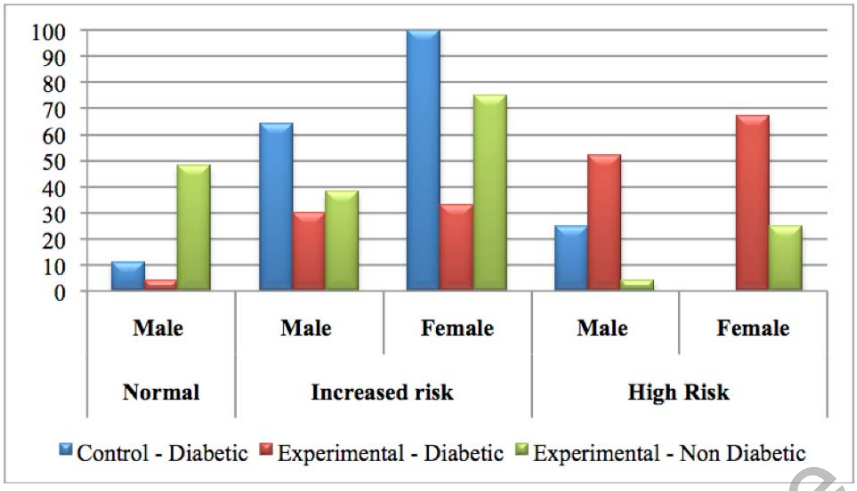

Figure 2: BMI classification of subjects in bittergourd fermented beverage.

Table 4: Percent Adequacy of Nutrient Intake with Reference to RDA in Bittergourd Fermented Beverage

Group		No	Energy	Protein	Fat	Calcium	Iron
			kcal	gm	gm	mg	mg
Control Diabetic	**Male**	28(93)	75	65	125	102	78
	Female	2(7)	81	66	112	112	86
Experimental Diabetic	**Male**	27(90)	79	62	114	73	59
	Female	3(10)	80	62	123	79	63
Experimental Non Diabetic	**Male**	21(84)	74	68	158	98	68
	Female	4(16)	78	69	156	107	78

[#]Values in parenthesis indicates percentage.

the RDA for Indians given by ICMR [32] and found to be alarming. Protein (62%-69%) intake was not adequate in subjects. The fat intake of the subjects was very high (112%-158%) compared to RDA and this was reflected in their high BMI values (Table **3**). Calcium intake was meeting the ICMR recommendations in female group as they were consuming more amount of milk and its products every day. When the food frequency was recorded rice, ragi was used in the daily diet and wheat was used on alternate days. Redgram dhal was used daily to prepare sambar or rasam. Horsegram dhal, blackgram dhal, greengram dhal, bengalgram dhal and field bean were used occasionally. Other vegetables such as beans, cabbage, radish, capsicum, leafy vegetables were used more frequently than potatoes, carrot. Milk was used in beverages like coffee, tea and milk, but the frequency of consumption was more in female group.

3.4. Effect of Feeding on Clinical Signs and Symptoms

Figure **3** shows that the majority (61%) of the subjects had diagnosed for diabetes before two years. The frequently seen symptoms in diabetes were recorded in the experimental diabetic group subjects before and after the supplementation of the beverage. Majority of the subjects had polyhagia (64%), fatigue (61%), polyurea (49%), general weakness (46%) and burning feet (39%) before the supplementation. When recorded after the supplementation of bittergourd beverage they showed very good response to reduce the above mentioned symptoms (Figure **4**). It is noteworthy to mention that, Polyphagia was reduced by 38%, fatigue was reduced by 37%, polyurea reduced by 33%, general weakness by 31% and burning feet by 19%. Exercise is considered to be beneficial in the treatment and prevention of insulin sensitivity and much of the effect occurs in muscle. As the selected subjects were also from the Police department, the subjects were actively involved in the physical activities such as horse riding, yoga, therefore hose riding too was considered as one of the physical activity. It is evident from Figure **5** that subjects who were diabetic were actively involved in the exercises such as horse riding (40% to 33%), yoga and walking (13 to 17%) but majority of the non diabetic (48%) subjects were not involved in any physical activity.

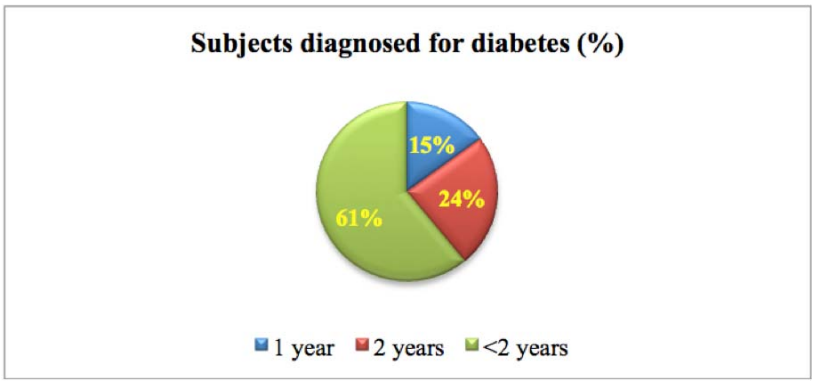

Figure 3: Subjects diagnosed for diabetes in bittergourd fermented beverage.

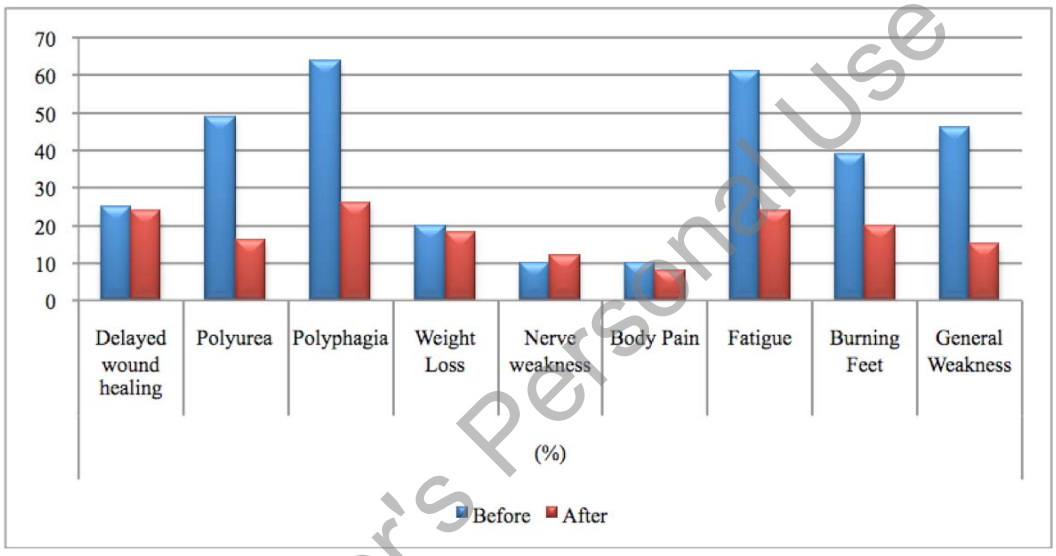

Figure 4: Effect of feeding bittergourd fermented beverage on clinical symptoms in experimental diabetic group.

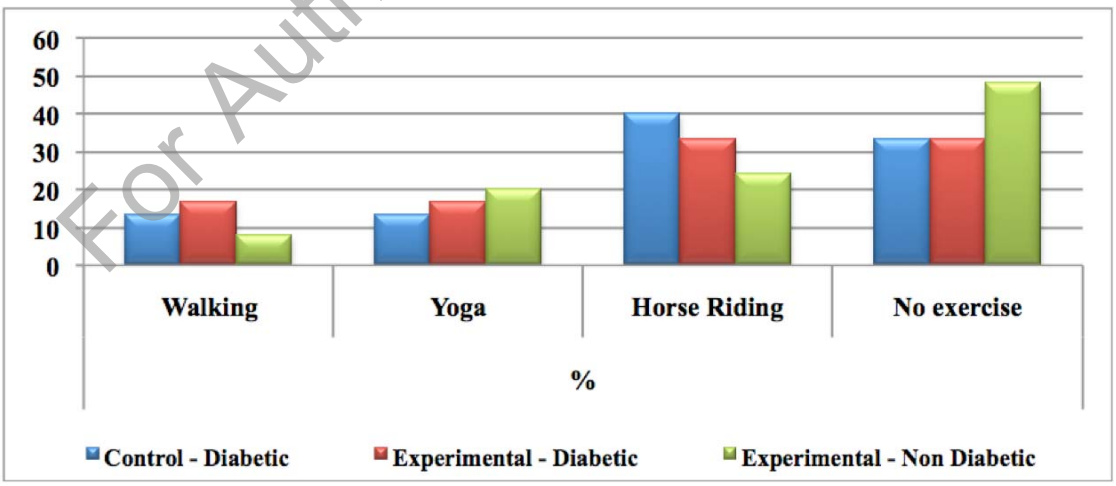

Figure 5: Percentage of physical activity in the subjects in bittergourd fermented beverage.

3.5. Effect of Feeding on Blood Glucose Levels of the Subjects

The fasting and post prandial blood glucose levels were analysed in the 85 subjects before and after the supplementation of the bittergourd fermented beverage by Accu check glucometer®. Fasting blood sugar was drawn after the subjects had fasted overnight and after one and half hour to two hours after breakfast the blood was again drawn for post prandial blood sugar levels. Results from Figures **6** & **7** shows the changes in

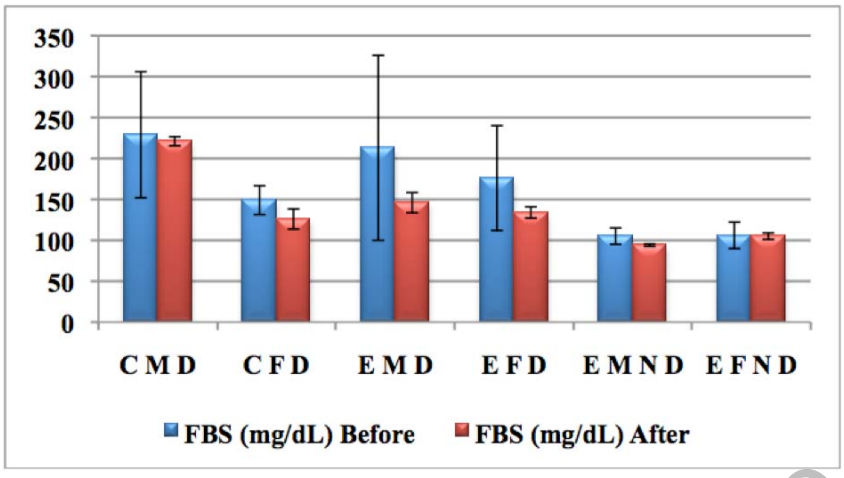

Figure 6: Effect of supplementation of bittergourd fermented beverage on fasting blood glucose levels.

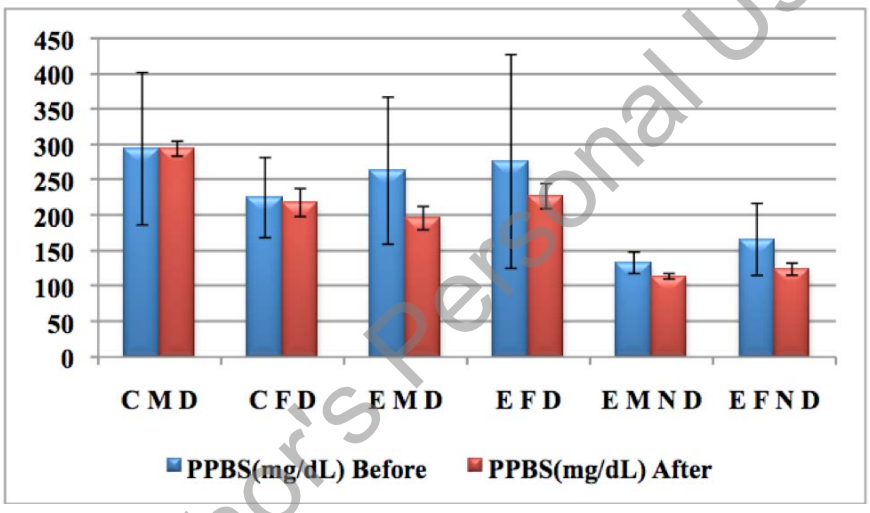

Figure 7: Effect of supplementation of bittergourd fermented beverage on post prandial blood glucose levels.

***Note:** CMD: Control male diabetic; CFD: Control female diabetic; EMD: Experimental male diabetic; EFD: Experimental female diabetic; EMND: Experimental male non diabetic; EFND: Experimental female non diabetic.

fasting and post prandial blood sugar levels of the subjects in each group. Supplementation of bittergourd fermented beverage showed reduction of blood sugar levels in both diabetic and non diabetic subjects. In the experimental diabetic subjects FBS reduced from 213mg/dL to 146mg/dL in males (Figure **6**) and from 176mg/dL to 134mg/dL in females (Figure **6**), and PPBS reduced from 263mg/dL to 196mg/dL in males and from 276mg/dL to 227mg/dL in females respectively. Around 24 to 31% of FBS and 18-25% of PPBS was reduced in the experimental group reflecting the hypoglycemic effect of bittergourd fermented beverage, while in the control group it was observed that reduction of 4mg/dL and 15mg/dL in FBS and PPBS levels respectively. It is clearly seen from Figures **6** & **7** that, the blood glucose levels were not reduced and it was almost same in the control group of subjects. In the group of non diabetic subjects the beverage had more influence on PPBS than FBS. Around 25% of reduction was observed in PPBS in female group (Figure **7**) and 15% in male group (Figure **7**), where as it has not much influence on FBS levels. Therefore, even non diabetic subjects too can consume the developed beverage as a health drink as it influenced more on PPBS by not affecting FBS. Bitter gourd contains a lectin that has insulin-like activity. The insulin-like bioactivity of this lectin is due to its linking together 2 insulin receptors. This lectin lowers blood glucose concentrations by acting on peripheral tissues and, similar to insulin's effects in the brain, suppressing appetite. This lectin is likely a major contributor to the hypoglycemic effect that develops after eating bittergourd and why it may be a way of managing adult-onset diabetes. Lectin binding is non-protein specific, and this is likely why bittergourd has been credited with immunostimulatory activity - by linking receptors that modulate the immune system, thereby stimulating said receptors. Charantin extracted by alcohol, is a

hypoglycemic agent composed of mixed steroids that is more potent than the drug tolbutamide, which is sometimes used in the treatment of diabetes to lower the blood sugar levels. *Momordica* also contains an insulin like polypeptide, polypeptide-P, which lowers blood sugar levels when injected subcutaneously into type 1 diabetic patient. The oral administration of 50-60 ml of the juice has shown good results in clinical trials. The effect of *Momordica charantia* on glucose and insulin concentrations was studied in nine non-insulin-dependent diabetics and six non-diabetic laboratory rats. A water-soluble extract of the fruits significantly reduced blood glucose concentrations during a 50 g oral glucose tolerance test in the diabetics and after force-feeding in the rats. Fried fruits consumed as a daily supplement to the diet produced a small but significant improvement in glucose tolerance. Improvement in glucose tolerance was not associated with an increase in serum insulin responses. These results shown that improves glucose tolerance in diabetes. Bittergourd has been shown to increase the number of beta cells in the pancreas thereby improving the body's ability to produce insulin. The fruit has also shown the ability to enhance cells' uptake of glucose, to promote insulin release, and potentiate the effect of insulin [33]. With the above results bittergourd fermented beverage showed excellent results in reducing the diabetic symptoms and reduced FBS and PPBS in the experimental groups. Twenty eight percent reduction in fasting blood glucose level was observed in experimental group and 22 % reduction in post-prandial blood glucose level was observed when compared to non significant changes in control group. This indicates that consumption of 45ml of the fermented bitter gourd beverage per day in empty stomach helps in reducing blood glucose levels in diabetic subjects. A scientific study at the Jawaharlal Institute of Postgraduate Medical Education and Research, India, has also proved that bitter melon increases insulin sensitivity [33]. Also, in the Philippine Department of Health issued a circular stating that bittergourd, as a scientifically validated herbal medicinal plant, can lower elevated blood sugar levels. The study revealed that a 100 milligram per kilo dose per day is comparable to 2.5 milligrams of the anti-diabetes drug Glibenclamide taken twice per day [34].

As there is evidence of research work carried out by the earlier researchers that bittergourd is having effect on lipid profile further studies were carried out on 16 Diabetic subjects to evaluate the effect of bittergourd fermented beverage on blood sugar profile, lipid profile and Glycoslated Haemoglobin (HbA1c). Baky *et al.* [35] reported that bitter gourd exert hypoglycemic, hypolipidaemic and antioxidative influence on both normoglycemic and hyperglycemic diabetic rats. bitter gourd extracts show triglyceride and cholesterol lowering activity in diabetic animals [36-38], as well as non-diabetic animals fed cholesterol-rich diets [39]. The subjects of the present were supplemented with the beverage for a period of 5 months. The above mentioned parameters were carried out before and after the fermentation. The supplementation of the beverage showed significant ($p<0.001$) decrease in estimated average glucose (mg/dL) and in Glycosalated haemoglobin (HaA1c-%) levels (Table **5**). It is more evident from Figure **8** that the supplementation of fermented beverage for 5 months showed decrease in the levels of FBS and PPBS. FBS reduced (43%) from 210 to 120mg/dL and PPBS reduced (41%) from 283 to 167mg/dL. Estimated average glucose reduced from 161.05 ± 38.17 to 118.24 ± 25.39 mg/dL. HbA1c test tells us about the glucose level in blood over 3 months and the results indicated that the subjects had fair control of glucose levels before the supplementation, where as after the supplementation they dropped out to good control in the glucose levels. In order to understand the direct action of the beverage on blood lipid profile–serum cholesterol, triglycerides, low density lipoprotein cholesterol, high density lipoprotein cholesterol as

Table 5: Effect of Supplementation of Bittergourd Fermented Beverage on Biochemical Parameters

Blood Parameters	Before	After
Estimated Average Glucose (mg/dl)	161.05 ± 38.17	118.24 ± 25.39[b]
HbA1c (%)	7.23 ± 1.33	5.74 ± 0.89 [b]
Serum Cholesterol (mg/dL)	187.13 ± 28.08	180.21 ± 13.83
Serum Triglycerides (mg/dL)	156.35 ± 82.70	160.94 ± 78.03
Serum HDL Cholesterol (mg/dL)	47.45 ± 9.04	40.85 ± 4.39[c]
Serum LDL Cholesterol (mg/dL)	122.35 ± 36.91	128.98 ± 27.37

[#]Values with different superscripts are significant difference with initial period at the level; [a]p>0.0001, [b]p<0.001, [c]p<0.01, [d]p<0.05.

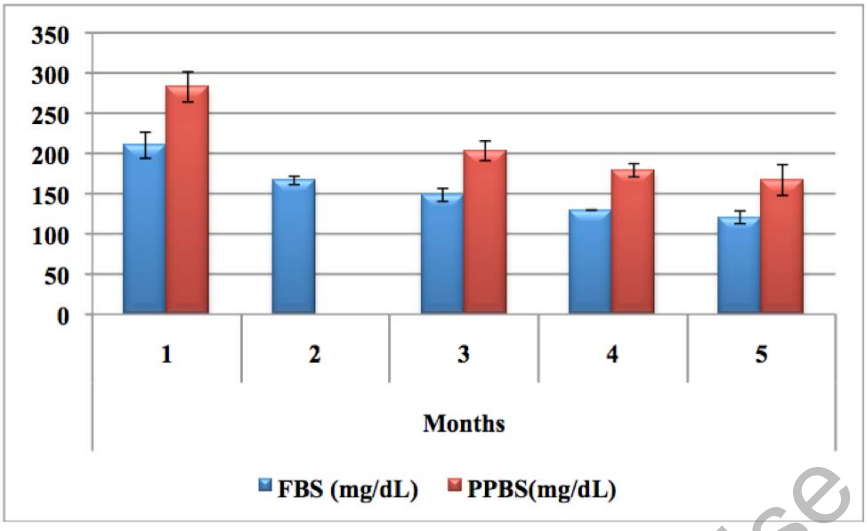

Figure 8: Effect of supplementation of bittergourd fermented beverage on blood glucose levels of second batch subjects.

measured before and after supplementation showed the changes by 4-7% which is not considerable. Therefore, the supplementation of bittergourd fermented beverage on diabetic subjects showed significant improvement in reducing the symptoms of diabetes, reduced the fasting and post prandial glucose levels and helped to control the glucose levels when compared with the control group.

4. CONCLUSION

The impact of supplementation of bittergourd fermented beverage on diabetic subjects, in the initial study showed that subjects showed significant improvement in reducing the symptoms of diabetes, reduced the fasting and post prandial glucose levels and helped to control the glucose levels when compared with the control group. In the further study of bittergourd fermented beverage on 16 diabetic subjects showed reduction in fasting and postprandial blood sugar. HbA1c results indicated that after the supplementation they have raised to good control from fair control. The effect of beverage supplementation showed no considerable changes in the lipid profile and had no influence on lipid profile. Therefore, the study clearly reflected the positive effect of bittergourd fermented beverage in reducing and controlling blood sugar levels.

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