MANAGEMENT OF NON-INSULIN DEPENDENT DIABETES MELLITUS BY INDIAN GUM ARABIC PODS POWDER

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Thesis

Doctor of Philosophy in Home Science

(Foods and Nutrition)

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This is to certify that **Mrs Priyanka Pareek** had successfully completed the oral preliminary examination held on __________ as required under the regulation for **Doctor of Philosophy Degree.**

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This is to certify that the thesis entitled **Management of Non-insulin Dependent Diabetes Mellitus by Indian Gum Arabic Pods Powder** submitted for the degree of **Doctor of Philosophy** in the subject of **Foods and Nutrition** embodies bonafide research work carried out by **Mrs Priyanka Pareek** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistant and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee in the pre thesis submission seminar held on 27th August, 2007.

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PH.D. THESIS, 2008

TOPIC: Management of Non-insulin Dependent Diabetes Mellitus by Indian Gum Arabic Pods Powder

ABSTRACT

Indian Gum Arabic (*Acacia nilotica*) is one of the indigenous tree which has many medicinal properties. The present study was conducted on the management of non insulin dependent diabetes mellitus by Indian Gum Arabic pods powder. The chemical composition of premature, seed developing and mature pods showed that carbohydrate (64.16 to 67.71%), ether extract (0.57 to 1.11%), crude fibre (10.41 to 12.53%) and energy (308 to 331 kcal/100g)increased ($P \leq 0.01$) with maturity and moisture (3 to 8%), ash (3.02 to 5.29%), iron (1.17 to 3.52 ppm), zinc (31.05 to 56.05ppm), copper (0.10 to 0.23 ppm), magnesium (11.7 to 18.2 ppm), manganese (0.05 to 0.20 ppm) chromium (0.40 to 1 ppm), total phenol (16.0 to 31.31 mg/g) and tannin (14.51 to 20.30 mg/g) decreased ($P \leq 0.01$) with maturity whereas, protein content (11.57 to12.63%) was almost same ($P \geq 0.05$) at all the stages of maturity on dry weight basis. Forty five NIDDM subjects (45-65 years) of either sex, not suffering from any disease and willing to participate were selected by organising a camp in Ayurvedic hospital premises, Udaipur. Most of the subjects were male (71.1%), literate (93.3%), Hindu (91.1%), married (97.7%), vegetarian (66.6%) and belonged to nuclear families (75.5%). Habit of smoking (31.1%), tabacco chewing (24.4%), alcohol consumption (22.2%) and gutka chewing (33.3%) was prevalent in the subjects. More than fifty per cent of the subjects were having family history of the disease. For intervention subjects were randomly divided in groups I, II and III who were given 2, 3 and 4 g of Acacia nilotica premature pods powder for 28 days. The adequacy of diet, body measurements, composition, blood glucose, lipid profile and blood pressure were measured before and after intervention. Dietary survey (24 hours recall) revealed that the food and nutrient intake before and after intervention was almost same in all the groups. Fats and oils consumption was more than adequate whereas, the intake of other food groups was 40 to 83 per cent of balanced diet. Intake of nutrients such as fat, β carotene, thiamine, vitamin C was adequate or more than adequate and those of energy, protein, iron, calcium, riboflavin, niacin and folic acid was less than adequate (53 to 88% of RDA). Nutritional status of the subjects revealed that 31.1 per cent of the subjects were overweight (23-24.9 kg/m^2) followed by 26.6 per cent obese (>25 kg/m^2). Nutritional profile of the subjects of three groups was same before and after intervention ($P \geq 0.05$). The intervention did not make any significant change on the nutritional profile of the subjects. The fasting and post prandial blood glucose reduced in all the three groups after intervention but the significant decrease was found in the third group of the subjects who were taking 4 g of pods powder daily for 4 weeks. Similarly the lipid profile (cholesterol, triglyceride and VLDL) and systolic and diastolic blood pressure also decreased significantly and HDL increased ($P \leq 0.01$)) in the third group of subjects. In addition the systolic blood pressure also decreased significantly in other two groups who were taking 2 and 3 g of pods powder daily. No adverse effect of pods powder was reported during the intervention period. It is concluded that premature pods powder intervention reduced the blood glucose, lipid profile and blood pressure of NIDDM subjects and it may be beneficial in coronary artery diseases.

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INTRODUCTION

Globally non communicable diseases are increasingly recognized as a major cause of morbidity and mortality .The WHO report 2004 had indicated that non communicable diseases account for almost 60 per cent of deaths and 47 per cent of global burden of diseases. Non communicable diseases (NCDs) have become a major problem not just in developed countries but also in developing countries. Seventy five per cent of the deaths attributed to the NCDs occur in developing countries (Ghaffar et al, 2004). Diabetes, cardiovascular diseases and cancer are the main chronic diseases. Diabetes mellitus is a chronic metabolic disorder it prevents the body to utilize glucose completely or partially. It is characterized by raised glucose concentration in blood and alterations in carbohydrate, protein and fat metabolism (Shrilakshmi, 2002). A person is said to have diabetes when his/her sugar level in the blood and urine is increased from normal level.

Diabetes mellitus, long considered a disease of minor significance to world health, is now emerging as one of the main threats to human health in the 21st century. The prevalence of diabetes ranges from nearly 0 per cent in New Guinea to 50 per cent in Pima Indians. Several epidemiological studies confirm that diabetes is one of the most common non communicable diseases globally and it is the forth or fifth leading cause of death in most developed countries. The past two decades have seen an explosive increase in the number of people diagnosed with diabetes world wide (Disdier-Flores et al, 2001). The WHO estimated that there were 171 million diabetics in 2000 and this number would increase to 366 million by the year 2030 (Wild et al, 2004). Some 246 million people worldwide have diabetes in 2007. The problem has reached pandemic proportions. Type 2 diabetes is the commonest form of diabetes constituting almost 90 per cent of diabetic population. It is estimated that 7.3 per cent of adults aged 20-79 in all International diabetes Federation member countries have diabetes. The Western Pacific region and the European region have the highest number of people with diabetes, approximately 67 to 53 million respectively. The highest rate of diabetes prevalence is to be found in the North American region (9.2 %) followed by the European region 8.4 per cent (Diabetes Atlas, 2005)

WHO has declared India as the gobal capital of diabetes the predicted number of diabetics in India to be nearly 80 million by 2030 (Wild et al, 2004). Complications from diabetes such as coronary artery and peripheral vascular disease, stroke, diabetic neuropathy, amputations, renal failure and blindness are resulting in increasing disability, reduced life expectancy and enormous health cost for virtually every society. Diabetes is the single, most important metabolic disease recognized worldwide as one of the leading casuses of death and disability (Zimmet, 1999). It is the fourth leading cause of death in most developed countries (Diabetes Atlas 3ed. 2005). Diabetes is certain to be one of the most challenging health problems in the 21st century. The number of people with diabetes is increasing due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity. This alarming increase in the prevalence of diabetes mellitus calls for the efficient and viable preventive and management strategies that are not only cost effective but also amiable and cordial.

In the modern world, allopathic medicines, are given importance because, of their immediate cure, or curing the disease in short period and got quick and fast spread all over the world, besides it is known, to mask the effect of indigenous medicinal plants. However, people have realized that allopathic medicines are having narcotic and also expensive to which poor people are not affordable. In addition, the allopathic medicines are not curing all the human diseases, there are diseases like jaundice, cancer, paralysis, diabetes, skin diseases etc. are not curable by the allopathic medicines. Therefore, the perception of medicare turn around towards the naturally grown traditional medicinal plants.

Although the modern allopathic drugs are greatly accepted in the treatment of diabetes, they may cause certain side effects. The sulfonylurea may cause allergic reactions, producing a variety of skin rashes. They may also cause gastro- intestinal symptoms such as loss of appetite, nausea, vomitting, indigestion and diarrhoea or constipation. Potentially more serious but rare side affects are liver damage, occassionaly causing jaundice and abnormilities of the blood cells. The biguanides may cause loss of appetite, nausea and diarrhoea. The most serious side effect of biguanides is lactic acidosis (Hillson, 1998). Since patient on oral hypoglycemic drugs may have to take them for prolonged periods of time, there is need to search for safe alternatives in the form of natural products for regulating blood glucose. In recent years, attempts have been initiated to conduct scientific researches on role of indigenious drugs in controlling diabetes.

Plants have played a significant role in maintaining human health and improving the quality of human life for thousand of year and have served human. The WHO estimate that more than 80 per cent of the earth's inhabitants mostly in developing countries, rely on traditional medicines for their primary health care and most of this therapy involves plant extraction their active compounds. The demand for medicinal plants got increased in both developed and developing countries due to growing recognition of natural products being non- narcotic with no side effects and cost effective (Reddy, 2008). Throughout the world, almost, a quarter of all medical prescriptions, are either for chemical compounds from plants or microorganisms or of synthetic versions.

India has one of the oldest, richest and most diverse cultural traditions called `folk tradition' associated with the use of medicinal herbs. Traditional folk medicine is the application of indigenous beliefs, knowledge, skills and cultural practices concerned with human health. In India, of the 17,000 species of plants, 7500 are known for medicinal uses. In India, traditional doctors, use more than 2500 plants for medicinal purpose. This proportion of medicinal plants is the highest proportion of plants known for their medical purposes in any country of the world for the existing flora of that respective country (Shiva, 1996). There are lots of evidence to show the use of medicinal plants to cure human diseases from very long period ago. The Rigveda (5000 BC) mentioned 67 medicinal plants, Yajurveda 81 and Athervaveda (4500-2500 year BC) 290 plants. Charak Samhita (700BC) has described medicinal properties and use of more than 1100 plants. Ayurveda, the oldest medical system in Indian sub-continent, has alone reported approximately 2000 medicinal plant species, followed by Siddha and Unani .

The Charak Samhita, an age-old written document on herbal therapy, reports on the production of 340 herbal drugs and their indigenous uses. Currently, approximately 25 per cent of drugs are derived from plants, and many others are synthetic analogues built on prototype compounds isolated from plant species in modern pharmacopoeia.

In India, Egypt and Sudan around 70 percent of the rural people use traditional medicine. Similar situation exists in a large number of developing countries. In India and China 60 per cent of the people affected with cholera and malaria are treated with herbal medicines. In these countries the market for traditional medicines is US $ 500 million while Western type medicine accounts for only 300 million US $. In Singapore 50 percent and in Australia 60 percent of population uses alternative medicine. Around 17,000 herbal products are registered in these countries. In Belgium 40 percent contemporary but 84 per cent home medicines and 74 percent acupuncture medicine is utilized. In France 50 percent of the people take advantage of complementary medicine. In Germany 10,000 to 13, 000 alternative medical practitioners are thriving well and 75 per cent of them utilize complementary medicines. In UK 90 per cent of the complementary medical practitioners utilize osteopathy and acupuncture. In US, where in 1990 only 30 per cent of the people were utilizing complementary medicines, it grew to 40 percent in 1997 (Kumar,2003).

The World Health Organization (WHO) has estimated the present demand for medicinal plants is approximately US $14 billion per year. The demand for medicinal plant-based raw materials is growing at the rate of 15 to 25 per cent annually, and according to an estimate of WHO, the demand for medicinal plants is likely to increase more than US $5 trillion in 2050. In India, the medicinal plant-related trade is estimated to be approximately US $1 billion per year. According to an estimate, the quantity of export of Ayurvedic products produced in India has tripled between two financial years (2001–2002 and 2002–2003).

Medicinal plants used to treat hypoglycemic or hyperglycemic conditions are of considerable interest for ethno-botanical community as they are recognized to contain valuable medicinal properties in different parts of the plant and a number of plants have shown varying degree of hypoglycemic and anti-hyperglycemic activity. The active principles of many plant species are isolated for direct use as drugs, lead compounds or pharmacological agents. Several species of medicinal plants are used in the treatment of diabetes mellitus, a disease affecting large number of people world-wide. Traditional plant medicines or herbal formulations might offer a natural key to unlock diabetic complications. According to “Indian Material Medica” *vijaysar, baelpatra, jamun, aloevera, fenugreek, bittergourd, neem, arjuna* and Indian gum arabic (*Babul*) are the indegenious plants which have hypoglycemic effect.

Indian Gum Arabic scientifically known as *Acacia nilotica* is naturally widespread in the drier areas of Africa, from Senegal to Egypt and down to South Africa, and in Asia from Arabia eastwards to India, Burma and Sri Lanka. It is also cultivated elsewhere, including Australia, Cape Verde islands, Indonesia, Iran, Iraq, Nepal, Vietnam, and West Indies (Christopher, 1992). The total land area of Rajasthan is 3, 42,239 sq km out of which 45.25 percent is characterized as wasteland. Out of the total weeds around 50 having important medicinal values while others produce related compounds. (Kotia and Kumar, 2001). Gum Arabic is widely distributed tree in Rajasthan. It covers 19.7 per cent of the forest area (http://envfor.nic.in/fsi/sfr99/chap3/rajasthan/rajasthan.html). Bhandari (1974) has reported that the seeds of *Acacia nilotica* are eaten roasted or raw, in times of very acute scarcity of food in Rajasthan. Pods are also used as a vegetable curry. Several parts of this plant like gum, bark, pods, seeds, flowers and leaves are used for different medicinal purpose as anti helmintic, anti bacterial, anti fungal, anti septic, anti spasmodic, anti inflammatory, anti platelet aggregatory, astringent, hemostatic, stimulant, antioxidant and hypoglycemic substance. Few scientific studies for hypoglycemic effect of Gum Arabic has been reported on animals i.e. rats and rabbits. However, none of the study in the literature reviewed through net as well as available journals have been reported its hypoglycemic effect on human beings. Therefore the proposed study had been planned with following objectives:

1. To analyze the chemical constituents of Indian Gum Arabic pods at different stages of maturity.
2. To assess the diet and nutritional profile of diabetic subjects.
3. To find out the effect of feeding of Gum Arabic in the regulation of blood glucose and lipid profile among diabetic subjects.

REVIEW OF LITERATURE

A comprehensive knowledge of the related literature not only helps the investigator to define the frontiers of the field but also helps in avoiding the unintentional replication of the previous work done. Therefore, extensive review of literature is must in any research endeavor to define the goals and interpretation of the significance of results. In this chapter, relevant literature having direct or indirect bearing on the present research on “Management of non insulin dependent diabetes mellitus by Indian Gum Arabic pods powder” has been reviewed and organized under the following heads:

2.1 Magnitude of diabetes

Global scenario

Indian scenario

2.2 Importance of medicinal plants

2.3 Role of medicinal plants in the management of diabetes

2.4 Taxonomy and chemical composition of Indian Gum Arabic

2.5. Traditional practices of Indian Gum Arabic to control the diseases

2.6 Medicinal use of Indian Gum Arabic

2.1 Magnitude of the diabetes:

Global scenario:

Diabetes is a serious condition for the individual and on the global scale; its rapidly increasing prevalence is a significant cause of concern. At worldwide 177 million people have diabetes (2001) and in coming decades the number of people with diabetes is expected to increase alarmingly and quickly among comparatively young and productive populations in the developing world (IDF, 2003). The major part of this numerical increase will occur in developed countries. There will be a 42 per cent increase from 51 to 72 million in developed countries and a 17 per cent increase from 84 to 228 million in the developing countries (King et al, 1998). The expected prevalence of diabetes by the year 2025 will be more than double in Africa, the Eastern Mediteranean, and Middle–East and South East Asia and rise by 20 per cent in Europe, 50 per cent in North America, 85 per cent in South and Central America and 75 per cent in Western Pacific region. For developing countries, there will be projected increase of a 170 per cent, for developed countries it will be 42 per cent (IDF, 2003).

Wild et al (2004) estimated the prevalence of diabetes and the number of people of all ages with diabetes for years 2000-2030. Data on diabetes prevalence by age and sex from a limited number of countries were extrapolated to all 191 WHO number states and applied to United Nations' population estimates for 2000 and 2030. Urban and rural populations were considered separately for developing countries. The prevalence of diabetes for all age- groups worldwide was estimated to be 2.8 per cent in 2000 and 4.4 per cent in 2030. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030. The prevalence is higher in men than women, but there are more women with diabetes than men. The urban population in developing countries is projected to double between 2000 and 2030. The most important demographic change to diabetes prevalence across the world appears to be the increase in the proportion of people >65 years of age.

Potential increase of the prevalence has been reported in Asia and Europe region and it may spurt 2-3 times more than the present situation in these countries (Table 1). It is estimated that the Asians will harbour 66 per cent of the total global projected number of diabetes by 2010 and available evidence points to the special vulnerability of Indians (Anonymous, 1997; Joshi, 1998). Whereas, in 2003, IDF has reported the highest prevalence rate in North American region (7.9%) and European region (7.8%). The highest number of diabetics was found European (48 million) and Western Pacific region (43 million).

Table 1: Continental distribution of diabetes mellitus

Country	**Prevalence (million)**
Africa	1
Asia	66
Europe	22
Latin America	13
North America	13
Ocenia	1

The percentage prevalence of diabetes among 20-79 years population in countries of the continents reveals a highest range of 3.8 per cent (Iran) to 14.8 per cent (Bahrin) in United Arab Emirat (Table 2).

Table 2: Prevalence of diabetes among 20-79 years age population

Country	Prevalence(million)	Percentage
United Arab Emirat		
Bahrin	56.3	14.8
Egypt	3384.1	9.3
Iran	1323.9	3.8
Iraq	499.9	4.1
Jordon	194.2	6.2
Kuwait	75.6	7.0
Africa region		
Cameron	61.1	0.9
Central Africa	-	-
Republic	-	-
Chad	-	-
Congo democratic	252.6	1.2
Republic of African region	8.6	0.7
Congo Republic of Africa region	42.7	0.7
Cole d' Voire		
Europe		
Albania	94.3	5.0
Australia	232.3	(5*)
Belgium	307.4	4.0
Bulgaria	254.3	4.1
Croatia	174.1	5.3
South East Asia		
Bangladesh	1759.7	2.1
India	32674.4	5.8
Mauritius	112.6	15.0
Nepal	0.0	0.0
Srilanka	333.4	2.9
North America		
Argentina	760.9	3.3
Bolivia	165.3	4.0
Brazil	3310.4	3.2
Chile	131.1	1.4
Columbia	946.9	9.0
Costarica	77.3	3.4
Western Pacific Region		
Combordia	781.3	5.9
China Hong kong	-	-
China Macan	614.4	12.1
China people's republic of western pacific region	34.5	10.7
Fizi	22,564.8	2.7
	42.3	9.1

Source E- Atlas IDF (2002)

The prevalence is lowest in Africa 0.9 per cent (Cameron) to 1.2 per cent (Congo republic of African region). The data suggest a difference in the rate of prevalence amongst the countries of a continent. Most affected countries world wide are Nauru. The United Arab Emirat, Qatar, Baharin and Kuwait (Table 3). The largest number of diabetics are residing in India and China (Table 4).

Table 3: Highest prevalence rate of diabetes

Name of the country	Prevalence rate (%)
Nauru	30.2
United Arab Emirat	20.1
Qatar	16.0
Baharin	14.9
Kuwait	12.8

IDF (2003)

Table 4: Worldwide largest number of adult diabetics

Name of country	Prevalence (million)
India	35.5
China	23.8
United States	16.0
Russia	9.7
Japan	6.7

IDF (2003)

Indian scenario:

India is the home for around 40 million diabetics and this number has brought India to the dubious distinction of being home to the largest number of diabetics in any one country. In keeping with the scenario of most developing countries, India has long passed the stage of diabetes epidemic. Now the problem has reached in a “Pandemic proportion”, in scientific language which means it has crossed the living line in which it is a problem associated with individual; no matter how large, a very large public health problem growing astronomically year after year, more than a matter of individual health and wellbeing (http:\\ www.diabetesindia. com).

As per Indian task force report, the crude prevalence rate in urban areas is about 9 per cent and it has increased in rural areas to around 3 per cent of the total population. The ratio of urban / rural population distribution is 70: 30 and the overall crude prevalence rate will be 4 per cent at a conservative estimate. The prevalence of impaired glucose tolerance (IGT) was also reported as high, which is around 8.7 per cent in urban and 7.9 per cent in rural areas (http:\\ www.diabetesindia.com). In the same line of action, Ramachandran et al (2001) reported the prevalence of diabetes and impaired glucose tolerance as 12.1 per cent and 14.0 per cent respectively with no gender differences. They reported increasing trend with age. Subjects under 40 years of age had a higher prevalence of IGT than diabetes (12.8 vs 4.6%; $p<0.0001$).

In a study conducted by ICMR (2001) on epidemiology of diabetes, distinct difference between the prevalence of diabetes in the urban and rural settings was observed

(Table 5). The tabulated difference concludes that urbanization relates to less energy expenditure, change in food habits and excess of saturated fat, which leads to overweight and higher prevalence rate of diabetes.

Table 5: Details of diabetics in urban and rural areas

Details	Urban	Rural
Prevalence (%)	2.1	1.5
Overweight (%) +15% Ideal weight	10.2-17.5	4.7-15.4
Sedentary occupation (%)	55	35
Energy expenditure per day (calories per kg body wt.)	34	41

ICMR (2001)

India leads the world today with the largest number of diabetics in any given country. In the 1970s, the prevalence of diabetics among urban Indians was reported to be 2.1 per cent and this has now risen to 12.1 per cent. Moreover, there is an equally large pool of individuals with impaired glucose tolerance, many of whom will develop type 2 diabetes mellitus in the future (Pradeepa and Mohan, 2002).

2.2 Importance of medicinal plants:

Medicinal plants are the local heritage with global importance. World is endowed with a rich wealth of medicinal plants. Herbs have always been the principal form of medicine in India and presently they are becoming popular throughout the developed world as people strive to stay healthy in the face of chronic stress and pollution, and to treat illness with medicines that work in concert with the body's own defenses. People in Europe, North America and Australia are consulting trained herbal professionals and are using the plant medicines. Medicinal plants also play an important role in the lives of rural people, particularly in remote parts of developing countries having few health facilities (Banerjee, 1995).

The variety and sheer number of plants with therapeutic properties is quite astonishing. It is estimated that around 70,000 plant species, from lichens to towering trees, have been used at one time or another for medicinal purposes. The herbs provide the starting material for the isolation or synthesis of conventional drugs. In Ayurveda about 2000 plant species are considered to have medicinal value while the Chinese Pharmacopia list over 5700 traditional medicines, most of which are of plant origin. About 500 herbs are still employed within conventional medicine, although whole plants are rarely used (Guha, 1977). Medicinal and aromatic plants are found in forest areas throughout South Asia, from the plains to the high Himalayas with the greatest concentration in the tropical and subtropical belts and arid region of *Thar* desert. India recognizes more than 2500 plant species as having medicinal value (Banerjee, 1995). The distribution of medicinal plant in world and in India had been reviewed by Kala et al (2006) which is presented in Table 6.

Table 6: Distribution of medicinal plants

Country or region	Total number of native species in flora	No of medicinal plant species reported	% of medicinal plants
World	297000	52885	10
India	17000	7500	44
Indian Himalayas	8000	1748	22

Kala et al (2006)

Human beings have been utilizing plants for basic preventive and curative health care since time immemorial. The estimates suggest that over 9,000 plants have known medicinal applications in various cultures and countries, and this is without having conducted comprehensive research amongst several indigenous and other communities. Medicinal plants are used at the household level by women taking care of their families and at the village level by medicine men or tribal shamans, and by the practitioners of classical traditional systems of medicine such as Ayurveda, Chinese medicine, or the Japanese Kampo system. The World Health Organization reported that 80 per cent of the world's population, or 4.3 billion people, rely upon such traditional plant-based systems of medicine to provide them with primary health care (Cunningham 1998).

Allopathic medicine too owes a tremendous debt to medicinal plants: one in four prescriptions filled in a country like the United States is either a synthesized form or derived form from plant materials. The global market for medicinal plants has always been very large. According to the International Trade Centre, as far back as 1967, the total value of imports of starting materials of plant origin for the pharmaceutical and cosmetics industry was of the order of USD 52.9 million. From this amount, the total values grew to USD 71.2 million in 1971, and then showed a steady annual growth rate of approximately 5-7 per cent through to the mid-1980. Interest in natural materials by the dominant economic powers had waned from the late 1960s to the early 1980s as new possibilities in biotechnology and the synthesization of drugs beckoned. But by the mid-1980s, there was a renewed interest in natural materials and approaches to health care, coupled with recognition that technology alone could not solve the pressing health care needs of the world's population (Tempesta and King, 1994).

The participation of various companies in the market also attests the strength of natural medicines and its importance. By 1990, some 223 major companies worldwide (of which about half were in the United States) were reportedly screening plants for new leads; the figure had been zero in 1980. Also in 1990, more than 2000 companies in Europe alone were marketing herbal medicines, with 30% having a turnover in excess of $20 million. Expenditure in the United States on "unconventional, alternative, or unorthodox" therapies reached $13.7 billion dollars during the same year (Kumar, 2003).

The use of alternative medicines has become increasingly popular in the developed world. For example, 1 in 3 Americans have at some time used unconventional medical therapies according to a national telephone survey published in the New England Journal of Medicine in 1993. In another survey conducted in 1994, it was found that 60 per cent of doctors had at some time referred patients to practitioners of alternative medicine. In response to the overwhelming interest in alternative therapies many of the prestigious allopathic medical institutions have also recognized their importance: an example is the National Institute of Health which created the Office of Alternative Medicine in 1991 to provide the public with information on alternative treatments and to assess those therapies which have proven successful (Holley and Cherla, 2002).

Medicinal plants are used to cure/manage several communicable and non communicable diseases i.e. diabetes, heart problems and liver problems etc. Diabetes mellitus is a metabolic disorder characterized by the decreased ability or complete inability of the tissues to utilize carbohydrates, accompanied by changes in the metabolism of fat, protein, water and electrolytes (Khanna et al, 1997). Several studies suggest that diabetes is primarily a life style disorder, the highest prevalence rates occur in developing countries and in populations undergoing “westernization” or “modernization” under such circumstances, genetic susceptibility seems to interact with environmental changes such as sedentary life and over nutrition, leading to type two diabetes (West 1978; Odea 1992; ADA, 2002).

2.3 Management of diabetes:

Role of medicinal plants in the management of diabetes:

Plants contain nutrients and secondary metabolites which play an important role in the management of non communicable diseases including diabetes. Lewis (1992) has reported the use of *Stevia rebaudiana* (Asteraceae) leaves as a sweetener as well as for the treatment of diabetes mellitus. Ivorra et al (1989) has extensively reviewed active natural principles (polysaccharides, protein, flavonoids and related compounds, steroids, terpenoids and alkaloids) and crude extracts of 45 plant species which have been experimentally studied in last 10 years. Table 7 illustrates in detail about various plants known for their antidiabetic action and compiles possible mode of action of these plants. Medicinal plants used in indigenous medicines in crude forms for the management of diabetes mellitus, contain both, the organic and inorganic constituents. It is known that certain inorganic mineral elements (potassium, zinc, calcium, traces of chromium, etc.) play an important role in the maintenance of normal glucose tolerance and in the release of insulin from beta cells of islets of langerhans. *Cucuma longa*, *Acacia arabica* (babul), *Vinca rosea* (shada-phul), *Cordia myxa* (naruvali), *Musa paradisiaca* (plantain) and *phyllanthus emblica* used in Islamic systems of medicine have been reported to have large amounts (1.0 to 6.5 ppm) of chromium as compared to carbohydrates.

Kumari et al (2002) studied the hypoglycemic effect of finger millet consumption on six NIDDM subjects. All the experimental diets were planned to be isocaloric and also to contain 75 g equivalent of carbohydrate load so that glycemic response could be compared with a 75 g glucose load. The glycemic response to breakfast items compared to that of glucose was determined by comparing the areas under the 2 hr glucose response curve. Consumption of finger millet based diets resulted in significantly lower plasma glucose levels, mean peak rise, and area under curve which might have been due to the higher fiber content of finger millet compared to rice and wheat. The lower glycemic response of whole finger millet based diets may also have been due to the presence of anti nutritional factors in whole finger millet flour which are known to reduce starch digestibility and absorption.

Plants have curative properties due to the presence of various complex chemical substances of different composition which are found as **secondary metabolites** in one or more parts of these plants. Subbulakshmi (1998) reported that active principles of plants are often definite substances. The first class of these substances with medicinal properties is vegetable bases which include amines and alkaloids. A considerable number of medicinal drugs owe their curative properties to these bitter alkaloids. Another class of these active principles includes glycosides, essential or volatile oils, resins and antibiotic each having their own functional significance.

Secondary metabolites are organic compounds that are not directly involved in the normal growth, development or reproduction of organisms. Unlike primary metabolites, absence of secondary metabolities results not in immediate death, but in long-term impairment of the organism's survivability or aesthetics, or perhaps in no significant change at all. The function or importance of these compounds to the organism is usually of an ecological nature as they are used as defenses against predators, parasites and diseases, for interspecies competition, and to facilitate the reproductive processes (coloring agents, attractive smells, etc). Contrary to primary metabolites these compounds are not ubiquitous in the living organisms that neither produce them nor are they necessarily expressed continuously. Although plants are better known as a source of secondary metabolites; bacteria, fungi and many marine organisms (sponges, tunicates, corals, snails) are very interesting sources, too. Secondary metabolites can be classified by their chemical structure or physical properties into one or more of the following groups: alkaloids, terpenoids, polyketides, aliphatic, aromatic, and heteroaromatic organic acids, phenols, steroids, saponins, peptides, ethereal oils, resins and balsams (http://en.wikipedia.org/wiki/Secondary_ metabolite)

Plants have many natural enemies; these include viruses, fungi, worms, insects, bacteria and many herbivorous animals. Due to their sessile lifestyle plants are unable to avoid these predators upon them and have therefore had to evolve mechanisms to protect themselves. In addition to having barriers to bacterial and fungal invasion such as a waxy outer layer known as the cuticle, and a secondary protective tissue known as the periderm, plants are able to create compounds known as secondary metabolites to protect themselves against herbivores. Some of these secondary compounds also have roles in addition to defence such as pigmentation or support. There are three main classes of secondary metabolites, these are phenolics, nitrogen based compounds, and terpenes. The study of these compounds was mainly pioneered by chemists around the turn of the 19th Century as they investigated the use of plant chemicals in flavourings, medicinal drugs and poisons. By far the largest groups of secondary metabolites that play a role in plant defence are the terpenes (Zotor and Amuna, 1998).

Phenols, sometimes called phenolics, are a class of chemical compounds consisting of a hydroxyl functional group (-OH) attached to an aromatic hydrocarbon group. The simplest of the class is phenol (C_6H_5OH). Although similar to alcohols, phenols have unique properties including relatively higher acidities due to the aromatic ring tightly coupling with the oxygen and a relatively loose bond between the oxygen and hydrogen. The acidity of the hydroxyl group in phenols is commonly intermediate between aliphatic alcohols and carboxylic acids. Loss of positive hydrogen from the hydroxyl group of a phenol forms a negative phenolate ion. There are several phenolic compounds such as caffeine, ellagic acid, epicatechin, flavinoids, quercetin, gallic acid, tannin etc. (http://www.wikipedia.org).

A polyphenol extract from a Corbières (France) red wine (P, 200 mg/kg), ethanol (E, 1 ml/kg), or a combination of both (PE) was administered by for 6 weeks to healthy control or streptozotocin (60 mg/kg)-induced diabetic rats (180-200g). Treatment groups included C or D (untreated control or diabetic) and CP, CE, or CPE (treated control) or DP, DE, or DPE (treated diabetic). P treatment induced a reduction in body growth, food intake, and glycemia in both CP and DP groups. In DP, hyperglycemia was reduced when measured 1 h after daily treatment but not at sacrifice (no treatment on that day). The hyperglycemic response to the oral glucose tolerance test (OGTT) and plasma insulin at sacrifice were impaired similarly in DP and D groups. In contrast, in DE or DPE, body growth was partially restored while hyperglycemia was reduced both during treatment and at sacrifice. In addition, hyperglycemia response to OGTT was reduced and plasma insulin was higher in DE or DPE than in D animals, indicating a long-term correction of diabetes in ethanol-treated animals. Morphometric studies showed that ethanol partially reversed the enlarging effect of diabetes on the mesenteric arterial system while the polyphenolic treatment enhanced it in the absence of ethanol. In summary, the study shows that (i) a polyphenol extract from red wine (used at a pharmacological dose) reduces glycemia and decreases food intake and body growth in diabetic and nondiabetic animals and (ii) ethanol (nutritional dose) administered alone or in combination with polyphenols is able to correct the diabetic state. Some of the effects of polyphenols were masked by the effects of ethanol, notably in diabetic animals. Further studies will determine the effect of nutritional doses of polyphenols as well as their mechanism of action (Najim et al, 2004).

Grassi et al (2005) reported that the consumption of dark chocolate improves glucose metabolism and decreases blood pressure. They studied 15 healthy young adults with typical Italian diets that were supplemented daily with 100 g dark chocolate or 90 g white chocolate, each of which provided 480 kcal. The polyphenols content of the dark and white chocolate were assumed to be 500 and 0 mg, respectively. The subjects were divided into 2 groups, each of which ingested one of the types of chocolate for 15 days, ingested no chocolate for a subsequent 7 days, and then ingested the other chocolate for an additional 15 days. The authors found that the dark chocolate supplement was associated with improved insulin resistance and sensitivity and decreased systolic blood pressure, whereas white chocolate had no effect. No data were shown on the changes in blood pressure during each study, although such data might have been useful to differentiate the potential short- and long-term effects of dark chocolate consumption. Also, it would have been useful to show insulin sensitivity and blood pressure values for each individual to assess a potential association between these two events.

Barabara (2003) studied the hypoglycemic effect of cinnamon on 60 people with type 2 diabetes, 30 men and 30 women aged 52.2 ± 6.32 years, were divided randomly into six groups. Groups 1, 2, and 3 consumed 1, 3, or 6 g of cinnamon daily, respectively, and groups 4, 5, and 6 were given placebo capsules corresponding to the number of capsules consumed for the three levels of cinnamon. The cinnamon was consumed for 40 days followed by a 20-day washout period. After 40 days, all three levels of cinnamon reduced the mean fasting serum glucose (18-29%), triglyceride (23-30%), LDL cholesterol (7-27%), and total cholesterol (12-26%) levels; no significant changes were noted in the placebo groups. Changes in HDL cholesterol were not significant. The results of the study demonstrate that intake of 1, 3, or 6 g of cinnamon per day reduces serum glucose, triglyceride, LDL cholesterol, and total cholesterol in people with type 2 diabetes and suggest that the inclusion of cinnamon in the diet of people with type 2 diabetes will reduce risk factors associated with diabetes and cardiovascular diseases.

Anderson et al (2004) isolated and characterize insulin-enhancing complexes from cinnamon that may be involved in the alleviation or possible prevention and control of glucose intolerance and diabetes. Water-soluble polyphenols polymers from cinnamon that increase insulin-dependent in vitro glucose metabolism roughly 20-fold and display antioxidant activity were isolated and characterized by nuclear magnetic resonance and mass spectroscopy. The polymers were composed of monomeric units with a molecular mass of 288. Two trimers with a molecular mass of 864 and a tetramer with a mass of 1152 were isolated. Their protonated molecular masses indicated that they are a type of doubly linked procyanidin oligomers of the catechins and/or epicatechins. These polyphenolic polymers found in cinnamon may function as antioxidants, potentiate insulin action, and may be beneficial in the control of glucose intolerance and diabetes.

Mantena et al (2005) studied the hypoglycemic effect of aqueous extract of *Coronopus didymus* on streptozotoxin induced diabetic mice. Blood sample were drawn after 2, 4, 6 hour of treatment for the determination of blood glucose levels. The extract showed significant hypoglycemic effect in the diabetic mices in a dose dependent manner. This may be due to the presence of various constituents like saponins, flavinoids and tannins. They potentiate plasma insulin effect by the pancreatic secretion of insulin from beta cells and may increase the peripheral uptake of glucose. The extract also exhibited significant free radical scavenging activity by its ability to react with DPPH and superoxide redicals. Free redicals are generated under various pathological conditions including hyperglycemia and hence diabetes is generally associated with increased oxidative stress.

Pinent et al (2004) reported that flavonoids are functional constituents of many fruits and vegetables. Some flavonoids have antidiabetic properties because they improve altered glucose and oxidative metabolisms of diabetic states. Procyanidins are flavonoids with an oligomeric structure, and it has been shown that they can improve the pathological oxidative state of a diabetic situation. To evaluate their effects on glucose metabolism, they administered an extract of grape seed procyanidins (PE) orally to streptozotocin-induced diabetic rats. This had an antihyperglycemic effect, which was significantly increased if PE administration was accompanied by a low insulin dose. In summary, procyanidins have insulin-like effects in insulin-sensitive cells that could help to explain their antihyperglycemic effect in vivo.

Gallic acid is also known as 3, 4, 5-trihydroxybenzoic acid. It has antifungal, antiviral and antioxidant property. It is used to treat diabetes (http://www.phytochemicals.info/phytochemicals/gallic acid.php).

A study was undertaken to evaluate anti mutagenic and cytotoxic effects of different extracts/fractions of *Acacia nilotica* prepared by maceration method. The potency order of different extracts was more or less similar in Ames assay as well as in cytotoxic assay. Considering the maximum potential of acetone extract in both the assays, the studies were initiated to fractionate this extract. Two pure fractions, namely AN-1 and AN-2, were obtained from acetone extract, of which AN-2 was found to be of gallic acid and AN-1 fraction is still to be identified. In conclusion, the anti mutagenic and cytotoxic activities exhibited by acetone extract may partially be ascribed to the presence of gallic acid and other polyphenols (Kaur et al, 2005).

Huang et al (2005) investigated the anti diabetic action of Punica granatum flower (PGF) extract by the activation of Peroxisame Proliferator-Activated Receptor (PPAR)-γ which is widely used in the treatment of type 2 diabetes because they improve the sensitivity of insulin receptors. They orally administered the methanol extract of PGF (500 mg/kg) daily to zucker diabetic fatty rats (ZDF) for 6 weeks. The results of the study suggest that the anti diabetic activity of PGF extract may result from improved sensitivity of the insulin receptor and the phenol, gallic acid is responsible for this activity. Similarly, Konishi et al (2006) invented a carbohydrate absorption inhibitor from evening primrose seeds (containing polyphenols preferably one or more selected among gallic acid, ellagic acid, catechin, pentagalloylglucose, procyanidin) which was significantly effective to cure diabetes mellitus and obesity.

The potential health benefits of cocoa have been gaining increasing interest with studies reporting that flavonoid-rich chocolate may reduce the risk of cardiovascular disease. The study used three-week old female mice and randomly assigned them to eat the AIN-93 diet supplemented with 0, 0.5, or 1.0 per cent for cacao liquor proanthocyanidins (72 per cent total polyphenol) for three weeks. The study reported that the proanthocyanidins reduced blood glucose levels in a dose-dependent manner. Indeed, blood glucose levels after four and five weeks of age and of fructosamine at six weeks of age were significantly lower than in those fed 0 per cent CLPr AIN-93 diet. Body weights and food consumption did not differ significantly among the groups. The decreased levels of blood glucose may be involved in improvement of insulin resistance by antioxidative effects of cocoa liquor proanthocyanidin (Tomura et al, 2007).

Potenza et al (2007) investigated the effects of EGCG (phenol in green tea) treatment to simultaneously improve cardiovascular and metabolic function in SHR rats (model of metabolic syndrome with hypertension, insulin resistance, and overweight). EGCG stimulated production of NO from endothelium using PI 3-kinase dependent pathways and simultaneously EGCG therapy improves metabolic and cardiovascular pathophysiology in SHR. These findings may be relevant to understanding potential benefits of green tea consumption in patients with metabolic syndrome.

Valentina et al (2003) reported preliminary data on the consumption of tannin-rich plants by sifakas (*Propithecus verreauxi*) living in the Kirindy forest, western Madagascar. Sifakas spent most of their time feeding on only a few plant species. The tannin intake during the period between the pregnancy and birth season was significantly higher in pregnant females or females with lactating infants than in non-reproductive females and males. Tannin consumption is associated with an increase in body weight and stimulation of milk secretion. Veterinarians administer tannins as an astringent, anti-hemorrhagic and anti-abortive. Their high potential as an alternative anti helminthic has also recently been recognized. Thus, when viewed as self-medicating behavior, controlled increase in tannin intake could have multiple prophylactic advantages for females during the periparturient period. The high selectivity in their plant choice, and the presence of unusual feeding habits by a particular group of individuals (females with infants) limited in time (birth season), suggests that an increase in tannin ingestion may be a self-medicating behavior with multiple directly adaptive benefits to female reproduction.

Micronutrients are involved in the complex process of development of the secondary complications of diabetes mellitus in a number of different ways. They may be integral components of antioxidant enzymes (Cu, Zn and Mn in the case of the superoxide dismutases and Se for GSHPX), cofactors in a a variety of enzymatic processes of importance in glucose and lipid metabolism (Zn, Mn, Cr) or potential pro- oxidant catalysts (Cu, Fe). It has been shown that glucose intolerance developed when these elements were deficient, either experimentally or due to nutritional inadequacy (Thompson and Godin, 1995).

Trace minerals play a part in controlling insulin and glucose. Recent study by Dawn et al (2006) has shown that many Type 2 diabetics have lower than average levels of chromium and magnesium**.** Chromium is a part of glucose tolerance factor and improves glucose utilization. Chromium is also directly involved in carbohydrate, fat and protein metabolism. Magnesium has many functions in the human body. It is used in muscle and nerve functioning and supports immune system and bone health. Magnesium plays a role in protein synthesis and energy metabolism. It also helps in controlling and preventing hypertension and cardiovascular disease. Its role in Type 2 diabetes is in regulating blood sugar levels. So it is probably wise for Type 2 diabetics to include magnesium and chromium supplements in their management programme. Recommended daily intake of magnesium for adults is 350mg per day. Excess magnesium does not appear to cause serious health problems but if diarrhea and abdominal cramping occur after taking magnesium, dosage should be lowered (http.springerlink. com).

The biological activity of chromium depends on its valency and the chemical form of the complex of which it is a part. Glucose tolerance factor (GTF) is a trivalent form of chromium that has high biological activity. GTF is a low molecular weight, soluble and dialysable organic compound. This is required for optimal glucose utilisation by the cells. That abnormalities in chromium metabolism exist in insulin dependent diabetics seems certain. Nanogram quantities of chromium are required in every insulin dependent system. It has been suggested that by acting on the ribosomes, chromium facilitates the insulin stimulated amino acid incorporation into protein. The glucose intolerance seen as age advances has been attributed to chromium deficiency. If chromium administration can be shown to consistently correct the glucose intolerance of ageing, it might replace the use of the less physiological oral hypoglycemic agents in the treatment of this condition. Chromium is not a hypoglycemic agent in the usual pharmacological sense or a substitute for insulin. It is a cofactor for the initiation of peripheral insulin action on the receptors on the cell membranes. Insulin dependent diabetics excrete more chromium than the control subjects. However, there is no significant difference in the urinary excretion of chromium between maturity onset diabetics and normal controls. Chromium deficiency has also been held responsible for vascular complications associated with diabetes mellitus. Increased incidence of aortic plaques has been shown in chromium deficient animals. Recent work has provided "Suggestive evidence for a relationship between certain body pools of chromium and carbohydrate metabolism in diabetes. Lastly, hyperglycemia occurring during total parenteral hyper alimentation has been shown to be controlled and insulin requirements reduced by oral administration of micrograms quantities of chromium (Rabinowitz et al, 1980).

Magnesium is known to be related to the carbohydrate and fat metabolism. Serum magnesium levels have been shown to be inversely related to the severity of diabetes. Definite lowering of serum magnesium has been shown in patients on long term treatment with insulin and those recovering from diabetic ketoacidosis. The cause of this hypomagnesemia is not known for certain but the following have been suggested as possible mechanisms: (1) increased loss of magnesium in urine due to the osmotic action of glycosuria; and (2) depression of the net tubular reabsorption of magnesium due to hyperglycemia. Magnesium may also play a role in the release of insulin. Magnesium depletion has an atherogenic potential. Hypomagnesemia has been postulated as a possible risk factor in the development and progression of diabetic retinopathy. Future research is called for to see if repletion of magnesium retards the progression of retinopathy. Patients with myocardial infarction had reversal of abnormal lipoprotein patterns to normal on administration of magnesium The Bantus have lower prevalence of ischemic heart disease and higher serum magnesium levels than the Europeans. Thus, magnesium may well have a local protective effect on the vessel well (Seelig and Heggtyeit, 1974).

Type 2 diabetes is a major cause of vascular complications affecting heart, kidney, retina and peripheral nerves. Hyperglycemia leads to oxidative stress that plays an important role in vascular degenerative lesions observed in diabetes. Zinc has numerous targets to modulate insulin activity, including its antioxidant capacity. Zinc status is decreased in most type 2 diabetes patients. The effect of zinc supplementation on antioxidant status is raised when complications are associated (Roussel et al, 2003). Scott and Fischer (1998) first recognized the relationship between zinc and insulin. They found that the normal human pancreas contained significant quantities of zinc whereas, the diabetic pancreas contained very little. Later, the availability of histochemical techniques for the detection of zinc confirmed that zinc and insulin concentrations in the pancreas changed in the same direction in a variety of situations in humans. Organic compounds which were capable of reducing the zinc content of the pancreas were found to be diabetogenic in animal experiments. Meltzer et al (1974) appear to be the first to have studied the urinary excretion of trace elements in diabetes mellitus. As a group, diabetics excrete more zinc in the urine than non-diabetics. The mean plasma, leukocyte and erythrocyte zinc levels are significantly lower in diabetics than in non-diabetics.

In experimental animals, pancreatectomy and diabetes have been correlated with decreased manganese levels in blood. Further, manganese supplements have reversed the impaired glucose utilization induced by manganese deficiency in guinea pigs. It is thus seen that several abnormalities of trace metal metabolism have been demonstrated in diabetes mellitus, both human and experimental. Their pathogenetic implications and therapeutic applications must await further elucidation (Seelig and Heggtyeit, 1974).

Certain food components can selectively modify kinase activity in favor of good health. These are referred to as **Selective Kinase Response Modulators** (SKRMs). Kinases are enzymes that translate dietary signals to positively or negatively influence numerous aspects of health. They function to chemically modify other proteins and regulate the majority of cellular pathways, especially those involved in the transmission of signals within the cell. *Acacia nilotica* and reduced iso-alpha acids (RIAA) derived from *Humulus lupulus L.* (hops) are two such SKRMs shown to modulate kinase signaling in adipocytes—fat-storing cells involved in glucose utilization and insulin signaling. While hops and acacia have been utilized traditionally for centuries, nutrigenomic research has uncovered new applications for their use. Components derived from hops, for example, have been shown to have anti-inflammatory properties. By supporting healthy kinase signaling, these SKRMs may help to maintain healthy triglyceride levels. *In vitro* testing of these ingredients has also demonstrated inhibition of IL-6 cytokines that influence insulin function. In addition, RIAA and acacia have been clinically shown in a preliminary study at the Functional Medicine Research Center the clinical research arm of Metagenics, to improve fasting insulin and lipid parameters (http://www. metagenics.com/about/patient_why.asp).

Bland (2007) and his clinical research group at MetaProteomics has been evaluating specific phytochemicals that historically have been part of the diet associated with populations that have a lower incidence of type 2 diabetes and CVD to see if there are any of these nutritive substances that serve as selective kinase response modulators (SKRMs) that could inhibit the kinase-mediated processes associated with insulin resistance and inflammation. After screening several hundred phytochemicals that had a history of safe use through diet intake, they discovered that several of them had uniquely high specificity and activity as inhibitors of the kinases that are involved in altered insulin signaling and intramyocellular lipid deposition. These specific selective kinase response modulating phytochemicals were then screened in two animal models of type 2 diabetes and found to be very active in improving insulin and blood glucose levels in these diabetic animals. These results then led to an Institutional Review Board-approved human clinical trial with volunteers who had been screened for metabolic syndrome. The participants in this study were both placed on a standardized diet and administered either a placebo or a nutraceutical formulation containing a mixture of phytochemicals that the MetaProteomics research staff had found, through in vitro screening and animal studies, to improve insulin sensitivity by modulating specific kinase enzymes that have been identified as hubs for insulin-signaling processes, including phosphoinositol-3-kinase and glycogen synthase-3-kinase. The outcome from this 12-week intervention trial was very positive in that the participants taking the phytochemical SKRM-based product had a very significant reduction in comparison to the placebo in both fasting serum triglycerides, which is a positive indicator of reduced metabolic syndrome, as well as a reduction in two-hour postprandial insulin levels measured after a controlled glucose tolerance test. The reduction of postprandial insulin in conjunction with a reduced fasting triglyceride level and a decrease in the fasting triglyceride to HDL ratio are consistent with reductions in apolipoprotein B.

2.4 Taxonomy and chemical composition of Indian Gum Arabic:

Acacia nilotica is a tree of 5-20 m high with a dense spheric crown, stems and branchlets usually dark to black coloured, fissured bark, grey-pinkish slash, excluding a reddish low quality gum. Thin, straight, light, grey spines in axillary pairs, usually in 3 to 12 pairs, 5 to 7.5 cm long in young trees, mature trees commonly without thorns. Leaves are bipinnate, with 3-6 pairs of pinnulae and 10-30 pairs of leaflets each. Its flowers are in globulous heads 1.2-1.5 cm in diameter of a bright golden-yellow color, set up either axillary or whorly on peduncles 2-3 cm long located at the end of the branches. Pods are grey, thick, softly tomentose, and straight or slightly curved, 5 to 15 cm long on a pedicel, 0.5 to 1.2 cm wide, with constrictions between the seeds giving a necklace appearance, fleshy when young, becoming black and hard at maturity (http://www.fao.org/docrep/006/q2190E/Q2190E14.htm).

It is widespread in Africa and Asia, and occurs in Australia. It is found in well watered Sahelian and Sudanian savannas to the southern Arabian Peninsula, East Africa and in the Gambia, the Sudan, Togo, Ghana, Nigeria, and on lateritic soil in the Himalayan foothills in India. Leaves used for feeding sheep and goats in the Hissar district in India. In Kenya, the fleshy pods are readily eaten by goats, sheep and cattle, but some tribes believe they cause bloat. They are occasionally browsed by goats (Brenan, 1983).

In India *Acacia nilotica* mostly grows in Haryana, Punjab, Uttaranchal, Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharastra, Gujarat and many more states of India. Annual availability of A. nilotica pods in India is about 600,000 metric tons. A. nilotica tree is a browse tree with pods and leaves that make excellent fodder and are available when there is no grass (Barman and Rai, 2004). Bark and leaves are used to treat hemorrhage, colds, diarrhoea, scurvy, dysentery and opthalmia etc (http://www.fao.org/ag/AGP/ AGPC/doc/publicate/Gutt-shel/x5556e0v.htm.).

Kabaija and Little (1987) analyzed the chemical composition of *Acacia nilotica* browse. Samples were collected from the Sidano southern rangelands and dried in an oven at 60° C and powdered for chemical analysis. The browse of *Acacia nilotica* contained 15 per cent protein, 30.7 per cent neutral detergent fibre, 28.1 per cent acid detergent fibre, 5.9 per cent ash, 8.1g/kg potassium, 0.5g/kg sodium, 18g/kg calcium, 1.9 g/kg magnesium, 2.2g/kg phosphorus, 2.3g/kg sulfur, 664 mg/kg iron, 66 mg/kg manganese, 31 mg/kg zinc and 9.0 mg/kg copper.

Carter et al (1988) reported that *Acacia nilotica* pods contain 12.30 per cent protein, 1.93 per cent fat, 15.36 per cent fibre, 5.26 per cent ash and 5.45 per cent tannin. In amino acid composition, *Acacia nilotica* pods contain lysine (4.98 %), histidine (2.63%), arginine (5.07), aspartic acid (28.69%), threonine (3.20%) serine (4.58%), glutamic acid (8.97%), proline (11.81%), glycine (4.05%), alanine (4.59), valine (5.00%), methionine (0.00%), isolucine (3.06%), leucine (5.45%), tyrosine (2.34%), phenylalanine (3.23%) and cysteine (2.35%). The relative tannin levels in *Acacia nilotica* from least to most are pods (5.4%), leaves (7.6%), bark (13.5%) and twigs (15.8%).

Siddhuraju et al (1996) investigated the nutritional and anti nutritional characteristics and biological value of *Acacia nilotica* (L.) seeds. The mature seeds contained 234 g kg^{-1} crude protein, 126 g kg^{-1} crude fibre, 66.6 g kg^{-1} crude fat, and 39.7 g kg^{-1} ash and 534 g kg^{-1} carbohydrates. Potassium, phosphorus, magnesium, iron and manganese occurred in high concentrations. The essential amino acid profile compared well with the FAO/WHO recommended pattern except for cystine, methionine and threonine. Cystine and methionine were the first limiting amino acids. When compared with the globulin fraction, albumins appeared to be a richer source of cystine, methionine, threonine, lysine and tryptophan. Oleic and linoleic acids constituted the predominant fatty acids (66.9%). Both dry-heating and autoclaving reduced the anti nutritional components significantly. The *in vitro* protein digestibilities of raw, dry heat-treated and autoclaved seeds were 61.2%, 77.4% and 80.2%, respectively. Biological value, true digestibility and net protein utilization were significantly higher in processed seed than in raw seeds. The utilizable protein difference was insignificant between raw and processed seed samples.

Fagg (2001) estimated the leaves of *Acacia nilotica* which contain 2.2–2.6 per cent nitrogen (N), 16.9–20.0 per cent neutral detergent fibre (NDF), 13.3–14.1 per cent acid detergent fibre (ADF), 7.2–8.7 MJ/kg energy, 10–21 per cent crude fibre and 6–9 per cent condensed tannins. Pod and seed contain 1.6–2.2per cent N, 10 MJ/kg energy, 12–18per cent crude fibre and 4–7 per cent condensed tannins. Pods alone contain 2 per cent N, 25 per cent NDF and 17 per cent ADF. The pods contain phenolic constituents, which consist of: m-digallic acid, gallic acid, its methyl and ethyl esters, protocatechuic and ellagic acids, leucocyanidin, m-digallic dimmer 3,4,5,7- tetrahydroxy flavan-3-ol, oligomer 3,4,7-trihydroxy flavan 3, 4-diol and 3,4,5,7-tetrahydroxy flavan-3-ol, and (-) epicatechol.

The digestible crude protein (DCP) and total digestible nutrient (TDN) values of acacia leaves are 10.21% and 66.46%, respectively. The total tannin content of babul pods and leaves is about 18.71% and 30%, respectively. Acacia pods and seed contain high levels of protein, e.g., 13.2 and 28.3%, respectively. Out of the 13.2% protein of acacia pods, 56.50% is rumen degradable protein, and 43.50% is rumen undegradable protein or bypass protein In terms of bypass protein, it is comparable to cottonseed meal, and it is highly beneficial for high-producing dairy cows. Nitrogen-free extract (NFE) content is 65.3 and 39.5%, respectively, in pods and chuni (Barman and Rai, 2004).

Kamal et al (2005) studied the variation in tannin's contents of *Acacia nilotica* in Sudan. The samples were collected from six different sites and Hyde powder method was used for the determination of the percentages of total tannin's content, while thin layer chromatography test was carried for qualitative comparison. The study revealed that the premature pods contained the higher amount of tannin and they were always better than mature ones.

Five legume vegetables harvested at the immature green and mature stages were analysed for weight and nutrient composition. In some types the seed weight increased up to seven-fold in the last 10 days of maturation. The protein, fat, carbohydrate and thiamin contents increased on maturation. However, the proportional increase varied widely from 10 to 100 % in the case of protein and carbohydrates. The changes observed in the nutrient composition and weight of vegetable legume seeds in the last 10 days of maturation suggest that it is advantageous to harvest vegetable legumes when mature (Geervani and Devi, 2006).

The biochemical composition of seeds and pod shells of beach pea was determined during growth and maturation. The content of crude and soluble protein, soluble sugars and phenolics was high in the fresh green seeds and pod shells, but these decreased rapidly during seed maturation. Meanwhile, the corresponding content of starch increased in seeds and decreased in pod shells. Glutamic acid was the predominant amino acid in seeds, and aspartic acid was dominant in pod shells. Levels of arginine, alanine and threonine were highest in fresh green seeds. Methionine and cysteine content increased during seed maturation, but declined in pod shells. Free amino acid content decreased rapidly during later stages of seed maturation. Potassium, calcium, sodium and phosphorus were the predominant minerals in fresh green seeds and pod shells, but iron content was highest in mature pod shells relative to that of other stages of maturation. Major changes in color (pigment interchanges) also occurred during maturation. Based on its biochemical composition, beach pea may be of special importance for widespread cultivation (Chavan et al, 1999).

Saharan et al (2002) were analyzed the high-yielding varieties of fababean (VH-82-1) and ricebean (RB-32) for physico-chemical properties and nutrient profile. On a dry weight basis, fababean contained higher concentrations of crude protein (25.5 g/100 g), fat (2.7 g/100 g), ash (5.1 g/ 100 g), various dietary fibre constituents and digestible starch (42.1 mg maltose released/g meal) than those of ricebean. On the other hand, ricebean contained higher concentrations of total soluble sugars (5.6 g/100 g) and non-reducing sugars (5.0 g/100 g), digestible protein (58.4%) and total and available Ca, P and Fe than fababean. Both the legumes contained quite high concentrations of anti nutrients viz. phytic acid (1012-2018 mg/100 g), polyphenols (750-1698 mg/100 g), saponins (1313-2168 mg/100 g) and trypsin inhibitor activity (TIA) (55.2-905.2 TIU/g).

2.5 Traditional uses of Indian Gum Arabic as medicine to control the diseases in India and other countries:

Several parts of Gum Arabic with other medicinal plants are being used as a medicine to cure/control the diseases not only in India but also in other countries. The leaves, the bark, the pods and the gum of the tree have medicinal virtues. The leaves and the bark are useful in arresting secretion or bleeding. The pods help to remove catarrhal matter and phlegm from the bronchial tubes. The gum allays any irritation of the skin and soothes the inflamed membranes of the pharynx, alimentary canal and genito-urinary organs (http://www.online-vitamins-guide.com/herbs/herbs.htm). Some uses are mentioned in following points:

The various parts of babul tree are useful in **diarrhea** of ordinary intensity. A mixture of equal parts of the tender leaves with white and black cumin seeds (*zeera*) can be administered in doses of 12 g thrice daily. An infusion made of the bark of the tree may also be taken thrice daily for the same purpose. The gum used either in decoction or in syrup is an effective medicine for diarrhea.

Chewing of fresh bark of this tree daily helps to strengthen **loose teeth** and arrest any bleeding from the gums. Dirty teeth can be cleaned effectively by brushing them with powder in which 60 g of charcoal of babul wood, 24 g of roasted alum and 12 g of rock salt have been included.

The bark of babul tree is useful in the treatment of **eczema**. About 25 g each of this bark and the mango bark should be boiled in about 1 liter of water and the vapors allowed to foment the affected part. After the fomentation, the affected part should be anointed with ghee. A decoction of the bark, mixed with rock salt, should be used as a gargle in treating **tonsillitis** (http://www.online-vitamins-guide.com/herbs/herbs.htm).

The leaves of babul tree are effective in the treatment of **conjunctivitis**. The leaves, ground to a paste, should be applied on the affected eyes at night, supported by a bandage which should be untied the next morning. This removes pain and redness.

The leaves are beneficial in treating **epiphora** - that is watering of the eyes, in which tears flow onto the cheeks due to abnormality of the tear drainage system. About 250 g of leaves should be boiled in one and a quarter liter of water until only a quarter liter of water is left. This should then be filtered and kept in a well-corked bottle. The eye-lids should be painted morning and evening with this liquid. The bark of the tree is useful in **leucorrhoea**. Its decoction should be used as a vaginal douche for treating this disorder.

Fresh pods of babul tree are effective in **sexual disorders** like spermatorrhoea, frequent night discharges, loss of viscidity of the semen and premature ejaculation. In Ayurveda, a preparation made from the pods is considered highly beneficial in treating these disorders. Tender, seedless pods are dried in shade, powdered and mixed with an equal weight of brown sugar. Six grams of this mixture may be taken with milk in the morning); (http://www.online-vitamins-guide.com/herbs/herbs.htm).

Acacia nilotica pods have anti hyperglycemic property. Pods are used to cure **diabetes**. Pods ground up in water are used as a drink for diabetics and people with ulcers (Audru et al, 1996). Ayurveda also reports that the premature pods are effective in diabetes. Three to six grams pods powder is recommended as a dose in Ayurveda (Singh R.S, 1969). Taking a teaspoonful of pods powder before breakfast is beneficial for diabetics (Breithaupt, 2002)

Bhandari (1974) also reported that seeds of *Acacia nilotica* are eaten roasted or raw, in times of very acute scarcity of food. Pods are used as a vegetable. The bark and the gummy fruit pulp are edible. In addition the pods are considered a famine food in certain areas. The pods of *Acacia nilotica* used as a vegetable; seeds fried and eaten alone or mixed with *jowar* or *bajra* (millet) flour (Brokensha and Riley, 1998). The pickles prepared from pods of Acacia arabica constitute a supplementary food (Sharma, 2000).

Oudhia (2003) reported through his ethno botanical surveys that the traditional healers of Chhattisgarh (India) have rich traditional medicinal knowledge about common herbs and herbal formulations used in treatment of Diabetes insipidus. The traditional healers of Narharpur region, use only *Gondla* roots in combination with *Sirka* (Vinegar) and *Shahad* (Honey). According to them there is no necessity of adding other herbs. They further informed that the internal use of this combination is having several other health benefits. It is a good tonic and helpful in treatment of gynecological troubles. The traditional healers of Chhattisgarh Plains use simple formulation. They mix the *Til* (Sesamum indicum) seeds and *Ajwain* (Carum copticum) seeds in equal proportion and convert it into powder. This powder is given internally with *Gud* (Jaggery) in form of small globules. Many healers avoid the use of *Gud* and suggest the patients to take the powder as such with water. This formulation is also popular as home remedy in many parts. The traditional healers of Bastar region use the herbal combination of *Imli* (Tamarind) seed pulp and leaf juice of *Munga* (Moringa oleifera) externally. This combination is converted into an aqueous paste and applied around the umbilicus. This application is recommended once in day till complete cure. The traditional healers of Sarguja region use the immature pods of common medicinal tree *Babool* (*Acacia nilotica*) for this purpose. The pods are collected and dried in shade. After drying it is converted into powder and roasted with cow ghee. Sugar is added for taste. This preparation is used internally. It is taken twice a day.

The traditional healers of Durg region use the *Singhara Ata* in combination with sugar internally in treatment. The traditional healers of Pendra region, rich in natural population of *Bamboo,* prepare the decoction by using both green and dry leaves of Bamboo and use it in treatment of this trouble. This use is very popular among the traditional healers. With the help of above mentioned herbs and herbal combinations the healers of Chhattisgarh try to manage the trouble (Oudhia, 2003).

Acacia nilotica is not only used in India as a traditional practice for the treatment of various diseases but it is also used in other countries as explained below:

Both the African and Australian varieties have tannin-rich bark. A decoction can be applied to inflamed tissue and burns to promote rapid healing and the knitting together of the tissues. This high tannin content also helps in the treatment of mouth ulcers and throat inflammations. Its astringency helps to check the growth of oral bacteria while soothing the delicate tissues that line the oral cavity. In Ayurvedic medicine, Acacia leaves, flowers, and pods have long been used to expel worms, to staunch bleeding, heal wounds, and suppress the coughing up of blood. Its strong astringent action is used to contract and toughen mucous membranes throughout the body in much the same way as witch hazel or oak bark. Black Catechu is used internally for chronic catarrh of the mucous membranes, dysentery, and bleeding (http://www.innvista.com/HEALTH/herbs/default.htm.).

In Chinese medicine, it is used for poorly healing ulcers, weeping skin diseases, oral ulcers with bleeding, and traumatic injuries. A small piece of cutch can be dissolved in the mouth to stop bleeding gums or heal canker sores. In Ayurvedic medicine, decoctions of the bark and heartwood are used for sore throats. Senegal gum is used as a mild stimulant and to impede absorption as well as for the treatment of catarrh and diarrhea. It is the source of the well-known Gum Arabic, as well as being a constituent of cough drops. It is also used in veterinary medicine for mild diarrhea in small animals, foals, and calves (http://www.innvista.com/HEALTH/herbs/default.htm.).

Mexicans use the flowers, leaves, and roots to make soothing teas and washes, good for the mucous membranes, and used mainly to treat bladder problems or as a topical antiseptic for skin and oral inflammations. The astringent fruit is used to treat dysentery. Although herbalists in the US rarely use acacia for parasitic infestations, it is commonly used in other cultures. For example, one species, *A. anthelmintica*, is specific for worms in Abyssinia; *A. nilotica* is specific for malaria in Nigeria; and *A. polyacantha* is specific for malaria in Tanzania (http://www.innvista.com/HEALTH/herbs/default.htm.).

The acacia in some South American cultures has been considered specific for venomous stings and bites and used in much the same manner in each culture. The juice of the chewed bark is swallowed, while the chewed bark itself is placed on the area of the bite. Decoctions made from the powdered leaves, stems, and pods are taken for shigella, malaria, dysentery, and diarrhea. The brew is both antimicrobial and anti-inflammatory. An infusion of the flowers and leaves is taken for gastrointestinal inflammations. The flowers are also sedating. The roots make a mucilaginous tea that is both antibacterial and anti-inflammatory. It helps to soothe mucous membranes from the mouth through to the anus, reducing inflammation and attacking microbial infections. Any part may be powdered and applied to fungal infections, infected wounds, and to stop the bleeding of wounds and prevent subsequent infection (http://www.innvista. com/HEALTH/herbs/default.htm). Bark used medicinally for coughing by the Mbeere in the Embu district of Kenya (Brokensha and Riley, 1998).

The *Acacia nilotica* fruits ('Gambia pods') are edible containing 30% tannin, Egyptian Nubians believe that diabetics may eat unlimited carbohydrates as long as they also consume powdered pods. Tender young pods are eaten as a vegetable, and roasted seeds serve as a spice or are fermented to make an alcoholic beverage (http:\\ herbaria.plants.ox.ac.uk/VFH/test sites).

It is reported that the fruits are given for diarrhea, haemorrhage, as sedative in labour, as a cure for sore gum and loose teeth and for diabetes by taking a teaspoonful before breakfast. Nubians in Southern Egypt believe that diabetic patient may take as much as food rich in carbohydrate if they take powdered pod regularly (http://www.metafro.be/prelude/view_country?cc=EG).

2.6 Medicinal uses of Indian Gum Arabic:

Several animal studies on rats and rabbits also reported the medicinal uses of *Acacia nilotica*. Few of them are presented below:

Acacia nilotica Delile (Leguminosae) is a spiny tree growing in western and central Africa and Arabia. Its flat brown pods are widely used in some African countries and the Middle East for the treatment of many conditions including diarrhea, cough, fever, common cold and influenza (Al-Gazali et al, 1987). It is taken either orally as an aqueous extract, applied topically as a powder or inhaled as fumes evolving from heated pods. Chemical analysis of the pods revealed the presence of tannins and some galloyalated flavans. Although there are a number of reports on the phytochemistry and pharmacology of *Acacia nilotica*, very little is known about its toxicological effects. Dafallah and Al-Mustafa (1996) reported analgesic, antipyretic and anti-inflammatory activity of an aqueous extract of *Acacia nilotica* administered orally to rats.

Wadwood et al (1989) studied the hypoglycemic effect of the powdered seeds of *Acacia nilotica* and roots of *Caralluma edulis* on normal and alloxan- diabetic rabbits. Powdered seeds of *Acacia nilotica* and roots of *Caralluma edulis* were administered in doses of 2, 3 and 4 g/kg body-weight to normal and alloxan-diabetic rabbits. The blood glucose levels were estimated before and 2, 4, 6 and 8 hours after the administration of plant suspension. The powdered seeds of *Acacia nilotica* exerted a significant ($P \leq 0.05$) hypoglycemic effect in normal rabbits. The hypoglycemic effect was not significant ($P \geq 0.01$) in alloxan diabetic rabbits. The powdered roots of *Caralluma edulis* did not produce any significant ($P \geq 0.01$) hypoglycaemic effect in normal as well as in alloxan diabetic rabbits. The doses used did not show any acute toxicity and behavioural changes. From this study it may be concluded that the powdered seeds of *Acacia nilotica* act by initiating the release of insulin from pancreatic beta cells of normal rabbits. Moreover, *Caralluma edulis* did not show any hypoglycaemic effect in normal as well as in diabetic rabbit.

Sotohy et al (1995) conducted a study on leaves from tannin containing plants, including *Acacia nilotica*, which are widely spread in Upper Egypt. From two plants, fruits were also investigated (*Acacia nilotica and Acacia farnesiana*). One of the objectives was to determine the total soluble polyphenols and the soluble condensed tannins of these plants. Furthermore the assumed antimicrobial effect of *Acacia nilotica and Acacia farnesiana* leaves and their extracts on C. perfringens, E. coli and S. typhimurium was studied "in-vitro" at dilutions of 0.5 per cent and 0.05 per cent. The tests were carried out in physiological saline solution and in rumen fluid medium (RFM). The results revealed that the total soluble polyphenols ranged from 10.27 per cent to 35.46 per cent and the condensed tannins from 0.5 per cent to 8.28 per cent on dry matter base. The antimicrobial effect of the plant material was only observed on C. perfringens but not on E. coli and S. typhimurium. *Acacia nilotica* leaves destroyed the suspension of C. perfringens immediately after being added. Leaves from *Acacia farnesiana* showed a delayed affect. Plant extracts were less effective than the raw plant material. In RFM *Acacia nilotica* leaves destroyed the bacterial suspension after 10 minutes only at the concentration of 0.5 per cent, but not at 0.05 per cent. With *Acacia farnesiana* at a concentration of 0.5 per cent only a reduction was observed. The concentration of 0.05 per cent had no influence. The presence of other proteins than bacterial suspension in rumen fluid (rumen bacteria, protozoa and plant proteins) inhibits the antimicrobial effect of the plant material in a concentration of 0.05 per cent, but not at 0.5 per cent.

Tahir et al (1998) observed the antiplasmodial activity of medicinal plants. Twenty-two plant organs from eleven plants (including *Acacia nilotica*) comprising five families were extracted and screened for antiplasmodial activity *in vitro* against *Plasmodium falciparum* 3D7 (chloroquine sensitive) and Dd2 (chloroquine resistant and pyrimethamine sensitive). Fifty nine percent of plant extracts from 22 extracts exerted activity on *P. falciparum* strain 3D7 with an IC_{50} less than 50 µg/ml, whereas 43 per cent of plant extracts showed an IC_{50} value within 50 µg/ml on Dd2 strains. Plant extracts from *Gardenia lutea, Haplophyllum tuberculatum, Cassia tora, Acacia nilotica* and *Aristolochia bracteolata* possessed IC_{50} values less than 5 µg/ml on both tested strains. Bioassay guided fractionation of *A. nilotica* revealed that the ethyl acetate extract possessed the highest activity (IC_{50} = 1.5 µg/ml). Phytochemical analysis indicated that the most active phase contained terpenoids and tannins and was devoid of alkaloids and saponins. The effect of plant extracts on lymphocyte proliferation showed low toxicity to the human cells. This plant has been subjected to long term clinical trials in folk medicine and is a promising plant.

Gilani et al (1999) reported a dose-dependent (3-30 mg/kg) fall in arterial blood pressure by methanol extract of *Acacia nilotica* pods (AN). Treatment of animals with atropine abolished the vasodilator response of acetylcholine, whereas the antihypertensive effect of the plant extract remained unaltered. Phentolamine (an-adrenergic blocker) abolished the vasoconstrictor effect of norepinephrine (NE), whereas pretreatment of the animal with *Acacia nilotica* did not modify the NE response. These results indicate that the antihypertensive effect of plant extract is independent of muscarinic receptor stimulation or adrenoceptor blockade. In the *in vitro* studies, *Acacia nilotica* produced a dose-dependent (0.3-3.0 mg/ml) inhibitory effect and spontaneous contractions in guinea-pig paired atria. Similarly, it inhibited the spontaneous contraction of rabbit jejunum in a concentration-dependent (0.1-3.0 mg/ml) manner. AN also inhibited potassium induced contractions in rabbit jejunum at a similar concentration range, which suggests that the antispasmodic action of AN is mediated through calcium channel blockade, and this may also be responsible for the blood pressure lowering effect of AN, observed in the *in vivo* studies.

Amos et al (1999) investigated an aqueous extract of the seed of *Acacia nilotica* for its pharmacological profile. On the isolated guinea-pig ileum, the extract displayed sustained dose-related contractile activity. The contractions which were reduced by hexamethonium, promethazine or atropine were completely abolished by nifedipine. The intravenous administration of the extract (11, 22, 44, 55 µg/kg) to anaesthetized cats produced a dose-related significant elevation of blood pressure. The mechanisms of the spasmogenic and vasoconstrictor actions of the extract have not been determined, however, the results suggest the involvement of calcium.

Hussein et al (1999) evaluated the inhibitory effect of Sudanese plant extracts (including *Acacia nilotica*) on HIV-1 replication and HIV-1 protease. Forty-eight methanol and aqueous extracts from Sudanese plants were screened. From them nineteen extracts showed inhibitory effects on HIV-induced cytopathic effects on MT-4 cells. The extracts were further screened against HIV-1 protease (PR) using an HPLC assay method. Of the tested extracts, the methanol extracts of *Acacia nilotica* (bark and pods), *Euphorbia granulata* (leaves), *Maytenus senegalensis* (stem-bark) and aqueous extracts of *A. nilotica* (pods) and *M. senegalensis* (stem-bark) showed considerable inhibitory effects against HIV-1PR.

Ammar et al (2001) collected thirty-seven plant organs (including *Acacia nilotica)* traditionally used as drugs, in Pakistan. These were extracted with 70% acetone and analyzed for their total phenolics concentration and antioxidant potential. Seven extracts showed more than 85% inhibition of lipid peroxidation in vitro as compared with blank. The results indicate that the extracts of *Nymphaea lotus* L. flowers, *Acacia nilotica* (Linn.) Delile beans, *Terminalia belerica Roxb.* fruits, and *Terminalia chebula Retz.* (fruits, brown) were stronger antioxidants than α-tocopherol, while *Terminalia chebula Retz*. (fruit coat), *Terminalia chebula Retz.* (fruits, black) and *Ricinus communis* L. leaves were weaker antioxidant extracts than α-tocopherol and BHT. Total phenolics concentration, expressed as gallic acid equivalents, showed close correlation with the antioxidant activity. High performance liquid chromatographic analysis with diode array detection at 280 nm of the seven extracts indicated the presence of hydroxybenzoic acid derivatives, hydroxycinnamic acid derivatives, flavonol aglycones and their glycosides as main phenolics compounds.

India is one of the 12 mega diversity countries in the world so it has a vital stake in conservation and sustainable utilization of its biodiversity resources. Plants secondary metabolites have been of interest to man for a long time due to their pharmacological relevance. With this in view, Arora et al (2003) had studied the anti mutagenic activities of the bark powder of *Acacia auriculiformis*, *A. nilotica*, *Juglans regia*, and the fruit powder of *Terminalia bellerica*, *T. chebula*, *Emblica officinalis*, and a combination drug *Triphala*, which are known to be rich in polyphenols. Acetone extracts of all the plants exhibited significant anti mutagenic activities among the other extracts tested but an acetone extract of *Acacia nilotica* showed a marked anti mutagent effect. Furthermore, it was more effective against indirect acting mutagen and direct acting mutagens. The results indicate that an acetone extract of bark and fruit of the medicinal plants under study harbors constituents with promising anti mutagenic/anti carcinogenic potential that could be investigated further.

Five medicinal plants (*Acacia nilotica, Acanthospermun hispidum, Gmelina arborea, Parkia biglobosa and Vitex doniana*) used in diarrhoea treatment in Kaduna State, Nigeria, were investigated by Agunu et al (2005). This study was carried out on perfuse isolated rabbit jejunum and castor oil-induced diarrhoea in mice. The aqueous methanol extracts (0.5, 1.0, 2.0 and 3.0 mg/ml) were generally found to cause a dose-dependent response in the isolated rabbit jejunum, though this was not uniform in all the plants. *Gmelina arborea* and *Vitex doniana* showed concentration dependent relaxation at low doses (0.5, 1.0 mg/ml), but showed no significant relaxation at higher doses (2.0, 3.0 mg/ml). Other extracts showed biphasic effects. For example, *Acacia nilotica* at 3.0 mg/ml caused initial relaxation quickly followed by contraction. In the castor oil-induced diarrhoeal, 100 per cent protections were shown by extracts of *Acacia nilotica* and *Parkia biglobosa* (100, 200 mg/kg) while *Vitex doniana* showed a dose-dependent effect. The least protection was shown by *Acanthospermun hispidum*, at the same dose, when compared with the other four plants. The results obtained revealed that the aqueous methanol extracts of all the five medicinal plants investigated have pharmacological activity against diarrhoea. This may explain their use in traditional medicine for the treatment of diarrhoea.

Phenol content in *Acacia nilotica* also shows the antioxidant capacity. Sundaram and Mitra (2007) studied the antioxidant activity of various extracts and fractions of *Acacia nilotica* by *in vitro* and *in vivo* experimental models. Various solvent extracts were prepared by soxhlet extraction. Extract fractionations were done by solvent-solvent extraction and flash chromatographic separation. *In vitro* lipid peroxidation was carried out by tertiary butyl hydroperoxide -induced lipid peroxidation. The most active fractions were identified and standardized by thin layer chromatography. *In vivo* experiments on the most active fraction were carried out with 50, 100, and 150 mg/kg, doses, in carbon tetrachloride (CCl_4)-induced hepatotoxicity, in rats. Various biochemical parameters like serum aspartate aminotransferase (AST), serum alanine aminotransferase (ALT), superoxide dismutase, catalase, glutathione peroxidase (GSH-Px), glutathione (GSH), and lipid peroxidation were estimated. Flash chromatographic fractions 2-6 of ethyl acetate extract exhibited maximum activity with *in vitro* lipid peroxidation. *In vivo* evaluation of this active fraction (AA) in CCl4-induced hepatotoxicity for 19 days at a dose of 150 mg/kg offered marked liver protection, which was evident by significant changes in lipid peroxidation, glutathione, superoxide dismutase and catalase ($P<0.01$). The treatment also showed significant changes in AST, ALT, and GSH-Px levels ($P<0.05$). At lower doses, the protection was not consistent. Concludingly the polyphenol rich active fraction of *Acacia nilotica* is a potent free radical scavenger and hepatoprotective and protects TBH-induced lipid peroxidation and CCl_4 -induced hepatic damage.

The antioxidant potency of acetone extract fractions of *Acacia auriculiformis* was investigated by employing various in vitro systems, such as DPPH, deoxyribose (site- and non-site-specific), reducing power, chelating power and lipid peroxidation in rat liver homogenate. The bark powder of the plant was extracted with different solvents by a maceration method in order of increasing and decreasing polarities and then partitioned. It was observed that the fractions were comparatively more effective than the crude acetone extract in all the assays. Maximum inhibitory activities noticed were 72.3%, 91.7%, 83.3%, and 70.9% in DPPH, deoxyribose, reducing power, chelating power and lipid peroxidation assays, respectively. The inhibitory potential was compared with known antioxidants (ascorbic acid and BHT) and correlated with the total phenolic content in crude extract and fractions. Fractions rich in polyphenolic content were more effective than crude extract. Further studies are underway to isolate and elucidate the structures of the active principles (Singh et al, 2007).

In addition to its (*Acacia nilotica* ssp *adansonii*) role in the management of different diseases, there is a traditional belief that it plays a role in the stimulation of milk production in lactating women; experiments were performed to determine the effect of an aqueous extract of *Acacia nilotica* (AN) on milk production in rats. Female rats that received oral doses of aqueous extract of this plant during their first lactation produced about 59 per cent more milk than controls ($P \leq 0{\cdot}01$). Pup weight gain was also significantly higher than that in the control group. A lower dose, comparable to that used by women to improve their milk yield, led to about 33 per cent more milk with the same growth rate for pups as that in the high-dose group. The extract of AN was found to stimulate the synthesis and release of prolactin (PRL) significantly ($P \leq 0{\cdot}05$). In addition, the mammary glands of oestrogenprimed rats treated with the extract showed clear lobuloalveolar development with milk secretion. This study demonstrates that the aqueous extract of AN can stimulate milk production and PRL release in the female rat and could consequently have the properties claimed for lactating women (Lompo–ouedraogo et al, 2004).

Zaki et al (2000) investigated the potential toxicity of *Acacia nilotica* in rats maintained on 2 per cent and 8 per cent acacia diet for 2 and 4 weeks. A significant reduction in body weight in all acacia-fed groups and a significant decrease in the levels of hemoglobin, serum total protein and total cholesterol in animals fed 8 per cent acacia diet for up to 4 weeks were observed. These effects were, however, reversed one week after treatment termination. No significant changes in serum parameters of hepatic and renal functions, fasting glucose and triglycerides were observed. Further, no deaths among treated animals and no significant histopathological changes in liver sections were noted. It is concluded that *A. nilotica*, at 2 per cent and 8 per cent has a low toxicity potential.

Tannin occurs naturally in coffee and tea and nearly all wood and vegetation contain some form of tannin in the leaves, twigs, bark, wood, or fruit. Tannins can also be found in a variety of plants utilized for food and feed including food grains (sorghum, millets, barley, dry beans, faba beans, peas, carobs, pigeonpeas, winged beans, and legumes), fruits (apples, bananas, blackberries, cranberries, dates, grapes, peaches, pears, plums, raspberries, and strawberries), and in wines, teas, and forages. Tannic acid is affirmed as Generally Recognized as safe (GRAS) by the Food and Drug Administration (FDA) for use as a direct food additive (with limitations) in numerous food and beverage products. Tannin, orally administered to rabbits, was absorbed by the gastrointestinal tract, metabolized, and excreted within 24 hours. It has low acute, subchronic, and chronic oral toxicities in animal studies, and is nonmutagenic and noncarcinogenic. In a teratologic evaluation of tannic acid on rats and mice, no effects on nidation (implantation), maternal or fetal survival, or abnormalities in soft or skeletal tissues were seen at dosages of up to 135 mg/kg body weight/day (mice) and 180 mg/kg body weight/day (rats) for ten consecutive days during pregnancy. In addition, a three generation rat reproduction study of 60 mg/kg body weight/day and 117 mg/kg body weight/day (lower pup weights at weaning), had no effects on fertility, gestation, viability, or lactation indices at any dose level (http://www.epa.gov/opprd001/inerts/tannin.pdf).

In view of the review presented above, it can be concluded that the *Acacia nilotica* is one of the medicinal plants which is being used to cure/control many diseases i.e. diarrhea, skin problems, dental caries, sexual disorders etc. Literature reports that pods are used in the form of decoction or powder as a traditional medicine to control the diabetes. Animal studies reports its role in the regulation of blood pressure and blood glucose levels without any toxic effect. Most of the studies are done on animals using leaves, barks and seeds of *Acacia nilotica* not on the pods of different maturity stages. Therefore, present study was conducted.

METHODOLOGY

The present investigation was carried out to find the effect of Indian Gum Arabic powder in the management of NIDDM subjects. The research procedure followed to achieve the foregoing objectives has been distinctly described under the following headings and subheadings.

3.1 Locale

3.2 Procurement of Gum Arabic pods

3.3 Chemical analysis of Gum Arabic pods

3.4 Intervention of Gum Arabic pods powder to diabetic subjects

3.4.1 Selection of subjects

3.4.2 Development of tool

3.4.3 Collection of data

a) General profile, health habits and the disease information

b) Food intake

c) Anthropometric measurements

d) Body composition

e) Blood glucose

f) Lipid profile

g) Blood pressure

3.4.4 Administration of pods powder

3.5 Experience and opinion of the subjects regarding intervention of Indian Gum Arabic pods powder

3.6 Data analysis

3.1 Locale:

The study was conducted in Udaipur city of Rajasthan. The Gum Arabic pods for analysis and intervention were collected from Udaipur. Nutrient analysis was done at laboratories of College of Home Science, Rajasthan College of Agriculture (MPUAT) and laboratory of Hindustan Zinc Smelter, Debari, Udaipur.

3.2 Procurement of Gum Arabic pods:

The pods of Gum Arabic (desi babul) were harvested from the campus of Maharana Pratap University of Agriculture and Technology and Mohan Lal Sukhadia University, Udaipur. The pods for the intervention and chemical analysis were plucked from ten to twelve trees of Gum Arabic in the month of February. The fruiting time of Gum Arabic is always after the flowering in the month of October-November, although it is possible to have three flowerings in a year at the beginning of each season (Audru et al, 1996). The fruiting time of Gum Arabic is of seventy five to eighty days. There is a change in the nutrient composition of legumes with maturation (Chavan et al, 1999). Therefore, about 750 g of pods at each of maturity stage i.e. premature (pod initiation), seed developing (physiological maturation) and mature (harvestable) were harvested for chemical analysis (Plate 3, 4 and 5). The inedible portion such as leaves, stems and dust were removed from the pods. The pods were dried in open shade separately and powdered in electrical mixer cum grinder for chemical analysis.

The premature pods are best for the use as medicine, as per the literature reported in Ayurveda (Garg et al, 1998). The premature legumes contain more amounts of secondary metabolites and minerals which may be beneficial for diabetic subjects. Five kilograms of premature pods were harvested for the intervention. After removing stems, leaves and dust the pods were dried on muslin cloth in open shade to retain the color and avoid any change in chemical composition due to sun rays. The pods were turned 2-3 times in a day so that it gets dried from all the sides. The pods became brittle after ten days. The brittleness was checked by breaking pods with hands. Dried pods were powdered in an electrical mixer cum grinder and stored in glass bottles (Plate 6). The bottles were kept in the refrigerator.

3.3 Chemical analysis of Gum Arabic pods:

Nutrient and secondary metabolites which help directly or indirectly in the management of diabetes were analysed using the standardized methods.

3.3.1 Proximate principles:

a) Moisture: Moisture is an important constituent of all foods. It is essential to determine the moisture to express the nutrients estimated on moisture free basis.

Procedure: Fresh sample of pods was weighed in a previously weighed petridish in triplicate and the sample was dried in an oven (Yorcko) at 60°C and cooled in a dessicator and weighed. The process of heating and cooling was repeated till a constant weight was achieved (NIN, 1983).

The moisture was calculated as under:

$$\text{Moisture (\%)} = \frac{\text{Initial Weight (g)} - \text{Final Weight (g)}}{\text{Weight of sample taken (g)}} \times 100$$

b) Crude Protein: protein was estimated in powdered moisture free samples using micro Kjeldhal method. The protein nitrogen is converted into ammonium sulphate by boiling with concentrated sulphuric acid. It is subsequently decomposed by addition of excess of alkali and the liberated ammonia is absorbed into boric acid solution containing an indicator by steam distillation. Ammonia forms a loose compound, ammonium borate with boric acid, which is titrated directly against standard HCL. The protein content of dried pods was obtained by estimating the nitrogen content of the pods and multiplying the nitrogen value by 6.25 (NIN, 1983).

i) Digestion- Hundred mg of sample in triplicate was digested in a micro Kjeldhal flask with 2 ml concentrated H2SO4 and 0.5g digestion mixture (98 parts K_2SO4 + 2 parts CuSo4) on a digestion rack till a clear solution was obtained. A reagent blank was run simultaneously.

ii) Distillation- This was carried out by adding 10 ml of 40% NaOH to the digested samples, which were then boiled. The steam liberated as ammonia was collected in a conical flask containing 5 ml of boric acid (4%) with 2 drops of mixed indicator till the distillate collected was about 15 ml.

iii) Titration- The content of the conical flask was titrated with 0.02 N standardized HCL till an end point of pink colour was reached. The ml of HCL used was noted as the titer value and calculation was done as follows:

- Titer value of sample – titer value of blank = x
- $$\text{Total Nitrogen \%} = x \times \frac{\text{Normality of HCL} \times 14 \times 100}{\text{Weight of the sample}} \times 100$$
- Protein = Total nitrogen % × a general factor 6.25

c) Ether extract: Fat was estimated as the crude ether extract of the dry pods powder. Crude fat was estimated using Soxhlet's method.

Procedure: A 5 g moisture free sample in triplicate was wrapped in whatman No. 41 filter paper of 10x10 cm in such a way that during extraction the sample does not come out. The packet was placed in the extracting tube of soxhlet's apparatus. An empty round bottom flask was weighed and filled three fourth with petroleum ether (40°-60° C). The flask was kept on heating mantle and then connected with extractor. The flask was heated for about 16 hours which ensured complete extraction of fat. Then the flask was disconnected and the ether was evaporated. The flask was cooled and weighed. The difference in initial and final weight of the flask was calculated to find out the fat content. The fat content was calculated as under.

$$\text{Crude fat (\%)} = \frac{\text{Weight of fat (g)}}{} \times 100$$

Weight of sample (g)

d) Ash: The ash of the food stuffs is an inorganic residue remaining after the organic matter has been burnt away. It is a measure of the total mineral content of the food.

Procedure: Five gram moisture free sample in triplicate was placed in previously weighed crucibles (after heating to about 600° C and cooling). The crucible was then heated over low flame till the material was completely charred, followed by heating in a muffle furnace (Yorcko) at 600° C for about 3-5 hrs. It was then cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weights were obtained and the ash was almost white. The ash content was calculated as under:

$$\text{Ash (\%)} = \frac{\text{Weight of the ash (g)}}{\text{Weight of the sample (g)}} \times 100$$

e) Crude fibre: Fibre is an insoluble vegetable matter which is indigestible by proteolytic and diastic enzymes and cannot be utilized by the human body. It is usually composed of cellulose, hemicellulose and lignin.

Method: A 3g of moisture and fat free sample in triplicate was weighed into a 500ml beaker. About 200 ml of boiling 0.25 N sulphuric acid was added to it. The mixture was boiled for 30 minutes and the volume was kept constant by adding water at frequent intervals. This mixture was filtered through a muslin cloth and the residue was washed with hot water till free from acid. The residue was then transferred to the same beaker and 200 ml of 1.25% NaOH was added. After boiling for 30 minutes as earlier, the mixture was filtered again through muslin cloth. The residue was washed with hot water till free from alkali followed by washing with 50 ml alcohol and 50 ml ether. It was then transferred to a crucible of known weight and dried overnight at 80°-100° C. The crucible was heated in a muffle furnace at 600° C for 2-3 hours cooled and weighed. The difference in weight represents the weight of the crude fibre (NIN, 1983). The fibre content was calculated as under:

$$\text{Crude fibre (\%)} = \frac{\text{Weight of the residue (g)- weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

f) Total carbohydrates: The amount of total carbohydrates was calculated by subtracting the sum of moisture, crude protein, crude fat, ash and crude fibre from 100 (Gopalan et al, 1994).

g) Energy: It was calculated by using physiological fuel values i.e. 4, 9, 4 kcal per gram for protein, fat and carbohydrates respectively.

3.3.2 Minerals: The minerals iron, zinc, calcium, sodium, potassium, copper, manganese, magnesium, and chromium were estimated in pods powder through atomic absorption spectrophotometer. Phosphorous was estimated using the method given by Fisher (1971). Sample were processed using wet digestion method which postulates that organic matter in food materials (solid) can be oxidized by boiling with sulphuric, perchloric and nitric acid.

Procedure: Accurately weighed 0.5 g of finely ground, moisture free sample were taken in 100 ml Kjeldhal flask. To each tube added 25 ml of triacid mixture i.e. concentrated nitric acid, perchloric acid and sulphuric acid in the ratio of 3:2:1. The tubes were left overnight for the brown fumes to be given off. After this the sample were digested with the help of digestion rack at the temperature of 90° C till the sample were cleared, then the sample were allowed to cool. The solution was then transferred to acid washed polythene bottles and stored till used for mineral analysis. The digested cool samples were transferred into 50 ml volumetric flask and the volume made up to 50 ml by double distilled water. A blank was simultaneously run along with the samples. Representative sample in the liquid form was sprayed into the flame of the atomic absorption spectrophotometer and the absorption or estimation of the mineral was measured at the specific wave length set for each mineral. The values were read against standard solution of each mineral.

Phosphorus: This mineral was analyzed using the method of Fisher (1971) for total phosphorus in pods powder. The method involves treatment of sample solution with ammonium molybdate which produces phosphomolybdic acid. This is reduced by the addition of hydroquinone reagent to give blue color which is propotional to the amount of phosphate present in the solution.

Procedure: An aliquot of 0.2 ml was drawn from the mineral solution (wet digestion) and diluted to 1 ml with distilled water. Added 2 ml of ammonium molybdate, 1 ml of hydroquinone (05%) and 1 ml of sodium sulphite (20%) solutions to all the tubes and the contents were thoroughly mixed. The volume was made up to 10 ml with water. The blue color developed was read at 660 nm on the spectrophotometer after 30 minutes. Similarly aliquots of standard potassium dihydrogen orthophosphate solution were prepared having 5.25 µg /ml and read against water blank. The standard graph was prepared and the concentration of phosphorus in test sample was calculated from this graph.

$$\text{Phosphorus (\%)} = \frac{\text{Unknown concentration from standard curve} \times 0.01 \times 50}{2 \times \text{weight of sample (g)}} \times 100$$

3.3.2 Secondary metabolites:

a) Total phenol (Waterman et al, 1994**)**: Total phenol was estimated by Folin-Ciocalteau method. Phenol reacts with phosphomolybdic acid in Folin- Ciocalteau reagent in alkali medium and produce blue colored complex (molybdnum blue).

Preparation of extract: Ethanol extract of pods was prepared for the estimation. Five gram of sample weighed in triplicate for extraction. Samples were ground in Pestle-Mortar in 10-50 ml of 80 per cent ethanol. Then samples were centrifuged at 10,000 rpm for 20 minutes and supernatants were collected in separate flask for estimation. Re-extraction of the residue was done with ethanol to collect the remaining substance. The supernatants were evaporated in boiling water bath to get dryness. The dry residuals were dissolved in 5 ml of distilled water.

Preparation of standard graph: Standard solution of catechol (0.1%) was prepared. Standard catechol (0.4-2ml) was drawn in test tubes (triplicate) and volume of each tube to 3 ml. was made up with distilled water. Simultaneously 0.5-1.0 ml. test solution in triplicate was taken in test tubes and volume made up to 50 ml by distilled water. Folin-Ciocalteau reagent (0.5 ml.) was added in each test tube and after shaking the all test tubes were kept for three minutes at ambient temperature. Two ml of 20 per cent sodium carbonate was added in each tube. After proper mixing tubes were placed in boiling water bath for one minute. Then absorption was read at 650 nm against a blank reagent.

b) Tannin: Tannin in food stuffs can be estimated using vanillin hydrochloride method. The vanillin reacts with any phenol that has a un substituted resorcinol or phloroglucinol nucleus and forms a colored substituted product which is measured at 500 nm (Jain and Mogra, 2006).

Preparation of extract: The ethanol extract of pods were prepared for the estimation. One gram ground sample was soaked in 50 ml ethanol for tannin extraction. It was mixed occasionally. After 20-28 hours, it was centrifuged at 2500 rpm for 20 minutes then supernatant was collected for further estimation.

Preparation of standard graph: Catechin (1 mg /1 ml methanol) was used as a standard solution. Ten ml of standard solution was diluted with 100 ml methanol for making working standard. Working standard (0.1-1 ml) and 1 ml extract in triplicate was drawn in a series of test tubes. 5 ml vanillin hydrochloride was added in each test tube. One blank is also prepared with 5 ml vanillin hydrochloride. After twenty minutes optical density was read at 500 nm. The standard curve was prepared and the concentration of tannin in the sample extract was calculated from the curve.

3.4. Intervention of Gum Arabic pods powder to diabetic subjects:

3.4.1 Selection of subjects: A camp was organized at Government Ayurvedic Hospital, Sundarwas, Udaipur to select diabetic patients. Seventy diabetic patients were enrolled in the camp. From them forty five subjects were selected on the basis of the following criteria:

- Who were in the age range of 45 -65 years.
- Can be of either sex.
- Suffering from diabetes from at least six months.
- No biochemical evidence of any other known disease.
- Willing to participate in the study and available through out the study period at Udaipur.

3.4.2 Development of tool: An interview schedule (Appendix I) was developed and pretested to collect the information on general profile, health habits, the disease, food intake, anthropometric measurements, body composition, blood glucose, lipid profile and blood pressure.

3.4.3 Collection of data on: The written consent (Appendix II) from the subjects was taken before starting the data collection after explaining in detail about the study. The data was collected by interviewing the subjects at the hospital premises. Food intake, anthropometric measurements, body composition, blood glucose, lipid profile and blood pressure were assessed after standardizing the technique before and after the intervention of pods powder.

a) General profile, health habits and about the diabetes:

About the families:

- Family type: It was collected in terms of nuclear and joint family.
- Nuclear family: A family was considered as nuclear when husband and wife with their children were sharing one kitchen with or without one dependent member (Desai, 1956).
- Joint family: A family was considered as joint, where more than one spouse was sharing a common kitchen with or without their children (Desai, 1956).
- Family size: It was operationally defined as a total number of members living in the family and sharing the same kitchen.
- Family income: It was the total income of the family earnings by the members and income from other sources such as agriculture, house rent and money interest.

About the subjects:

- Age: As told by subject was noted and confirmed by calculating age from date of birth.
- Food habits: It was noted as vegetarian, non-vegetarian and ovo-vegetarian.

- Educational level: Level of education was assessed in terms of illiterate, literate, primary, middle, secondary, graduate, post graduate and professional degree /certificate.
- Occupation: Occupation of the subjects was also noted.
- Marital status: It was recorded as married, unmarried and widow/ widower.

Health habits: Habit of smoking and drinking alcohol, tea or coffee in large amounts may increase the risk of diabetes, therefore, information regarding frequency of these health attributes as never, daily, weekly and occasionally was collected for each subject. Regular exercise regime forms the corner stone of treatment and prevention of type 2 diabetes mellitus especially when disease is diagnosed early in its course when blood sugar levels are only mildly to moderately elevated (John, 2002).Therefore, information regarding type, duration and frequency of health habits as never, daily, weekly or occasionally was collected from each member of the study group.

About the diabetes: Age of onset and date of diagnosis were collected. Type of treatment taken by the NIDDM subjects to manage the disease was enquired in terms of dietary modifications made, oral hypoglycemic drugs used and physical exercise done, alone or in combination to manage the disease was noted down.

b) Food intake: Dietary survey was carried out by 24 hours recall method using standardized cup set for two days to assess the food and nutrient intake at beginning and at the end of the study period. The methodology followed is described below:

Raw quantity taken for cooking as well as the cooked quantity prepared especially for the subjects or the whole family and consumed by the subject was noted. The consumption of the cooked food by the subject was recorded to find out the quantum of raw food intake. Raw and cooked amounts were quantified either in terms of household measures (standardized cup set) or by weight or number (Plate 7). From these cooked and raw amounts of food, the raw amount consumed by each subject was calculated by using a calculator using the following formula:

$$\text{Raw amount of a particular food stuff consumed by the individual from a preparation (g)} = \frac{\text{Individual intake of cooked amount of the preparation} \times \text{Total raw quantity of food stuff used in the preparation (g)}}{\text{Total cooked quantity of the preparation (g)}}$$

The raw quantity of flour used in the preparation of a chapati was assessed by the number of chapaties prepared per kg of flour or the flour used by the family in the household measures. This value was then multiplied by the number of chapaties consumed by the subject to find out the raw amount of flour consumed by the subject. The intake of different food groups was then calculated and compared with the balanced diet (NIN, 1998) for normal sedentary worker as there was no separate recommendation for diabetic patients.

Nutrient intake was calculated using food composition tables (Gopalan et al, 1994) from a computer programme developed by Choudhry et al (2001) in a DBMS package. Mean intake of nutrients was compared with Recommended Dietary allowances for adult male/ female (ICMR, 1994) and suggested modification in energy requirement for diabetics (Raghuram, 1996).

c) Anthropometric measurements: It provides information on gross body size, skeletal form or configuration and on skeletal and soft tissue development. These methods are noninvasive, inexpensive, universally applicable and reflect nutritional and health status. Following measurements were taken for each subject and body mass index and waist hip ratio were calculated.

Weight (Jelliffe, 1966): It is a measurement of body mass and is the most in use. It also provides a wide evaluation of overall fat and muscle stores. For healthy adults, increase in body weight usually but not always indicate an increase in body fatness (Robinson et al 1988).

Technique: A platform spring balance was used for measuring weight. The subjects were asked to stand in the center of the platform bare feet, with minimum clothes and without touching anything else. Weight was recorded to the nearest of 0.25 kg (Plate 8).

Height (Cameron, 1978): It is a linear measurement made up of sum of four components-legs, pelvis, spine and skull. While, for detailed studies of body proportions all these measurements are required whereas, in field nutritional anthropometry only total height is measured (Jellife, 1966).

Technique: Height of a subject was measured using a vertical anthropometric rod (Plate 9). After removing shoes and socks the subject was asked to stand on a horizontal platform with heels together and hands hanging by the sides. The anthropometric rod was positioned behind the subject so that the lower end stands between the heels and the beam passes vertically between the buttocks touching the back of the head. The subject was made to look straight and it was ensured that the inferior orbital margin and the tragus of the ear fall in the same horizontal plane parallel to the ground. The head piece of the rod which consisted of a metal bar was gently lowered touching the hair and making its contact with the top of the head. Height was recorded to the nearest of 1 mm.

Body Mass Index (BMI): It accounts for differences in body composition by defining the level of adiposity according to the relationship of weight to height, thus eliminating dependence on frame size (Stensland and Margolis, 1990).

Technique: The body weight and height were taken as described above. To obtain the body mass index weight in kg was divided by the height in meters square as follows:

$$\text{BMI kg/m}^2 = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

Waist and Hip Circumference (Despress et al, 1997): With the recognition of fat distribution as an indicator of risk, circumferential or girth measurement has been ascribed importance. The most frequently used measure of adiposity is the waist to hip ratio.

Technique: The circumferences were measured using a non-stretchable and durable plastic tape at specific sites of waist and hip (Plate 10 and 11), Waist circumference was measured at the waist over the greater trochanters. The subjects were asked to stand erect with the weight distributed equally on both the legs. After the subjects breathed lightly waist was measured at the end of gentle expiration. The readings were made with an accuracy of ± 0.1 cm.

Waist Hip ratio: It differences between android and gynoid obesity. A WHR of greater than 0.85 in woman and 1.0 in man is indicative of android obesity and increased risk for obesity related diseases (WHO, 2000). It was calculated as follows:

$$\text{WHR} = \frac{\text{Waist circumference (cm)}}{\text{Hip circumference (cm)}}$$

d) Body composition: Body composition topology is related to several diseased conditions and predominantly with the heart disease and diabetes (Sowers et al, 2000). Therefore, various body composition parameters viz. body fat, lean body mass (LBM), total body water (TBW), intracellular water (ICW), extracellular body water (ECW), body cell mass (BCM) were analyzed using body composition analyzer "Bodystat Quadscan unit 4000" working on the principle of bioelectrical impedance.

Principle (Scheltinga et al, 1991): Bioelectrical impedance analysis, or BIA, is considered as one of the most exact and accessible method of screening body fat. Body's lean compartment, comprising approximately 73% electrolytic water conducts electricity for better than the body's fat compartment, which is very low in body water content (between 5-10%). These two compartments have, therefore, very different impedance (or resistance) values to a high frequency electric current. The high electrolytic water content in the lean compartment makes it a good conductor of current and this yields low impedance. For converse reasons, the fat compartment is a bad conductor with high impedance to the high frequency current. The impedance measurement therefore reflects the degree of resistance to the flow of current in the body, water being a good conductor but fat a bad conductor. A tiny torch operated electrical current is sent through the supine body via electrodes attached to the right foot and hand. During the procedure the impedance value, which is related to the subject's body fat and lean proportions, is registered on the quadscan 400 LCD display screen along with the impedance values at 5100 and 200 kHz and the details of ECW, ICW etc. These numbers, together with other details of age, height, weight and gender are used by the regression equations to analyze the data and within seconds produce a comprehensive personal body composition report.

Technique (Bodystat Ltd, 2000): The subjects were pre informed not to eat or drink 4-5 hours prior to the test, not to exercise 12 hours prior to the test and not to consume alcohol or caffeine 24 hours prior to the test, while performing to the test, the subject was asked to lie down in supine position in such a way that no part of the body was touching one another (Plate 12). The quadscan unit is provided with two sets of electrodes. Each set of electrodes has red and black leads. The red lead of one set was attached on behind the knuckles and black lead on the wrist next to the ulnar head on the right hand with the help of crocodile clips. The other set of electrodes was attached on the right foot with red lead placed behind the toes and black lead on the ankle at the level of and between the medial and lateral malleoli (the large protruding bones on the sides of the ankle). Thereafter, the quadscan 4000 unit was switched "ON". The subject data i.e. age, gender, height, weight, activity, waist and hip circumference were entered. Subject was asked to remain in supine position for approximately 4/5 minutes. Enter key was then pressed to perform the measurements. Results were displayed on the LCD screen and thereafter electrodes were removed by disconnecting the crocodile clips. Subject was then allowed to sit or stand up. The unit was switched "OFF". The same procedure was followed for each one of the subjects. Later the results on following body composition parameter were downloaded using a software programme of bodystat quadscan.

Body fat: Body fat is the amount of fat in a person's body. It reflects both essential fat and storage fat. Essential fat is that amount necessary for maintenance of life and reproductive functions. Storage fat consists of fat accumulation in adipose tissue, part of which protects internal organs in the chest and abdomen (http://en.wikipedia.org/wiki/Body_fat_percentage).

Lean body mass: All body tissue except storage fat is lean body mass. It is made up of structural and functional elements in cells, body water, muscle and other body organs such as heart, liver and kidney (Ferrario et al, 1995).

Total body water: Total body water is all the water in the body including water inside and outside the cells including water in the gastrointestinal and urinary tracts (http://en.wikipedia.org/wiki/ Body_water_percentage). TBW is distributed in two major compart-ment or spaces based on differential concentration of the two major cations, sodium and potassium. The two compartments are intracellular water (ICW) and extracellular water (ECW).

Intracellular water: It designates the liquid contained inside the cell membranes, usually containing dissolved solutes and constituents 73 per cent of the weight of metabolically active cells of muscle and viscera (Johnson, 1992).

Extracellular water: Extracellular water consists of water component of the extracellular fluid, plasma, intestinal fluid and the water component of extracellular solids including tendon, fascia, dermis, collagen, elastin and skeleton. It chiefly consists of protein and electrolytes (Johnson, 1992).

Body cell mass: The total mass of all the cellular elements in the body which constitute all the metabolically active tissue of the body is defined as body cell mass (BCM). The BCM includes muscle tissue, organ tissue, intracellular and extracellular water and bone tissue. In normally nourished individual, muscle tissue accounts for 20 per cent of BCM, with the remaining 20 per cent made up of red cells and tissue cells. The BCM also contains the large majority (98-99%) of the body's potassium (Med terms medical dictionary, 2004).

e) Blood glucose: Fasting and post prandial blood samples before and after intervention were taken. Post prandial blood sample were analysed after two hours of the ingestion of breakfast at zero day and pods powder and breakfast after twenty eighth days (± 2 days) of intervention. The capillary blood samples were estimated using glucometer (One touch ultra).

f) Lipid profile: Lipid profile was analyzed at zero and twenty eighth day (± 2 days) of intervention using the facilities of pathology laboratory of General hospital, Udaipur. Serum cholesterol, serum triglycerides and high density lipoprotein were estimated by enzymatic methods using estimation kits. Low density lipoprotein and very low density lipoprotein were calculated by using standard formula from the analysed values of lipid profile parameters. Three ml of venous blood was drawn using disposable syringe and transferred to vial for analysis (Plate 13).

Serum cholesterol: Body fat pattern has been reported to be strongly associated with lipid concentration with an upper or central predicting higher concentration of cholesterol.

Principle: The absorbance of chromophore is directly propotional to the cholesterol concentration in the sample.

$$\text{Cholesterol esters} \xrightarrow{\text{CHE}} \text{Cholesterol} + \text{Fatty acid}$$

$$\text{Cholesterol} + O_2 \xrightarrow{\text{CHO}} \text{Cholest-4-en-3-one} + H_2O_2$$

$$2H_2O_2 + \text{4- Aminoantipyrene} + \text{Phenol} \xrightarrow{\text{Peroxidase}} \text{Red Quinoeimine} + H_2O$$

CHE = Cholesterol esterase

CHO= Cholesterol oxidase

Assay procedure: The serum total cholesterol was determined by enzymatic ERBA test given by Allain et al (1974). The reagents were brought to room temperature prior to use.

Pipette into tube marked	Blank	Standard	Sample
Working reagent	1000 µl	1000 µl	1000µl
Distilled water	20 µl	-	-
Standard	-	20 µl	-
Sample	-		20 µl

The contents of each test tube were mixed well, incubated at 37°C for 10 min. and absorbance was noted using spectrophotometer at 510 nm.

Serum triglyceride: The serum triglyceride was estimated by spectrophotometer using enzymatic kit as described by Jacobs & Denmark (1991).

Principle: Triglyceride in the samples was hydrolysed by lipoprotein lipase to glycerol and free fatty acids. Glycerol is phosphorylated by ATP to glycerol -3- phosphate (G-3-P) in are action catalyzed by glycerol kinase. G-3-P is oxidized to dihydroxy acetone phosphate (DHAP) in a reaction catalyze by the enzyme glycerol phosphate oxidase (GPO). In this reaction hydrogen peroxide is produced in equimolar concentration to the level of produced in equimolar concentration to the level of triglycerides present in sample. H_2O_2 react with 4-aminoantipyrine and 3, 5, dichloro-2-hydroxy benzene sulphonic acid (DHBS) in a reaction catalyzed by peroxide. The results of this oxidative coupling is a quinoneimine red colored dye. The absorbance of the dye in solution is propotional to the concentration of triglycerides in the sample.

$$\text{Triglyceride} + H2O \xrightarrow{\text{Lipoprotein lipase}} \text{Glycerol + Fatty acids}$$

$$\text{Glycero + ATP} \xrightarrow{\text{Glycerol kinase}} \text{Glycerol-3-phosphate +ADP}$$

$$\text{Glycerol-3-phosphate} + O_2 \xrightarrow{\text{Glycerol Phosphate oxidase}} \text{Dihydroxyacetone phosphate} + H_2O_2$$

$$H_2O_2 + \text{Phenolic chromogens} \xrightarrow{\text{Peroxidase}} \text{Quinoneimine} + H_2O_2$$

Assay procedure: The serum triglyceride was determined by enzymatic ERBA-test. The reagents were brought to room temperature prior to use.

Pipette into tube marked	Blank	Standard	Sample

Working reagent	1000µl	1000µl	1000µl
Distilled water	10µl	-	-
Standard	-	10 µl	-
Sample	-		10 µl

The content of each tube were mixed well, incubated at 37°C for 10 min. and absorbance was noted using spectrophotometer at 510 nm.

HDL Cholesterol:

Principle: Chylomicrons, LDL and VLDL (low and very low density lipoproteins) are precipitated from serum by phosphotungstate in the presence of divalent cation such as magnesium. The HDL cholesterol remains unaffected in the supernatant and is estimated using ERBA cholesterol reagent as described by Miller (1971).

$$\text{Serum / plasma} \xrightarrow[\text{Mg++}]{\text{Phosphotungstate}} \text{HDL fraction} + \underset{\text{(precipitate)}}{\text{(LDL+VLDL+ chylomicrons)}}$$

For Precipitation of LDL, VLDL and chylomicrones

Pipette	Volumes
Test sample	250 µl.
Precipitant reagent	500µl

Mix well and allow the reaction mixture to stand for 10 min. at room temperature centrifuge at 4000rpm for 10 min to obtain clear supernatant. Supernatent was used to determine the concentration of HDL-C in sample.

Assay procedure:

Pipette into tube marked	Blank	Standard	Sample
Working reagent	1000µl	1000 µl	1000 µl
Distilled water	20µl	-	-
HDL-C	-	20µl	
Supernatant			20µl

The content of each test tube was mixed well, incubated for 10 min. at 37°C, or 12 min. at 30°C and absorbance was not from spectrophotometer at 505 nm.

LDL Cholesterol: LDL cholesterol is calculated by using Friedewald's et al (1972) equation.
Total cholesterol – (HDL +TG/5)
Provided TG levels are <400 mg/dl

VLDL Cholesterol: VLDL is present in a concentration equal to one fifth of triglyceride concentration. This assumption is valid for triglyceride concentration of <400 mg/dl. VLDL was calculated by using following formula of Fridewald et al (1972).

VLDL (mg/dl) = TG/5

g) Blood Pressure (mm Hg): Hypertension (> 120/ 90 mm Hg) seems about twice as frequently in people with diabetes than in general population. The combined presence of hypertension and diabetes considerably accelerates the development of both macro vascular and micro vascular diabetes complications. Therefore levels of blood pressure were analysed for each of the subject.

Technique: Blood pressure is defined as the lateral pressure exerted by blood on vessels wall while flowing through it (Chatterjee, 1976). The instrument for measuring it was mercury sphygmomanometer which consists of rubber bag connected by rubber tubing, bag supported by a cloth cuff to be placed around the upper arm, bulb, manometer and a stethoscope (Plate 14). The cloth cuff was wrapped around the arm and then inflated with air to compress the brachial artery. Then with the stethoscope placed on the skin above the bend in the elbow, the air pressure in the cuff was slowly released. The first sound was heard as the brachial artery begins to open, it was caused by the blood coming into the forearm in spurts and hitting the stationary column of the blood. The level of the mercury column on manometer gauge at that point was recorded as systolic pressure. The level of mercury column at which the sounds become faint and die away was recorded as diastolic pressure. The normal blood pressure recommended for an adult are: systolic 120-130 mm Hg and diastolic 80-90 mm Hg (Chatterjee, 1976).

3.4.4 Administration of pods powder:

Selected forty five subjects were randomly divided into three experimental groups to determine the most effective dose. Packets (420×3) of 2, 3 and 4 g of pods powder were prepared for all the subjects for four weeks. A dose of 2, 3 and 4g/day were given to the subjects of groups I, II and III respectively for a period of four weeks. The doses were decided as suggested in the literature of Ayurveda (Garg et al, 1998). All the patients were asked to take the prescribed dosage before breakfast and to follow their routine diet and activity pattern throughout the investigation period.

Details	**Groups**		
	I (n=15)	II (n=15)	III (n=15)
Dose/day (g)	2	3	4
Duration of intervention (weeks)	4	4	4
Assessment of diet and nutritional profile	Pre and post	Pre and post	Pre and post
Fasting and post prandial blood glucose	Pre and post	Pre and post	Pre and post
Lipid profile	Pre and post	Pre and post	Pre and post

Distribution of the pods powder: In all 1260 packets 420 each of 2, 3 and 4 g were prepared and distributed to the subjects in two installments. The follow up from the subjects was taken through the telephonic conversation and personal meeting at the hospital to ensure the regular intake of the pods powder and any side effect observed by the subjects.

3.5 Experience and opinion of the subjects regarding intervention of Indian Gum Arabic pods powder:

An interview schedule (Appendix IV) was developed to gather the information on their experience and opinion of taking Gum Arabic pods powder. The information was collected after the completion of intervention.

3.6 Data analysis:

The data on religion, caste, family type and size, food habits, age, educational level, marital status, family income, health habits, family history, information about diabetes, management of the disease and food consumption pattern was expressed as frequencies and percentages. Mean±SD values of chemical composition of pods, anthropometric measurements such as weight, height, BMI, waist circumference, hip circumference, WHR and body composition were calculated. Mean±SD were also calculated for food and nutrient intake and compared with Balanced diet and RDA and suggested modifications in energy for diabetes respectively. ANOVA was calculated to test the significant difference between the chemical compositions of Gum Arabic pods at different maturity stages. Paired't' test was used for testing the significant difference between blood glucose levels, lipid levels, blood pressure anthropometric measurements, body composition, food and nutrient intake before and after intervention.

RESULTS

The present study was undertaken to determine the effect of *Acacia nilotica* pods powder in the management of NIDDM. The results obtained during the course of investigation are presented under the following heads:

4.1 Chemical analyses of Indian Gum Arabic Pods

4.2 Profile of diabetics selected for intervention

4.2.1 General profile of the subjects and their family
4.2.2 Health habits of the subjects
4.2.3 Information about the disease

4.3 Effect of Indian Gum Arabic pods powder intervention on

4.3.1 Meal pattern and dietary habits
4.3.2 Food and Nutrient intake
4.3.3 Anthropometric measurement and indices
4.3.4 Body composition
4.3.5 Blood glucose
4.3.6 Lipid profile
4.3.7 Blood pressure

4.4 Experience and opinion of the subjects regarding intervention of Gum Arabic pods powder

4.1 Chemical analyses of Indian Gum Arabic pods

The chemical components present in premature, seed developing and mature pods of Indian Gum Arabic were analysed. The proximate principles (moisture, protein, ether extract, fibre and ash) and minerals (iron, calcium, phosphorus, sodium, potassium, zinc, magnesium, copper, manganese, and chromium) were analysed in triplicate. The total carbohydrate and energy were calculated. Two secondary metabolites i.e. total phenol and tannin were also analyzed. The chemical constituents were analyzed on dry weight basis and calculated on fresh weight basis also. The results are presented in Tables 8 to 11.

4.1.1 Proximate principles

a) Moisture: Premature pods contained the highest amount of moisture on dry (8.0%) and fresh (60.0%) weight basis. The F value revealed a significant difference ($P \leq 0.01$) in the moisture content among premature, seed developing and mature pods on dry as well as fresh weight basis (Tables 8 and 9). CD values showed that the moisture content of premature pods was significantly higher than the mature pods. The difference was insignificant in moisture content between the premature and seed developing pods. Similarly Chavan et al (1999) also reported the decreasing trend in the moisture content of beach pea with maturity.

b) Crude Protein: The protein content of pods on dry weight basis ranged from 11.57 (premature pod) to 12.63 per cent (mature pod) and on fresh weight basis 4.65 (Premature pod) to 6.23 per cent (mature pod); (Tables 8 and 9). Similarly Carter (1988) reported 12.30 per cent protein in the pods of *Acacia nilotica*. Barman and Rai (2004) reported 13.2 g per cent protein in pods of *Acacia nilotica*. There was no significant difference in protein content amongst three stages of maturity on dry as well as fresh weight basis. This may be due to the reason that the protein present in envelops of pods at premature stages may be utilized for the formation of seeds at the mature stage.

c) Ether Extract: The value of ether extract ranged from 0.57 (premature pod) to 1.11 per cent (mature pod) on dry weight basis and 0.23 (premature pods) to 0.61 per cent (mature pods) on fresh weight basis. The ether extract increased with maturity ($P \leq 0.01$) in dry as well as fresh weight basis. The CD values revealed that mature pods contained significantly higher amount of ether extract than seed developing and premature pods on dry as well as fresh weight basis. However, ether extract between premature and seed developing pods were not significantly different (Table 8). The ether extract values of the present study are comparatively lower than the values (1.93%) reported by Carter (1988) in *Acacia nilotica* pods. The difference in the values may be due to the geographical area and condition under which the crops are grown.

d) Crude fibre: The fibre content at three stages of maturity were 10.41 (premature pod), 10.66 (seed developing pod) and 12.53 g per cent (mature pods) on dry weight basis (Table 8). The fibre content ranged between 4.16 (premature pod) to 5.72 per cent (mature pod) on fresh weight basis (Table 9). Similar results have been reported by Fagg (2001) that the *Acacia nilotica* pods contain 12-18 per cent of fibre. Carter (1988) also reported the presence of 15.36 per cent fibre in *Acacia nilotica* pods. The F value revealed the significant difference in fibre content at different stages of maturity on dry and fresh weight basis. Like ether extract the fibre content also increased significantly with maturity. The difference between the fibre content of premature and seed developing pods was non significant in dry as well fresh pods.

e) Ash: The premature pods contained the highest (5.29% dry weight and 2.08 g on fresh weight) amount of ash. The least amount (3.02 % dry weight and 1.46% fresh weight) was present in mature pods. The results of ash values are in harmony with the values (5.26%) reported by Carter (1988) in *Acacia nilotica* pods. The ash content was significantly ($P \leq 0.01$) different amongst three stages of maturity. CD values revealed that the ash content of premature pods was significantly different from seed developing and mature pods on dry as well as fresh weight basis whereas, the ash content was not significant between seed developing and mature pods on fresh weight basis (Tables 8and 9).

f) Total Carbohydrate : The carbohydrate values of premature, seed developing and mature pods were 64.16, 66.38 and 67.71 per cent respectively on dry weight basis (Table 8) and 28.88 (premature pod), 30.87 (seed developing pod) and 35.31 per cent (mature pod) on fresh weight basis (Table 9). Significant difference ($P \leq 0.01$) was found in total carbohydrate content at three stages of maturity. Mature pods contained significantly higher amount of carbohydrate than premature pods on both the basis but the carbohydrate content did not differ significantly between premature and seed developing stage.

g) Energy: The energy value was computed on the basis of the physiological fuel values of protein, fat and carbohydrate. On dry weight basis the energy content ranged between 307.80 (Premature pod) to 331.10 kcal/100g (mature pod; Table 8). Fresh pods at premature, seed developing and mature stage contained 116, 147.80 and 171.40 kcal/100g energy respectively (Table 9). Energy content was significantly different at all the three stages of maturity.

4.1.2 Minerals: The results of mineral and secondary metabolites analysis on dry as well as fresh weight basis in *Acacia nilotica* pods are given in Tables 10 and 11. The calcium and phosphorus were found with in the range of 120 (mature pod) to 161.80 ppm (premature pod) on dry weight basis and 56.00 (seed developing) to 83.23 ppm (mature pod) on fresh weight basis. The amount of zinc ranged between 31.05 (mature pod) to 56.05 ppm (premature pod) in dry pods and 14.90 (seed developing pod) to 22.42 ppm (premature pod) in fresh pods. The amount of magnesium for premature, seed developing and mature pods on dry and fresh weight bases was 18.20, 15.15, 11.67 and 7.28, 6.36 and 5.60ppm respectively. The premature pods contained 1ppm chromium followed by 0.74 in seed developing pods and 0.40 ppm in mature pods. It has been observed that the mineral content in *Acacia nilotica* pods decreased with maturity on dry as well as fresh weight basis ($P \leq 0.01$) except sodium. All the minerals i.e. iron, calcium, phosphorus, potassium, zinc, copper, magnesium, manganese and chromium were present in higher amount in premature pods as compared to seed developing and mature pods. CD values revealed that iron, calcium, phosphorus, potassium, zinc, copper, magnesium and chromium contents were significantly different between the stages of maturity but in fresh pods the difference was insignificant for iron and phosphorus between seed developing and mature pods. *Acacia nilotica* pods contain the higher amount of zinc and chromium as compared to broad beans, cluster beans, field beans and french beans (Gopalan et al, 1994).

4.1.3 Secondary metabolites: Total phenol and tannin were also analysed at different stages of maturity.

a) Total Phenol: Premature pods contained 31.31 mg/g, seed developing pods 20.0 mg/g followed by 16.0 mg/g total phenol in mature pods on dry weight basis (Table 10). On fresh weight basis values ranged from 7.68 (mature pod) to 12.52 mg/g (premature pod; Table 11). Phenol content differ significantly (P≤0.01) among premature, seed developing and mature pods on dry weight basis. CD values revealed that premature pods contained higher amount of phenol than seed developing and mature pods. Fagg (2001) also reported the presence of phenolic compounds in *Acacia nilotica* pods. The amount of total phenol in *Acacia nilotica* is higher than the amount present in faba beans (7.5-16.98 mg/g) as reported by Saharan et al (2002).

b) Tannin: Tannin content of *Acacia nilotica* pods ranged between 14.51 (mature pod) to 20.30 mg/g (premature pod) on dry weight basis (Table 10). On fresh weight basis the premature, seed developing and mature pods contained 8.12, 7.30 and 6.90 mg/g of tannin respectively (Table 11). A significant (P≤0.01) difference was observed in tannin content amongst three stages of pods on dry weight basis. CD values also showed the significant difference is tannin content at different stages of pods. Similarly, Kamal et al (2005) also reported the higher amount of tannin in premature pods. Tannin is also present in food grains (barley, dry beans, faba beans, pigeonpea etc.), fruits (apple, banana, date, grapes etc.), wines and teas. Tannic acid is affirmed as Generally Recognized as Safe (GRAS) by Food and Drug Administration (FDA) for human beings as a direct food additive in numerous food and beverages. Tannin orally administered to rabbits was absorbed by gastrointestinal tract, metabolized and excreted with in 24 hours. The dose of 135mg/kg body weight/ day (mice) and 180 mg/kg body weight/day (rats) have no side effects (http://www.epa.gov/apprdool/inerts/ tannin.pdf). Therefore, 2, 3 and 4 g of pods powder for intervention to human diabetic subjects will not have any side effect as these doses will contain 40.6 to 81.2 mg of tannin.

The above results reveal that the ether extract, carbohydrate, fibre and energy contents increased with maturity whereas, moisture, ash and minerals including i.e., iron, calcium, phosphorus, potassium, zinc, magnesium, manganese, copper, and chromium decreased with maturity. The results are in harmony with the study conducted by Shakra et al (2006) on the chemical composition of chick pea related to leguminous family. They reported that ether extract, carbohydrate and fibre increased with the maturity and moisture, ash and minerals decreased with the maturity in chick pea.

4.2 Profile of diabetics selected for intervention

Seventy NIDDM subjects visited the hospital on the day camp was organized to select the patient for feeding. Out of these patients, 45 patients, who fulfilled the criteria of selection and willing to participate in the study for four weeks and submitted written consent, were selected. The results are presented in Tables 12 to 30 and fig 1 to 10 and discussed below.

4.2.1 General profile of the subjects and their family: The group wise general profile of the subjects and their family (Tables 12 to 23) is discussed below :

a) Information about family:

- **Religion and Caste:** The distribution of the subjects by religion in three intervention groups revealed that majority of the subjects 91.1 per cent (86.6 % I, 86.6 % II and 100 % III group) were Hindu. Almost half (48.8%) of them were Brahmin, 28.8 per cent were Jain and remaining 22.2 per cent belonged to other castes i.e. Mathur, Sahu, Khan and others Tables 12 and 13).

- **Family type:** Majority (75.5%) of the subjects belonged to nuclear family (Table 14).

- **Family Size:** Table 15 reveals that the maximum number of the subjects (40%) in all the three groups was having family size of 4-6 members. The distribution of subjects by family size in three intervention groups was almost same.

- **Family Income and its major source:** Income of the families was ascertained by considering their income from different sources. Table 16 reveals that 44.4 per cent of the families were earning five to ten thousand rupees per month (46.6 % group I, 40.0 % group II and 46.6 % group III). About Twenty nine per cent were earning ten to fifteen thousand, 20.0 per cent families were earning more than fifteen thousand and remaining 4.4 per cent were earning less than five thousand. Government or private service was the main source of income among study groups (Table 17).

b) Information about the subjects: Information regarding the age, sex educational level, occupation, food habits, and marital status was collected from each subject and is presented in Tables 18 to 23 and the results are discussed below.

- **Age:** The onset of diabetes is related to the age of the subjects. Earlier i.e. 2-3 decades ago the disease used to occur during the age of 50-60 years and above. Now the disease occurs even in children and during the age of 40 years. The distribution of subjects by age in three groups of intervention reveals that most of the subjects in all the groups were in either 45-50 years or 60-65 years of age group (Table 18).

- **Sex :** In the study groups over all 71.1 per cent (73.3 % I, 66.6 % II and 73.3 % III group) were male and 28.8 per cent (26.6 % I, 33.3 II and 26.6 % III group) were female (Table 19).

- **Educational level:** Educational level of the subjects has been concised in Table 20 indicates that most of the subjects in all the study groups were secondary or senior secondary passed.

- **Occupation:** Occupation also affects the health of an individual. It also decides the life style pattern of an individual. Table 21 indicates that majority of the subjects were engaged in service. However, in all the groups same number of the subjects was engaged in either business or was retired. Out of 45 subjects, 13 were females from them 11 were housewives and 2 were in government service.

- **Marital Status:** All the subjects were married and one of the subjects at the time of study was widow (Table 22).

- **Food Habits :** The food habits in terms of vegetarian, non - vegetarian and ovo - vegetarian reveals that the majority (66.6 %) of the subjects were vegetarian and the distribution in three groups were also almost same (73.3 % group I, 60.0 % group II and 66.6 % group III). The remaining subjects were either non vegetarian or ovo–vegetarian (Table 23).

4.2.2 Health habits of the subjects: Health habits play an important role in the occurrence and management of diabetes, hence information regarding health habits were collected and presented in Tables 24 and 25.

a) **Smoking:** The present study shows that 31 per cent of the subjects (33.3 % I group, 26.6 % II group and 33.3 III group) were smokers and most of them (28.8 %) were smoking daily (Table 24).

b) **Tobacco Chewing:** Table 24 reveals that 24.4 per cent subjects were tobacco chewer. From them, 17.7 per cent were chewing daily and 6.6 per cent used to chew weekly.

c) **Alcohol Consumption:** Results revealed that 22.2 per cent (20.0% I group, 26.6% II group & 20.0% III group) of the subjects were consuming alcohol either daily (11.1%) or weekly (11.1%; Table 24).

d) **Tea and Coffee Intake:** Hundred per cent of the subjects were drinking tea. Out of them 95.5 per cent were consuming daily and 4.4 per cent were consuming occasionally. More than 80 per cent subjects were consuming coffee either weekly (31.1) or occasionally (51.1%; Table 24).

e) **Gutka:** Present study shows that 33.3 per cent subjects were chewing gutka. About twenty seven per cent were chewing daily (26.6% I group I, 33.3% II group and 20.0% III group) remaining 6.6 per cent (20.0 I group) of the subjects were chewing weekly. The remaining 66.6 per cent were not chewing gutka (Table 24).

f) **Exercise:** Table 25 reveals that about half of the subjects (48.8 %) were doing exercise daily. Fifty one per cent of the subjects (53.3% I group, 60.0% II and 40.0% III group) were not doing exercise. Out of the subjects doing exercise daily, 31.1 per cent were doing walk (33.3% I group, 20.0% II group and

40.0% III group) and 15.5 per cent were doing yoga. Subjects were doing the exercise for 30 (17.7%) to sixty minutes (17.7%).

4.2.3 Information about the disease: Information regarding the family history, onset and diagnosis of the disease avoidance and inclusion of foods and treatment taken for the management of disease were collected and presented in Tables 26 and 29.

a) **Family history of the disease:** Table 26 gives the information on prevalence of diabetes among family members of the subjects. It was noticed that half of the subjects (51.1%) had family history of the disease. Father (26.6 %) Mother (15.5 %), brother (6.6) and sister (2.2) of these subjects were suffering from the disease. The results are in conformity with findings of study conducted by Kaur et al (2007). They observed that the family history of the disease due to diabetic mother was more prevalent among the subjects as compared to diabetic father or diabetic parents.

b) **Onset of disease and age of diagnosis:** The age of onset of diabetes in most of the subjects (46.6 %) was 40-50 years. In 40 per cent of the subject it started between 50-60 years age. Rests of the subjects were suffering from diabetes from the age of less than 40 years or after 60 years. Most of the subjects (46.6%) suffering from the disease since past 1 to 5 years (Table 27). This reflects that diabetes starts to emerge during the middle age of the subjects. Similar were the findings of an earlier study conducted by Jali et al (2006) to find out the prevalence of diabetes amongst the family members of known diabetics. Study showed that the prevalence was more in the age group of 40-49 years (18-24%). This shows that the changing trends in the age of onset of disease are affecting the people of productive age group and making them socio economically inefficient.

c) **Treatment for the control of disease:** The treatment strategy followed by 31.1 per cent of the study subjects was drug along with exercise and while 22.2 per cent was taking drugs only with no change in the diet. About 20 per cent subjects were dependent on dietary modification and exercise. Sixteen per cent were following dietary modification along with drug and exercise and remaining 8.8 and 4.4 per cent were following exercise and dietary modification respectively (Table 28).

d) **Foods included due to diabetes:** Foods like fenugreek (6.6 %), bitter gourd (2.2 %), Jamun seeds powder (4.4 %) and beal patra + neem leaves (4.4 %) were consumed daily by the subjects as a measure to improve or control diabetic condition (Table 29).

e) **Avoidance of foods:** The subjects also reported the avoidance of many foods due to their diabetic condition (Table 30). Thirteen per cent of the subjects avoided sugar and 73.3 per cent were taking restricted amount of sugar. However, sweets were restricted by 64.4 per cent of the subjects. Preserved items such as syrup, squash, jam and jelly rich in sugar were avoided by 40 per cent of the subjects and same number of subjects restricted these items. Remaining 17.7 per cent were taking the diet as before the onset or diagnosis of disease. Eighty per cent subjects were consuming oil as usual only 20 per cent were restricting the oil consumption. About half of the subjects avoided butter, 24.4 per cent restricted and 28.8 per cent did not restrict it. More than half of the subjects were not avoiding the ghee in their diet. Thirty three per cent were consuming limited amount of ghee and 4.4 per cent were avoiding the ghee consumption. Dry fruits were occasionally consumed and none of them avoided its consumption. In carbohydrate rich foods, potato were restricted by 55.5 per cent of the subjects, 33.3 per cent avoided it and 11.1 per cent did not avoid it. Rice were avoided by 71.1 per cent and restricted by 24.4 per cent of the study subjects.

4.3 Effect of Indian Gum Arabic pods powder intervention:

Selected subjects divided in three groups were fed 2, 3 and 4g of Gum Arabic pods powder daily before breakfast for 28 days. The information on food and nutrient intake, anthro-pometric measurements including body composition, blood pressure and blood profile for glucose and lipids were collected before and after administration of Gum Arabic pods powder.

4.3.1 Meal pattern and dietary habits: The dietary habits of the subjects showed that 44.4% of the subjects followed 2 meals pattern i.e. lunch and dinner and 37.7 per cent of the subjects were taking three meals in a day. Thirty seven per cent of the subjects were consuming snacks such as biscuits, namkeen and fried items like samosa and kachori in between meals (Table 31). The consumption of these snacks was almost same in all the three groups.

4.3.2 Food and Nutrient intake: Man needs a wide range of nutrients to perform various functions in the body and to lead a healthy life. These nutrients include protein, fat, carbohydrate, vitamins, minerals and water is varying amounts depending upon age, sex, occupation and physiological conditions of an individual. In diabetic subjects management of disease by diet depends upon the judicious selection of foods to provide carbohydrates, adequate protein and a determined restriction of total fat.

The mean age of study subjects was 53 years and was following sedentary life style. About 20 per cent of the study subjects were enjoying retired life, 24.4 per cent subjects were housewives, 37.4 per cent were in government or private sector service as teacher, clerk and office job and remaining 20 per cent were engaged in sedentary type business.

a) **Foods intake:** In the present study the dietary intake of diabetic subjects was studied by 24 hours recall method for two days i.e. before and after intervention. Adequacy of the food intake was compared with the balanced diet (NIN, 1998) suggested for normal healthy individuals as recommendations for diabetics has not been reported. The results are presented in Tables 32, 33 and Fig. 1, 2 and discussed below:

Cereals and millets: Cereals constitute a major component of diets consumed in India. They contribute 70-80 per cent of calorie and a significant amount of several other nutrients except vitamins A and D. The mean values of cereal consumption before treatment were 260.8, 235.7 and 245.8 g/day for I, II and III group respectively (Table 32), which correspond to 62, 56 and 59 per cent of balanced diet (Table 33 and Fig.1). After intervention the cereal consumption was 250.0 g for I, 240.3 g for II and 240.5 g for III group of study (Fig.2).

Pulses and legumes: Protein increases insulin secretion because of the variable effects of amino acids. Pulses are rich sources of protein in the diet. The mean intake of pulses before intervention was 27.7, 26.7 and 26.4 g/day by I, II and III group respectively and after intervention it was 28.3 g/day for I group, 28.5 g/day for II group and 27.5 g/day for III group of the study (Table 32). Pulses consumption before and after intervention was inadequate by all the subjects of three groups. The intake ranged from 44 to 48 per cent of balanced diet (Table 33 and Fig.1, 2).

Green leafy vegetables: Addition of leafy vegetables in the diabetic diet reduces glycosylated hemoglobin and insulin requirement (Ceruti et al, 1987). Before intervention the intake ranged from 29.7 (I group) to 44.7 g/day (II group) respectively and after intervention it was 40.3, 48.2 and 40 for I, II and III group respectively (Tables 32, 33 and Fig.1, 2). Same as pulses, intake of leafy vegetables before and after intervention was inadequate. This may be due to less availability of leafy vegetables in summer season although; diabetics are advised to take ample amount of leafy vegetables in their diet.

Roots and tubers: Roots and tubers have variable effects on blood glucose depending upon the structure of starch and the processing technique employed. Intake of roots and tubers among all the three groups i.e. I, II and III was 59.7, 55.3 and 61.7 g/day respectively before feeding pods powder (Table 32). After intervention the mean values of roots and tubers consumption ranged between 54.7 (II group) to 59.0 g/day (III group). The intake of roots and tubers before and after intervention was also less than the balanced diet suggested for normal population (Table 33 and Fig.1, 2).

Other vegetables: Those vegetables which are not included under leafy vegetables and roots and tubers are the other vegetables. Due to the presence of inhibitors and potent adregenic neuron blocking substance, some of the other vegetables like bitter gourd, drumsticks inhibit lower glucose response (William et al, 1993). Although the diabetics are advised to consume other vegetables in more than the recommended amount for normal population. The mean intake of other vegetables before intervention was 60.0(I group), 65.3 (II group) and 70.3 g/day (III group). After intervention the intake ranged between 60.8 (II group) to 73.3 g/day (II group; Table 32). The intake before and after intervention ranged between 60-73 per cent (Table 33 and Fig.1, 2).

The vegetables may be leafy, roots and tubers or other prepared in the form of curry to eat chapati with it. Hence, the consumption of these vegetables depends upon the selection of vegetable to prepare a curry.

Fruits: Fruits included in the form of dietary fibre are found to reduce glycosylated hemoglobin and insulin requirement (Karlstrom et al, 1987). Subjects were consuming water-melon, papaya, mango and banana fruits. The fruit consumption was 50 and 55 per cent of balanced diet before intervention for I, II and III group respectively. After intervention the intake ranged from 50 (II group) to 60 per cent (III group) of the balanced diet. The diabetic patients are advised to take one fruit in a day from the list of selected fruits. The study subjects were taking fruit daily but intake was less than the balanced diet (Table 33 Fig.1, 2).

Milk and milk products: Milk and milk products because of fat content lower post prandial glucose. It has also been observed that milk consumption was almost same in all the groups before and after intervention. Before intervention the milk and milk consumption ranged between 240 (group I) to 250 ml/day (III group) and after intervention it was 230 (I group) to 248 ml /day (III group); (Table 32). Generally they used to consume butter milk and curd. The milk consumption ranged between 77 to 83 per cent of balanced diet (Table 33 and Fig. 1, 2).

Fats and edible oils: For diabetics quantity and quality of fat consumed is important. The mean values of fat intake before intervention were 26.7, 25.7 and 26.2 g/ day for I, II and III group respectively and these w ere almost same

(P≥0.05) in all the groups after intervention (Table 32). The intake ranged from 131 to 149 per cent of balanced diet (Table 33 and Fig.1, 2).

Sugar: Simple sugars should be avoided in diabetes as they are the immediate source of glucose but dietary sucrose as a part of mixed meal does not aggravate immediate hyperglycemia (ADC, 1991). Though, sugar and sweet foods were avoided by the diabetics, the mean sugar intake ranged between 43 to 45 per cent before and 45 to 48 per cent of balanced diet after the intervention (Table 33 and Fig.1, 2).

The above results reveal that the subjects of all the three groups before and after intervention were consuming cereals, pulses green leafy vegetables, roots and tubers, other vegetables, fruits and milk and milk product in inadequate amount. The intake of fat and edible oils was more than adequate for all the subjects. The meal pattern and food intake by all the three groups before and after intervention was almost same (P≥0.05) except for some foods (P≤0.05).

The significant difference in the intake of cereals and leafy vegetable in the subjects of first group and pulses and other vegetables in second group of intervention may be due to day to day variation in the menu, availability of food, selection of food etc. The significant difference observed in the intake of some foods has not made any change in the adequacy of the food group in the daily diet.

b) Nutrient Intake: Intake of various nutrients for each subject was calculated using food composition tables (Gopalan et al, 1994) and compared with RDA and suggested for sedentary worker modification of nutrients for diabetics (Raghuram, 1996). The results are presented in Tables 34 and 35 and Figure 3 and 4 discussed below:

Protein: People with type 2 diabetes have an increased need of protein during moderate hyperglycemia and altered adaptive mechanism for protein sparing during weight loss (Eely, 1996). The intake of Protein before intervention ranged between 41.7 (I group) to 46.3 g/day (II group) and after intervention 41.0 (I group) to 46.7 g/day (II group) which is around 70-80 per cent of RDA (Tables 34, 35 and Fig 3, 4). The intake of protein in the subjects of third group of intervention was significantly different. This difference may be due to the variation in selection of food as per the menu. The significant difference has not changed the adequacy of the diet. American Diabetic Association (ADA) has recommended that the protein intake should provide 10-20 per cent of calories to diabetics which are consistent with protein intake of the normal person of 0.8g/kg body weight. In the present study the protein is providing 12 to 14 per cent energy to the subjects. As the cereal and pulses intake of the subjects is less than balanced diet the protein in take is also less than RDA. The findings are in close conformity with the results of the study conducted by Bordia (2003) to assess the nutrient intake of diabetic patients of Udaipur city, who observed average daily intake of 52.5 g/day which is also inadequate.

Fat: Diabetic subjects have an increased risk of coronary heart disease, therefore the primary goal is to decrease the intake of saturated fat and cholesterol (ADA, 2001). Mean fat intake (visible + invisible) by three groups was 60.0, 55.7 and 59.0 g/day for I, II and III group respectively before the intervention. After intervention it was almost same in all the three groups. The visible fat intake ranged from 25.7 (II group) to 29.7 g/day (I group) before intervention and 26.9 (III group) to 29.0 g/day (I group) after intervention of pods powder (Table 34). Fat intake before and after intervention was more than RDA by all the three groups (Table 35 and Fig.3, 4). Raghuram (1996) recommended that 15-25 per cent of total calories can be derived from fat in diabetes. The percentage of energy provided by the fat ranged between 32 to 39 per cent in study subjects. Same results of higher intake of fat were observed by Gokani et al (1992) in a study on fifty one NIDDM subjects.

Carbohydrate: Carbohydrate is one of the main source o energy. In Indian diet, carbohydrate derived from cereals is the chief source of energy (Gopalan et al, 1994). It was 200.3, 196.5 and 188.7 g/day for I, II and III group respectively before intervention and after intervention it ranged between 192.1 (III group) to 196.5 g/day (I group; Table 34). Khanna et al (1997) suggested a moderate restriction of carbohydrate calories to about 55 to 70 per cent of total calories where as, Raghuram (1996) suggested that 60-70 per cent of total calories should be provided from carbohydrate. In the present study the percentage of calories provided by carbohydrate ranged between 49 to 55 per cent of total calories intake (Table 35 and Fig.3, 4). On the contrary, Morani (1994) assessed the dietary pattern of diabetic patients of Udaipur city and observed the average daily intake of carbohydrate as 224.34/day. Bordia (2003) also revealed the average daily intake of carbohydrate by the diabetic patients of Udaipur city, as 241.1g/day.

Energy: Our body needs energy for maintaining body temperature, metabolic activity, supporting growth and for physical activity. Table 34 reveals that energy intake before and after intervention ranged from 1499 (II group) to 1511 Kcal /day (III group) and 1509 (II group) 1520 kcal/day (III group) respectively. The energy intake was about 63 per cent of RDA before an after intervention (Table 35 and Fig.3, 4). The ideal body weight was calculated using the formula (height-100) ×0.9; Raghuram et al, 1993) for all the 45 subjects is given in appendix III.

Further the energy required for ideal body weight by each subject was also calculated and average intake of calorie ranged between 71 to 116 per cent of the calorie requirement for ideal body weight (Tables 36 to 38). Most of the subjects in all the three groups were not taking energy as per their ideal body weight requirement.

Crude Fibre: Dietary fibre plays an important role in the management of diabetes. Raghuram (1996) recommends an intake of 40g dietary fibre per day or 25g / 1000kcal for diabetics. Intake of crude fibre was very low by the subjects. Fibre intake was ranged between 5.24 (I group) to 6.3 g/day (III group) before intervention and after intervention it ranged between 5.2 (I group) to 6.0 g/day (II group). Khanna et al (1997) has reported that crude fibre is equal to one fifth or half (20-50%) of dietary fibre. Accordingly 40g of dietary fibre is equal to 8-20 g of crude fibre. The intake of fibre by the subjects of present study is low (Table 34). The results are in the line of the study conducted by Gokani et al (1992). They also reported the lower intake of dietary fibre by the diabetic patients. Catopano et al (1991) and Morani (1994) also observed less consumption of fibre i.e. 10.69± 3.29 and 13.0 ± 3.00g respectively by diabetics. Similarly Bordia (2003) also witnessed the lower intake of crude fibre 8.60±1.80 (21.5%) by the diabetics. These findings are in close conformity with the present study that fibre rich foods are not included in adequate amount in the diet by diabetic patients.

Calcium: The calcium intake by the subject of three groups less than adequate (Table 34, 35 and Fig. 3, 4). The mean values of calcium intake before and after intervention ranged between 340.0(III group) to 350.5 mg/day (I group) and 331.4 (I group) to 348.0 mg/day (II group) respectively. On the contrary the higher intake of calcium by the diabetics was reported by Bordia (2003). This may be due to the 230 to 250 ml consumption of milk and milk products by the subjects in their daily diet.

Iron: Iron intake was less than the RDA for all the subjects (Table 35 and Fig.3, 4). The mean intake of iron in study groups ranged from 16 to 18 mg/day (Table 34). It was due to less consumption of iron rich foods such as leafy vegetables.

β Carotene: The Vitamin A intake was calculated as intake of β carotene per day. The intake of β carotene before and after intervention was adequate in all the groups (Table 35 and Fig. 3, 4). For Third group of study after feeding, intake was 107 per cent of RDA may be due to the variation in day to day diet.

Thiamin: The intake of thiamin was more than adequate in all the three groups (Table 35 and Fig.3, 4). The second group consumed the highest (1.4 mg pre and post) amount of thiamin as compared to I (1.2 mg pre and post) and III group (1.3

mg pre and post). The thiamin requirement is 0.5 mg/1000 kcal. The intake of thiamin by the subjects on the basis of their calorie intake was more than adequate. On the contrary lower intake of thiamin (88.30% of RDA) was observed by Bordia (2003) in a study on diabetic patients.

Riboflavin: Before and after intervention the riboflavin intake was same (1.0 mg/day) for II and III group of study corresponds to 75 per cent of RDA. The riboflavin intake of I group before intervention was 1.1 mg/day and after intervention it was 1.0 mg/day (Tables 34 and 35). The riboflavin intake was inadequate in comparison to the recommendation for normal population (Fig.3 and 4). The riboflavin requirement is 0.6 mg/1000 kcal. The intake of ribloflavin by the subjects on the basis of calorie intake was either adequate or more than adequate. In contrast to the present findings, a much lower intake of riboflavin by diabetics was observed by Bordia (2003). The average intake of riboflavin was 0.70 mg which was only 49.99 per cent of RDA.

Niacin: The mean intake of niacin as percentage of RDA before intervention for I, II and III group was 58.1, 66.0 and 67.5 and after intervention, it was 59.0, 66.0 and 68.0 respectively (Table 34). The niacin intake by all the groups was less than adequate when compared with the RDA (Table 35 and Fig.3, 4). On the basis of calorie intake, it should be 6 mg/1000 kcal and it was found to be adequate for all the subjects when compared with their calorie consumption.

The results show that thiamin, riboflavin and niacin intake was either adequate or more than adequate when calculates on the basis of their calorie intake as the energy intake of these diabetics was less than RDA.

Folic acid: The mean intake of folic acid before intervention was 53.4, 58.8 and 64.5 mg/day for I, II and III group respectively. After intervention the values of folic acid intake were 60.0 mg (I group), 62.7 mg (II group) and 55.6 mg (III group); (Table 34). The intake ranged between 53 to 64 per cent of RDA (Table 35 and Fig.3, 4) due to less intake of fruits.

Vitamin C: The intake of Vitamin C was more than adequate on the basis of RDA (Table 35 and Fig 3 and 4). The intake ranged between 142 to 160 per cent of RDA respectively. The difference between pre and post intake in all the groups was non significant.

The above results reveal that the nutrient intake of all the three groups was almost same. There was slight variation in the intake of nutrients by the subjects before and after feeding of pods powder. Further the results on meal pattern, food and nutrient intake suggest that the patients were not taking frequent meals in a day which is advised to the diabetics. Two heavy meals taken by the patients in a day are not advisable as it increases the carbohydrate load and in turn it may increase the blood glucose level. Diabetics are advised to take more of complex carbohydrate foods, ample amount of leafy and other vegetables, restricted amount of saturated fats, oil, sugar and preserved foods. However, the subjects of present study were taking more of oil and less amount of complex carbohydrate foods such as cereals, leafy vegetables etc.

The energy intake was not according to their ideal body weight. The diet was deficient in protein, energy, fibre, iron, calcium, riboflavin, niacin and folic acid. These results advise that patients should be given nutrition education and follow dietary counseling regularly to maintain blood glucose level and avoid further complications.

4.3.3 Anthropometric measurement and indices: In the present study height, weight, waist circumference and hip circumference were taken before and after intervention. The body mass index and waist hip ratio were calculated to assess the nutritional status of the subjects. The results are presented in Tables 39 to 41.

a) Weight: Weight is an important guide to assess the current nutritional status. The weight of I group of subjects was maximum i.e. 64kg followed by (62kg) group III and (59kg) group II (Table 39). There was no significant difference in weight before and after intervention amongst the three groups. Further the calculated ideal body weight of each of the forty five subjects (Appendix III) reveals that 6.7 per cent subjects had ideal body weight 15.5 per cent less than and 77.7 per cent had more than ideal body weight. The pods powder intervention had no effect on body weight.

b) Height: Table 39 shows that the mean height of I, II and III group was 164, 163 and 163 cm respectively.

c) Body mass index (Quetlet Index): Body mass index has shown positive association with diabetes in Indian population (Rao, 2002). The mean values of BMI before intervention were 23.51, 22.33 and 23.53 kg/m^2 for I, II and III group respectively (Table 39). After intervention it ranged between 22.33 (II group) to 23.65 kg (I group). There was slight change in BMI in study groups before and after intervention. The difference was non significant ($P \geq 0.05$) when compared by paired't' test. When BMI was compared with the classification given by WHO for Asia Pacific inhabitants (2000) showed that 31.1 per cent of the subjects were over weight and obese 26.6 per cent. Twenty four per cent of the subjects were in normal weight category (Table 40). This shows that overweight and obesity may be one of the risk factor for their diabetes or due to diabetes they were gaining weight. On the contrary Radha et al (2006) reported a significant change in the BMI of the study subjects (60 NIDDM subjects) after the treatment by Vilvai leaf (*Algel marmelos*) powder.

d) **Waist and hip circumference:** Waist circumference (WC) may predict intra abdominal fat as accurately as the waist hip ratio. It alone also correlates well with the amount of visceral fat and the relationship is similar in men and women. A high waist circumference is associated with an increased risk for type 2 diabetes, high cholesterol, high blood pressure and cardiovascular disease (WHO, 1995). The mean waist circumference before intervention was 107.5, 101.2 and 102.0 cm for I, II and III group respectively. After intervention it was quite similar for all the groups (Table 39). When classified on WHO classification (1995) criteria (Table 41) most of the males were having WC either ≥ 94 cm (36.3% I, 40% II & 63.6% III group) or ≥ 102 cm (36.3% I, 40% II and 27.2 % III group) waist circumference. Almost all the females irrespective of the intervention group were having more than the normal level. These results show that majority of the subjects were having higher values for waist circumference. The hip circumference of the subjects ranged from 109 to 112 cm. The difference between waist and hip circumference is only of 8 to 10 cm.

Waist hip ratio (WHR): Fat accumulations around the belly put pressure on the organs of this area. Therefore, pancreas needs to work harder to secrete more insulin to bring sugar levels to normal, hence WHR was calculated. The mean values of waist hip ratio for I, II and III group were 0.95, 0.92 and 0.92 respectively before and after intervention (Table 39). A waist hip ratio of greater than 0.95 in men and 0.80 in women indicates abdominal obesity (WHO, 1995). In males most of the subjects of I and III group were having ≥0.95 WHR and females majority had WHR ≥0.80 (Table 41). These results indicate that abdominal obesity was prevalent in more than 50 per cent of the subjects.

4.3.4 Body composition: Body composition was evaluated as body fat, fat free mass, body water and body cell mass using body composition analyzer (Bodystat Quandscan Unit 4000). The results are presented in Table 42.

a) **Body fat:** Body fat, the fraction of the total body mass that is adipose tissue is often used as an index to monitor progress during intervention. The gross amount of body fat component varies widely as per the individual degrees of obesity and age. With increase in weight and age, the body fat percentage enhances. The high degree of excess body fat as characterized by obesity has been invariably linked to high blood pressure, heart disease, diabetes, cancer and other disabling conditions. The mean body fat of the subjects before intervention was 26.43 per cent (26.41% I, 26.5 7II & 26.33 III group) and 26.48 per cent (26.40% I, 26.75% II & 26.30% III group) after intervention. The calculated 't' value showed non significant difference between the pre and post intervention values of body fat .

b) Lean Body Mass: This metabolically active component of body whose relative compartment size is somewhat controlled genetically and somewhat by environmental factors, namely under or over eating relative to need, holds vital importance for all body functions and a decrease in this vital component results in complications and an associated morbidity and mortality. Lean body mass accounts for anything from 30 per cent to 70 per cent of total body weight (Segal et al, 1985; Len and Vivian, 1998; Heyward, 1991). The present study configured that a mean lean body mass percentage was 56.07 per cent, 59.14 per cent and 57.01 per cent for first second and third group respectively before intervention there was no significant change in lean body mass after intervention in three groups (55.68 I, 59.27II and 57.01 III %). The values were lesser than the normal LBM of 70 per cent, may be due to the age and diabetes.

c) Total body water: Total body water makes up approximately 55 to 60 per cent of body water. Increase in age is associated with decrease in total body water (Len & Vivian 1998; Wilmore et al, 1986). The mean per cent of total body water was almost same before and after intervention in all the groups ($P \geq 0.05$). Body water is divided into two compartment viz., water that located inside cells (ICW) and that located outside cells (ECW).

d) Intracellular water (ICW): The non homogenous fluid compartment comprises of 2/3rd of the body's water and approximately 30-40 per cent of body weight and represents a conglomeration of fluids from different cells. Intracellular water was found to comprise larger fluid compartment of the two in both males and females (Len and Vivian, 1998; Wilmore et al, 1986). In the present study there was slight difference ($P \geq 0.05$) between pre and post intracellular water for all the study groups (Table 39). The mean values of ICW before intervention for all the three groups were 24.79, 27.34 and 28.21 per cent and after intervention 23.34, 24.59 and 24.35 per cent.

e) ECW: That comprises remaining 1/3rd of body's water includes all water and electrolytes outside of cells (intestitial fluid, plasma and lymph, Len and Vivian, 1998; Wilmore, 1986). This is rather a smaller compartment constitute approximately 15-25 per cent of body weight in reference individual. In present study the mean value of ECW was almost same for all the groups before and after intervention. Before intervention the mean values of extra cellular body water were 23.54, 24.60 and 24.21 per cent for first, second and third group. No significant difference was found in extracellular body water due to intervention in all the groups.

f) Body cell mass: This functional compartment represents the metabolically active component of the body and comprises 35-45 per cent of body weight in reference individual. Increase in age is associated with a decline in BCM (Med Term medical dictionary, 2004). The mean values of BCM before intervention (27.73 % I, 29.27 % II and 28.21 % III group) a change after intervention was non significant ($P \geq 0.05$).

The body composition after intervention did not change reveals that the diet, exercise and other health habits followed were same throughout the intervention period.

The above results show that the administration of pods powder did not change body measurements, indices and body composition of the subjects revealing that these subjects be advised to reduce body weight as obesity and overweight are prevalent amongst the subjects and these are the risk factors of diabetes.

4.3.5 Blood Glucose: The fasting and post prandial blood glucose levels of three study groups at zero day i.e. before intervention are given in Table 43. The statistical analysis of these levels revealed a significant difference in fasting blood glucose level among three groups of intervention ($P \leq 0.05$). This difference is due to randomly allocating the subjects in three intervention groups. Therefore, the out layers i.e. subjects having <110mg/dl and >300mg/dl fasting blood glucose levels were excluded from the groups. Three subjects from group I, 4 from group II and 2 from group III were excluded. After deleting the out layers the fasting blood glucose level among the three groups was non significant (Table 44).The post prandial blood glucose with and without exclusions was non significant at zero day.

The results of effect of feeding pods powder on blood glucose and lipid profile are presented for 12 subjects in group I, 11 in group II and 13 in III group. Before administration of *Acacia nilotica* pods powder, the mean fasting blood glucose of I, II and III group was 155.33, 147.18 and 180.23 mg/dl respectively and after administration it decreased to 153, 140.00 and 157.92 mg/dl respectively (Table 45 and Fig.5). The per cent decrease is 10.2 (I group), 11.6 (II group) and 19.1 per cent (III group) after 4 weeks of intervention (Table 46). However, the reduction was insignificant ($P \geq 0.05$). The mean values of post prandial blood glucose decreased from 7.3 (I group) to 35.5 (III group) per cent after intervention (Table 43). The significant decrease was observed among the subjects who were given 4 g of *Acacia nilotica* pods powder per day for 4 weeks (Table 45 and Fig.6). These results show that 4 g pods powder is beneficial for controlling blood glucose level of diabetic patients. However, this dose reduced the post prandial blood glucose level but it could not reach to the normal level. The above results suggest that the dose of *Acacia nilotica* taken once in a day before breakfast cannot maintain the fasting blood glucose level. So, the frequency of dose may be increased and studied. Secondly, the increase in duration of the intervention of *Acacia nilotica* pods may also be studied to achieve normal blood glucose level. The hypoglycemic effect of *Acacia nilotica* seeds were also observed by Wadwood et al (1989). They reported that the powdered seeds (2, 3 and 4 g/kg body weight) exerted a significant hypoglycemic effect in normal rabbits. The dose did not show any toxicity and behavioural changes among the study animals.

The active component in *Acacia nilotica* has not been identified or reported for regulating the blood glucose level. However, Ayurveda suggests the consumption of 3-6g *Acacia nilotica* fruit powder to control diabetes and other health problems (Singh, 1969). It is also used as a traditional medicine in other countries also. In Egypt it is a traditional practice to take a teaspoonful of *Acacia nilotica* pods powder to control diabetes (http:\\ herbaria.plants.ox.ac.uk/VFH/test sites). Bhandari (1974) has reported that *Acacia nilotica* pods are being used as a vegetable and roasted seeds are eaten during famine condition. Zaki et al (2000) found that feeding of 2-8 per cent diet of *Acacia nilotica* to rats did not show any toxicity. The pods contain the appreciable amount of total phenol that may help in regulating blood glucose and lipid profile of diabetic subjects. The premature pods powder used for intervention in the present study contains 31.31 mg phenol/g of powder. Subjects of group III who were administered 4 g of pods powder per day consumed 125 mg of phenol per day. Phenolic compounds have been reported to control the blood sugar levels. They reduce the infiltration of immune cells into the islets of lengerhans, the specific area of the pancreas where the insulin producing beta cells reside. Similarly, Grassi et al (2005) observed that the intake of 500 mg poyphenol in 100 g dark chocolate for 15 days improved the glucose metabolism in fifteen healthy adults. Bioactive phenols in cinnamon (Anderson et al, 2004) and green tea (Potenza et al, 2007) are involved in the alleviation or possible prevention and control of glucose intolerance and diabetes. Andrew et al (1996) reported that 7.3g cocoa in chocolates contain 146 mg total phenol, 41g of milk chocolate 205 mg phenols and 140 ml red wine 210 mg total phenols have been found to be hypoglycemic . Black and green tea containing 80-100 mg/g of total phenols are the other sources of phenols (Khokhar, S and Magnusdottir, 2002). It has been reported that epigallocatechin gallate (EGCG) in green tea (Potenza et al, 2004) and procyanidin in red wine (Pinent et al, 2007) are the bioactive phenols having hypoglycemic effect. This shows that not only the quantity of total phenol but the type of phenol present in food stuff is also important. In *Acacia nilotica* a phenol-gallic acid is present which may be more effective than other type of phenols as hypoglycemic agent.

Certain food components can selectively modify kinase activity in favour of good health. These are known as Selective Kinase Response Modulators (SKRMs). Kinases are enzymes that translate dietary signals to positively or negatively influence numerous aspects of health. *Acacia nilotica* and reduced iso-alpha acids (RIAA) derived from *Humulus lupulus* L. (hops) are two such SKRMs shown to modulate kinase signaling in adipocytes-fat storing cells involved in glucose utilization and insulin signaling.

Hops and acacia have been utilized traditionally for centuries, nutrigenomic research has uncovered new applications for their research and use. RIAA and acacia have been clinically shown in a preliminary study at the Functional Medicine Research arm of Metagenics, to improve fasting insulin and lipid parameter. They tested over 200 natural substances and extracts for their influence on insulin responses in adiposites cells. The best performing substances were found to be *Acacia nilotica* and hops extract. They have made a herbal blend called "insinase" for blood sugar support. Insinase contained Selective Kinase Response Modulators (SKRMs) i.e. reduced iso-alpha acids and *Acacia nilotica* extract, which have been shown to support healthy insulin production (http://www.metagenics.com/about/ patient_why.asp). Therefore, the hypoglycemic effect of *Acacia nilotica* in the present study may be due to the Selective Kinase Response Modulators present in it.

4.3.6 **Lipid profile:** Table 47 shows the reduction in cholesterol triglyceride, LDL and VLDL levels after the intervention in all the groups. The cholesterol level before intervention ranged between 183.06 (II group) to 194.03 mg/dl (II group) and after intervention 177.36 (II group) to 181.50 mg/dl (III group; Fig. 7, 8). The maximum per cent decrease was 10.8 per cent third group (Table 46). The significant reduction was found among the III group of subjects. The values of triglyceride for I, II and III group were 196.94, 205.33 and 224.0 mg/dl respectively. The per cent decrease was 5.8 (II group) to 17.7 per cent (III group). The significant reduction is triglyceride and VLDL was found in III group of subjects. A significant ($P \leq 0.01$) increase was found in HDL level of III group after intervention. The results show that the *Acacia nilotica* pods powder has lipid regulating effect and the dose of 4 g is most effective dose. The lipid levels were compared with the normal range suggested by WHO (1988), it was observed a shift towards the normal levels (Tables 48 and 49).

The lipid lowering effects were also observed by Zaki et al (2000) in their study on potential toxicity of *Acacia nilotica* feeding in rats. Presence of phenolic compounds may reduce the risk of cardiovascular diseases by antioxidative properties (Anderson et al, 2004 and Tomura et al, 2007). The lipid lowering effect of cinnamon (contain phenolic compounds) on 60 people suffering with type 2 diabetes was reported by Barabara (2003). The SKRMs may also help to maintain triglyceride levels by supporting healthy kinase signaling. A 12-week open labeled randomized 2 arm study conducted at the FMRC, the clinical research arm of Metagenies consisted of 44 subjects reported the lipid lowering effect of the *Acacia nilotica* and hop extract.

4.3.7 Blood pressure: Table 50 shows that the mean systolic blood pressure before intervention ranged between 137 mm Hg (II group) to 147.50 mm Hg (I group). After intervention it was 129.45 (II group) to 138.90 mm Hg (II group). The per cent decrease were 8.5 to (I group) to 11.6 per cent (III group). A significant decrease after intervention was found in systolic blood pressure of all the three groups means the Gum Arabic pods powder is effective in the regulation of blood pressure (Fig.9 and 10). In diastolic blood pressure a significant decrease was observed in III group of study. When blood pressure levels were compared with JNC VII (2003) classification, the subjects showed a shifting towards the normotension (Table 51). Similar were the findings on an earlier study conducted by Gilani et al (1991). They reported the fall in arterial blood pressure by methanol extract of *Acacia nilotica* pods in guinea pigs. Grassi et al (2005) studied the blood pressure lowering effect of 100g dark chocolate (containing 500 mg polyphenol) on 15 healthy young adults.

On the basis of the above results it can be concluded that 4 g of premature *Acacia nilotica* pods powder per day is beneficial to reduce blood pressure, blood glucose, lipid (except HDL) levels and to increase HDL level. The pods powder intervention did not effect body measurements, body composition and food intake hence, for the management of the disease the patients in addition should be counseled for diet and exercise.

4.4 Experience and opinion of the subjects regarding intervention of Gum Arabic pods powder:

After four weeks of intervention a feed back was gathered from the subjects. All the subjects consumed the *Acacia nilotica* pods powder in the morning before breakfast. More than 50 per cent of subjects of all the groups reported the other benefits after consuming the pods powder such as relief from constipation (60%), feeling of lightness (10%), yet 30 per cent noticed no change. About 80 per cent of the subjects had no problem, while 20 per cent had flatulence initially which become normal later. When enquired about the taste of powder 80 per cent of the subject reported the bitterness in powder but it was bearable. The subjects also showed the desire to continue the babul pods consumption.

Acacia nilotica pods powder showed desirable changes in blood levels of the diabetics and were acceptable by the subjects. The results suggest that diabetics should consume pods for the management of disease.

SUMMARY, CONCLUSION AND RECOMMENDATION

Diabetes mellitus is a “hormone metabolic” disorder characterized by hyperglycemia, resulting from defects in insulin action or both. The chronic hyperglycemia of diabetes is associated with long term damage, dysfunction and failure of various organs especially the eyes, kidneys, nerves, heart and blood vessels. In diabetes the metabolism of all three major classes of macromolecules i.e. carbohydrates, proteins and fats are altered and the mineral metabolism is also not spared. The diabetes epidemic relates particularly to type 2 diabetes and is taking place both in developed and developing nations predominately due to changing demography and increased longevity. Diabetes can be managed through the combination of diet, drug and exercise. Although, there are several allopathic medicines available to control diabetes but they have some limitation so there is a need to explore some alternatives to manage diabetes. Plants have medicinal properties due to the presence of active components. Medicinal plants are used to cure several non communicable diseases including diabetes. Several plants are being used as a traditional practice due to hypoglycemic property.

Indian Gum Arabic (*Acacia nilotica*) is one such medicinal plant. Therefore, this study was planned to find out the effect of *Acacia nilotica* pods powder in the management of patient’s suffering from non insulin dependent diabetes.

The Gum Arabic pods were collected from the university campus for chemical analysis and intervention to diabetic patients. For chemical analysis pods were collected at three stages of maturity i.e. premature, seed developing and mature. A sample of 750g of each stage was open shade dried and analysed for proximate principles, minerals and secondary metabolites. For intervention 5 kg premature fresh pods were open shade dried and powdered.

Forty five diabetic subjects (45-65 years) irrespective of sex, not having any known disease and willing to participate in the study were selected after organizing a camp at the Government Ayurvedic Hospital premises. The subjects were randomly divided in three groups (I, II and III) and were given 2, 3 and 4 g/day of *Acacia nilotica* pods powder (premature pod) respectively. Subjects were asked to follow their normal dietary, physical activity and other routine. Each subject was instructed to take the powder daily before breakfast for four weeks. An interview schedule was developed to collect the general profile of the subjects, information regarding the disease and management of disease. The dietary survey, anthropometric measurements, body composition, blood pressure, blood glucose and lipid profile of the subjects were assessed before and after intervention.

The chemical composition of premature, seed developing and mature pods showed that carbohydrate (64.16 to 67.71%), ether extract (0.57 to 1.11%), crude fibre (10.41 to 12.53%) and energy (308 to 331 kcal/100g)increased ($P \leq 0.01$) with maturity and moisture (3 to 8%), ash (3.02 to 5.29%), iron (1.17 to 3.52 ppm), zinc (31.05 to 56.05ppm), copper (0.10 to 0.23 ppm), magnesium (11.7 to 18.2 ppm), manganese (0.05 to 0.20 ppm) chromium (0.40 to 1 ppm), total phenol (16.0 to 31.31 mg/g) and tannin (14.51 to 20.30 mg/g) decreased ($P \leq 0.01$) with maturity whereas, protein content (11.57 to12.63%) was almost same ($P \geq 0.05$) at all the stages of maturity on dry weight basis.

Most of the diabetic subjects were male (71.1%), Hindu (91.1%), married (97.7%), literate (93.3%), vegetarian and belonged to nuclear family (75.5%). In health habits 48.8 percent of the subjects were performing exercise mainly yoga (15.5%) and walking (31.1%).Habit of smoking (31.1%), tobacco chewing (24.4%) and alcohol consumption (22.2%) were also prevalent in subject. Family history of the disease was present in 51.1% subjects.

The dietary survey conducted by 24 hours recall method revealed that 44.4 per cent of the subjects were following two meal pattern. The foods and nutrient intake of the three groups was almost same before and after the intervention ($P \geq 0.05$). The intake of cereals (56-62%), pulses (44-48%), vegetables (30-48%) and fruits (50-60%) and milk and milk products (77-83%) was inadequate. The intake of fats and edible oils was more than adequate in all the subjects. The intake of fat, carotene, thiamin and vitamin C were adequate or more than adequate (90-160%) while, intake of protein, carbohydrate, energy, fibre, iron, niacin, folic acid and calcium were inadequate (53-88%). The overweight (31.1%) and obesity (26.6%) was prevalent among the subjects which is one of the risk factor of the disease

The fasting and post prandial blood glucose reduced in all the three groups after intervention but the significant decrease was found in the third group of the subjects who were taking 4 g of pods powder daily. Similarly, the lipid profile (cholesterol, triglyceride and VLDL) and systolic and diastolic blood pressure also decreased significantly and HDL increased significantly in the third group of the subjects. In addition the systolic blood pressure was also decreased significantly in other two groups who were taking 2 and 3 g of pods powder. No adverse effect of pods powder was reported by the subjects during the intervention period.

It is concluded that pods powder intervention reduced the blood glucose, lipid profile and blood pressure in diabetic subjects and it may be beneficial for the coronary artery diseases. However, dietary counseling and advice for regular exercise should also be given simultaneously as the subjects were not following modified diet and performing exercise which helps in the management of disease.

Recommendation for further studies: Further studies on following aspects may be carried out to recommend *Acacia nilotica* pods powder for the management of diabetes:

- Increased frequency of the doses of pods powder
- Increased duration of the pods powder intervention
- Increased amount of doses of pods powder
- Shelf life and suitable packaging of pods powder

Table 7 : Commonly used antidiabetic foods in the indigenous system of health care

Botanical name	Common Name	Symptoms treated with	Active principle	Possible mode of action	Form and dosage	Research studies
Aegel marmelos	*Bilva Bael* fruitBengal quince	Diabetes	Not known	Improves digestion Reduces blood sugar and urea	Juices of leaves	Krishnan (1968), Santhoshumari et al (1990) and Shiva (1998)
Azadirachta indica	Indian liliac, *Neem*	Diabetes	Bitter principles nimbin, nimbinin, nimbidin47	Lowers blood glucose	Juice of leaves, bark and flowers, seed oil.	Siddiqui (1942), Murthy et al (1978), Pillai and Santhakumari (1981) and Shiva (1998)
Butea monosperma	*Palash*	Diabetes	Phytochemical substances	Not known	Flowers kept in water overnight and water taken every day for 11/2 to 2 months	Shiva (1998)
Cassia auriculata	Mature tea tree	Diabetes	Tannins	Not known	Seed powder, decoction of flower buds	Shiva (1998)
Cephalandra / Coccinia indica	*Tondli Kovai*	glycosuria	Glucoside alkaloids, glucokenin	Reduces blood and urine sugar	Fresh juice of leaves stem or roots	Kamble et al (1996)
Citrulluscolocynthis	Indian wild gourd, bitter apple, bitter cucumber	Diabetes	Colocynthin-a bitter principle	Not known	Pulp	Nadkarni (1954)
Coscinium fenestratum	Tree turmeric	Dyspepsia	Berberines and saponin	Not known	Infusion/ tincture	Mahapatra (1997)
Curuma longa	Saffron turmeric	Diabetes	Turmerone curcumin	Blood purifier	powder	Tank et al (1990),
Embilica aplicenel	Indian gooseberry	Diabetes	Not known	Stimulates pancreas	1 tbsp of amla juice with a cup of bitter gourd juice	Upadhyay et al (1996),
Eugenia Jambolana	Black plum/berry, *Jambul*	Diabetes	Jamboline - a glucoside	Prevents pathological conversion of starch to glucose	Jambu seeds	Shrotri et al (1963), Lal and Chaudhary (1968), Antarkar (1983) and Upadhyay et al (1996)

Botanical name	Common Name	Symptoms treated with	Active principle	Possible mode of action	Form and dosage	Research studies
Ficus bengalensis	Banyan Tree	Diabetes	Not known	Lowers blood sugar, cholesterol, and urea	Infusion of bark	Chopra and Chopra (1955), Shrotri and Aiman (1960) and Vora et al (1969)
Gymnema sylvestre	Periploca of the woods, small Indian ipecacuanha	Glycosuria	Gymnema saponins I-II and gymnemic acids I-IX	Neutralizes excess sugar	-	Gupta and Variyar (1964) and Baskaran et al (1990)
Madhuca indica	Honey tree, *Mahua* of South India	Diabetes	Not known	Not known	Bark	Shiva (1998)
Momordica charantia	Bitter gourd	Diabetes	Momordicine-a bitter glucoside anthelmintic principle	Increases glucose uptake in the liver cells acts as a plant insulin	Fruits, leaves and roots	Lal and Chaudhary (1968) and Upadhyay et al (1996)
Ocimum sanctum	*Tulsi* Holy basi	Reduces blood glucose, uric acid, Total amino acid, cholesterol Triglycerides, phospholipids, triglycerides	Not known	Not known	-	Agrawal et al (1996)
Pterocarpus marsupium	*Vijaysar*		Pterostilbene isoliquiritigenin	Not known	-	Shah (1967) and Kohli (1994)
Trigonella foenum graecum	Fenugreek	Glycosuria	Mucilaginous fiber, trigonelline - an alkaloid	Lower cholesterol and triglycerides	Seeds (25 g per day)	Raghuram et al (1993) and Shiva (1998)

Table 8: Mean ±SD values of proximate principles at different maturity stages in *Acacia nilotica* pods on dry weight basis

Proximate principles on dry weight basis (%)	Maturity stages of pods			'F'	CD 5%	CD 1%
	Premature	Seed developing	Mature			
Moisture	8.00 ±1.02	7.30±0.98	3.03 ±0.90	10.01**	2.90	4.40
Crude protein	11.57±2.10	11.46±0.86	12.63±1.33	0.54^{NS}	-	-
Ether extract	0.57 ±0.06	0.78±0.06	1.11±0.09	41.81**	0.12	0.18
Crude fibre	10.41±0.50	10.66±0.42	12.53±0.25	24.68**	0.94	1.43
Ash	5.29±0.20	3.42±0.19	3.02±0.07	165.54**	0.19	0.28
Total carbohydrate	64.16±1.93	66.38±1.03	67.71±1.96	18.17**	2.96	3.50
Energy (kcal/100g)	307.80 ±3.68	318.00±5.40	331.10 ±4.82	25.58**	2.40	4.23

Level of significance: * P≤0.05, ** P≤0.01 and NS = Non Significant

Table 9: Mean ±SD values of proximate principles at different developmental stages of *Acacia nilotica* pods on fresh weight basis

Proximate principles on fresh weight basis (%)	Maturity stages of pods			F value	CD 5%	CD 1%
	Premature	Seed developing	Mature			
Moisture	60.00 ± 2.00	58.00±1.00	50.67±1.75	34.31**	0.85	1.28
Crude protein	4.65±1.05	4.81±0.30	6.23±0.66	4.17^{NS}	-	-
Ether extract	0.23±0.02	0.32±0.03	0.61±0.10	32.41**	0.15	0.22
Crude fibre	4.16±0.20	4.57±0.29	5.72±0.74	24.68**	0.81	1.22
Ash	2.08±0.12	1.43±0.10	1.46±0.05	46.39**	0.33	0.49
Total carbohydrate	28.88±1.57	30.87±1.30	35.31±1.16	25.66**	2.12	4.10
Energy (kcal/100g)	116.00 ±3.10	147.80 ±4.18	171.40 ±4.50	20.70**	3.12	5.60

Level of significance: * P≤0.05, ** P≤0.01 and NS = Non Significant

Table 10 : Mean ±SD values of minerals and secondary metabolites at different maturity stages in *Acacia nilotica* pods on dry weight basis

Minerals (ppm)	Maturity stages of pods			F value	CD 5%	CD 1%
	Premature	Seed developing	Mature			
Iron	3.52±0.02	1.77±0.03	1.17±0.03	27760.0**	0.05	0.08
Calcium	161.80±1.73	143.61±2.88	120.01±3.21	1240.00**	2.48	4.21
Phosphorus	208.02±2.00	159.31±1.15	133.01±1.73	1563.62**	3.33	5.04
Sodium	24.10±1.16	20.42±1.30	18.04 ±1.42	0.05^{NS}	-	-
Potassium	26.30±1.53	19.32±0.58	12.29±0.58	147.00**	0.75	1.14
Zinc	56.05±1.03	36.02±1.01	31.05±1.01	470.50**	0.04	0.06
Copper	0.23±0.03	0.16±0.02	0.10±0.01	31.75**	0.01	0.02
Magnesium	18.20±0.28	15.15±0.13	11.67±0.58	32.06**	0.75	1.14
Manganese	0.20±0.01	0.11±0.01	0.05±0.00	188.0**	0.03	0.05
Chromium	1.00±0.01	0.70±0.03	0.40±0.01	627.75**	0.04	0.06
Total phenol(mg/g)	31.31±1.32	20.00±1.55	16.00±0.63	15.77**	1.41	2.14
Tannin (mg/g)	20.30±1.27	17.40±1.36	14.51±0.87	54.35**	1.12	1.70

Level of significance: * P≤0.05, ** P≤0.01 and NS = Non Significant

Table 11: Mean ±SD values of minerals and secondary metabolites at different maturity stages in *Acacia nilotica* pods on fresh weight basis

Minerals (ppm)	Maturity stages of pods			'F'	CD 5%	CD 1%
	Premature	Seed developing	Mature			
Iron	1.40±0.12	0.74±0.03	0.56±0.00	511.44**	0.14	0.21
Calcium	64.42 ±1.21	60.31±1.08	56.00±1.04	156.33**	1.20	3.86
Phosphorus	83.23±4.59	67.90±1.41	64.71±2.39	30.42**	6.19	9.37
Sodium	9.60±0.50	8.62±1.20	7.21 ±1.22	0.03^{NS}	-	-
Potassium	10.52±0.47	8.11±0.13	5.89±0.43	108.40**	0.75	1.14
Zinc	22.42±0.07	15.12±0.00	14.90±0.01	45.00**	0.05	0.08
Copper	0.09±0.01	0.06±0.01	0.04±0.00	24.00**	0.01	0.02
Magnesium	7.28±0.48	6.36±0.12	5.60±0.37	14.87**	0.71	1.08
Manganese	0.15±0.01	0.10±0.01	0.08±0.00	143.33**	0.01	0.02
Chromium	0.4±0.01	0.33±0.02	0.20±0.01	133.50**	0.03	0.05
Total phenol(mg/g)	12.52±1.79	8.40±1.26	7.68±1.08	2.59^{NS}	-	-
Tannin (mg/g)	8.12±1.79	7.30±1.26	6.96±1.08	0.06^{NS}	-	-

Level of significance: * P≤0.05, ** P≤0.01 and NS = Non Significant

Table12: Distribution of the subjects by *Acacia nilotica* dose and religion

Religion	Frequency (%)			Total (n = 45)
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	
Hindu	13 (86.6)	13 (86.6)	15 (100.0)	41 (91.1)
Muslim	1 (6.6)	2 (13.3)	-	3 (6.6)
Sikh	1 (6.6)	-	-	1 (2.2)

$ Group I, II & III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table13: Distribution of the subject by *Acacia nilotica* dose and caste

Caste	Frequency (%)			Total (n = 45)
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	
Jain	5 (33.3)	4 (26.6)	4 (26.6)	13 (28.8)
Brahmin	8 (53.3)	9 (60.0)	5 (33.3)	22 (48.8)
Other	2 (13.3)	2 (13.3)	6 (40.0)	10 (22.2)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 14: Distribution of the subjects by *Acacia nilotica* dose and family type

Family Type	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Joint	3 (20.0)	4 (26.6)	4 (26.6)	11 (24.4)
Nuclear	12 (80.0)	11 (73.3)	11 (73.3)	34 (75.5)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 15: Distribution of the subjects by *Acacia nilotica* dose and family size

Family Size	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
2-4	4 (26.6)	5(33.3)	6(40.0)	15 (33.3)
4-6	6 (40.0)	7 (46.6)	5 (33.3)	18 (40.0)
6-8	4 (26.6)	3 (20.0)	4 (26.6)	11 (24.4)
>8	1 (6.6)	-	-	1 (2.2)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 16: Distribution of the subjects by *Acacia nilotica* dose and family income

Family Income month (Rs.)	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
<5000	1 (6.6)	1 (6.6)	-	2 (4.4)
5000-10,000	7 (46.6)	6(40.0)	7 (46.6)	20 (44.4)
10,000-15,000	5 (33.3)	4 (26.6)	5 (33.3)	13 (28.8)
> 15,000	2 (13.3)	4 (26.6)	3 (20.0)	9 (20.0)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 17: Distribution o families by *Acacia nilotica* doses and major source of income

Source of income	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Agriculture	-	1 (2.2)	-	1 (2.2)
Service	6 (40.0)	7 (46.6)	7 (46.6)	20 (44.4)
Business	6 (40.0)	5 (33.3)	5 (33.3)	16 (35.5)
Service + Business	1 (6.6)	-	-	1 (2.2)
Agriculture + Business	1 (6.6)	2(13.3)	1 (2.2)	4(8.8)
Agriculture + Service	1 (6.6)	-	-	1 (2.2)
Other	-	-	2 (4.4)	2 (4.4)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 18: Distribution of the subjects by *Acacia nilotica* dose and age

Age	Frequency (%)			Total
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	(n = 45)
45-50	3 (20.0)	6 (40.0)	7 (46.6)	16 (35.5)
50-55	2 (13.3)	2 (13.3)	4 (26.6)	8 (17.7)
55-60	5 (33.3)	2 (13.3)	-	7 (15.5)
60-65	5 (33.3)	5 (33.3)	4 (26.6)	14 (31.1)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 19: Distribution of the subjects by *Acacia nilotica* dose and sex

Sex	Frequency (%)			Total
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	(n = 45)
Male	11 (73.3)	10 (66.6)	11 (73.3)	32 (71.1)
Female	4 (26.6)	5 (33.3)	4 (26.6)	13 (28.8)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 20: Distribution of the subjects by *Acacia nilotica* dose and education level

Educational Level	Frequency (%)			Total (n = 45)
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	
Illiterate	1 (6.6)	-	2 (13.3)	3 (6.6)
Primary	1 (6.6)	3 (20.0)	-	4 (8.8)
Middle	3 (20.0)	2 (13.3)	2 (13.3)	7 (15.5)
Secondary	5 (33.3)	2 (13.3)	4 (26.6)	11 (24.4)
Sr. Secondary	2 (13.3)	6 (40.0)	2 (13.3)	10 (22.2)
Under graduate	1 (6.6)	2 (13.3)	3 (20.0)	6 (13.3)
Post graduate	2 (13.3)	-	1 (6.6)	3 (6.6)
Vocational	-	-	1 (6.6)	1 (2.2)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 21: Distribution of the subjects by *Acacia nilotica* dose and occupation

Occupation	Frequency (%)			Total (n = 45)
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	
Government service	2 (13.3)	4 (26.6)	6 (40.0)	12 (26.6)
Private service	1 (6.6)	1 (6.6)	1 (6.6)	4 (8.8)
Retired	4 (26.6)	4 (26.6)	1 (6.6)	9 (20.0)
Business	3 (20.0)	2 (13.3)	4 (26.6)	9 (20.0)
Housewife	4 (100.0)	4 (80.0)	3 (75.0)	11 (84.6)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 22: Distribution of the subjects by *Acacia nilotica* dose and marital status

Marital Status	Frequency (%) Intervention Groups $ I (n = 15)	II (n = 15)	III (n = 15)	Total (n = 45)
Married	14 (93.3)	15 (100)	15 (100)	44 (97.7)
Unmarried	-	-	-	-
Widows	1 (6.6)	-	-	1 (2.2)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 23: Distribution of the subjects by *Acacia nilotica* dose and food habits

Food habits	Frequency (%) Intervention Groups $ I (n = 15)	II (n = 15)	III (n = 15)	Total (n = 45)
Vegetarian	11 (73.3)	9 (60.0)	10 (66.6)	30 (66.6)
Non-vegetarian	4 (26.6)	4 (26.6)	2 (132.3)	10 (22.2)
Ovo-vegetarian	-	2 (13.3)	3 (20.0)	5 (11.1)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 24: Distribution of the subjects by *Acacia nilotica* dose and health habits

Details	Frequency (%)			Total (n = 45)
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	
Smoking				
Yes	5 (33.3)	4 (26.6)	5 (33.3)	14 (31.1)
No	10 (66.6)	11 (73.3)	10 (66.6)	31 (68.8)
If yes				
Daily	5 (33.3)	3 (20)	5 (33.3)	13 (28.8)
Weekly	-	1 (6.6)	-	1 (2.2)
Occasionally	-	-	-	-
Tobacco				
Yes	6 (40)	3 (20.0)	2 (13.3)	11 (24.4)
No	9 (60.0)	12 (80.0)	13 (86.6)	34 (75.5)
If yes				
Daily	4 (26.6)	3 (20.0)	1 (6.6)	8 (17.7)
Weekly	2 (13.3)	-	1 (6.6)	3 (6.6)
Occasionally	-	-	-	-
Alcohol consumption				
Yes	3 (20.0)	4 (26.6)	3 (20.0)	10 (22.2)
No	12 (80.0)	11 (73.3)	12 (80.0)	35 (77.7)
If yes				
Daily	2 (13.3)	3 (20.0)	2 (13.3)	5 (11.1)
Weekly	1 (6.6)	1 (6.6)	1 (6.6)	3 (2.2)
Occasionally	-	-	-	-
Tea				
Yes	15 (100)	15 (100)	15 (100)	45 (100)
No	0 (0)	0 (0)	0 (0)	0 (0)
If yes				
Daily	15 (100)	15 (100)	13 (86.6)	43 (95.5)
Weekly	-	-	2 (13.3)	2 (4.4)
Occasionally	-	-	-	-
Coffee				
Yes	12 (80.0)	15 (100)	10 (66.6)	37 (82.2)
No	3 (20.0)	0 (0.0)	5 (33.3)	8 (17.7)
If yes				
Daily			-	
Weekly	9 (33.3)	5 (33.3)		14 (31.1)
Occasionally	3 (20.0)	10 (66.6)	10 (66.6)	23 (51.1)
Gutka				
Yes	7 (46.6)	5 (33.3)	3 (20.0)	15 (33.3)
No	8 (53.4)	10 (66.6)	12 (80.0)	30 (66.6)
If yes				
Daily	4 (26.6)	5 (33.3)	3 (20.0)	12 (26.6)
Weekly	3 (20.0)	-	0 (0.0)	-
Occasionally	-	-	-	-

$ Group I, II and III were fed 2, 3 and 4g of Acacia nilotica pods powder respectively

Table 25: Distribution of the subjects by *Acacia nilotica* dose and exercise performed

Details	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Exercise				
Yes	7 (46.6)	6 (40.0)	9 (60.0)	22 (48.8)
No	8 (53.3)	9 (60.0)	6 (40.0)	23 (51.1)
Type of exercise				
Yoga	2 (13.3)	3 (20.0)	2 (13.3)	7 (15.5)
Walking	5 (33.3)	3 (20.0)	6 (40.0)	14 (31.1)
Cycling	-	-	1 (6.6)	1 (2.2)
Frequency of exercise				
Daily	7 (46.6)	6 (40.0)	9 (60.0)	22 (48.8)
Weekly	-	-	-	-
Fortnightly	-	-	-	-
Monthly	-	-	-	-
Occasionally	-	-	-	-
Duration (minutes)				
30	3 (20.0)	2 (13.3)	3 (20.0)	8 (18.7)
45	3 (20.0)	2 (13.3)	1 (6.6)	13 (13.3)
60	1 (6.6)	2 (13.3)	5 (33.3)	8 (17.7)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 26: Distribution of the subjects by *Acacia nilotica* dose and family history of diabetes

Details	Frequency (%)			Total
	Intervention Groups $			(n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Family history of diabetes				
Yes	9 (60.0)	7 (46.6)	7 (46.6)	23 (51.1)
No	8 (53.3)	8 (53.3)	8 (53.3)	22 (48.8)
Relationship with the subject				
Father	5 (33.3)	3 (20.0)	4 (26.6)	12 (26.6)
Mother	1 (6.6)	3 (20.0)	3 (20.0))	7 (15.5)
Brother	2 (13.3)	1 (6.6)	-	3 (6.6)
Sister	1 (6.6)	-	-	1 (2.2)
Grand parents	-	-	-	-

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 27: Distribution of the subjects by *Acacia nilotica* dose and occurrence of disease

Details	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Age of onset (years)				
< 40	-	2 (13.3)	1 (6.6)	3 (6.6)
40 – 50	6 (40.0)	6 (40.0)	9 (60.0)	21 (46.6)
50 – 60	8 (53.3)	6 (40.0)	4 (26.6)	18 (40.0)
≥ 60	1 (6.6)	1 (6.6)	1 (6.6)	3 (6.6)
Duration of the disease after diagnosis (years)				
1 - 5	6 (40.0)	8 (53.3)	7 (46.6)	21 (46.6)
5 - 10	9 (60.0)	6 (40.0)	6 (40.0)	18 (40.0)
10 - 15	-	1 (6.6)	2 (13.3)	6 (13.3)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 28: Distribution of the subjects by *Acacia nilotica* dose and treatment taken for the management of diabetes

Details	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Diet	-	-	2 (13.3)	2 (4.4)
Exercise	3 (20.0)	-	1 (6.6)	4(8.8)
Drug	2 (13.3)	5 (33.3)	3 (20.0)	10(22.2)
Diet + exercise	3 (20.0)	3 (20.0)	2 (13.3)	8 (17.7)
Drug + exercise	7 (46.6)	5(33.3)	2 (13.3)	14 (31.1)
Diet + Drug + Exercise	-	2 (13.3)	5 (33.3)	7 (15.5)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 29: Distribution of the subjects by *Acacia nilotica* dose and inclusion of foods due to diabetes

Details	Frequency (%) Intervention Groups $			Total (n = 45)
	I (n = 15)	II (n = 15)	III (n = 15)	
Fenugreek seeds	1 (6.6)	2 (13.3)	-	3 (6.6)
Bitter gourd	1 (6.6)	-	-	1 (2.2)
Jamun seeds powder	-	2 (13.3)	-	2 (4.4)
Beal patra + neem leaves	1 (6.6)	-	1 (6.6)	2 (4.4)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 31: Distribution of the subjects by *Acacia nilotica* dose and meal pattern

Details	Frequency (%)			Total
	Intervention Groups $			
	I (n = 15)	II (n = 15)	III (n = 15)	(n = 45)
Number of meals				
2 meals	7 (46.6)	7 (46.6)	6 (40.0)	2 (44.4)
3 meals	6 (40.0)	5 (33.3)	6 (40.0)	17 (37.7)
4 meals	2 (13.3)	3(20.0)	3(20.0)	8 (17.7))
Snacks between meals				
Yes	6 (40.0)	6 (40.0)	5 (33.3)	17 (37.7)
No	10 (66.6)	9 (60.0)	9 (60.0)	28 (62.2)
Commonly consumed snacks				
Biscuit	2 (13.3)	-	2 (13.3)	4 (8.8)
Samosa / Kachori	1 (6.6)	-	-	1 (2.2)
Biscuit + namkeen	3 (20.0)	6 (40.0)	3 (20.0)	12 (26.6)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 33: Pre and post intervention food intake of the groups as percentage of balanced diet

Food intake	Intervention groups$					
	I (n = 15)		II (n = 15)		III (n = 15)	
	Pre	Post	Pre	Post	Pre	Post
Cereal grains product	62	60	56	57	59	57
Pulses & legumes	46	47	45	48	44	46
Green leafy vegetables	30	40	45	48	43	40
Roots and tubers	60	58	55	55	62	59
Other vegetables	60	66	65	61	70	73
Fruits	51	56	51	50	55	60
Milk & Milk products	80	85	90	93	92	91
Fats and oils	149	145	129	142	131	135
Sugar	45	46	40	45	40	48

$Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 35: Pre and post intervention nutrient intake of the groups as percentage of RDA

Nutrients	Intervention groups$		
	I (n = 15)	II (n = 15)	III (n = 15)

	Pre	Post	Pre	Post	Pre	Post
Protein	70.0	68.0	77.0	78.0	75.0	70.0
Visible fat	149.0	145.0	129.0	142.0	131.0	135.0
Energy	61.8	62.2	61.8	62.2	62.3	62.6
Calcium	85.0	83.0	86.7	87.0	87.6	85.0
Iron	57.0	61.0	56.0	58.0	64.0	63.0
β Carotene	99.7	98.4	92.0	93.0	90.0	107.0
Thiamine	100.0	100.0	116.6	116.6	108.3	108.3
Riboflavin	79.0	75.0	75.0	75.0	75.0	75.0
Niacin	58.0	59.0	66.0	66.0	68.0	68.0
Folic acid	53.0	58.0	59.0	63.0	64.0	59.0
Vitamin C	160.0	142.5	147.0	143.0	149.0	145.0

RDA = Recommended dietary allowances

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 36: Pre and post intervention energy intake of the I group on the basis of ideal body weight (IBW)

S. No.	Calorie Requirement	Calorie intake (kcal/day)			
		Pre		Post	
		(kcal/day)	Percent of kcal on the basis of IBW	(kcal/day)	Percent of kcal on the basis of IBW
1.	1917	1499	78.1	1520	79.2
2.	1728	1500	86.8	1570	90.8
3.	1755	1490	84.9	1500	85.4
4.	1431	1455	101.6	1460	102.0
5.	1728	1499	86.7	1500	86.8
6.	1944	1500	77.1	1470	75.6
7.	1674	1500	89.6	1500	859.6
8.	1971	1500	76.1	1500	76.1
9.	1296	1480	114.1	1500	115.7
10.	1701	1554	91.3	1550	91.1
11.	1620	1520	93.8	1510	93.2
12.	1971	1499	76.0	1510	76.6
13.	1836	1500	81.6	1470	80.0
14.	1755	1480	86.0	1500	85.4
15.	1539	1499	96.1	1500	97.4
Mean	1456	1499	87.9	1509	88.3

€ Group I was fed 2g of Acacia nilotica pods powder

Table 37: Pre and post intervention energy intake of the II group on the basis of ideal body weight (IBW)

S.No.	Calorie Requirement (kcal)	Calorie intake (kcal/day)			
		Pre		Post	
		(kcal/day)	Percent of kcal on the basis of IBW	(kcal/day)	Percent of kcal on the basis of IBW

1.	1917	1530	79.8	1530	79.8
2.	1971	1500	76.1	1540	78.1
3.	1998	1450	72.5	1460	73.0
4.	1404	1501	106.9	1500	106.8
5.	1350	1510	111.8	1518	112.4
6.	1377	1487	107.9	1500	108.9
7.	1728	1499	86.7	1510	87.3
8.	1917	1500	78.2	1500	78.2
9.	1647	1450	88.0	1456	88.4
10.	1728	1550	89.6	1600	92.5
11.	1755	1500	85.4	1523	86.7
12.	2079	1600	76.9	1640	102.5
13.	1350	1500	111.1	1529	113.2
14.	1350	1530	113.3	1520	112.5
15.	2025	1500	74.0	1515	74.8
Mean	1706	1500	83.8	1512	93.0

€ Group II was fed 3g *Acacia nilotica* pods powder

Table 38: Pre and post intervention energy intake of the III group on the basis of ideal body weight (IBW)

S.No.	Calorie Requirement (kcal)	Calorie intake (kcal/day)			
		Pre		Post	
		(kcal/day)	Percent of kcal on the basis of IBW	(kcal/day)	Percent of kcal on the basis of IBW
1.	1836	1455	79.2	1480	80.6
2.	1728	1500	86.8	1512	87.5
3.	1458	1600	109.7	1600	109.7
4.	1917	1570	81.8	1600	83.4
5.	1890	1510	79.8	1510	79.8
6.	1296	1488	114.8	1499	115.6
7.	1809	1499	82.8	1499	82.8
8.	1404	1500	106.8	1520	108.2
9.	1917	1450	75.6	1470	76.6
10.	2025	1500	74.0	1520	75.0
11.	2106	1500	71.2	1500	71.2
12.	1404	1540	109.6	1555	110.7
13.	1647	1590	96.5	1580	95.9
14.	1350	1400	103.7	1380	102.2
15.	2025	1510	74.5	1540	76.0
Mean	1607	1511	89.7	1520	90.3

€ Group III was fed 4g *Acacia nilotica* pods powder

Table 40 : Pre and post intervention nutritional status of the groups

Body mass index (kg/m^2)	Frequency (%) Intervention groups$ I (n = 15)		II (n = 15)		III (n = 15)		Total (n=45)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
> 18.5 (Chronic energy deficiency)	-	-	2 (13.3)	2 (3.13)	1 (6.6)	1 (6.6)	3 (6.6)	3 (6.6)
18.5 - 19.9 (Low weight normal)	1 (6.6)	1 (6.6)	1 (6.6)	1 (6.6)	2 (13.3)	2 (13.3)	4 (8.8)	4 (8.8)
20 - 22.9 (Normal)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	12 (26.6)	12 (26.6)
23 - 24.9 (Overweight)	6 (40.0)	6 (40.0)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	14 (31.1)	14 (31.1)
> 25 (Obese)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	4 (26.6)	12 (26.6)	12 (26.6)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 43: Means ± SD values of blood glucose before intervention of *Acacia nilotica* pods powder

Blood glucose (mg/dl)	Intervention groups$			'F'
	I (n = 15)	II (n = 15)	III (n = 15)	
Fasting	143.73±37.05	135.47±29.34	205.80±80.03	9.233*
Post prandial	216.47±52.86	212.00±61.34	301.87±116.37	4.281^{NS}

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 44 : Means ± SD values of blood glucose before intervention of *Acacia nilotica* pods powder

Blood glucose (mg/dl)	Intervention groups$			'F'
	I (n = 12)	II (n = 11)	III (n = 13)	
Fasting	155.33±31.73	1477.18±25.01	180.23±42.87	3.045 ^{NS}
Post prandial	222.33±55.52	221.73±66.20	274.77±98.75	1.956^{NS}

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 46 : Percent decrease in biophysical and biochemical parameters due to Acacia nilotica pods powder intervention

S. No.	Parameters	Per cent change		
		Group I (n=12)	Group II (n=11)	Group III (n=13)
1.	Blood glucose			
	➢ Fasting blood glucose	10.2	11.6	19.1
	➢ Post prandial blood glucose	7.3	10.6	35.5
2.	Blood pressure			
	➢ Systolic blood pressure	8.5	10.0	11.6
	➢ Diastolic blood pressure	12.4	11.9	12.7
3.	Lipid levels			
	➢ Cholesterol	7.9	5.1	10.8
	➢ Triglyceride	16.0	5.8	17.0
	➢ HDL	10.4	5.0	10.0
	➢ LDL	8.8	7.1	10.2
	➢ VLDL	15.2	7.1	15.3

$ Group I, II and III were fed 2, 3 and 4g of Acacia nilotica pods powder respectively

Table 48 : Risk of macro-vascular disease among the groups before intervention of *Acacia nilotica* pod powder

S. No.	Lipid profile fractions (mg/dl)	Risk	Percentage (number)		
			Group I	Group II	Group III
1.	Total cholesterol				
	<200	Low	8(66.6)	8(72.7)	7(53.8)
	200 – 239	Moderate	3(25.0)	1(9.0)	6(46.1)
	>240	High	1(8.3)	2(18.1)	-
2.	Triglyceride				
	<120	Low	1(8.3)	1(9.0)	-
	121 -160	Moderate	4(33.3)	2(18.1)	7(53.8)
	161-200	High moderate	3(25.0)	4(36.3)	1(7.6)
	> 200	High	4(33.3)	4(36.3)	5(58.4)
3.	HDL-C				
	<40	High	5(41.6)	4(36.3)	6(46.1)
	41 -60	Moderate	7(58.3)	5(45.4)	6(46.1)
	>60	Low	-	2(18.1)	1(7.6)
4.	LDL				
	<100	Low	4(33.3)	5(45.4)	5(58.4)
	101 – 115	Moderate	3(25.0)	3(27.2)	2(15.3)
	116-130	High moderate	2(16.6)	-	3(23.0)
	>130	High	3(25.0)	3(27.2)	3(23.0)
5.	VLDL				
	<30	Low	5(41.6)	3(27.2)	6(46.1)
	31-40	Moderate	5(41.6)	4(36.3)	1(7.6)
	>40	High	2(16.6)	4(36.3)	6(46.1)

- WHO (1988)

$ Group I, II and III were fed 2, 3 and 4g of Acacia nilotica pods powder respectively

Table 49 : Risk of macro-vascular disease among the groups after intervention of *Acacia nilotica* pod powder

S. No.	Lipid profile fractions (mg/dl)	Risk	Percentage (number)		
			Group I	Group II	Group III
1.	Total cholesterol				
	<200	Low	10(83.3)	8(72.7)	10(76.2)
	200 – 239	Moderate	1(8.3)	2(18.1)	3(23.0)
	>240	High	1(8.3)	1(9.0)	-
2.	triglyceride				
	<120	Low	1(8.3)	1(9.0)	-
	121 -160	Moderate	4(33.3)	2(18.1)	7(53.8)
	161-200	High moderate	4(33.3)	5(45.4)	1(7.6)
	> 200	High	3(25.0)	3(27.2)	5(58.4)
3.	HDL-C				
	<40	High	2(16.6)	3(27.2)	2(15.3)
	41 -60	Moderate	10(83.3)	5(45.4)	1184.6)
	>60	Low	-	3(27.2)	
4.	LDL				
	<100	Low	5(41.6)	7(63.6)	7(53.8)
	101 – 115	Moderate	2(16.6)	1(9.0)	2(15.3)
	116-130	High moderate	2(16.6)	1(9.0)	2(15.3)
	>130	High	3(25.0)	2(18.1)	2(15.3)
5.	VLDL				
	<30	Low	5(41.6)	3(27.2)	6(46.1)
	31-40	Moderate	5(41.6)	6((54.5)	2(15.3)
	>40	High	2(16.6)	2(18.1)	5(58.4)

- WHO (1988)

$ Group I, II and III were fed 2, 3 and 4g of Acacia nilotica pods powder respectively

Table 30 : Distribution of the subjects by *Acacia nilotica* dose and avoidance of foods due to diabetes

Details	Frequency (%) Intervention Groups $									Total (n = 45)		
	(n = 15)			(n = 15)			(n = 15)			As usual	Restricted	Avoid
	Asusual	Restricted	Avoid	As usual	Restricted	Avoid	As usual	Restricted	Avoid			
Sugar and sugar products												
Sugar	2 (13.3)	10 (66.6)	3 (20.0)	4 (26.6)	10 (66.6)	1 (6.6)	-	13 (86.6)	2 (13.3)	6 (13.3)	33 (13.3)	6 (13.3)
Sweet	2 (13.3)	7 (46.6)	6 (40.0)	4 (26.6)	11 (73.3)	-	-	11 (73.3)	4 (26.6)	6 (13.3)	29 (64.4)	10 (22.2)
Preserved food	-	4 (26.6)	11 (73.3)	4 (26.6)	8 (53.3)	3 (20.0)	5 (33.3)	6 (40.0)	4 (26.6)	8 (17.7)	18 (40.0)	18 (40.0)
Fats and oils												
Oil	12 (80.0)	3 (20.0)	-	10 (66.6)	5 (33.3)	-	14 (93.3)	1 (6.6)	-	36 (80)	9 (20.0)	-
Butter	-	4 (26.6)	11 (73.3)	-	5 (33.3)	10 (66.6)	13 (86.6)	2 (13.3)	-	13 (28.8)	11 (24.4)	21 (46.6)
Ghee	10 (66.6)	5 (33.3)	-	10 (66.6)	5 (33.3)	-	8 (53.3)	5 (33.3)	2 (13.3)	28 (62.2)	15 (33.3)	2 (4.4)
Dry fruits	11 (73.3)	4 (26.6)	-	10 (66.6)	5 (33.3)	-	10 (66.6)	5 (33.3)	-	31 (68.8)	14 (31.1	-
Ground nuts	15 (100)	-	-	5 (100)	-	-	15 (100)	-	-	45 (100)	-	-
Carbohydrate rich foods												
Potato	2 (13.3)	8 (53.3)	5 (33.3)	-	9 (60.0)	6 (40.0)	3 (20.0)	8 (53.3)	4 (26.6)	5 (11.1)	25 (55.5)	15 (33.3)
Sweet potato	-	3 (20.0)	12 (80.0)	-	-	15 (100)	-	5 (33.3)	10 (66.6)	-	8 (17.7)	37 (82.2)
Rice	2 (13.3)	2 (13.3)	11 (73.3)	-	3 (20.0)	12 (80.0)	-	6 (40.0)	9 (60.0)	2 (4.4)	11 (24.4)	32 (71.1)

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Table 32: Pre and post intervention food intake of the groups

Foods	Mean±SD								
	Intervention Groups $								
	I (n = 15)			**II (n = 15)**			**III (n = 15)**		
	Pre	**Post**	**Paired 't'**	**Pre**	**Post**	**Paired 't'**	**Pre**	**Post**	**Paired 't'**
Cereal & millets	260.8±8.50	250.0±17.73	2.911*	235.7±7.19	240.3±13.62	2.090 NS	245.8±8.42	240.5±6.90	2.080 NS
Pulses & legumes	27.7±1.95	28.3±4.50	0.493 NS	26.7±14.50	28.5±5.30	2.284*	26.4±6.11	27.53±4.53	0.640 NS
Green leafy vegetables	29.7±6.94	40.0±11.25	3.007**	44.7±14.07	48.2±10.18	2.037 NS	42.6±3.07	40.0±5.00	0.829 NS
Roots and tubers	59.7±5.50	58.0±18.21	0.320 NS	55.3±12.02	54.7±9.90	0.192 NS	61.7±11.90	59.0±5.07	0.738 NS
Other vegetables	62.0±11.34	66.0±15.38	1.843 NS	65.3±3.99	60.8±8.34	2.807*	70..3±7.67	73.3±4.50	0.858 NS
Fruits	51.0±16.06	55.7±11.16	0.750 NS	50.5±7.68	50.0±4.63	0.189 NS	55.0±10.0	60.0±10.77	3.929 NS
Milk & Milk products (ml)	240.0±52.50	230.0±58.61	0.406 NS	245.0±44.40	248.0±36.45	1.855 NS	250.0±47.43	240.0±34.27	2.141 NS
Fats and oils	29.7±6.40	29.0±5.16	10.000 NS	25.7±5.12	28.3±5.23	1.533 NS	26.2±5.09	26.9±5.21	0.056 NS
Sugar and Jaggery	9.0±3.99	9.2±2.44	0.292 NS	8.0±3.57	9.0±3.14	0.887 NS	9.0±3.27	9.6±3.28	0.049 NS

$Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * P≤ 0.05, ** p ≤ 0.01, NS= non significant

Table 34: Pre and post intervention nutrient intake of the groups

Nutrient	Mean ± SD								
	Intervention Groups $								
	I (n = 15)			II (n = 15)			III (n = 15)		
	Pre	Post	Paired 't'	Pre	Post	Paired 't'	Pre	Post	Paired 't'
Protein (g)	41.7±12.15	41.0±8.12	0.211 NS	46.3±5.36	46.7±5.60	0.405 NS	45.0±7.90	42.2±7.92	2.845*
Total Fat (g)	60.0±9.92	62.6±9.17	1.533 NS	55.7±12.22	55.8±12.35	0.056 NS	59.0±8.40	57.0±8.93	1.160 NS
Visible fat (g)	29.7±3.08	29.0±3.61	0.100NS	25.7±2.08	28.3±3.10	0.020NS	28.2±2.40	26.9±3.18	0.018 NS
Invisible fat (g)	30.3±3.95	33.5±3.00	0.310NS	30.1±2.50	27.4±2.90	0.010 NS	30.8±2.80	30.0±2.90	0.015 NS
Fibre (g)	5.2±1.2	5.2±0.82	0.089 NS	5.9±1.29	5.8±0.76	0.294 NS	6.3±1.48	6.0±1.00	0.949 NS
Carbohydrate (g)	200.3±36.34	196.5±28.12	0.419 NS	187.7±37.93	195.0±39.92	1.162 NS	188.7±32.58	192.1±35.05	0.061 NS
Energy (Kcal)	1500.0±98.81	1512.0±133.63	0.445 NS	1499.0±103.13	1509±122.16	2.005 NS	1511.0±123.99	1520.0±150.06	1.033 NS
Calcium (mg)	340.5±142.12	331.4±130.40	1.199 NS	346.8±140.65	348.0±136.45	1.436 NS	350.5±145.13	340.0±147.18	1.198 NS
Iron (mg)	16.0±2.16	17.2±2.50	0.280 NS	15.6±2.00	16.2±1.36	0.486 NS	18.0±2.59	17.6±2.80	0.0.890 NS
β Carotene (μg)	2395.0±50.59	2362.0±529.0	0.063 NS	2200.5±496.84	2000.5±431.11	0.028 NS	2150.2±602.89	2558.0±656.20	0.868 NS
Thiamin (mg)	1.2±0.25	1.2±0.21	0.052 NS	1.4±0.20	1.4±0.21	0.042 NS	1.3±0.19	1.3±0.21	2.007 NS
Riboflavin (mg)	1.1±0.34	1.0±0.24	0.637 NS	1.0±0.25	1.0±0.19	0.014 NS	1.0±0.25	1.0±0.20	0.395 NS
Niacin (mg)	9.3±1.71	9.5±1.55	0.828 NS	10.5±1.56	10.6±1.79	0.079 NS	10.8±1.72	10.8±1.99	0.836 NS
Folic acid (μg)	53.4±16.15	60.0±16.02	0.734 NS	58.8±15.20	62.7±24.79	0.569 NS	64.5±22.44	55.6±15.48	1.221 NS
Vitamin C (mg)	64.1±18.68	56.8±13.51	1.314 NS	59.0±19.10	57.2±10.81	1.036 NS	59.7±16.12	58.0±15.19	1.044 NS

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * P≤ 0.05, ** p ≤ 0.01, NS= non significant

Table 39: Pre and post intervention anthropometric measurements and indices of the groups

Anthropometric measurements & indices	Mean ± SD								
	Intervention Groups $								
	I (n = 15)			II (n = 15)			III (n = 15)		
	Pre	Post	Paired 't'	Pre	Post	Paired 't'	Pre	Post	Paired 't'
Weight (kg)	64.27±10.16	64.47±10.53	0.764[NS]	59.60±10.89	59.47±11.01	1.468[NS]	62.93±10.93	62.60±10.47	0.863[NS]
Height (cm)	164.00±7.90	-	-	163.0±9.60	-	-	163.0±9.60	-	-
BMI (kg/m^2)	23.51±2.86	23.65±3.00	1.382[NS]	22..33±3.46	22.34±3.38	0.083[NS]	23.53±2.95	23.39±3.24	1.362[NS]
Waist circumference (cm)	107.5±5.50	107.0±5.51	1.232 [NS]	101.2±7.56	101.0±0.0	1.202 [NS]	102.0±8.0	101.0±8.0	1.112 [NS]
Hip circumference (cm)	112.0±7.50	112.0±7.0	1.024 [NS]	110.0±5.62	109.5±5.02	1.360 [NS]	110.0±9.60	111.2±8.0	1.002 [NS]
Waist hip ratio	0.95±0.04	0.95±0.04	1.000[NS]	0.92±0.04	0.92±0.04	0.837[NS]	0.92±0.04	0.92±0.06	0.830[NS]

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * P≤ 0.05, ** p ≤ 0.01, NS no significant

Table 42 : Pre and post intervention body composition of the groups

Body composition parameters (%)	**Mean ± SD**								
	Intervention Groups $								
	I (n = 15)			**II (n = 15)**			**III (n = 15)**		
	Pre	**Post**	**Paired 't'**	**Pre**	**Post**	**Paired 't'**	**Pre**	**Post**	**Paired 't'**
Body fat	26.41±2.73	26.38±2.73	0.38 NS	26.57±4.97	26.93±5.41	8.21 NS	26.33±7.58	26.27±7.48	0.43 NS
Lean body mass	56.07±1.98	55.68±1.66	1.69 NS	54.14±1.98	54..27±2.12	0.71 NS	57.0±12.67	57.11±3.45	0.31 NS
Total body water	53.16±2.31	53.08±2.38	0.45 NS	53.23±3.58	53.21±3.59	0.64 NS	52.38±4.64	52.17±4.65	1.47 NS
Extra cellular water	23.54±1.76	23.34±1.69	0.47 NS	24.60±3.08	24.59±3.09	0.20 NS	24.21±3.28	24.35±3.28	0.81 NS
Intra cellular water	24.79±8.05	24.77±7.96	0.28 NS	27.34±7.71	27.19±7.71	1.87 NS	28.21±5.31	28.17±5.32	0.20 NS
Body cell mass	27.73±6.51	27.53±6.48	1.51 NS	29.27±4.26	29.25±4.31	0.17 NS	28.11±4.91	27.89±5.15	1.48 NS

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * P≤ 0.05, ** p ≤ 0.01, NS= non significant

Table 45 : Pre and post intervention blood glucose level of the groups

Blood glucose mg/dl	Mean ± SD								
	Intervention Groups $								
	I (n = 12)			II (n = 11)			III (n = 13)		
	Pre	Post	Paired 't'	Pre	Post	Paired 't'	Pre	Post	Paired 't'
Fasting	155.33±31.73	153.83±37.57	0.321^{NS}	147.18±25.01	140.00±31.47	1.143^{NS}	180.23±42.87	157.92±51.79	1.776^{NS}
Post Prandial	222.32±55.52	230.17±60.86	0.944^{NS}	221.73±66.20	213.55±77.81	1.249^{NS}	274.77±98.75	206.69±83.90	2.952*

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * $P \leq 0.05$, ** $p \leq 0.01$, NS non significant

Table 47: Pre and post intervention lipid profile of the groups

Lipid levels	Mean ± SD								
	Intervention groups$								
	I (n = 12)			II (n = 11)			III (n = 13)		
	Pre	Post	Paired 't'	Pre	Post	Paired 't'	Pre	Post	Paired 't'
Cholesterol	191.83±39.49	182.31±35.96	1.367 NS	183.06±47.94	177.36±45.44	1.187 NS	194.03±29.06	181.50±27.04	2.328*
Triglycerides	196.94±65.32	179.50±53.12	1.762 NS	205.33±67.71	199.72±64.02	1.783 NS	224.00±102.82	198.76±75.00	2.206*
HDL	43.56±8.03	45.88±5.68	1.756 NS	48.63±15.77	49.25±15.40	1.710 NS	46.07±8.55	47.88±7.30	3.365**
LDL	114.42±49.22	100.41±43.92	1.324 NS	104.33±45.61	99.18±43.08	1.873 NS	108.37±25.13	102.89±26.52	1.329 NS
VLDL	39.20±12.59	35.95±10.66	0.640 NS	41.07±13.54	40.02±12.82	1.629 NS	44.80±20.77	39.77±14.97	2.295*

$Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * $P \leq 0.05$, ** $p \leq 0.01$, NS non significant

Table 50 : Pre and post intervention blood pressure levels of the groups

Blood pressure mm/hg	Mean ± SD								
	Intervention Groups $								
	I (n = 12)			II (n = 11)			III (n = 13)		
	Pre	Post	Paired 't'	Pre	Post	Paired 't'	Pre	Post	Paired 't'
Systolic blood pressure	147.50±19.08	139.42±16.10	2.691*	137.09±19.60	129.45±12.49	2.224*	138.00±11.17	124.31±9.04	5.816**
Diastolic blood pressure	97.08±9.39	87.08±13.60	3.516 NS	91.64±13.02	84.64±8.62	1.954NS	91.15±8.02	84.46±6.90	2.116*

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * P≤ 0.05, ** p ≤ 0.01, NS non significant

Table 51 : Pre and post intervention hypertension status of the groups

Blood pressure	Classification	Frequency (%)					
		Intervention groups					
		I (n = 12)		II (n = 11)		III (n = 13)	
		Pre	Post	Pre	Post	Pre	Post
Systolic							
< 120	Normal	-	-	2 (18.1)	2 (18.1)	-	5(38.4)
120 - 139	Pre - hypertension	6 (50.0)	7 (58.3)	3 (27.2)	6 (54.5)	6 (46.1)	7 (53.8)
140 - 159	Stage I hypertension	4 (33.3)	4 (33.3)	4 (36.3)	3 (27.2)	6 (46.1)	1 (7.6)
≥ 160	Stage II hypertension	2 (16.6)	1 (8.3)	2 (18.1)	-	1 (7.6)	-
Diastolic							
< 80	Normal	-	2 (16.6)	2 (18.1)	2 (18.1)	1 (7.6)	4 (30.7)
80 - 90	Pre - hypertension	4 (33.3)	7 (58.3)	3 (27.2)	4 (36.3)	3 (23.0)	5 (38.4)
90 - 99	Stage I hypertension	2 (16.6)	-	1 (9.0)	2 (18.1)	5 (38.4)	4 (30.7)
90 - 99	Stage II hypertension	6 (50.0)	2 (16.6)	5(45.4)	7 (63.6)	4 (30.7)	-

$ Group I, II and III were fed 2, 3 and 4g of *Acacia nilotica* pods powder respectively

Level of significance : * P≤ 0.05, ** p ≤ 0.01, NS non significant

Table 41 : Distribution of the subjects by *Acacia nilotica* dose and waist circumference and waist hip ratio

S. No.	Anthropometric indices	Frequency (%)											
		Intervention groups$											
		M=11		F=4		M=10		F=5		M=11		F=4	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1.	Waist circumference Male												
	< 94 cm. (normal)	4 (36.3)	4 (36.3)			2 (20.0)	2 (20.0)			1 (9.0)	1 (9.0)		
	≤ 94 cm. level 1 (alerting zone)	4 (36.3)	4 (36.3)			4 (40.0)	4 (40.0)			7 (63.3)	7 (63.3)		
	≥102 cm level 2 (action zone)	3 (27.2)	3 (27.2)			4 (40.0)	4 (40.0)			3 (27.2)	3 (27.2)		
	Female												
	< 80 cm (normal)			-	-						1 (25.0)	1 (25.0)	
	≥ 80 cm level 1 (alerting zone)			2 (50.0)	2 (50.0)			4 (80.0)	4 (80.0)		2 (50.0)	2 (50.0)	
	≤ 80.8 cm level 2 (action zone)			2 (50.0)	2 (50.0)			1 (20.0)	1 (20.0)		1 (25.0)	1 (25.0)	
2.	Waist hip ratio (WHR) Male												
	< 0.95 (normal)	4 (36.3)	4 (36.3)			6 (60.0)	6 (60.0)			5 (45.4)	5 (45.4)		
	≥ 0.95 (high)	7 (63.6)	7 (63.6)			4 (40.0)	4 (40.0)			6 (54.5)	6 (54.5)		
	Female												
	< 0.8 (normal)			11 (25.0)	1 (25.0)			2 (40.0)	2 (40.0)			1 (25.0)	1 25.0
	≥ 08 (high)			3 (75.0)	3 (75.0)			3 (60.3)	3 (60.0)			3 (75.0)	3 (75.0)

M = Male, F = Female

$ Group I, II and III were fed 2, 3 and 4 g *Acacia nilotica* pods powder respectively.

∈ classification devised by WHO expert committee, 1995.

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