

Anti-diabetic Effect of Elephant-foot Yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) in Streptozotocin-induced Diabetic Rats

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ABSTRACT

In the present study, the effect of the acetone extract of elephant-foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) at 0.1 and 0.25% in the diet of streptozotocin-induced male Wistar diabetic rats was studied. The study involved a comparison between control and diabetic groups: starch-fed control/diabetic (SFC/SFD), 0.1% acetone extract fed control/diabetic (AEFC_{0.1}/AEFD_{0.1}), 0.25% acetone extract fed control/diabetic (AEFC_{0.25}/AEFD_{0.25}) and aminoguanidine fed control/diabetic (AFC/AFD). The rats were examined for water intake, diet intake, urine output, gain in body weight, urine sugar, fasting blood sugar (FBS) and glomerular filtration rate (GFR). A concentration-dependent amelioration of the diabetic status was observed with respect to all the above studied parameters. FBS of AEFD_{0.1} and AEFD_{0.25} groups showed a 23% and 37% reduction, respectively whereas the AFD group showed a 45% reduction relative to the SFD group. The GFR of experimental rats in AEFD_{0.1} and AEFD_{0.25} groups showed a 28% and 41% reduction, respectively whereas the AFD group showed a 54% reduction compared to the SFD group. The results clearly indicate that the acetone extract of elephant foot yam is an effective anti-diabetic agent for streptozotocin-induced diabetic rats.

Keywords: fasting blood sugar, glomerular filtration rate, urine sugar

INTRODUCTION

Diabetes mellitus is an endocrine disorder characterized by inappropriate hyperglycemia resulting from defects in insulin secretion, insulin action, or both (Chandra *et al.* 2004; Frode and Medeiros 2008; Wadkar *et al.* 2008). It disturbs the metabolism of carbohydrates, fats, proteins and electrolytes leading to series of secondary complications like diabetic nephropathy, neuropathy, retinopathy, polyurea, polyphagia, polydipsia, ketosis and also cardiovascular disorders (Rohrbach and Martin 1982; Shimomuna and Spiro 1987; Kumar and Clark 2002; Oyedemi *et al.* 2011). The incidence of diabetes is on the rise affecting 4% of the population worldwide and is expected to increase to 5.4% by 2025, and it is estimated that India, China and the United States will have the largest number of people with diabetes by 2030 (Wild *et al.* 2004; Chung *et al.* 2011).

Plants continue to play an important role in the treatment of diabetes, and they could fill the gap that exists to conventional treatments in different parts of the world. Antidiabetic agents from plants are considered to be less toxic with minimum or no adverse side effects (Rao *et al.* 1999; Pari and Umamaheswari 2000; Sakthi *et al.* 2010; Oyedemi *et al.* 2011). The World Health Organization (WHO) has recommended the evaluation of natural products from plant sources for the treatment and control of diabetes (Day 1998).

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson syn. *Amorphophallus campanulatus*), is an edible tuber crop grown in tropical and subtropical regions, particularly in South-east Asia. It is commercially cultivated in India, Sri Lanka, China, Malaysia, Thailand, Indonesia and the Philippines and in tropical regions of Africa. The corm of elephant foot yam is mainly used as a

vegetable in the preparation of various delicious cuisines and is a major ingredient in indigenous Ayurvedic prescriptions (Misra *et al.* 2002; Srinivas and Ramanathan 2005; Angayarkanni *et al.* 2007). It is restorative, carminative, stomachic and tonic. Fresh yam acts as an acrid stimulant and expectorant (Chopra *et al.* 1958; Ghani 1998). The tuber is useful in the treatment of piles, acute rheumatism (Chopra *et al.* 1958; Yusuf *et al.* 1994), enlarged spleen, abdominal tumors, boils, asthma (Yusuf *et al.* 1994), abdominal pain, dyspepsia and elephantiasis (Kirtikar and Basu 1994; Kailash *et al.* 2007). The fermented juice of petioles is used to treat diarrhea whereas seeds are used to treat rheumatic swelling (Chatterjee and Pakrashi 2001).

The major sugars identified from tuber are glucose, galactose and rhamnose while flavonoids, phenols, coumarins, terpenoids, sterols, tannins, steroids and alkaloids have also been reported (Harborne 1984; Shilpi *et al.* 2005; Nataraj *et al.* 2009; Yadu and Ajoy 2010). Amblyone (a triterpenoid) and 3,5-diacetylambulin (a flavonoid) have been isolated from tubers (Khan *et al.* 2008a, 2008b). The tuber is reported to have antiprotease (Prathibha *et al.* 1995), analgesic (Shilpi *et al.* 2005), antibacterial, antifungal, cytotoxic (Angayarkanni *et al.* 2007; Khan *et al.* 2007, 2008b), central nervous system depressant (Dey *et al.* 2009), anti-inflammatory (Dey *et al.* 2010), anthelmintic (Ramalingam *et al.* 2010), immunomodulatory (Tripathi *et al.* 2010), antioxidant (Angayarkanni *et al.* 2010) and hepatoprotective activity (Shastry *et al.* 2010; Surendhra *et al.* 2011).

There are no scientific reports available on the antidiabetic effect of elephant foot yam. Hence, the present investigation was undertaken to study the effect of acetone extract of elephant foot yam in streptozotocin induced diabetic rats.

MATERIALS AND METHODS

Plant material

Fresh and healthy corms of elephant-foot yam (var. Gajendra) were procured from the local market of Mysore, Karnataka, India. The corm was identified and authenticated by Prof. Shivamurthy, Head, Department of Botany, University of Mysore, Mysore, India. The procured corms were washed, sliced into cubes and dried in a hot air oven at 40°C for 24 h and powdered using a 60 mesh in an apex-comminuting mill (Apex Constructions, London).

Chemicals

Streptozotocin, aminoguanidine and *p*-dinitrosalicylic acid were obtained from Sigma Chemicals Co., (St. Louis, USA). GOD/POD (Glucose oxidase (E.C 1.1.3.4)-Peroxidase (E.C 1.11.1.7) and creatinine kits were purchased from M/S Span Diagnostics Ltd., Surat, India. Folin-Ciocalteu reagent and all the organic solvents (AR grade) used for extraction were purchased from E. Merck, Mumbai, India. All other chemicals used were of analytical grade.

Preparation of corm extracts

The dried powder of elephant-foot yam was serially extracted with solvents (1:10, w/v) of increasing polarity, namely hexane, chloroform, ethyl acetate, acetone and methanol, on a shaker at 100 rpm for 48 h at room temperature. The extracts were filtered and concentrated by using a rotary evaporator (Buchi Rota Vapor R-124). The concentrated extracts were lyophilized and stored at -18°C in a refrigerator. The acetone extract was used for the experiment because of its highest total phenol and flavonoid content when compared with other extracts (Table 1).

Preparation of diet

Acetone extract powder at 0.1 and 0.25% and aminoguanidine at 0.05% were incorporated to replace an equivalent amount of corn starch in AIN-76 basal diet containing 63.5% corn starch, 20% protein, 10% fat, 3.5% AIN-76 mineral mix, 1% AIN-76 vitamin mix, 0.2% choline chloride (Bieri *et al.* 1997) and was stored at 4°C.

Animals and induction of diabetes

The present study had the approval (Approval document number IAEC-92/06) of the Institutional Animal Ethical Committee, CFTRI, Mysore, India. Male Wistar rats (breed OUTB-Wistar, IND-CFT (2C)), weighing 140-160 g were obtained from the Animal House, Department of Biochemistry, Central Food Technological Research Institute (CFTRI), Council of Scientific and Industrial Research (CSIR), India, and housed in individual steel cages at the animal house facility of the institute.

Rats were divided into eight groups: starch fed control (SFC) and diabetic (SFD), acetone extract at 0.1% fed control (AEFC_{0.1}) and diabetic (AEFD_{0.1}), acetone extract at 0.25% fed control (AEFC_{0.25}) and diabetic (AEFD_{0.25}), and aminoguanidine fed control (AFC) and diabetic (AFD). Each of the control groups had 6 rats and diabetic groups had 14 rats. Rats were rendered diabetic by a single intraperitoneal (i.p.) injection of streptozotocin at 45 mg/kg body weight in freshly prepared citrate buffer (pH 4.5, 0.1 M) (Jamuna *et al.* 2010). The animals had free access to water and diet, which was in powder form. The rats were sacrificed after 12 weeks of induction of diabetes.

Collection of blood and urine samples

Blood was drawn, after overnight fasting, from the retro-orbital plexus of the rats either during the experiment or at the end of the experiment from the heart, after sacrificing them under ether anesthesia. Blood was collected in tubes with heparin sodium (20 U/ml blood) prepared in 0.9% saline. For urine collection, rats were kept in metabolic cages for a period of 24 h and urine was collected under a layer of toluene (Jamuna *et al.* 2010).

Table 1 Total phenol and flavonoid content of elephant foot yam extracts.

Elephant foot yam extracts	Total phenols (mg Gallic acid equivalents/g of extract)	Total flavonoids (mg Catechin equivalents/g of extract)
Hexane	-	-
Chloroform	-	-
Ethyl acetate	27.40	6.66
Acetone	866.27	585.70
Methanol	50.30	32.14

Determination of water intake, diet intake, body weight, urine volume and urine sugar

Water intake, diet intake, body weight, urine volume and urine sugar were monitored biweekly. Water intake, diet intake, body weight and urine volume were measured gravimetrically. The content of reducing sugar present in urine was measured by the 3, 5-dinitrosalicylic acid method (Miller 1959). 10-100 µl of sample was taken and diluted to 1ml with distilled water. To this, 1 ml of dinitrosalicylic acid (DNS) reagent was added and boiled for 10 min in a water bath. The solution is cooled and diluted with 4ml of distilled water. Intensity of colour was measured at 540nm. Dextrose was used as a standard (Miller 1959).

Determination of fasting blood sugar and glomerular filtration rate

Fasting blood sugar (FBS) and glomerular filtration rate (GFR) were analyzed at the end of 12 weeks. Rats were fasted overnight to determine the FBS. FBS was measured by glucose oxidase method (Hugget and Nixon 1957) using glucose oxidase/oxidase kit. Creatinine was estimated by Bower's method in blood and urine (24 h collection) using creatinine kit (Bowers 1980). GFR was determined by estimating creatinine level in urine and plasma (Yokozawa *et al.* 1996) using the following formula:

$$\text{GFR (ml/min)} = \frac{\text{Urinary creatinine (mg/dl)} \times \text{urine volume (ml)}}{1000 \text{ (g)}/\text{Plasma creatinine (mg/dl)} \times \text{body weight (g)} \times 1440 \text{ (min)}}$$

Statistical analysis

Values are presented as mean ± SD in all control and diabetic groups. Data were analysed by one-way analysis of variance (ANOVA) using Microsoft Excel XP® (Microsoft Corp., USA), and *post-hoc* mean separations were performed by Duncan's Multiple Range Test (DMRT) at $P < 0.05$ (Harter 1960).

RESULTS AND DISCUSSION

Effect of acetone extract of elephant foot yam on water intake, diet intake, body weight and urine output in control and diabetic rats

Higher intake of water during diabetes was reported (Shetty *et al.* 2004). Table 2 shows the effect of acetone extract of elephant foot yam on water intake (ml/24hr) in control and diabetic rats. There was no significant ($P > 0.05$) difference in water intake of control groups. Consumption of water was higher in diabetic rats compared to control rats. Acetone extract at 0.1% (AEFD_{0.1}) and 0.25% (AEFD_{0.25}) fed diabetic groups and aminoguanidine fed diabetic group showed significant ($P < 0.05$) reduction in intake of water.

Table 3 shows the effect of acetone extract of elephant foot yam on diet intake (g/24hr) in control and diabetic rats. Diabetic rats consumed higher quantity of diet compared to control rats. Significant ($P < 0.05$) reduction in diet intake was observed in extract incorporated and aminoguanidine fed diabetic groups. There was no significant ($P > 0.05$) difference in diet intake between starch-fed control and acetone extract fed control groups.

Severe loss in body weight is characteristic feature of STZ-induced diabetes (Chen and Ianuzzo 1982). Body

Table 2 Effect of acetone extract of elephant foot yam on water intake (ml/24 h) in control and diabetic rats.

Experimental Group	Duration (weeks)					
	II	IV	VI	VIII	X	XII
SFC	17.8±2.05a	20.5±2.28a	23.7±2.27a	25.3±2.47a	28.6±2.51a	30.6±2.32a
SFD	80.2±8.22e	101.7±11.2e	128.5±12.3e	147.6±12.4e	158.2±10.6e	167.9±11.8e
AEFC _{0.1}	18.5±2.03a	20.8±2.17a	24.9±2.42a	27.6±2.24a	29.4±2.43a	31.7±2.16a
AEFD _{0.1}	69.4±8.46d	80.6±12.6d	94.8±11.41d	109.5±12.4d	115.4±11.89d	126.3±12.14d
AEFC _{0.25}	18.4±2.09a	20.9±2.63a	22.8±2.56a	24.2±2.23a	27.3±2.13a	29.8±2.14a
AEFD _{0.25}	58.3±9.3c	69.5±10.1c	76.8±9.05c	88.7±12.5c	95.6±12.2c	103.4±11.4c
AFC	16.9±2.63a	19.7±2.49a	22.3±2.22a	25±2.58a	27.9±2.38a	32.1±2.18a
AFD	52.6±9.66b	61.5±9.61b	68.4±8.52b	76.7±10.17b	80.8±10.6b	91.3±9.87b

SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean ± Standard Deviation (SD) of control and diabetic groups. Value of 'n' is 6 for control groups and 8 for diabetic groups. Values with different alphabets in the same column indicate significant differences among groups at $P < 0.05$

Table 3 Effect of acetone extract of elephant foot yam on diet intake (g/24 h) in control and diabetic rats.

Experimental Group	Duration (weeks)					
	II	IV	VI	VIII	X	XII
SFC	12.8±0.78a	13.9±0.88a	14.4±0.84a	15.2±0.54a	16.6±0.71a	17.8±0.82a
SFD	19.2±1.24e	21.5±1.69e	23.3±1.49e	26.1±1.13e	29.3±1.12e	32±1.21e
AEFC _{0.1}	13.3±1.08a	14.3±0.95a	14.8±1.09a	15.6±0.9a	16.3±1.02a	17.2±0.85a
AEFD _{0.1}	17.6±0.79d	20±0.96d	21.3±1.42d	22.8±1.24d	24.1±1.23d	25.9±1.21d
AEFC _{0.25}	13.7±1.02a	14.1±0.87a	15.1±1.12a	16.1±0.65a	16.9±0.94a	18.1±0.78a
AEFD _{0.25}	16.8±1.32c	18.2±1.44c	19.7±1.45c	20.2±1.56c	21.4±1.64c	22.3±1.62c
AFC	13.6±0.91a	14.1±0.95a	14.9±1.22a	15.6±1.14a	16.9±0.91a	17.4±0.98a
AFD	15.4±1.53b	16.3±0.94b	16.9±1.28b	17.4±1.12b	18.6±1.74b	19.8±1.36b

SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean ± Standard Deviation (SD) of control and diabetic groups. Value of 'n' is 6 for control groups and 8 for diabetic groups. Values with different alphabets in the same column indicate significant differences among groups at $P < 0.05$

Table 4 Effect of acetone extract of elephant foot yam on body weight (g) in control and diabetic rats

Experimental Group	Duration (weeks)						
	0	II	IV	VI	VIII	X	XII
SFC	157.6±6.72	208.6±8.8a	254.2±9.5a	269.5±11.7a	296.0±12.9a	315.5±15.9a	324.1±18.41a
SFD	162.4±7.84	172.4±9.5d	175.3±11.4e	180.8±12.1e	192.2±12.8e	203.8±13.54e	212.5±14.1e
AEFC _{0.1}	155.6±6.76	206.3±8.6a	251.6±8.2a	264.4±9.4a	294.0±10.8a	316.6±13.4a	330.2±18.8a
AEFD _{0.1}	158.1±7.29	179.1±8.2cd	193.8±9.82d	213.6±10.1d	224.5±11.4d	243.2±12.8d	257.4±13.5d
AEFC _{0.25}	155.3±5.93	212.3±7.47a	253.5±8.21a	271.5±9.15a	291.8±10.9a	313.1±12.3a	326.0±15.96a
AEFD _{0.25}	159.7±6.43	182.8±8.83bc	200.8±9.91c	225.1±10.4c	248.1±12.3c	263.0±13.8c	274.8±14.65c
AFC	157.5±6.87	214.5±9.82a	256.1±10.1a	274.2±11.7a	292.7±12.3a	311.3±13.7a	329.6±16.8a
AFD	162.6±6.63	189.2±9.7b	217.3±10.8b	239.8±11.7b	264.6±13.8b	278.1±14.9b	289.2±15.1b

SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean ± Standard Deviation (SD) of control and diabetic groups. Value of 'n' is 6 for control groups and 8 for diabetic groups. Values with different alphabets in the same column indicate significant differences among groups at $P < 0.05$

Table 5 Effect of acetone extract of elephant foot yam on urine output (ml/24 h) in control and diabetic rats.

Experimental Group	Duration (weeks)					
	II	IV	VI	VIII	X	XII
SFC	5±1.0a	5±0.5a	5.5±0.5a	5±1.0a	5.5±0.5a	6.1±0.3a
SFD	29±5.13e	30±4.73e	38.5±3.2e	42.6±2.9e	47.1±2.38e	55.3±3.12e
AEFC _{0.1}	4.5±0.5a	7±1.0a	5.5±0.5a	5±0.5a	8±2.0a	5.1±0.5a
AEFD _{0.1}	27±3.64d	26.2±5.02d	29.8±3.45d	33.5±2.06d	35.3±3.93d	38.6±4.32d
AEFC _{0.25}	7±1.0a	5.5±0.5a	6.5±1.5a	6.5±1.5a	6.5±1.5a	6±0.3a
AEFD _{0.25}	25.2±4.17c	26.5±4.04c	26.8±5.32c	24.5±2.85c	27.3±1.95c	31.8±2.58c
AFC	4.5±0.5a	5.5±0.5a	7±1.0a	4.5±0.5a	6.5±0.5a	5±0.5a
AFD	20.1±4.92b	22.5±3.1b	23.7±2.74b	24.8±2.31b	28.7±3.29b	30.5±3.94b

SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean ± Standard Deviation (SD) of control and diabetic groups. Value of 'n' is 6 for control groups and 8 for diabetic groups. Values with different alphabets in the same column indicate significant differences among groups at $P < 0.05$

weight of control rats increased over a period of time and there was not much difference in body weight gain among the control groups (Table 4). On the other hand gain in body weight of diabetic rats was too low and the weight gain of AEFD_{0.1} and AEFD_{0.25} groups was significant ($P < 0.05$) compared to SFD group. Aminoguanidine fed diabetic group showed significant ($P < 0.05$) gain in body weight over SFD group.

Table 5 shows the effect of acetone extract of elephant foot yam on urine output (ml/24hr) in control and diabetic

rats. The urine output was 5-8 ml/day in all the control groups. The polyuria was pronounced in SFD group and volume of urine excreted was about 55 ml/day at the termination of the experiment. The reduction in polyuria was significant ($P < 0.05$) in AEFD_{0.1} (39 ml/day), AEFD_{0.25} (32 ml/day) and AFD (31 ml/day) groups.

Table 6 Effect of acetone extract of elephant foot yam on urine sugar (g/24 h) in control and diabetic rats.

Experimental Group	Duration (weeks)					
	II	IV	VI	VIII	X	XII
SFC	0.04±0.01a	0.07±0.005a	0.08±0.005a	0.01±0.005a	0.06±0.002a	0.03±0.007a
SFD	3.91±0.52e	4.42±0.68e	6.08±0.9e	7.99±0.79e	8.83±0.35e	9.25±0.93e
AEFC _{0.1}	0.023±0.005a	0.05±0.015a	0.07±0.005a	0.03±0.004a	0.08±0.001a	0.05±0.002a
AEFD _{0.1}	3.71±0.65d	4.19±0.74d	4.92±0.81d	5.22±0.48d	5.81±0.66d	6.03±0.81d
AEFC _{0.25}	0.085±0.005a	0.08±0.011a	0.09±0.004a	0.02±0.009a	0.07±0.011a	0.063±0.008a
AEFD _{0.25}	3.15±0.61c	3.72±0.84c	4.12±1.01c	4.43±0.46c	4.35±0.61c	4.18±0.73c
AFC	0.073±0.001a	0.05±0.001a	0.03±0.003a	0.03±0.002a	0.051±0.011a	0.049±0.005a
AFD	2.78±0.85b	3.25±0.68b	3.72±0.72b	3.74±0.33b	3.21±0.37b	3.24±0.67b

SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean ± Standard Deviation (SD) of control and diabetic groups. Value of 'n' is 6 for control groups and 8 for diabetic groups. Values with different alphabets in the same column indicate significant differences among groups at $P < 0.05$

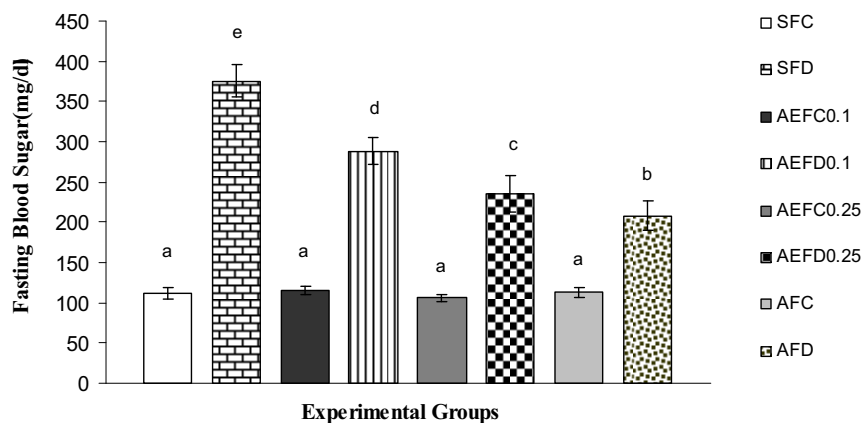


Fig. 1 Effect of acetone extract of elephant foot yam on fasting blood sugar (mg/dl) in control and diabetic rats. SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean ± Standard Deviation (SD) of control and diabetic groups (n values as in Table 1) at $P < 0.05$.

Effect of acetone extract of elephant foot yam on urine sugar, fasting blood sugar and glomerular filtration rate in control and diabetic rats

There was no significant ($P > 0.05$) difference in urine sugar among the control groups (Table 6). The rats in starch fed diabetic group excreted 9 g of urine sugar per day, during last week of the experiment. Decrease in urine sugar excretion by about 35 and 55% was observed in AEFD_{0.1} and AEFD_{0.25} groups respectively, whereas in AFD group a decrease of 65% was observed and the results were statistically significant ($P < 0.05$) from SFD group.

Streptozotocin causes damage to the β -cells of pancreas resulting in reduction in insulin secretion and increased blood glucose (Halliwell and Gutteridge 1985; Zhang and Tan 2000; Kumar *et al.* 2011). The fasting blood sugar of all control groups on 12th week was 106-115 mg/dl and was not significantly ($P > 0.05$) different from one another (Fig. 1), whereas, fasting blood sugar in starch fed diabetic group was 376 mg/dl. Fasting blood sugar of AEFD_{0.1} and AEFD_{0.25} groups showed 23 and 37% reduction, respectively, whereas, AFD group showed 45% reduction in comparison to SFD group.

In diabetic condition disorder in renal glomerulus was reported (Michael Brownlee 2001). The glomerular filtration rates were significantly ($P < 0.05$) higher in diabetic groups (Fig. 2), when compared to control groups (1.1-1.25 ml/min). The GFR of SFD was much higher (6.3 ml/min) than the AEFD_{0.1} group (4.5 ml/min) and AEFD_{0.25} group (3.7 ml/min). The AEFD_{0.1} group showed 28% reduction and AEFD_{0.25} group showed 41% reduction, whereas the AFD group showed 54% reduction in GFR at the end of the experiment, when compared to SFD group.

Streptozotocin-induced diabetic rat is widely used animal model to study the bioactivity of antidiabetic agents (Henriksen *et al.* 2000). Streptozotocin generates oxygen

free radicals in the body, which are involved in pathogenesis and various secondary complications of diabetes (Halliwell and Gutteridge 1985; Baynes 1991; Bonnefont-Rousselot *et al.* 2000; Rahimi *et al.* 2005; Naveen and Khanum 2010). Prevention and control of secondary complications associated with diabetes has become one of the important areas in biomedical research. In this context, dietary management of diabetes along with other means of control is of prime significance.

A diet rich in phytochemicals is reported for anti hyperglycemic activity (Loizzo *et al.* 2011). Investigations revealed that regular intake of fruits and vegetables rich in phytochemicals lowered the risk of diabetes (Boyer and Liu 2004; Harunobu *et al.* 2009). Fruits like apple, jamun, karonda and vegetables like bitter melon, garlic, pseudostem of banana and purple yam exhibited good antidiabetic potential (Day *et al.* 1990; Platel and Srinivasan 1997; Khan and Safdar 2003; Mallick *et al.* 2006; Young *et al.* 2007; Adyanthaya *et al.* 2010; Jamuna *et al.* 2011; Maithili *et al.* 2011; Prakash *et al.* 2011).

Members of the *Amorphophallus* genus are traditionally used in diet for the control of diabetes. Hypoglycemic effect of *Amorphophallus konjac* was proved experimentally (Mao and Gu 1999). In the present investigation, feeding of acetone extract of elephant foot yam at 0.1% and 0.25% level in diet to streptozotocin-induced diabetic rats showed beneficial effects with respect to diet intake, water intake, gain in body weight, urine output, urine sugar, fasting blood sugar and glomerular filtration rate. It is evident from the results that there is gradual amelioration over the experimental period in the diabetic status of AEFD_{0.1}, AEFD_{0.25} and AFD groups when compared to SFD group. Similar results were reported by using bitter melon and quercetin (Shetty *et al.* 2004, 2005a).

The anti-diabetic effect of acetone extract of elephant foot yam may be attributed to its bioactive substances like

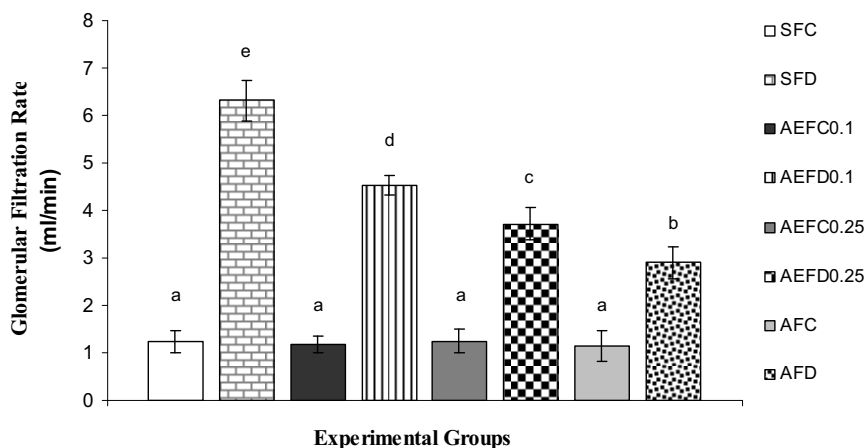


Fig. 2 Effect of acetone extract of elephant foot yam on glomerular filtration rate (ml/min) in control and diabetic rats. SFC: starch fed control, SFD: starch fed diabetic, AEFC_{0.1}: elephant foot yam extract at 0.1% fed control, AEFD_{0.1}: elephant foot yam extract at 0.1% fed diabetic, AEFC_{0.25}: elephant foot yam extract at 0.25% fed control, AEFD_{0.25}: elephant foot yam extract at 0.25% fed diabetic, AFC: aminoguanidine fed control, AFD: aminoguanidine fed diabetic. Values are expressed as mean \pm Standard Deviation (SD) of control and diabetic groups (*n* values as in **Table 1**) at *P* < 0.05.

phenols and flavonoids. Presence of such bioactive components in elephant-foot yam was reported by earlier workers (Khan *et al.* 2008b; Nataraj *et al.* 2009). Research work has shown that phenols and flavonoids have antidiabetic properties (Thompson *et al.* 1984; Pathak *et al.* 1991; Ahmad *et al.* 2000; Waltner-Law *et al.* 2002; Young *et al.* 2008). These bioactive components of plants scavenge free radicals, inhibit lipid peroxidation and prevent secondary complications of diabetes (Sabu and Ramadasan 2004; Kwon *et al.* 2007; Truong *et al.* 2009; Jamuna *et al.* 2011).

Polyphenols control diabetes by inhibiting α -amylase and α -glucosidase enzymes involved in hyperglycemia (Loizzo *et al.* 2011). Flavonoids have the ability to regenerate beta cells of pancreas and stimulate insulin secretion (Chakravarti *et al.* 1980, 1981; Hoa *et al.* 2007). Quercetin (bioflavonoid) present in apple and onion improved diabetic condition with respect to diet intake, water intake, gain in body weight, urine output, urine sugar, fasting blood sugar and glomerular filtration rate (Shetty *et al.* 2004). Beneficial effect of polyphenols and flavonoids present in banana flower and pseudostem on diabetic parameters like urine volume, urine sugar and fasting blood sugar has been reported (Jamuna *et al.* 2011).

CONCLUSION

From this study it can be concluded that elephant-foot yam may be used as therapeutic dietary source to minimize complications of diabetes. Further investigations are underway to understand the mechanism of antidiabetic potential of elephant-foot yam.

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