum extract, CVII: supplemented with 75 mg/kg BW/day C. verum extract, GSI: supplemented with 50 mg/kg BW/day G. sylvestre extract, GSII: supplemented with 50 mg/kg BW/day G. sylvestre extract, MKI: supplemented with 50 mg/kg BW/day M. koenigii extract, MKII: supplemented with 75 mg/kg BW/day M. koenigii extract, MIX I: supplemented with 75 mg/kg BW/day Mixture of plant extracts, MIX II: supplemented with 75 mg/kg BW/day Mixture of plant extracts
4.2.4.2 Mean serum total-C levels of diabetic rats supplemented with plant extracts

![Graph showing mean serum total-C levels](image)

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day *C. verum* extract, CVII: supplemented with 75 mg/kg BW/day *C. verum* extract, GSI: supplemented with 50 mg/kg BW/day *G. sylvestre* extract, GSII: supplemented with 75 mg/kg BW/day *G. sylvestre* extract, MKI: supplemented with 50 mg/kg BW/day *M. koenigii* extract, MKII: supplemented with 75 mg/kg BW/day *M. koenigii* extract, MIX I: supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIX II: supplemented with 75 mg/kg BW/day Mixture of plant extracts

4.2.4.3 Mean serum HDL-C levels of diabetic rats supplemented with plant extracts

![Graph showing mean serum HDL-C levels](image)
4.2.4.4 Mean serum LDL-C levels of diabetic rats supplemented with plant extracts

![Bar chart showing mean serum LDL-C levels](chart1.png)

4.2.5.1 (a) Mean serum TBARS levels of diabetic rats supplemented with plant extracts

![Bar chart showing mean serum TBARS levels](chart2.png)

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day C. verum extract, CVII: supplemented with 75 mg/kg BW/day C. verum extract, GSI: supplemented with 50 mg/kg BW/day G. sylvestre extract, GSII: supplemented with 75 mg/kg BW/day G. sylvestre extract, MKI: supplemented with 50 mg/kg BW/day M. koenigii extract, MKII: supplemented with 75 mg/kg BW/day M. koenigii extract, MIX I: supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIX II: supplemented with 75 mg/kg BW/day Mixture of plant extracts
4.2.5.1. (b) Mean tissue TBARS level of diabetic animals supplemented with plant extracts

4.2.5.2 (a) Mean serum reduced glutathione levels of diabetic rats supplemented with plant extracts
Results

4.2.5.2. (b) Mean tissue reduced- GSH levels of diabetic rats supplemented with plant extracts

4.2.5.3 Mean tissue total SOD activity of diabetic rats supplemented with plant extracts

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day *C. verum* extract,
CVII: supplemented with 75 mg/kg BW/day *C. verum* extract, GSI: supplemented with 50 mg/kg BW/day *G. sylvestre* extract,
GSII: supplemented with 75 mg/kg BW/day *G. sylvestre* extract, MKI: supplemented with 50 mg/kg BW/day *M. koenigii* extract,
MKII: supplemented with 75 mg/kg BW/day *M. koenigii* extract, MIX I: supplemented with 50 mg/kg BW/day Mixture of plant extracts,
MIX II: supplemented with 75 mg/kg BW/day Mixture of plant extracts
4.2.5.4 Mean tissue CAT activity of diabetic rats supplemented with plant extracts

![Graph showing CAT activity](image)

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day C. verum extract, CVII: supplemented with 75 mg/kg BW/day C. verum extract, GSI: supplemented with 50 mg/kg BW/day G. sylvestre extract, GSII: supplemented with 75 mg/kg BW/day G. sylvestre extract, MKI: supplemented with 50 mg/kg BW/day M. koenigii extract, MKII: supplemented with 75 mg/kg BW/day M. koenigii extract, MIXI: supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIXII: supplemented with 75 mg/kg BW/day Mixture of plant extracts

4.2.5.5 Mean tissue GSH-Px activity of diabetic rats supplemented with plant extracts

![Graph showing GSH-Px activity](image)
4.2.6 Mean serum uric acid level of diabetic rats supplemented with plant extracts

![Graph showing the mean serum uric acid levels of diabetic rats supplemented with plant extracts.]

4.2.7.(a) Mean serum ALT levels of diabetic rats supplemented with plant extracts

![Graph showing the mean serum ALT levels of diabetic rats supplemented with plant extracts.]

CND: control Non diabetic, CD: control diabetic, CVI: supplemented with 50 mg/kg BW/day C. verum extract, CVII: supplemented with 75 mg/kg BW/day C. verum extract, GSI: supplemented with 50 mg/kg BW/day G. sylvestre extract, GSII: supplemented with 75 mg/kg BW/day G. sylvestre extract, MKI: supplemented with 50 mg/kg BW/day M. koenigii extract, MKII: supplemented with 75 mg/kg BW/day M. koenigii extract, MIX I: supplemented with 50 mg/kg BW/day Mixture of plant extracts, MIX II: supplemented with 75 mg/kg BW/day Mixture of plant extracts.
4.2.7. (b) Mean serum AST levels of diabetic rats supplemented with plant extracts

![Graph showing mean serum AST levels before and after supplementation for different groups.]
4.3 HUMAN SUPPLEMENTATION

Total 100 type 2 diabetic patients were enrolled for the study, out of them 57 were males and 43 were females. The mean age of male patients was 47.82±5.91 yrs (range 42-59 yrs) and mean BMI was 27.34 ± 4.57. The mean duration of disease was 3.90±2.80yrs. The mean dietary intake per day of the male patients was 2707±303 kcal energy, 45.5±2.3 g protein, 43.3±2.80 g fat, 4.10± 0.23 g fibers. The mean age of female patients was 49.92±4.94 yrs (range 43-57 yrs). Mean BMI of the females was 28.35±5.43 and the mean duration of DM was 4.26±2.3 yrs. Their dietary intake per day was 1568±411 kcal energy, 41.0±2.3 g protein, 26.20±7.5 g fat and 1.30±0.93g fiber. 33% patients had the family history of diabetes. About 71% patients reported the problem of general weakness although kidney or eye related symptoms were not present.

4.3.1 Fasting Blood Glucose (FBG)

Fig 4.3.1 depicts the FBG of diabetic subjects of different groups before and after supplementation. Mean FBG level of CON group was 126.77 ± 5.96 and 127.1 ± 6.37 mg/dL before and after supplementation and there was no significant difference between these two values. In CV group mean FBG level before supplementation was 127.82 mg/dL and it decreased to 118.92 mg/dL, significantly lower (p < .0001) than the previous level. Mean Δ FBG (difference between pre and post supplementation values) in this group was 8.92 ± 6.27 mg/dL. FBG level of GS group before and after supplementation was 126.6 ± 6.75 and 117.51 ± 6.89 mg/dL respectively. After supplementation FBG level was significantly (p<.0001) lower than pre supplementation, mean Δ FBG in this group was 9.08 ± 3.77 mg/dL. In MK group, Δ FBG was 5.92 ± 5.65 mg/dl because before supplementation FBG level was observed 131.23 ± 6.06 mg/dL and after supplementation it was 125.31 mg/dL significant difference (p<.0001) was observed in these two values. In MIX group mean FBG level was 128.72 ± 6.09 mg/dL before the experimentation and at the end of supplementation period it was 116.88 mg/dL and mean Δ FBG was 11.84 ± 6.45 mg/dL (p<.0001). Effect of supplementation of plant extracts to lower FBG,
calculated was 9.19% in MIX group, 7.17% in GS group, 6.48% in CV group and 4.51% in MK group.

4.3.2 Glycated Hemoglobin (HbA1c)

Fig. 4.3.2 explains the HbA1c level of all experimental groups before and after supplementation. Mean HbA1c level of CON group was 7.94 ± 0.33 and 7.89 ± 0.35% before and after supplementation. There was no significant difference between these two values. In plant extract supplemented groups a significant decrease was observed. Before supplementation mean HbA1c level in these groups was CV (8.03 ± 0.39%), GS (8.11 ± 0.39 %), MK (7.88 ± 0.38 %), MIX (8.02 ± 0.34%). At the end of treatment these values were 7.68 ±0.44%, 7.60 ±0.48%, 7.5 ±0.32%, 7.34 ±0.30% respectively.

HbA1c level of treated groups decreased, in ascending order it was CV (4.23%) Δ HbA1c (0.34 ± 0.15%) < MK (4.87%) Δ HbA1c (0.38 ± 0.21%) < GS (5.30%) Δ HbA1c ( < Mix (8.22%) Δ HbA1c(0.43 ± 0.31%). There was no significant different between the effect in CV, MK and GS supplementation but significant difference between these groups and MIX group.

4.3.3 Lipid Profile

4.3.3.1 Total Triglycerides (TG)

Fig No.4.3.3.1 depicts the serum TG level of experimental groups. Mean serum TG level before supplementation estimated 191.95 ± 10.00, 189.15 ± 8.46, 191.70 ± 8.23, 193.20 ± 12.10 and 184.2 ± 9.55 mg/dL of groups CON, CV, GS, MK and MIX respectively. After supplementation mean serum TG level observed 192.40 ± 10.40, 179.90 ± 8.71, 183.70 ± 7.73, 186.8 ± 10.80 and 179.55 ± 12.10 mg/dL respectively from groups CON, CV, GS, MK and MIX. Significantly low level of TG was found in all supplemented groups at the end of supplementation period. Mean Δ TG in these groups was 9.75 ± 8.09 (CV), 8.00 ± 4.64, 6.40 ± 5.35 (MK) and 7.65 ± 6.13 (MIX) mg/dL. Serum TG level in different groups was 5.15% (CV), 4.17% (GS), 3.31% (MK) and 4.058% (Mix) lower than those of previous values.
4.3.3.2 Total Cholesterol (TC)

Fig. 4.3.3.2 represents the mean serum TC levels of experimental groups before and after supplementation. Mean TC of CON group was 220.65 ± 13.32 mg/dL at the starting of treatment period and at end it was 217.80 ± 17.54 mg/dL. There was no significant difference between these two values. In CV group before supplementation serum TC was 231.85 ± 6.49 and after supplementation it was 215.85 ± 9.86 mg/dl. ΔTC of this group was 16.00 ± 8.29 mg/dL (6.90% lower). In GS, MK and MIX groups mean TC before supplementation observed 217.90 ± 8.15, 214.50 ± 10.67, and 234.10 ± 9.43 mg/dL respectively. After 60 days mean TC level of these three groups was 204.70 ± 10.31, 201 ± 1.5 ± 8.29 and 220.10 ± 10.85 mg/dL respectively. Mean ΔTC of these three groups observed 13.20 ± 7.90 (GS), 13.35 ± 8.50 (MK), 14.00 ± 7.76 (MIX). Serum TC level of all supplemented groups became significantly lower after the supplementation. Effect of supplementation in increasing order was Mix (5.98%) < GS (6.05%) < MK (6.22%) < CV (6.90%).

4.3.3.3 HDL–Cholesterol (HDL–C)

Fig.4.3.3.3 explains serum HDL-C levels of experimental groups before supplementation and after supplementation recorded as CON– 36.55±4.11, 37.10±3.47, CV – 38.40±2.60, 40.15 ±3.19, GS– 39.27±2.98, 41.89±2.41, MK–37.45±2.91, 38.40±2.76, MIX– 37.59±2.84, 39.27±2.54 mg/dL. A significant difference was observed in the post supplementation serum HDL-C and pre supplementation HDL–C level of supplemented groups but in control group there was no difference. Effect of supplementation of plant extracts in different groups calculated as CV-4.55% (ΔHDL-C 1.75±2.75 mg/dL), GS group 6.59% (ΔHDL-C 2.59 ± 2.15 mg/dL), MK group- 2.80% (ΔHDL-C 1.05±1.60 mg/dL), MIX group-(ΔHDL-C-1.68±2.20 mg/dL) 4.46% higher.

4.3.3.4 LDL–Cholesterol (LDL–C)

Fig 4.3.3.4 depicts serum LDL–C levels of diabetic subjects in different groups observed before supplementation and after supplementation. In CON group mean LDL–C was 145.05 ± 8.10 mg/dL before supplementation and 147.20 ± 8.04
mg/dL after supplementation. There was no significant difference between these two values. In CV group mean LDL-C value decreased to 123.30 ± 10.15 from 133.95 mg/dL at the end of supplementation. Mean Δ LDL–C in this group was 10.75 ± 6.04 mg/dL, 8.02% lower and this difference was significant at .001 level.

In GS group mean LDL-C was 134 ± 15.45 mg/dL before supplementation and it was observed level of this group was. In this group LDL- C was decreased 10.40% (120.15 ± 13.45 mg/dL, mean Δ LDL–C - 13.95 ± 10.62 mg/dL) after supplementation and this change was significant.

In MK group mean LDL-C was 147.75 mg/dL before supplementation and 145.05 ± 16.95 mg/dL after supplementation. There was no significant difference found in LDL–C level of MK group after supplementation.

In MIX group mean LDL–C was 131.70±11.75 mg/dL before supplementation and it was estimated 120.15±10.98 mg/dL after supplementation and there was a significant difference (p <.001) between these two values. Δ LDL–C was 11.55 ± 10.09 mg/dL, in this way 8.76% LDL–C was decreased as an effect of supplementation.

4.3.4 Oxidative Stress

Fig 4.3.4 a and b represent mean serum TBARS and reduced Glutathione (GSH) levels of experimental groups of diabetic patients. Serum TBARS levels of CON group before and after supplementation was 3.87 ± 0.81 and 4.12 ± 1.23 n mol/mL. There was no significant difference in these values. In supplemented groups CV, GS, MK and MIX serum TBARS level before supplementation was 4.13 ± 1.18, 4.28 ± 1.39, 4.35 ± 1.11 and 4.49 ± 1.14 n mol/mL respectively. At the end of study period TBARS of these all groups significantly reduced. Δ TBARS level of CV group 1.60 ± 1.58, GS – 1.49 ± 1.60, MK – 1.49 ± 1.02, Mix 2.03 ± 1.62 n mol/dL. Effectiveness of supplementation to control thiobarbituric reactive substances in increasing order was – MK (34.25%) < GS (34.81%) < CV (38%) < MIX (45.21%)
Mean serum reduced GSH of experimental group before supplementation was CON– 0.28 ± 0.04, CV– 0.26 ± 0.05, GS – 0.27 ± 0.04, MK– 0.27 ± 0.04 and MIX 0.28 ± 0.04 n mol/L and after supplementation it was 0.29 ± 0.10, 0.36 ± 0.06, 0.29 ± 0.06, 0.33 ± 0.07, 0.35 ± 0.04 n mol/L respectively. Serum reduced GSH level of CV, MK and MIX groups was found to be significantly increased after supplementation but there was no significant difference was observed in the red-GSH levels of GS and CON groups. Δ GSH of these groups was CV– 0.10±0.08 (38.46%), MK – 0.05 ±0.08 (20.93%) and MIX–0.07 ± 0.07 (24.30%).

4.3.5 Uric Acid

Fig 4.3.5. In CON group mean serum uric acid level was 4.86 ± 0.82 mg/dL before supplementation and after supplementation it was 4.77 ± 0.71 mg/dL. There was no significant difference in these two values.

In CV supplemented group mean serum uric acid level before the supplementation was 4.70 ± 0.79 mg/dL and after supplementation. Uric acid level estimated 4.03 ± 1.12 mg/dL significantly ($p<.05$) lower than previous levels. Δ Uric acid level was 0.67 ± 1.22 mg/dL. In this group uric acid level found to be decrease 14.25%

In GS group no significant difference was observed in serum uric acid level at the end of supplementation. While in MK and MIX groups serum uric acid level was found to be significantly reduced at end of supplementation. Mean Δ uric acid level of these groups was 0.78 ± 1.30 and 0.83 ± 0.61 mg/dL respectively. On the basis of effectiveness of supplementation in controlling uric acid level in increasing order was 14.25% (CV group) 17.84% (MK group), 22.26% (MIX).

4.3.6 Transaminases

Fig 4.3.6. a,b depicts mean serum ALT and AST activity in experimental groups. Serum ALT level of experimental groups before supplementation was CON– 40.95 ± 16.10, CV– 39.55 ± 17.44, GS– 35.40 ± 14.04, MK– 50.80 ± 16.61
and MIX- 40.35 ± 17.73 u/L. After supplementation serum ALT level of these groups was 40.05±13.75, 39.2±16.15, 36.45±13.84, 44.55±12.40 and 42.55± 5.38 u/L. No significant difference was observed in the ALT level of all experimental groups after supplementation expect MK group. ALT level of MK group was found to be significantly ($p<0.05$) reduced at the end of supplementation. AST level before and after supplementation of different groups was estimated and no significant difference was observed as an effect of supplementation.
4.3.1 Pre and post mean FBG levels of diabetic subjects supplemented with plant extracts

![FBG Levels Graph](image)

4.3.2 Pre and post mean HbA1c levels of diabetic subjects supplemented with plant extracts

![HbA1c Levels Graph](image)

CON: Control Group, CV: Supplemented with C. verum extract, GS: Group Supplemented with G. sylvestre extract, MK: Group Supplemented with M. koenigii extract, MIX: Group Supplemented with Mixture of Plant extracts
4.3.3.1 Pre and post mean serum total TG levels of diabetic subjects supplemented with plant extracts

CON: Control Group, CV: Supplemented with C. verum extract, GS: Group Supplemented with G. sylvestre extract, MK: Group Supplemented with M. koenigii extract, MIX: Group Supplemented with Mixture of Plant extracts

4.3.3.2 Pre and post mean serum TC levels of diabetic subjects supplemented with plant extracts

CON: Control Group, CV: Supplemented with C. verum extract, GS: Group Supplemented with G. sylvestre extract, MK: Group Supplemented with M. koenigii extract, MIX: Group Supplemented with Mixture of Plant extracts
4.3.3.3 Pre and post mean serum HDL-C levels of diabetic subjects supplemented with plant extracts

CON : Control Group, CV : Supplemented with C. verum extract, GS : Group Supplemented with G. sylvestre extract, MK : Group Supplemented with M. koenigii extract, MIX : Group Supplemented with Mixture of Plant extracts

4.3.3.4 Pre and post mean serum LDL-C levels of diabetic subjects supplemented with plant extracts

CON : Control Group, CV : Supplemented with C. verum extract, GS : Group Supplemented with G. sylvestre extract, MK : Group Supplemented with M. koenigii extract, MIX : Group Supplemented with Mixture of Plant extracts
4.3.4.1 Pre and post mean serum TBARS levels of diabetic subjects supplemented with plant extracts

![Graph showing serum TBARS levels for different groups before and after supplementation.]

4.3.4.2 Pre and post mean serum reduced-GSH levels of diabetic subjects supplemented with plant extracts

![Graph showing serum GSH levels for different groups before and after supplementation.]

CON : Control Group, CV : Supplemented with C. verum extract, GS : Group Supplemented with G. sylvestre extract, MK : Group Supplemented with M. koenigii extract, MIX : Group Supplemented with Mixture of Plant extracts
4.3.5 Pre and post mean serum uric acid levels of diabetic subjects supplemented with plant extracts

4.3.6.1 Pre and post mean serum ALT levels of diabetic subjects supplemented with plant extracts

CON : Control Group, CV : Supplemented with C. verum extract, GS : Group Supplemented with G. sylvestre extract, MK : Group Supplemented with M. koenigii extract, MIX : Group Supplemented with Mixture of Plant extracts
4.3.6.2 Pre and post mean serum AST levels of diabetic subjects supplemented with plant extracts
4.4 PRODUCT DEVELOPMENT

Dietary restrictions and modifications are integral part of diabetes management. To increase the feasibility of intake of efficacious plant products. Nine variations of each products prepared S – standard, AI– product incorporated with 3% cinnamon powder, A II- incorporated with 5% cinnamon powder, BI – product incorporated with 3% Gyneama sylvestre leaves powder, B II- containing 5% Gumar leaves powder. CI – 3% Curry tree bark powder incorporated products, C II – 5% Curry tree bark incorporated food products. D I – 3% mixture of plant products, D II – 5% mixture of plant products.

4.4.1 Dal Samosa

Fig 4.4.1 shows the hedonic scores of dal samosa prepared from the incorporation of plant product powders. In dal samosa highly accepted product was CI in all parameters among the modified products, followed by BI and C II. Acceptability scores of this versions equal to standard in texture and taste. In all products 3% versions were more accepted than 5% versions but in product B there was no significant difference between I and II versions.

4.4.2 Sev

In Sev all products were highly accepted (Fig. 4.4.2), liked very much to extremely. Most accepted product was AI, followed by CI and A II. Although standard was best among all. In appearance, color and texture A I, A II and C I got highest scores. But in taste BI was most accepted. In texture and appearance cinnamon incorporated products were highly accepted.

4.4.3 Carrot Soup

Fig. 4.4.3 illustrates the mean acceptability scores of carrot soup. Standard Carrot Soup was more accepted than modified versions. A I version was most accepted among all plant products incorporated products, followed by A II, B I, B II, D1and C I. There was no significant difference acceptability A II, B I, C I and D1. Appearance, color of A I and A II versions were more accepted than other products. All version got highest scores in overall acceptability, C I was best in odor.
4.4.4 Crunchy Triangles

Crunchy triangles (Fig 4.4.4) were baked chips of whole wheat flour and roasted bengal gram flour. All the products were liked moderately to extremely. Product C I was the most acceptable product among all even more than S. After C I second most acceptable product was C II followed by B I and B II. C I Product got highest mean scores in appearance texture, odor, and overall acceptability even more than S. While C II got highest score in color and taste.

4.4.5 Cake

From the feedback of patients it was found that diabetic patients miss sweets and cakes the most. Thus cake was prepared with very finely ground wheat flour. Standard was although most acceptable but among plant parts incorporated products, AI was most accepted. There was no significant difference between the mean scores of AI and S in all parameters, After A1, B1, and C1 products were most accepted and there was no significant difference in the preference of B1 and C1. B II version was the least accepted product among all but this version was also liked moderately in all parameters.

4.4.6 Cold Coffee

Coffee was most frequently consumed product among diabetics. Among all modified products AI product was most accepted product and got highest mean scores in appearance, color, odor, and taste. Product AI was even more preferred than S in color, odor and taste. AI was followed by A II, B I, DI and C I products in acceptability and there was no significant difference in mean scores of these three products. Although C II was the product to get least scores but all versions of cold coffee were liked moderately too extremely.

4.4.7 Dhokla

Dhokla is the fermented product of bengal gram flour. Standard product was although got highest scores. Among plant parts incorporated products B I was to get highest mean scores followed by AI and there was no significant difference in the scores of these two products. Acceptability of A II, DI, DII and B II was also same
(no significant difference). All modified products were liked very moderately to very much except CI and C II, those liked slightly and got least mean acceptability scores.

### 4.4.8 Baked Papad

Baked papad were prepared to satisfy the snacks’ cravings of diabetics. Products AI and CI products got highest mean acceptability scores. There was no significant difference between the mean scores of AI and CI. In color, texture and taste CI got highest mean scores. AI got highest mean score in appearance. Acceptability of DI and D II was less than AI and CI but higher than the other versions. BI and B II were the least accepted products.

### 4.4.9 Stuffed Idli

Fig 4.4.8 shows the mean acceptability scores of different versions of idli. Standard versions of stuffed in idli was although was most acceptable but modified forms were also well accepted. Among the modified products A I and A II were most accepted, followed by B I and C II. Product AI was best in appearance, color, odor and taste, although overall acceptability of product A II was highest among all. Although product was to get least acceptability scores but it was liked very much to extremely. There was no difference in the acceptability of DI and DII products.
4.4.1 Hedonic acceptibility evaluation scores of the food product - Dal Samosa

4.4.2 Hedonic acceptibility evaluation scores of the food product - Sev

4.4.3 Hedonic acceptibility evaluation scores of the food product - Carrot Soup
4.4.4 Hedonic acceptibility evaluation scores of the food product - *Crunchy Triangles*

![Graph for Crunchy Triangles]

4.4.5 Hedonic acceptibility scores of the food product - *Cake*

![Graph for Cake]

4.4.6 Hedonic acceptibility scores of the food product - *Cold Coffee*

![Graph for Cold Coffee]
4.4.7 Hedonic acceptibility evaluation scores of the food product - Dhokla

![Graph showing hedonic acceptibility scores for Dhokla]

4.4.8 Hedonic acceptibility evaluation scores of the food product - Baked Papad

![Graph showing hedonic acceptibility scores for Baked Papad]

4.4.9 Hedonic acceptibility evaluation scores of the food product - Stuffed Idli

![Graph showing hedonic acceptibility scores for Stuffed Idli]