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ORIGINAL ARTICLE

# Hypoglycemic and hypolipidemic effect of *Aloe vera L.* in non-insulin dependent diabetics

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**Abstract** Ninety non-insulin dependent diabetic subjects were selected from Punjab Agricultural University and Civil hospitals of Ludhiana. The selected subjects were divided into three groups viz. Group I, II and III having thirty subjects each. The subjects of group I were not given any treatment. The subjects of group II and III were supplemented with 100 mg and 200 mg of *Aloe vera L.* gel powder respectively for a period of 3 months and supplementation was continued along with nutrition counselling for the next 3 months. The nutrition education was given for 3 months after 15 days interval to the subjects of group II and III through individual and group contact. The blood glucose and lipid profile were analyzed. The blood pressure of the subjects was also measured. It was seen that there was a significant ($p \leq 0.01$) reduction in fasting blood glucose level by 11.4% and 15.4% and post prandial glucose level 18.5% and 27.8% in the subjects of group II and III respectively after the study. Significant ($p \leq 0.01$) reduction in total cholesterol 8.6% and 10.1%, triglycerides 9.6% and 12.2%, low density lipoprotein cholesterol (LDL-C) 12.8% and 14.6%, very low density lipoprotein cholesterol (VLDL-C) 9.6% and 12.2% and an increase in high density lipoprotein cholesterol (HDL-C) 7.3% and 9.4% was observed in the subjects of group II and III respectively. The ratio of total cholesterol to HDL-C reduced from 5.6 to 4.8 and 6.1 to 5.0 and LDL-C to HDL-C from 3.7 to 3.0 and 4.1 to 3.1 in the subjects of group II and III respectively after the study. There was also a significant decrease ($p \leq 0.01$) in the blood pressure of the subjects of group II and III and a non significant decrease ($p \leq 0.01$) was seen in the subjects of group I. With the intervention of *Aloe vera L.*, significant reduction was observed in blood glucose, lipid profile and blood pressure of the diabetic patients.

**Keywords** *Aloe vera L.* · Nutrition counselling · Blood glucose · Lipid profile · Blood pressure

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Diabetes is a chronic disease marked by the higher level of blood glucose from defects in insulin production, insulin action or both. Diabetes is fast becoming a leading cause of morbidity, mortality and disability across the world. Diabetes is a global metabolic epidemic affecting essential biochemical activities in almost every age group (Gupta et al. 2008). The prevalence of diabetes has drastically increased in the latter half of the 20th century, largely due to the ready availability of large quantities of calorie rich foods and the technology driven reduction in routine daily exercise. According to International Diabetes Federation, diabetes currently affects 285 million people worldwide and India has the largest number of people with diabetes i.e. 50.8 million. India has been declared as the "Diabetic capital of world". By 2030 there would be 438 million diabetics throughout the world and 80 million diabetics would be in India alone (IDF 2010). Obesity and physical inactivity independently contribute to the development of type 2 diabetes. However, the magnitude of risk contributed by obesity is much greater than that imparted by lack of physical activity (Rana et al. 2006).

These days great attention is being given to management of diabetes with medicinal plants along with dietary restriction. Modern medicine is rooted in ethno botanical traditions using indigenous flora to treat symptoms of human diseases or to improve specific aspects of the body conditions. Today a great number of modern drugs are still derived from natural sources and 25% of all prescriptions contain one or more active ingredients from plants (Thorfeldt 2005).

*Aloe vera* has been used for many centuries for its curative and therapeutic properties *Aloe vera* is a perennial succulent xerophyte, which develops water storage tissue in the leaves to survive in dry areas of low or erratic rainfall. The aloe leaf can be divided into two major parts, namely the outer green rind, including the vascular bundles, and the inner colourless parenchyma containing the aloe gel. Main chemical constituents of *Aloe vera* include: amino acids, anthraquinones, enzymes, minerals, vitamins, lignins, monosaccharide, polysaccharides, salicylic acid, saponins, and phytosterols (Surjushe et al. 2008).

*Aloe vera* has marvelous medicinal properties. *Aloe vera* lowers blood glucose levels in diabetic patients. It also improves the responsiveness of the body tissues towards insulin, thereby making insulin more effective. Active components present in *Aloe vera* also help in lowering high blood pressure. This makes *Aloe vera* extremely suitable for wide scale treatment to all diabetic conditions (Misawa et al. 2008). *Aloe vera* helps in reducing serum cholesterol and tri-glycerides and increasing level of high density lipoprotein cholesterol (HDL-C). Phytosterols (Sitosterol, Campesterol and Lupeol) which are structurally similar to cholesterol help in reducing serum concentrations of cholesterol by reducing the absorptions of cholesterol from the gut by competing for the limited space for cholesterol in mixed micelles (Josias 2008). Hence, the present study was designed to see the hypoglycemic and hypolipidemic effect of *Aloe vera L.* in non-insulin dependent diabetics.

## Materials and methods

Ninety non-insulin dependent diabetic male patients in the age group of 35–65 years free from serious complications of diabetes were selected from the Punjab Agricultural University and Civil hospitals of Ludhiana. Selection was based on their fasting and post prandial blood glucose level followed by blood pressure. The selected subjects were divided into three groups viz. group I, II and III, each group having thirty subjects each. The subjects of group I was given no treatment. The subjects of group II and III were given two treatments. In first treatment, the subjects of group II and III were supplemented with 100 mg and 200 mg of *Aloe vera L.* gel powder respectively for a period of 3 months and in second treatment i.e. nutrition intervention, supplementation was continued along with nutrition counselling for the next 3 months. The nutrition education was given for 3 months after 15 days interval to the subjects of group II and III through individual and group contact. Feeding trials were carried out for a period of 6 months with daily dosage of two capsules containing 50 mg powder each to group II and 100 mg powder each to group III. One capsule was given immediately on rising and another after dinner.

General and diabetic information pertaining to age, education, marital status, occupation, size and type of family, physical activities, food habits, causes and symptoms of the disease was recorded for all the subjects through questionnaire schedule. Blood pressure was

**Table 1** General information of the subjects

| Characteristics | Group I | Group II | Group III |
|---|---|---|---|
| Age (years) | | | |
| 35–45 | 15(50.0) | 16(53.3) | 16(53.3) |
| 46–55 | 10(33.3) | 8(26.7) | 10(33.3) |
| 56–65 | 5(16.7) | 6(20.0) | 4(13.3) |
| Religion | | | |
| Hindu | 12(40.0) | 14(46.7) | 10(33.3) |
| Sikh | 18(60.0) | 16(53.3) | 20(66.7) |
| Education | | | |
| Illiterate | 2(6.7) | 3(10.0) | 1(3.3) |
| High School | 20(66.7) | 16(53.3) | 22(73.3) |
| Higher Secondary | 7(23.3) | 3(10.0) | 6(20.0) |
| Graduate | 1(3.3) | 8(26.7) | 1(3.3) |
| Occupation | | | |
| Business | 25(83.3) | 21(70.0) | 28(93.3) |
| Service | 5(16.7) | 9(30.0) | 2(6.7) |
| Marital Status | | | |
| Married | 30(100.0) | 30(100.0) | 30(100.0) |
| Type of family | | | |
| Nuclear | 8(26.7) | 11(36.7) | 7(23.3) |
| Joint | 22(73.3) | 19(63.3) | 23(76.7) |
| Family size | | | |
| 2–4 | 8(26.7) | 11(36.6) | 7(23.3) |
| 5–6 | 17(56.7) | 13(43.3) | 19(63.3) |
| 7–8 | 5(16.7) | 6(20.0) | 4(13.3) |

Figures in parenthesis are percentages

**Table 2** Causes of disease

| Factors | Group I | Group II | Group III |
|---|---|---|---|
| Heredity | 12(40.0) | 14(46.7) | 9(30.0) |
| Obesity | 16(53.3) | 13(43.3) | 19(63.3) |
| Others | 2(6.7) | 3(10.0) | 2(6.7) |

Figures in parenthesis are percentages

**Table 3** Signs and symptoms before and after supplementation of *Aloe vera L.* and nutrition intervention(supplementation of *Aloe vera L.* + nutrition counselling)

| Signs and symptoms | Before | Group I | | Before | Group II | | Before | Group III | |
|---|---|---|---|---|---|---|---|---|---|
| | | After | | | After | | | After | |
| | | 3 months | 6 months | | SA | NI | | SA | NI |
| Polydipsia | 17(56.7) | 17(56.7) | 15(50.0) | 16(53.3) | 14(46.7) | 10(33.3) | 19(63.3) | 14(46.7) | 9(30.0) |
| Polyurea | 15(50.0) | 15(50.0) | 14(46.7) | 14(46.7) | 12(40.0) | 9(30.0) | 15(50.0) | 11(36.7) | 8(26.7) |
| Tiredness | 13(43.3) | 13(43.3) | 13(43.3) | 14(46.7) | 10(33.3) | 7(23.3) | 13(43.3) | 10(33.3) | 7(23.3) |
| Loss of weight | 13(43.3) | 13(43.3) | 13(43.3) | 5(16.7) | 3(10.0) | 3(10.0) | 4(13.3) | 2(6.7) | – |
| Nocturea | 12(40.0) | 12(40.0) | 12(40.0) | 11(36.7) | 9(30.0) | 7(23.3) | 10(33.3) | 8(26.7) | 5(16.7) |
| Polyphagia | 11(36.7) | 11(36.7) | 10(33.3) | 9(30.0) | 6(20.0) | 4(13.3) | 8(26.7) | 6(20.0) | 4(13.3) |
| Hypertension | 9(30.0) | 9(30.0) | 9(30.0) | 15(50.0) | 12(40.0) | 9(30.0) | 8(26.7) | 5(16.7) | 2(6.7) |
| Excessive sweating | 5(16.7) | 5(16.7) | 4(13.3) | 5(16.7) | 3(10.0) | 2(6.7) | 7(23.3) | 4(13.3) | 2(6.7) |
| Itching | 3(10.0) | 3(10.0) | 3(10.0) | 6(20.0) | 2(6.7) | – | 5(16.7) | 1(3.33) | – |
| Delayed healing | 2(6.7) | 2(6.7) | 2(6.7) | 1(3.3) | – | – | 1(3.3) | – | – |

Figures in parenthesis are percentages. *SA* Supplementation of *Aloe vera L, NI* Supplementation of *Aloe vera L.* + Nutrition counselling

recorded with sphygmomanometer (Maclead 1984).Blood analysis was done for glucose (Trinder 1969), serum total cholesterol (TC) (Richmond 1973), triglycerides (TG) (Fossati and Principle 1982), high density lipo protein cholesterol (HDL-C) (Lopes-Virella et al. 1977), low density lipo protein cholesterol (LDL-C) (Frieldwalds et al. 1972) and very low density lipo protein cholesterol (VLDL-C) (Triglycerides/5). Ratio of total cholesterol to HDL-C and LDL-C to HDL-C was also calculated.

*Method to prepare Aloe vera L. gel powder* Matured leaves of *Aloe vera L.* were initially washed in a water solution (200 ppm solution of sodium hypochlorite) and then further rinsed with a dilute solution of sodium hypochlorite (20 ppm). If leaves were extremely muddy then they were pre washed with deionised water. In order to avoid contamination of internal fillet with the yellow sap, the traditional hand-filleting method of processing aloe leaves was developed. In this method, the lower 1 in. of the leaf base (the white part attached to the large rosette stem of the plant), the tapering point (2–4 in.) of the leaf top and the short, sharp spines located along the leaf margins were removed by a sharp knife, then the knife, was introduced into the mucilage layer below the green rind avoiding the vascular bundles and the top rind was removed. The bottom rind was similarly removed and the rind parts, to which a significant amount of mucilage remains attached, were discarded. The inner fillet was washed again ensuring that there was no possibility of bacterial contamination, after which, the fillet was cut in to pieces and dried in a hot air oven at a temperature of 50 °C for a period of 12 h. The dried fillet then ground and stored for further study (Gulia et al. 2009).

*Statistical analysis* The data on all the blood parameters was analyzed statistically. The mean standard error, percen-

**Table 4** Physical activity pattern of the subjects

| | Before | Group I | | Before | Group II | | Before | Group III | |
|---|---|---|---|---|---|---|---|---|---|
| | | After | | | After | | | After | |
| | | 3 months | 6 months | | SA | NI | | SA | NI |
| Physical Exercise | | | | | | | | | |
| Yes | 5(16.7) | 5(16.7) | 5(16.7) | 3(10.0) | 3(10.0) | 8(26.7) | 9(30.0) | 9(30.0) | 14(46.7) |
| No | 25(83.3) | 25(83.3) | 25(83.3) | 27(90.0) | 27(90.0) | 22(73.3) | 21(70.0) | 21(70.0) | 16(53.3) |
| Type of Exercise | | | | | | | | | |
| Walking | 3(10.0) | 3(10.0) | 3(10.0) | 2(6.7) | 2(6.7) | 6(20.0) | 5(16.7) | 5(16.7) | 10(33.3) |
| Yoga | 2(6.7) | 2(6.7) | 2(6.7) | 1(3.3) | 1(3.3) | 2(6.7) | 4(13.3) | 4(13.3) | 4(13.3) |

Figures in parenthesis are percentages *SA* Supplementation of *Aloe vera L, NI* Supplementation of *Aloe vera L.* + Nutrition counselling

**Table 5** Food habits of the subjects

| Food habits | Group I | Group II | Group III |
|---|---|---|---|
| Vegetarian/non vegetarian | | | |
| Vegetarian | 22(73.3) | 20(66.7) | 23(76.7) |
| Ova/Non-Vegetarian | 8(26.6) | 10(33.3) | 7(23.3) |
| Food likes and dislikes | | | |
| Sweet food | | | |
| Liked | 16(53.3) | 18(60.0) | 19(63.3) |
| Disliked | 14(46.7) | 12(40.0) | 11(36.7) |
| Salty food | | | |
| Liked | 23(76.7) | 22(73.3) | 21(70.0) |
| Disliked | 7(23.3) | 8(26.7) | 9(30.0) |
| Fried food | | | |
| Liked | 17(56.7) | 20(66.7) | 19(63.3) |
| Disliked | 13(43.3) | 10(33.3) | 11(36.7) |
| Fast food | | | |
| Liked | 21(70.0) | 23(76.7) | 20(66.7) |
| Disliked | 9(30.0) | 7(23.3) | 10(33.3) |

Figures in parenthesis are percentage

tages, analysis of variance, CD value, paired t- test and their statistical significance was ascertained using a computer programme package.

## Results and discussions

Initially, ninety non-insulin dependent diabetic male subjects were identified and divided into three groups. General information of the subjects showed that majority of the subjects belonged to the age group of 35–45 years and studied up to high school (Table 1). Most of them had their own business (Table 1). Majority of the subjects belonged to Sikh religion and had joint family with a family size of 5–6 members (Table 1). The most common reason for diabetes among the selected subjects was obesity (Table 2). Obesity among the subjects was due to faulty eating habits, sedentary life style and lack of physical exercise. Signs and symptoms of the disease showed that majority of the subjects in group I, II and III suffered form polydypsia followed by polyurea, tiredness, loss of weight and nocturea (Table 3). The physical activity pattern of the subjects showed that majority of the subjects were not doing any kind of physical exercise. After nutrition intervention 26.7 and 46.7% of the subjects in group II and III started some kind of physical exercise while there was no change in group I (Table 4). Majority of the subjects in group I, II and III were vegetarian and had craving for sweet foods (Table 5).

At the end of 3 months with supplementation of *Aloe vera L.* gel powder, the subjects of group II and III showed a significant ($p \leq 0.01$) reduction in fasting and post prandial blood glucose levels with an improvement in lipid profile. Similar to findings of the present study, a significant reduction in blood glucose level was observed after administration of phytosterols such as lophenol, 24-methyl-lophenol, 24-ethyl-lophenol, cycloartanol and 24-methylene-cycloartanol in non insulin dependent diabetes by Tanaka et al. (2006). Arora et al. (2009) also reported a significant reduction in total cholesterol, total triglycerides, LDL, and VLDL levels after supplementation of *Aloe vera*.

**Table 6** Mean fasting and post prandial blood glucose levels of the subjects before and after supplementation of *Aloe vera L.,* and nutrition intervention (supplementation of *Aloe vera L.* + nutrition counselling)

| Blood glucose level (mg/dl) | Before | After | | CD | % Change | | t-value | | Normal range (mg/dl) |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | Between 1 and 2 | Between 1 and 3 | Between 1 and 2 | Between 1 and 3 | |
| Control | | 3 months | 6 months | | | | | | |
| Group I | | | | | | | | | |
| Fasting | 126.8±2.6 | 125.9±2.6 | 125.4±2.6 | NS | 0.7 | 1.1 | 1.0 $^{NS}$ | 1.5 $^{NS}$ | 70–110$^{\#}$ |
| Post prandial | 185.0±2.0 | 183.6±2.0 | 183.1±2.2 | NS | 0.8 | 1.0 | 1.7 $^{NS}$ | 1.6 $^{NS}$ | 120–140$^{\#}$ |
| Experimental | | SA | NI | | | | | | |
| Group II | | | | | | | | | |
| Fasting | 130.9±2.6 | 122.1±2.7 | 116.0±2.4 | 5.89 $^{\bullet\bullet}$ | 6.7 | 11.4 | 17.5$^{\bullet}$ | 14.0$^{\bullet}$ | 70–110$^{\#}$ |
| Post prandial | 188.0±2.0 | 167.8±5.9 | 153.3±4.3 | 9.85 $^{\bullet\bullet}$ | 10.8 | 18.5 | 12.9$^{\bullet}$ | 6.3$^{\bullet}$ | 120–140$^{\#}$ |
| Group III | | | | | | | | | |
| Fasting | 134.6±2.4 | 118.8±2.9 | 113.9±2.6 | 5.97 $^{\bullet\bullet}$ | 11.8 | 15.4 | 16.4$^{\bullet}$ | 14.9$^{\bullet}$ | 70–110$^{\#}$ |
| Post prandial | 189.7±1.7 | 153.5±4.6 | 136.9±4.8 | 8.89 $^{\bullet\bullet}$ | 19.1 | 27.8 | 6.0$^{\bullet}$ | 10.8$^{\bullet}$ | 120–140$^{\#}$ |

Values represent Mean±SE $^{\bullet}$ =Significant 1%, $^{\bullet\bullet}$ =Significant 5%, *NS* Non significant, *SA* Supplementation of *Aloe vera L., NI* Supplementation of *Aloe vera L.* + Nutrition counselling, #=Raghuram et al. (2007)

The reduction after supplementation of *Aloe vera L.* gel powder could be due to the presence of high molecular weight polysaccharides or phytosterols in the *Aloe vera*. Significant ($p \leq 0.01$) decrease was observed in biophysical parameters like systolic blood pressure and diastolic blood pressure. First treatment i.e. supplementation of 100 mg and 200 mg of *Aloe vera L.* gel powder significantly ($p \leq 0.01$) reduced the fasting blood glucose (130.9 mg% to 122.1 mg % and 134.6 mg% to 118.8 mg%) and post prandial blood glucose (188.0 mg% to 167.8 mg% and 189.7 mg% to 153.5 mg%) in the subjects of group II and III (Table 6). Trace elements like zinc, chromium, magnesium and manganese also play an important role in the management of diabetes mellitus by enhancing the effectiveness of insulin. Rajendran et al. (2007) also reported the role of these inorganic elements in the improvement of impaired glucose tolerance, their indirect role in the management of diabetes mellitus and hypoglycemia. In second treatment ie nutrition intervention, reduction in fasting and post prandial blood glucose level was more as compared to the first treatment in which only supplementation was done. Nutrition intervention reduced the fasting blood glucose (116.0 mg% and 113.9 mg%) and post prandial glucose level (153.3 mg% and 136.9 mg%) of the subjects of group II and III respectively (Table 6). This further reduction could be due to the nutrition counselling imparted to the subjects in group II and III. Sook et al. (2001) also reported that elderly diabetics showed significantly improved food habit scores with changes of food habits after the nutrition education.

Significant reduction in TC (207.2 mg% to 196.9 mg% and 211.5 mg% to 198.1 mg%), TG (171.9 mg% to

**Table 7** Lipid profile of the subjects before and after supplementation of *Aloe vera L.* and nutrition intervention (supplementation of *Aloe vera L.* + nutrition counselling)

| Variables | Before | After | | CD | % Change | | t-value | | Normal range (mg/dl) |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | Between 1 and 2 | Between 1 and 3 | Between 1 and 2 | Between 1 and 3 | |
| Control | | 3 months | 6 months | | | | | | |
| Group I | | | | | | | | | |
| Total Cholesterol | 211.3±2.4 | 209.5±2.3 | 208.9±2.2 | NS | 0.9 | 1.2 | 1.4 $^{NS}$ | 1.7 $^{NS}$ | <200* |
| Triglycerides | 168.1±1.2 | 166.3±0.9 | 165.8±1.0 | NS | 1.1 | 1.3 | 2.2 $^{NS}$ | 2.6 $^{NS}$ | <150* |
| HDL-C | 34.8±0.9 | 35.4±0.8 | 35.5±0.8 | NS | 1.5 | 1.8 | 0.9 $^{NS}$ | 1.9 $^{NS}$ | >50* |
| LDL-C | 142.8±1.6 | 140.8±1.4 | 140.2±1.6 | NS | 1.4 | 1.8 | 1.6 $^{NS}$ | 1.9 $^{NS}$ | <130* |
| VLDL-C | 33.6±0.2 | 33.2±0.1 | 33.1±0.2 | NS | 1.1 | 1.3 | 2.2 $^{NS}$ | 2.6 $^{NS}$ | <30* |
| Total cholesterol/HDL-C | 6.1±0.1 | 5.9±0.1 | 5.9±0.1 | NS | 2.6 | 3.0 | 1.6 $^{NS}$ | 2.3 $^{NS}$ | <4$^{\#}$ |
| LDLC/HDL-C | 4.1±0.1 | 4.04±0.1 | 4.0±0.1 | NS | 3.1 | 3.7 | 1.6$^{NS}$ | 2.6 $^{NS}$ | <3$^{\#}$ |
| Experimental | | SA | NI | | | | | | |
| Group II | | | | | | | | | |
| Total Cholesterol | 207.2±2.4 | 196.9±2.4 2.49 | 189.4±3.2 | 6.1$^{\bullet\bullet}$ | 4.9 | 8.6 | 10.9$^{\bullet}$ | 12.2$^{\bullet}$ | <200* |
| Triglycerides | 171.9±1.2 | 162.7±1.4 | 155.4±2.0 | 3.5$^{\bullet\bullet}$ | 5.3 | 9.6 | 16.1$^{\bullet}$ | 12.2$^{\bullet}$ | <150* |
| HDL-C | 36.9±0.9 | 38.8±0.9 | 39.8±1.0 | 2.1$^{\bullet\bullet}$ | 4.9 | 7.3 | 6.6$^{\bullet}$ | 4.0$^{\bullet}$ | >50* |
| LDL-C | 135.9±1.6 | 126.8±1.6 | 118.5±2.7 | 4.6$^{\bullet\bullet}$ | 6.7 | 12.8 | 12.2$^{\bullet}$ | 8.5$^{\bullet}$ | <130* |
| VLDL-C | 34.3±0.2 | 32.5±0.2 | 31.0±0.3 | 0.7$^{\bullet\bullet}$ | 5.3 | 9.6 | 16.0$^{\bullet}$ | 12.2$^{\bullet}$ | <30* |
| Total cholesterol/HDL-C | 5.6±0.1 | 5.1±0.1 | 4.8±0.1 | 0.2$^{\bullet\bullet}$ | 9.2 | 15.0 | 12.1$^{\bullet}$ | 6.3$^{\bullet}$ | <4$^{\#}$ |
| LDLC/HDL-C | 3.7±0.1 | 3.3±0.1 | 3.0±0.1 | 0.1$^{\bullet\bullet}$ | 11.4 | 18.8 | 12.2$^{\bullet}$ | 6.0$^{\bullet}$ | <3$^{\#}$ |
| Group III | | | | | | | | | |
| Total Cholesterol | 211.5±2.3 | 198.1±2.7 | 190.1±2.6 | 5.8$^{\bullet\bullet}$ | 6.3 | 10.1 | 15.2$^{\bullet}$ | 23.8$^{\bullet}$ | <200* |
| Triglycerides | 177.4±1.6 | 163.8±1.8 | 155.7±1.6 | 3.7$^{\bullet\bullet}$ | 7.6 | 12.2 | 24.6$^{\bullet}$ | 24.7$^{\bullet}$ | <150* |
| HDL-C | 34.9±0.9 | 37.2±0.8 | 38.5±0.9 | 2.0$^{\bullet\bullet}$ | 6.4 | 9.4 | 7.0$^{\bullet}$ | 17.4$^{\bullet}$ | >50* |
| LDL-C | 141.1±1.5 | 128.1±2.1 | 120.5±1.8 | 4.1$^{\bullet\bullet}$ | 9.2 | 14.6 | 12.0$^{\bullet}$ | 22.4$^{\bullet}$ | <130* |
| VLDL-C | 35.4±0.3 | 32.7±0.3 | 31.1±0.3 | 0.7$^{\bullet\bullet}$ | 7.6 | 12.2 | 24.6$^{\bullet}$ | 24.7$^{\bullet}$ | <30* |
| Total cholesterol/HDL-C | 6.1±0.1 | 5.3±0.1 | 5.0±0.1 | 0.2$^{\bullet\bullet}$ | 12.8 | 18.7 | 7.9$^{\bullet}$ | 21.4$^{\bullet}$ | <4$^{\#}$ |
| LDLC/HDL-C | 4.1±0.1 | 3.4±0.1 | 3.1±0.1 | 0.2$^{\bullet\bullet}$ | 15.5 | 22.8 | 7.6$^{\bullet}$ | 20.3$^{\bullet}$ | <3$^{\#}$ |

Values represent Mean±SE, $^{\bullet}$ =Significant 1%, $^{\bullet\bullet}$ =Significant 5%, *NS* Non significant, *SA* Supplementation of *Aloe vera L.*, *NI* Supplementation of *Aloe vera L.* + Nutrition counselling, *HDL-C* High density lipo protein cholesterol, *LDL-C* Low density lipo protein cholesterol, *VLDL-C* Very low density lipo protein cholesterol, $^{\#}$ = American Heart Association (2004),* = Ghafoorunissa and Krishnaswamy (2007)

162.7 mg% and 177.4 mg% to 163.8 mg%), LDL-Cholesterol (135.9 mg% to 126.8 mg% and 141.1 mg% to 128.1 mg%), VLDL-Cholesterol (34.3 mg% to 32.5 mg % and 35.4 mg% to 32.7 mg%) and an increase in HDL-Cholesterol (36.9 mg% to 38.8 mg% and 34.9 mg% to 37.2 mg%) was observed in the subjects of group II and III (Table 7). A significant ($p \leq 0.01$) reduction in the ratio of total cholesterol to HDL-C (5.6 to 5.1 and 6.1 to 5.3) and LDL-C to HDL-C (3.7 to 3.3 and 4.1 to 3.4) in the subjects of group II and III were also observed after first treatment. The per cent reduction in total cholesterol could be due to phytosterols present in *Aloe vera* which are structurally similar to cholesterol helps in reducing serum concentrations of cholesterol by reducing the absorptions of cholesterol from the gut by competing for the limited space for cholesterol in mixed micelles. Chandrakar et al. (2008) also reported a significant reduction in cholesterol levels after *Aloe vera* supplementation. After administration of an active component barbaloin and polysaccharide with glycoprotein, verectin present in *Aloe vera,* there was significant reduction in serum triglycerides levels as reported by Yagi et al. (2009). Second treatment further reduced TC(189.4 mg% and 190.1 mg%),TG (155.4 mg% and 155.7 mg%), LDL-Cholesterol (118.5 mg% and 120.5 mg%), VLDL-Cholesterol (31.0 mg% and 31.1 mg %) and increased HDL-Cholesterol (39.8 mg% and 38.5 mg%) was observed in the subjects of group II and III (Table 7). A significant ($p \leq 0.01$) reduction in the ratio of total cholesterol to HDL-C (4.8 and 5.0) and LDL-C to HDL-C (3.0 and 3.1) of the subjects of group II and III respectively (Table 7). It was found that second treatment had improved lipid profile more effectively than first treatment. Sartorelli et al. (2004) also observed a significant reduction in lipid profile and total cholesterol after nutrition education.

First treatment significantly ($p \leq 0.01$) reduced systolic blood pressure (137.6 mm Hg to 131.6 mm Hg and 140.1 mm Hg to 129.8 mm Hg) and diastolic blood pressure (86.0 mm Hg to 83.1 mm Hg and 88.6 mm Hg to 83.6 mm Hg) of the subjects of group II and III respectively (Table 8). Reduction in blood pressure after *Aloe vera* supplementation could be due to active components such as aloe-emodin, aloin A, elgonica dimmer A and bisbenzopyran present in *Aloe vera*. A significant reduction in blood pressure after *Aloe vera* supplementation had been reported by Saleem et al. (2001). Second treatment further reduced the systolic blood pressure (126.8 mm Hg and 124.5 mm Hg) and diastolic blood pressure (80.4 mm Hg and 81.4 mm Hg) of the subjects of group II and III (Table 8) respectively. In second treatment ie nutrition intervention, reduction in systolic and diastolic blood pressure was more as compared to the first treatment. This reduction could be due to the nutrition counselling imparted to the subjects in group II and III where they were taught to have low intake of salt, pickles, papads, chutneys, highly refined foods and red meat.

## Conclusion

The investigation of present study revealed that second treatment was more effective in improving the blood

**Table 8** Mean blood pressure of the subjects before and after supplementation of *Aloe vera L.,* and nutrition intervention (supplementation of *Aloe vera L.* + nutrition counselling)

| Variables | Before | After | | CD | % Change | | t-value | | Normal range (mm Hg) |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | Between 1 and 2 | Between 1 and 3 | Between 1 and 2 | Between 1 and 3 | |
| Control | | 3 months | 6 months | | | | | | |
| Group I | | | | | | | | | |
| Systolic BP | 139.6±1.2 | 138.6±1.3 | 138.4±1.3 | NS | 0.7 | 0.9 | 1.1 $^{NS}$ | 1.7 $^{NS}$ | 120$^{\#}$ |
| Diastolic BP | 89.3±1.2 | 87.6±1.2 | 87.4±1.4 | NS | 1.9 | 2.1 | 2.0 $^{NS}$ | 1.7 $^{NS}$ | 80$^{\#}$ |
| Experimental | | SA | NI | | | | | | |
| Group II | | | | | | | | | |
| Systolic BP | 137.6±1.7 | 131.6±2.1 | 126.8±1.7 | 4.1 $^{\bullet\bullet}$ | 4.3 | 7.9 | 6.9$^{\bullet}$ | 16.6$^{\bullet}$ | 120$^{\#}$ |
| Diastolic BP | 86.0±1.2 | 83.1±1.4 | 80.4±1.1 | 1.6 $^{\bullet\bullet}$ | 3.4 | 6.5 | 8.2$^{\bullet}$ | 10.1$^{\bullet}$ | 80$^{\#}$ |
| Group III | | | | | | | | | |
| Systolic BP | 140.1±1.5 | 129.8±1.1 | 124.5±1.7 | 3.3 $^{\bullet\bullet}$ | 7.4 | 11.1 | 8.4$^{\bullet}$ | 17.7$^{\bullet}$ | 120$^{\#}$ |
| Diastolic BP | 88.6±1.3 | 83.6±1.5 | 81.4±1.2 | 3.0 $^{\bullet\bullet}$ | 5.6 | 8.1 | 8.2$^{\bullet}$ | 16.1$^{\bullet}$ | 80$^{\#}$ |

Values represent Mean±SE $^{\bullet}$ =Significant 1%, $^{\bullet\bullet}$ =Significant 5%, *NS* Non significant, *SA* Supplementation of *Aloe vera L.*, *NI* Supplementation of *Aloe vera L.* + Nutrition counselling, #=Raghuram et al. (2007)

parameters of the subjects as compared to the first treatment as nutrition counseling was imparted to them along with supplementation whereas in first treatment only supplementation was done. Nutrition intervention significantly ($p \leq 0.01$) reduced the fasting blood glucose level (11.4% and 15.4%) post prandial glucose level (18.5% and 27.8%), total cholesterol (8.6% and 10.1%), triglycerides (9.6% and 12.2%), low density lipoprotein cholesterol (LDL-C) (12.8% and 14.6%), very low density lipoprotein cholesterol (VLDL-C) (9.6% and 12.2%) and increased high density lipoprotein cholesterol (HDL-C) (7.3% and 9.4%) of the subjects of group II and III respectively. The ratio of total cholesterol to HDL-C reduced from 5.6 to 4.8 and 6.1 to 5.0 and LDL-C to HDL-C from 3.7 to 3.0 and 4.1 to 3.1 in the subjects of group II and III respectively. Nutrition intervention also significantly reduced the systolic blood pressure (7.9% and 11.1%), diastolic blood pressure (6.5% and 8.1%) of the subjects of group II and III respectively. Hence it can be inferred from the results that supplementation of *Aloe vera L.* gel powder along with nutrition counselling significantly reduced blood glucose levels and blood pressure along with an improvement in lipid profile in the non-insulin dependent diabetics.

## References


AHA (2004) Cholesterol ratio−American Heart Association. http://www.americanheart.org

Arora D, Goyal M, Agarwal RP (2009) Efficacy of Aloe vera juice consumption on glycemic response in type-2 diabetic patients. J Food Sci Technol 46(2):160–162

Chandrakar M, Palekar S, Chirade S, Hafiz S (2008) Hypocholesterolemic effect of *Aloe vera* (L.) extract on high cholesterol fed calotes versicolor daudin. Asian J Exp Sci 22(3):295–298

Fossati P, Principle L (1982) Qualitative determination of triglycerides in serum or plasma by enzymatic DHBC colorimetric method. Clin Chem 28:2077

Frieldwalds WT, Levy RI, Friedrickson DS (1972) Estimation of plasma or serum low density lipoprotein cholesterol concentration without use of preparaline ultracentrifuge. Clin Chem 18:499

Ghafoorunissa, Krishnaswamy K (2007) Diet and heart diseases. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad

Gulia A, Sharma HK, Sarkar BC, Upadhyay A, Shitandi A (2009) Changes in physico-chemical and functional properties during convective drying of aloe vera (*Aloe barbadensis*) leaves. Food Bioprod Process 30:1–4

Gupta R, Bajpai KG, John S, Saxena AM (2008) An: overview of Indian novel traditional medicinal plants with antidiabetic potentials. African J Trod Comp Alt Med 5(1):1–17

IDF (2010) Diabetes Atlas 4. http://www.worlddiabetesfoundation.org

Josias HH (2008) Composition and applications of Aloe vera leaf gel. Molecules 13(8):1599–1616

Lopes-Virella MF, Stone P, Ellis S, Cohwel JA (1977) Qualitative determination of HDL-Cholesterol in serum or plasma by phospotungstate method. Clin Chem 23:882

Maclead J (1984) Daviosons principles and practice of medicine. 14th ed ELBS/Churchill Living Stone.

Misawa E, Tanaka M, Nomaguchi M, Yamada M, Toida T, Takase M, Iwatsuki K, Kawada T (2008) Administration of phytosterols isolated from Aloe vera gel reduce visceral fat mass and improve hyperglycemia in Zucker dabetic fatty (ZDF) rats. J Obe Res Clin Prac 2:239–245

Raghuram TC, Pasricha S, Sharma RD (2007) Diet and diabetes. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad

Rajendran A, Narayanan V, Gnanavel I (2007) Study on the analysis of trace elements in Aloe vera and its biological importance. J App Sci Res 3(11):1476–1478

Rana SJ, Li YT, Manson EJ (2006) Adiposity compared with physical inactivity and risk of type 2 diabetes in women. Diab Care 33 (6):1047–1052

Richmond W (1973) Qualitative determination of cholesterol in serum or plama by enzymatic method. Clin Chem 19:1350

Saleem R, Faizi S, Shaheen SB, Ahmed M, Hussain SA, Qazi A, Dar A, Ahmad SI, Qazi MH, Akhtar S, Hasnain SN (2001) Hypotensive effect of chemical constituents from Aloe barbadensis. Planta Med 67(8):757–760

Sartorelli DS, Sciarra EC, Franco LJ, Cardoso MA (2004) Global prevalence of diabetes. Diabetes care 27:1047–1053

Sook M, Kim MJ, Son SM, Kim MJ (2001) The effect of nutrition education programme for various chronic diseases in elderly visiting public health centre". Korean J of community Nutr 6:668–677

Surjushe A, Vasani R, Saple DG (2008) Aloe vera: a short review. Indian J Dermatol 53(4):163–166

Tanaka M, Misawa E, Ito Y, Habara N, Nomaguchi K, Yamada M, Toida T, Hayasawa H, Takase M, Higuchi IR (2006) Identification of five phytosterols from Aloe vera gel as antidiabetic compounds. Biol Pharm Bull 29:1418–1422

Thorfeldt S (2005) Herbs in diabetes mellitus. Alt Med Rev 9:13–18

Trinder P (1969) Practical clinical biochemistry. Vol X, 5th edn. William Heinnemann Medical Books Limited, New York

Yagi A, Hegazy S, Kabbash A, Wahab E (2009) Possible hypoglycemic effect of *Aloe vera L.* high molecular weight fractions on type 2 diabetic patients. Saudi Pham J 17(3):209–215