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EVALUATION OF ANTIHYPERGLYCEMIC ACTIVITY IN THE LEAF EXTRACTS OF *MANGIFERA INDICA* AND *COSTUS IGNEUS* BY *INVITRO* METHODS - COMPARATIVE STUDY

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Abstract: Diabetes mellitus is a metabolic disorder characterized by a loss of glucose homeostasis with disturbances of carbohydrate, fat and protein metabolism. The current study is focused to evaluate the antihyperglycemic activities in the leaf extracts of *Mangifera indica* and *Costus igneus* by *invitro* methods. Leaves of *Mangifera indica* and *Costus igneus* were subjected to two different *invitro* antihyperglycemic studies. Ethanolic extract of Costus igneus was found to be more effective in inhibiting glycosylation of hemoglobin and it also enhanced the glucose uptake. The effect of *Costus igneus* ethanol extract on glycosylation of hemoglobin and glucose uptake paves a therapeutic approach to diabetes.

Keywords: *Glucose homeostasis, antihyperglycemic activities, Costus igneus, glycosylation*

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1.0 INTRODUCTION

Traditional use of herbal medicine is usually an integral part of culture around the world, which has been used in medical practice for thousands of years and has made a great contribution for maintaining human health before spread of modern science[16]. Although modern medicine may be available in developed and developing countries, herbal medicine has often maintained popularity for historical and cultural reasons[15].

The emerging importance of biologically active medicinal plants and their constituents as possible therapeutic measures has become a subject of active scientific investigation. It is likely that in future safe and effective medicines will be developed from medicinal plants to treat various degenerative diseases. Many pharmaceutical companies show interest in plant derived drugs mainly due to the current widespread belief that 'Green Medicine' is safe and more dependable than the costly synthetic drugs, which have adverse side effects[8].

Diabetes mellitus, a metabolic disorder characterized by a loss of glucose homeostasis with disturbances of carbohydrate, fat and protein metabolism results from defects in insulin secretion, insulin action, or both. According to WHO, it is estimated that 3% of the World's population have diabetes and the prevalence is expected to double by the year 2025 to 6.3%[7].

The presence of diabetes confers increased risk of many devastating complications such as cardio vascular disease, peripheral vascular disease complications such as coronary artery disease, stroke, neuropathy, renal failure, retinopathy amputations and blindness. Insulin and various types of hypoglycemic agents such as biguanides and sulfonylureas are available for the treatment of diabetes. The main disadvantages of the currently available drugs are that they have to be given throughout the life characterized with side effects[6].

Biological actions of the plant products used as alternative medicines to treat diabetes are in relevance to their chemical composition. Herbal products or plant products are rich in flavonoids, phenolic compounds[13]. Flavonoids and phenolic compounds are part of the secondary metabolites that constitute the active principles in plant products. These active ingredients are responsible for the therapeutic and or pharmacological activities, such as antidiabetic effects of medicinal plants[11].

Costus igneus commonly known as Fiery costus or Insulin plant is native to South and Central America. This is a recent introduction to India from America as an herbal cure for diabetes and hence commonly called as 'insulin plant'**.** *Costus igneus* leaves have been proven to possess various pharmacological activities.*Mangifera indica* (Anacardiaceae) is a tree, distributed in rural and semi urban parts of the India. It is one of the most important tropical plants marketed in the world**.** *Magnifera indica* is a large evergreen tree in the anacardiaceae family that grows

to a height of 10-45 m, dome shaped with dense foliage, typically heavy branched from a stout trunk. Phytochemical research from different parts of *M. indica* has demonstrated the presence of phenolic constituents, triterpenes, flavonoids, phytosterol, and polyphenols[10].

Thus the current study is focused to evaluate the antihyperglycemic activities in the leaf extracts of *Mangifera indica* and *Costus igneus* by *in vitro* methods.

2.0 MATERIALS AND METHODS

2.1 COLLECTION AND PREPARATION OF PLANT MATERIALS

Healthy fresh leaves of *Mangifera indica* and *Costus igneus* were collected from the nearby areas of Coimbatore district. The leaves were rinsed with distilled water and dried at room temperature under well ventilated shade for 10 days. The dried leaves were powdered and stored in air-tight container for further analysis.

2.2 EXTRACTION OF PLANT MATERIAL

The powdered leaves were extracted in various solvents, viz hexane, ethyl acetate and ethanol[5]. One part of the powdered leaves were macerated in three parts of hexane, ethyl acetate and ethanol separately and kept for 24 hours at 37°C. Filtered and collected the solvents. The solvents were evaporated to obtain the hexane, ethyl acetate and ethanol extracts.

2.3 *INVITRO* ANTIDIABETIC ACTIVITY

2.3.1 NON-ENZYMATIC GLYCOSYLATION OF HEMOGLOBIN METHOD

Invitro antidiabetic activity of the extracts were investigated by estimating the degree of Non-enzymatic glycosylation of hemoglobin method with modification[2,9]. Glucose (2%), hemoglobin (0.06%) and Gentamycin (0.02%) solutions were prepared in phosphate buffer 0.01 M, pH 7.4. 1.0 ml each of above solution was mixed and 1.0 ml of extracts of varying concentrations (100,200,300,400,500,600,700,800,900,1000µg/ml) were added to it. The reaction mixture was incubated in dark at room temperature for 72 hrs and then the degree of glycosylation of hemoglobin was measured colorimetrically at 520 nm. Metformin was used as a standard for assay. The readings were taken in triplicates. The percentage inhibition was calculated using the formula,

% of Inhibition = (Abs of sample – Abs of control)/Abs of sample * 100

Where, Abs control is the absorbance of the control reaction (containing all reagents except the test sample) and Abs sample is the absorbance of the test sample.

2.3.2 GLUCOSE UPTAKE BY YEAST CELLS METHOD

In vitro antidiabetic activity of the extracts were assessed through glucose uptake by yeast cells method with slight modification[3]. The commercial baker's yeast in distilled water was subjected to repeated centrifugation (3,000×g, 5 min) until clear supernatant fluids were obtained and a 10% (v/v) of the suspension was prepared in distilled water. Various concentrations of plant extracts (250,500,750,1000 µg/ml) were added to 1ml of glucose solution (5, 10 and 25 mM) and incubated together for 10 min at 37 °C. Reaction was started by adding 100 µL of yeast suspension followed by vortexing and further incubation at 37 °C for 60 min. After 60 min, the tubes were centrifuged (2,500 × g, 5 min) and amount of glucose was estimated in the supernatant. Metronidazole was used as standard. The readings were taken in triplicates. The percentage increase in glucose uptake by yeast cells were calculated using the following formula:

% of Inhibition = (Abs of sample – Abs of control)/Abs of sample * 100

Where, Abs control is the absorbance of the control reaction (containing all reagents except the test sample) and Abs sample is the absorbance of the test sample.

3.0 RESULTS AND DISCUSSIONS

3.1 COLLECTION AND PREPARATION OF PLANT MATERIALS

Healthy fresh leaves of *Mangifera indica* and *Costus igneus* are collected from the nearby areas of Coimbatore district. The leaves are rinsed with distilled water and dried at room temperature under well ventilated shade. The dried leaves are powdered and stored in air-tight container for further analysis.

3.2 EXTRACTION OF PLANT MATERIAL

The extract is prepared by adding 150 ml of hexane, ethyl acetate and ethanol to 50 g of powdered leaves. After 24 hours, the solvent is allowed to evaporate at room temperature to obtain the hexane, ethyl acetate and ethanol extracts.

3.3 *INVITRO* ANTIDIABETIC ACTIVITY

3.3.1 NON-ENZYMATIC GLYCOSYLATION OF HEMOGLOBIN ASSAY

Human bodies possess enzymatic and non-enzymatic antioxidative mechanisms which minimize the generation of reactive oxygen species, responsible for many degenerative diseases including diabetes. Increased concentration of glucose in the blood leads to its binding to hemoglobin which may result in the formation of the reactive oxygen species[4]. Plant extracts

play an important role the inhibition of the glycosylation end products. An increase in the glycosylation was observed on incubation of hemoglobin with the increasing concentration of the glucose over a period of 72hrs. However, the plant extracts significantly inhibited the hemoglobin glycosylation which is indicated by the presence of increasing concentration of hemoglobin[14].

The hemoglobin has a tendency to get bound to glucose which is present in the red blood cell. The greater the blood-glucose concentration, the greater is the amount of glucose-bound hemoglobin. As the concentration of drug increases formation of glucose-hemoglobin complex decreases and free hemoglobin increases, which show the inhibition of glycosylated hemoglobin[1]. Therefore it is quite important to evaluate the inhibitory activity of the extracts on glycosylation of hemoglobin.

Inhibitory effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glycosylation of hemoglobin

The inhibitory effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glycosylation of hemoglobin are presented in the table 1.

Table 1: Inhibitory effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glycosylation of hemoglobin

Concentration (µg/ml)	Name of the extract	Control	Non-enzymatic glycosylation of hemoglobin method	
			% of Inhibition	
			% Inhibition of Sample	% Inhibition of Metformin*
100	Hexane	0.09	10.00 ± 0.91	35.71 ± 1.01
200		0.09	30.76 ± 0.78	43.75 ± 1.07
300		0.09	35.71 ± 0.71	50.00 ± 1.23
400		0.09	47.05 ± 0.98	59.09 ± 1.09
500		0.09	52.63 ± 0.76	66.66 ± 0.91
600		0.09	60.86 ± 0.78	73.52 ± 0.78

700		0.09	68.96 ± 0.65	79.54 ± 0.81
800		0.09	73.52 ± 0.34	83.33 ± 0.65
900		0.09	80.00 ± 0.65	88.31 ± 0.76
1000		0.09	82.69 ± 0.91	90.42 ± 0.43
100	Ethyl acetate	0.09	18.18 ± 0.34	35.71 ± 0.76
200		0.09	30.76 ± 0.56	43.75 ± 1.21
300		0.09	40.00 ± 0.67	50.00 ± 1.43
400		0.09	47.05 ± 0.69	59.09 ± 1.09
500		0.09	55.00 ± 0.78	66.66 ± 0.45
600		0.09	64.00 ± 0.81	73.52 ± 0.67
700		0.09	70.96 ± 0.84	79.54 ± 0.78
800		0.09	75.67 ± 0.65	83.33 ± 0.34
900		0.09	80.58 ± 0.47	88.31 ± 1.56
1000		0.09	83.92 ± 0.51	90.42 ± 1.54
100	Ethanol	0.09	18.18 ± 0.77	35.71 ± 1.83
200		0.09	35.71 ± 0.66	43.75 ± 1.21
300		0.09	43.75 ± 0.53	50.00 ± 0.98
400		0.09	50.00 ± 0.87	59.09 ± 0.34
500		0.09	55.00 ± 0.92	66.66 ± 0.77
600		0.09	64.00 ± 0.56	73.52 ± 0.89
700		0.09	71.87 ± 0.19	79.54 ± 0.66
800		0.09	76.92 ± 0.72	83.33 ± 0.55
900		0.09	83.33 ± 0.67	88.31 ± 0.91

1000		0.09	86.36 ± 0.89	90.42 ± 1.21

*Metformin = Standard ** (Values are expressed as mean ± SD)

The inhibitory activity of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* are tabulated in the Table 1. Ethanol extract of *Mangifera indica* has high inhibitory activity than hexane and ethyl acetate. The percentage inhibition of ethanol extract of *Mangifera indica* is found to be 86% at 1000 µg/ml concentration of plant extract. It is significant when compared to the standard metformin used which possess 90% inhibition on glycosylation of hemoglobin at 1000 µg/ml concentration. There is a dose dependent increase in the percentage of inhibition. It was reported that the ethanol extracts of *Clitora ternatea* also showed maximum inhibition on glycosylation of hemoglobin [14].

Inhibitory effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glycosylation of hemoglobin

The inhibitory effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glycosylation of hemoglobin are presented in the table 2.

Table 2: Inhibitory effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glycosylation of hemoglobin

Concentration (µg/ml)	Name of the extract	Control	Non-enzymatic glycosylation of hemoglobin method	
			% of Inhibition	
			% Inhibition of Sample	% Inhibition of Metformin*
100	Hexane	0.09	10.00 ± 0.23	35.71 ± 1.01
200		0.09	25.00 ± 0.97	43.75 ± 1.07
300		0.09	35.71 ± 0.56	50.00 ± 1.23
400		0.09	50.00 ± 1.23	59.09 ± 1.09
500		0.09	57.14 ± 0.89	66.66 ± 0.91
600		0.09	66.66 ± 1.06	73.52 ± 0.78
700		0.09	75.67 ± 0.09	79.54 ± 0.81

800		0.09	80.43 ± 1.45	83.33 ± 0.65
900		0.09	84.74 ± 1.08	88.31 ± 0.76
1000		0.09	85.93 ± 0.67	90.42 ± 0.43
100		0.09	10.00 ± 0.23	35.71 ± 0.76
200	Ethyl acetate	0.09	30.76 ± 0.56	43.75 ± 1.21
300		0.09	40.00 ± 0.87	50.00 ± 1.43
400		0.09	50.00 ± 0.56	59.09 ± 1.09
500		0.09	60.86 ± 0.93	66.66 ± 0.45
600		0.09	68.96 ± 0.56	73.52 ± 0.67
700		0.09	75.67 ± 0.88	79.54 ± 0.78
800		0.09	81.25 ± 1.21	83.33 ± 0.34
900		0.09	86.15 ± 1.45	88.31 ± 1.56
1000		0.09	87.67 ± 0.67	90.42 ± 1.54
100		0.09	30.76 ± 0.99	35.71 ± 1.83
200	Ethanol	0.09	35.71 ± 0.34	43.75 ± 1.21
300		0.09	43.75 ± 0.12	50.00 ± 0.98
400		0.09	55.00 ± 0.45	59.09 ± 0.34
500		0.09	62.50 ± 0.99	66.66 ± 0.77
600		0.09	70.96 ± 1.20	73.52 ± 0.89
700		0.09	78.57 ± 1.33	79.54 ± 0.66
800		0.09	82.00 ± 0.88	83.33 ± 0.55
900		0.09	87.50 ± 0.97	88.31 ± 0.91
1000		0.09	88.31 ± 0.32	90.42 ± 1.21

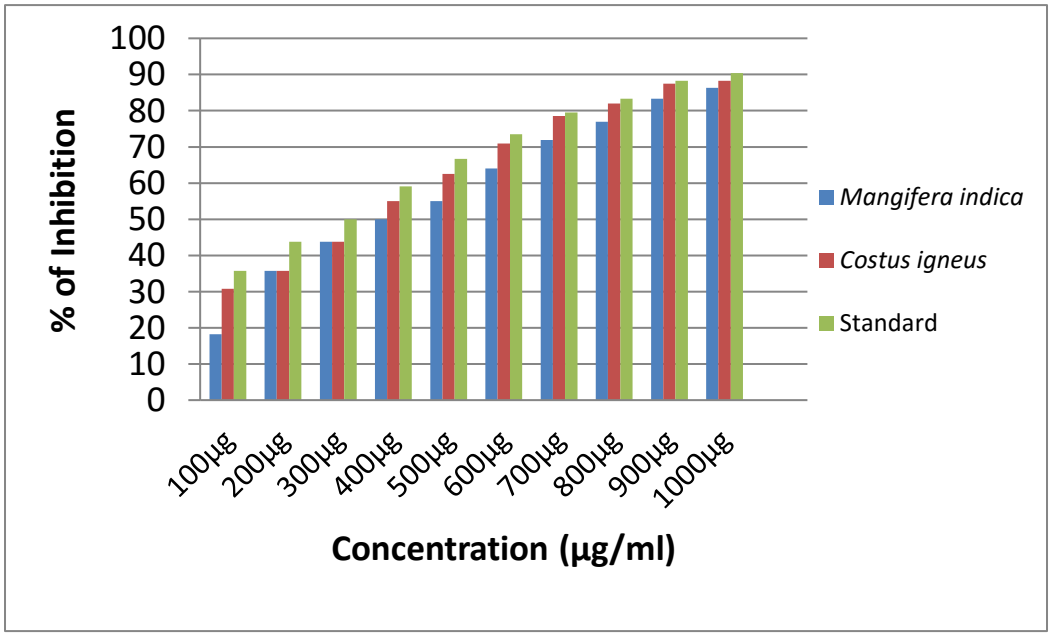
*Metformin = Standard ** (Values are expressed as mean ± SD)

Table 2 represents the inhibitory activities of hexane, ethyl acetate and ethanol extracts of *Costus igneus.* Like *Mangifera indica,* ethanol extracts of *Costus igneus* has high inhibitory activity than hexane and ethyl acetate. The percentage inhibition of ethanol extract of *Costus igneus* is found to be 88% at 1000 µg/ml concentration of plant extract. It is significant when compared to the standard metformin used which possess 90% inhibition on glycosylation of hemoglobin at 1000 µg/ml concentrations. There is a dose dependent increase in the percentage of inhibition. It was reported that the methanol extracts also showed maximum inhibition on glycosylation of hemoglobin. The ethanol extracts of *Clitora ternatea* also showed maximum inhibition on glycosylation of hemoglobin[14].

Inhibitory effect of ethanol extracts of *Mangifera indica* and *Costus igneus* on glycosylation of hemoglobin

From Table 1 and 2 it is clear that ethanol extract of both *Mangifera indica* and *Costus igneus* is found to have higher inhibitory percentage. A comparative inhibitory effect of ethanol extracts of *Mangifera indica* and *Costus igneus* on glycosylation of hemoglobin are presented in the figure 1.

Figure 1: Inhibitory effect of ethanol extracts of *Mangifera indica* and *Costus igneus* on glycosylation of hemoglobin



Among the ethanol extracts of *Mangifera indica* and *Costus igneus* (Figure 1), maximum inhibition on glycosylation of hemoglobin is shown by the ethanol extract of *Costus igneus* with 88% inhibition at 1000 µg/ml concentration of plant extract.

3.3.2 GLUCOSE UPTAKE BY YEAST CELLS METHOD

Regulation of glucose level in the blood of the diabetic patient can prevent the various complications associated with the disease. The maintenance of plasma glucose concentration for a long term under a variety of dietary conditions is one of the most important and closely regulated processes observed in the mammalian species[12]. Type II Diabetes is characterised by the deficiency of insulin causing increased amount of glucose in blood. After the treatment of the yeast cells with these plant extracts, the glucose uptake was found to increase in a dose dependent manner[14]. It is stated that transport of glucose across yeast cell membrane occurs by facilitated diffusion down the concentration gradient. Hence glucose transport occurs only if the intracellular glucose is effectively reduced (utilized)[1]. Therefore it is necessary to evaluate the effect of the plant extracts on glucose uptake.

Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 5mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 5mM Glucose concentration are presented in the table 3.

Table 3: Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 5mM Glucose concentration

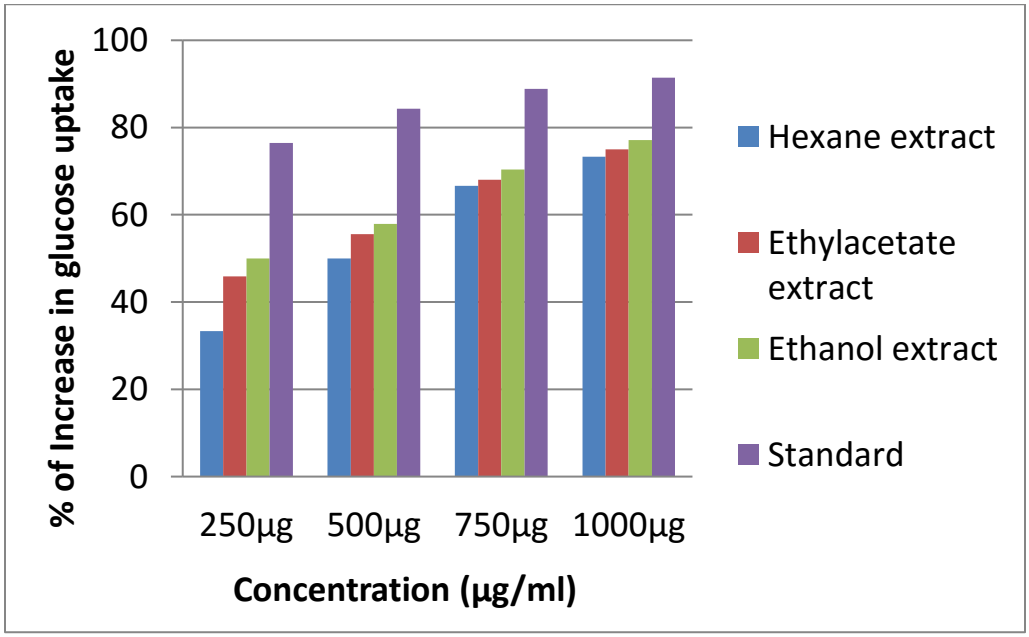
Concentration (µg/ml)	Name of the extract	Control	Glucose uptake by yeast cells method	
			% Increase in glucose uptake	
			% Increase by Sample	% Increase by Metronidazole*
250	Hexane	0.08	33.33 ± 0.34	76.47 ± 1.22
500		0.08	50.00 ± 0.54	84.31 ± 1.01
750		0.08	66.66 ± 0.65	88.88 ± 1.09
1000		0.08	73.33 ± 0.78	91.39 ± 1.20
250	Ethyl acetate	0.08	45.85 ± 0.83	76.47 ± 1.23
500		0.08	55.55 ± 0.91	84.31 ± 1.54

750		0.08	68.00 ± 1.01	88.88 ± 1.62
1000		0.08	75.00 ± 1.23	91.39 ± 1.73
250	Ethanol	0.08	50.00 ± 0.99	76.47 ± 1.07
500		0.08	57.89 ± 1.78	84.31 ± 1.19
750		0.08	70.37 ± 1.65	88.88 ± 1.56
1000		0.08	77.14 ± 1.05	91.39 ± 1.45

* Metronidazole = Standard ** (Values are expressed as mean ± SD)

The effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 5mM Glucose concentration are presented in the figure 2.

Figure 2: Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 5mM Glucose concentration



From the figure 2, it is noted that the ethanol extract of *Mangifera indica* shows high percentage increase in glucose uptake at 5mM glucose concentration with an increase of 77% at 1000µg/ml concentration of plant extracts.

Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 5mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 5mM Glucose concentration are presented in the table 4.

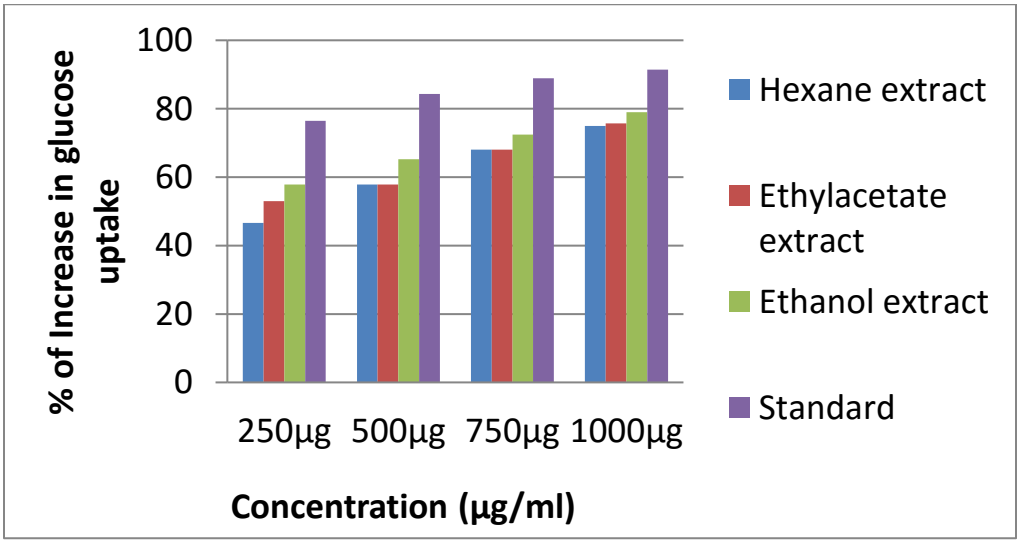
Table 4: Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 5mM Glucose concentration

Concentration (µg/ml)	Name of the extract	Control	Glucose uptake by yeast cells method	
			% Increase in glucose uptake	
			% Increase by Sample	% Increase by Metronidazole*
250		0.08	46.66 ± 0.67	76.47 ± 1.22
500	Hexane	0.08	57.89 ± 0.92	84.31 ± 1.01
750		0.08	68.00 ± 0.16	88.88 ± 1.09
1000		0.08	75.00 ± 0.56	91.39 ± 1.20
250	Ethyl acetate	0.08	52.94 ± 0.97	76.47 ± 1.23
500		0.08	57.89 ± 0.65	84.31 ± 1.54
750		0.08	68.00 ± 0.06	88.88 ± 1.62
1000		0.08	75.75 ± 1.01	91.39 ± 1.73
250	Ethanol	0.08	57.89 ± 1.34	76.47 ± 1.07
500		0.08	65.21 ± 1.57	84.31 ± 1.19
750		0.08	72.41 ± 1.54	88.88 ± 1.56
1000		0.08	78.94 ± 1.73	91.39 ± 1.45

* Metronidazole = Standard ** (Values are expressed as mean ± SD)

The effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 5mM Glucose concentration are presented in the figure 3.

Figure 3: Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 5mM Glucose concentration



From the figure 3, it is noted that the ethanol extract of *Costus igneus* shows high percentage increase in glucose uptake at 5mM glucose concentration with an increase of 79% at 1000µg/ml concentration of plant extracts.

Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 10mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 10mM Glucose concentration are presented in the table 5.

Table 5: Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 10mM Glucose concentration

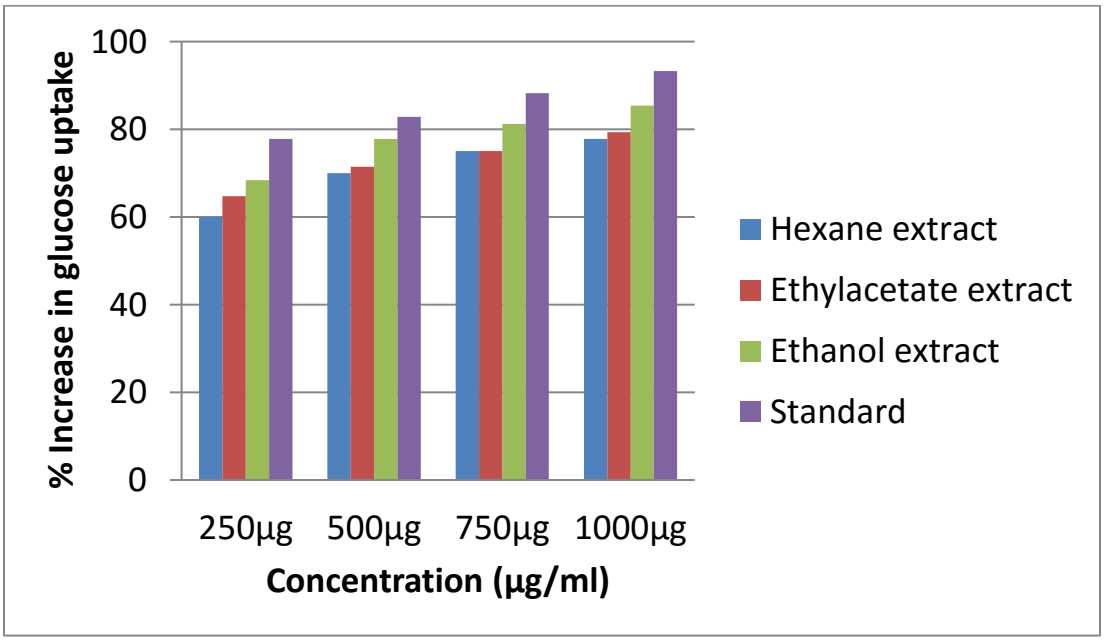
Concentration (µg/ml)	Name of the extract	Control	Glucose uptake by yeast cells method	
			% Increase in glucose uptake	
			% Increase by Sample	% Increase by Metronidazole*
250	Hexane	0.06	60.00 ± 0.09	77.77 ± 1.22
500		0.06	70.00 ± 1.01	82.85 ± 1.01

750		0.06	75.00 ± 1.23	88.23 ± 1.09
1000		0.06	77.77 ± 1.54	93.25 ± 1.20
250	Ethyl acetate	0.06	64.70 ± 1.76	77.77 ± 0.98
500		0.06	71.42 ± 1.90	82.85 ± 0.54
750		0.06	75.00 ± 1.45	88.23 ± 0.67
1000		0.06	79.31 ± 0.97	93.25 ± 0.78
250	Ethanol	0.06	68.42 ± 0.86	77.77 ± 1.04
500		0.06	77.77 ± 0.74	82.85 ± 1.78
750		0.06	81.25 ± 1.05	88.23 ± 1.56
1000		0.06	85.36 ± 0.95	93.25 ± 1.54

* Metronidazole = Standard ** (Values are expressed as mean ± SD)

The effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 10mM Glucose concentration are presented in the figure 4.

Figure 4: Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 10mM Glucose concentration



From the figure 4, it is noted that the ethanol extract of *Mangifera indica* shows high percentage increase in glucose uptake at 10mM glucose concentration with an increase of 85% at 1000µg/ml concentration of plant extracts.

Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration are presented in the table 6.

Table 6: Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration

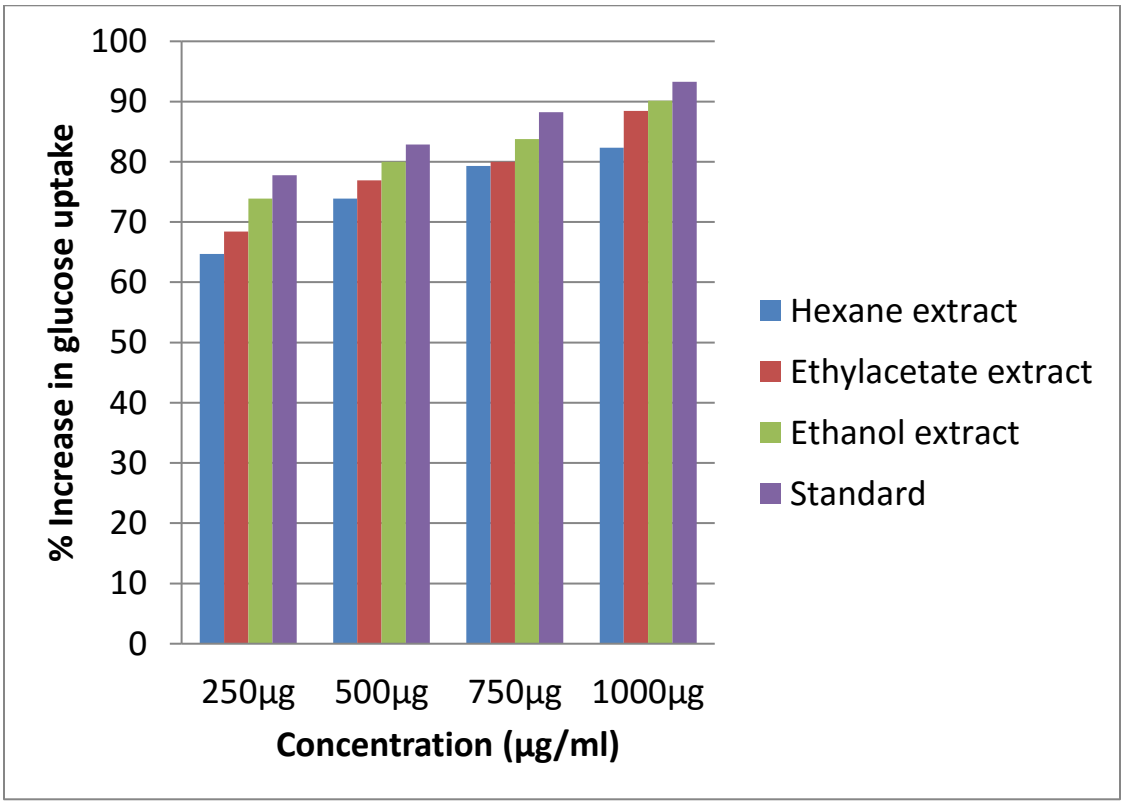
Concentration (µg/ml)	Name of the extract	Control	Glucose uptake by yeast cells method	
			% Increase in glucose uptake	
			% Increase by Sample	% Increase by Metronidazole*
250	Hexane	0.06	64.70 ± 0.97	77.77 ± 1.22
500		0.06	73.91 ± 1.23	82.85 ± 1.01
750		0.06	79.31 ± 1.43	88.23 ± 1.09
1000		0.06	82.35 ± 1.87	93.25 ± 1.20
250	Ethyl acetate	0.06	68.42 ± 1.76	77.77 ± 0.98
500		0.06	76.92 ± 1.34	82.85 ± 0.54
750		0.06	80.00 ± 0.93	88.23 ± 0.67
1000		0.06	88.46 ± 0.67	93.25 ± 0.78
250	Ethanol	0.06	73.91 ± 1.34	77.77 ± 1.04
500		0.06	80.00 ± 1.45	82.85 ± 1.78
750		0.06	83.78 ± 1.07	88.23 ± 1.56

1000		0.06	90.16 ± 0.91	93.25 ± 1.54

* Metronidazole = Standard ** (Values are expressed as mean ± SD)

The effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration are presented in the figure 5.

Figure 5: Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration



From the figure 5, it is noted that the ethanol extract of *Costus igneus* shows high percentage increase in glucose uptake at 10mM glucose concentration with an increase of 90% at 1000µg/ml concentration of plant extracts.

Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 25mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 25mM Glucose concentration are presented in the table 7.

Table 7: Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 25mM Glucose concentration

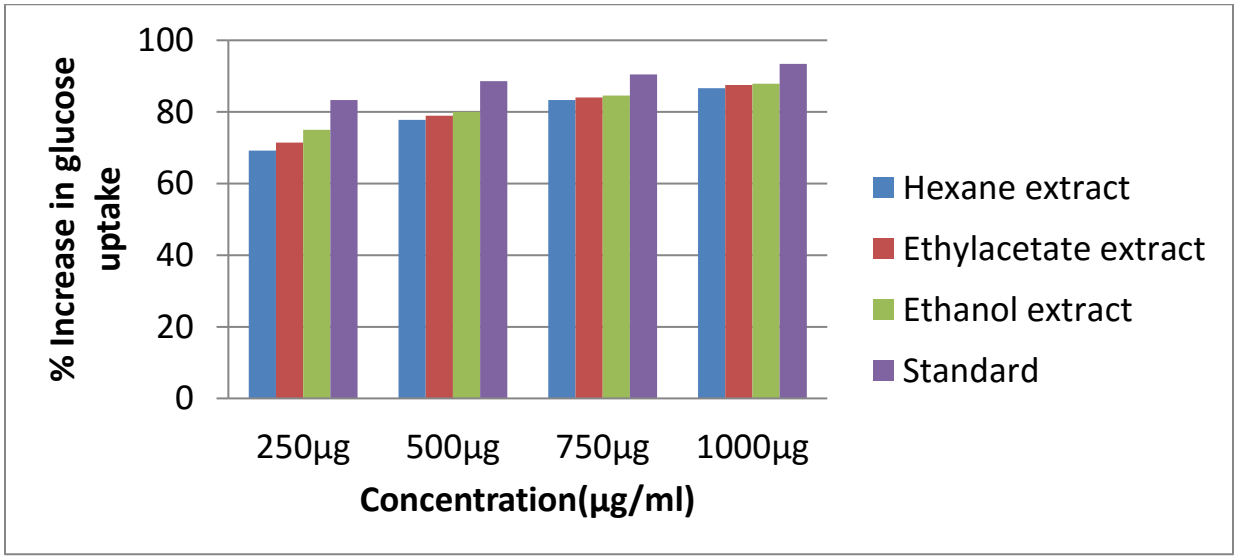
Concentration (µg/ml)	Name of the extract	Control	Glucose uptake by yeast cells method	
			% Increase in glucose uptake	
			% Increase by Sample	% Increase by Metronidazole*
250	Hexane	0.04	69.23 ± 0.98	83.33 ± 0.98
500		0.04	77.77 ± 0.67	88.57 ± 1.09
750		0.04	83.33 ± 0.88	90.47 ± 1.26
1000		0.04	86.66 ± 1.21	93.44 ± 0.67
250	Ethyl acetate	0.04	71.42 ± 1.04	83.33 ± 0.78
500		0.04	78.94 ± 1.09	88.57 ± 1.22
750		0.04	84.00 ± 1.43	90.47 ± 1.65
1000		0.04	87.50 ± 1.54	93.44 ± 1.78
250	Ethanol	0.04	75.00 ± 1.67	83.33 ± 1.34
500		0.04	80.00 ± 1.98	88.57 ± 1.72
750		0.04	84.61 ± 1.03	90.47 ± 1.34
1000		0.04	87.87 ± 1.44	93.44 ± 1.23

* Metronidazole = Standard ** (Values are expressed as mean ± SD)

Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 25mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 25mM Glucose concentration are presented in the figure 6.

Figure 6: Effect of hexane, ethyl acetate and ethanol extracts of *Mangifera indica* on glucose uptake by yeast cells at 25mM Glucose concentration



From the figure 6, it is noted that the ethanol extract of *Mangifera indica* shows high percentage increase in glucose uptake at 25mM glucose concentration with an increase of 88% at 1000µg/ml concentration of plant extracts.

Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 25mM Glucose concentration

The effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 25mM Glucose concentration are presented in the table 8.

Table 8: Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 25mM Glucose concentration

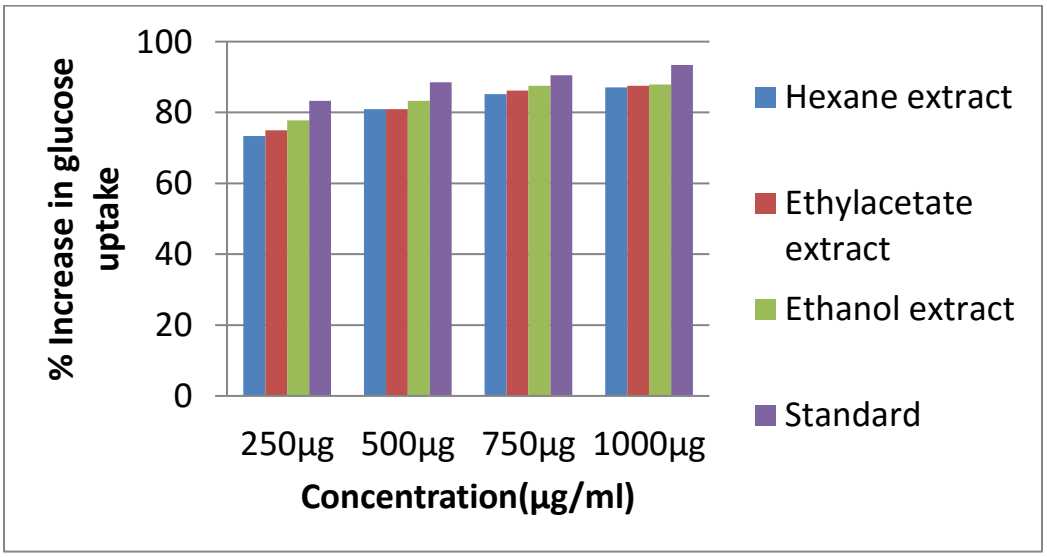
Concentration (µg/ml)	Name of the extract	Control	Glucose uptake by yeast cells method	
			% Increase in glucose uptake	
			% Increase by Sample	% Increase by Metronidazole*
250	Hexane	0.04	73.33 ± 1.11	83.33 ± 0.98
500		0.04	80.95 ± 0.67	88.57 ± 1.09

750		0.04	85.18 ± 0.99	90.47 ± 1.26
1000		0.04	87.09 ± 0.56	93.44 ± 0.67
250	Ethyl acetate	0.04	75.00 ± 0.52	83.33 ± 0.78
500		0.04	80.95 ± 0.67	88.57 ± 1.22
750		0.04	86.20 ± 1.12	90.47 ± 1.65
1000		0.04	87.50 ± 1.43	93.44 ± 1.78
250	Ethanol	0.04	77.77 ± 1.77	83.33 ± 1.34
500		0.04	83.33 ± 1.30	88.57 ± 1.72
750		0.04	87.50 ± 0.07	90.47 ± 1.34
1000		0.04	87.87 ± 0.90	93.44 ± 1.23

* Metronidazole = Standard ** (Values are expressed as mean ± SD)

The effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 25mM Glucose concentration are presented in the figure 7.

Figure 7: Effect of hexane, ethyl acetate and ethanol extracts of *Costus igneus* on glucose uptake by yeast cells at 25mM Glucose concentration



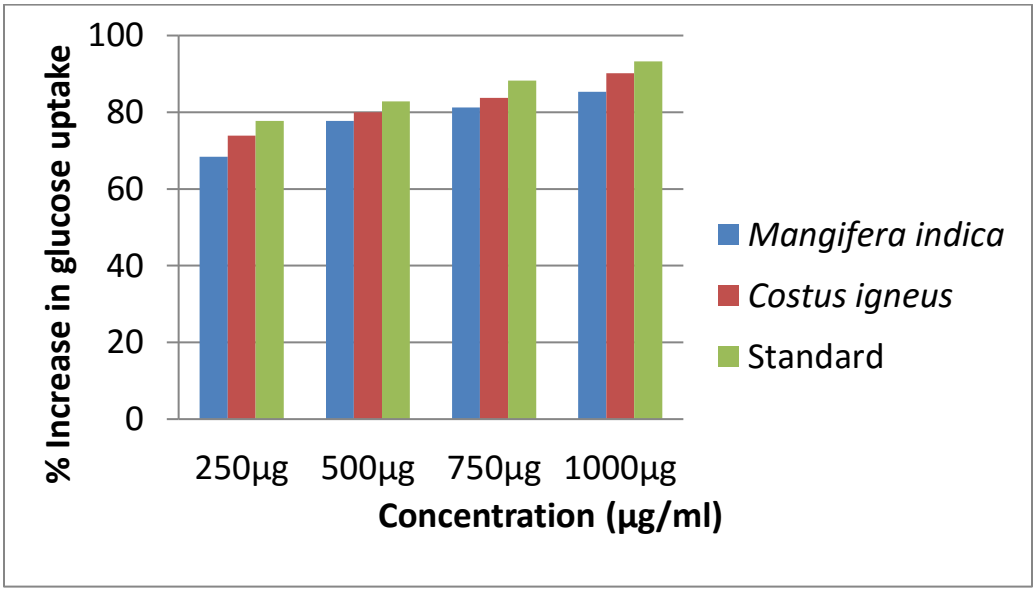
From the figure 7, it is noted that the ethanol extract of *Costus igneus* shows high percentage increase in glucose uptake at 25mM glucose concentration with an increase of 87% at 1000µg/ml concentration of plant extracts.

Effect of ethanol extracts of *Mangifera indica* and *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration

The ethanol extract of *Mangifera indica* has high percentage increase in glucose uptake than hexane and ethyl acetate extracts at all glucose concentration showing the maximum increase in 10mM glucose concentration i.e. 85% increase at 1000µg/ml concentration of plant extract. The ethanol extract of *Costus igneus* has high percentage increase in glucose uptake than hexane and ethyl acetate extracts at all glucose concentration showing the maximum increase in 10mM glucose concentration i.e. 90% increase at 1000µg/ml concentration of plant extract. Metronidazole which is used as standard had 93% increases in glucose uptake at 1000µg/ml concentration. The above results are similar to the work of (Suganya et *al.,* 2014) who reported that the ethanol extract of *Clitoria ternatea* also exhibited significantly higher activity at all glucose concentrations showing the maximum increase in 10mM Glucose concentration.

The effect of ethanol extracts of *Mangifera indica* and *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration are presented in the figure 8.

Figure 8: Effect of ethanol extracts of *Mangifera indica* and *Costus igneus* on glucose uptake by yeast cells at 10mM Glucose concentration



Among the ethanol extracts of *Mangifera indica* and *Costus igneus* (Figure 8), the ethanol extract of *Costus igneus* at 10mM glucose concentration shows maximum increase in glucose uptake.

The data obtained clearly suggests that the plant extract is capable of effectively enhancing glucose uptake which in turn suggests that it is capable of enhancing effective glucose utilization thereby controlling blood glucose level.

4.0 CONCLUSION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by a chronic hyperglycemic condition resulting from defects in insulin secretion, insulin action or both. The findings of the current study suggests that the ethanol extract of *Costus igneus* is more effective in inhibiting glycosylation of hemoglobin and thereby controlling the formation of Reactive Oxygen Species (ROS). It also proves to be a great enhancer of glucose uptake and thereby controls blood glucose level. Ethanol extract of *Costus igneus* has a definite beneficial role in the treatment of diabetes.

5.0 BIBLIOGRAPHY

1. Abirami, N., Natarajan, B and Sagadevan, E. (2014), Phytochemical Investigation and *In Vitro* Evaluation Of Hypoglycemic Potential Of *Grewia Hirsuta*, International Journal of Pharma Bio Sciences, 5(1): 76 – 83.

2. Adisa R. A., Oke, J., Olomu, S. A & Olorunsogo, O. (2004), Inhibition of human haemoglobin glycosylation by flavonoid containing leaf extract of *Cnestis ferruginea*, Journal of the Cameroon Academy of Sciences, 4: 351-359.

3. Cirillo, V.P. (1962), Mechanism of glucose transport across the yeast cell membrane, Journal of Bacteriology, 84, 485–491.

4. Clifford, J. (1989), Review article Traditional Plant Medicines as Treatments for Diabetes, Diabetes care, 12(8):24-8.

5. Gayathri, P and Jeyanthi, G.P. (2013), Radical scavenging activity of Saraca indica bark extracts and its inhibitory effect on the enzymes of carbohydrate metabolism, International Journal of Chemical and Pharmaceutical Sciences, 4(3):87-96.

6. Halim, E.M. (2003), Effect of *Coccinia indica* and *Abroma augusta* on glycemia, lipid profile and on indicators of end organ damage in streptozotocin induced diabetic rats, Indian Journal of Clinical Biochemistry, 18:54-63.

7. Meenakshi, P., Bhuvaneshwari, R., Rathi, M.A., Thirumoorthi, L., Guravaiah, D.C., Jiji, M.J. (2010), Antidiabetic activity of ethanolic extract of *Zaleya decandra* in alloxan-induced diabetic rats, Journal of Applied Biochemistry & Biotechnology, 162(4):1153-9.

8. Nikhal, S (2010), Evaluation of antibacterial and antioxidant activity of *Mangifera indica* (leaves), Journal of Pharmaceutical Science & Research, 2(1):45-47.

9. Parker, K. M., England, J. D., Da-Costa, J., Hess, R. L & Goldstein D. E. (1981), Improved Colorimetric assay for glycosylated hemoglobin, Clinical Chemistry 25(5): 669-672.

10. Raajshree, K.R. and Chitra, P. 2016. "A comparative study on the *in vitro* anti-inflammatory and antibacterial activities in the leaf extracts of *Costus igneus and Mangifera indica*", International Journal of Current Research, 8, (08), 36714-36722.

11. Raajshree, K.R. and Chitra, P. 2016. " Characterisation, *Invitro* and *Insilico* Antidiabetic activity in the leaf Extracts of *Mangifera indica,* World Journal of Pharmaceutical Research,5, (09), 1063-1082.

12. Raghavendra, N.M., Reddy, N.V., Sneha, J.S and Anarthe. (2010), In Vitro Antioxidant and Antidiabetic activity of *Asystasia gangetica* Chinese Violet Linn Acanthaceae. International Journal of Research in Pharma and BioSciences, 1(2):2229-3701.

13. Shaw, E.J., Sicree, R.A and Zimmet, P.Z. (2010), Global estimates of the prevalence of diabetes for 2010 and 2030, Diabetes Research & Clinical Practice, 87 (1), 4–14.

14. Suganya, G., Sampath, P., Dheeba, B and Sivakumar, R. (2014), *In Vitro* Antidiabetic, Antioxidant And Anti-Inflammatory Activity of *Clitoria Ternatea* L, International Journal of Pharmacy and Pharmaceutical Sciences, 6(7):45-49.

15. Tiwari, S. (2008), Plants: A Rich source of herbal medicine, Journal of Natural Products, 1: 27-35.

16. Verma, S and Singh, S. P. (2008), Current and future status of herbal medicines, Veterinary World, 1(11): 347-350.