The Effects of the Extracts of Ginger and Aloe Vera on Wistar Rats Model of Type 2 Diabetes Induced With Dexamethasone and High Fat Diet

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Abstract*: Africa and Nigeria to be precise is characterized by a rich diversity of ethno-medicinal plants as well as a rich traditional medicine system. An ethno-botanical survey was conducted to collect information about medicinal plants used for the treatment of diabetes especially the type 2 diabetes, ginger and aloe vera were part of the commonly used plant parts in Nigeria. This study assessed insulin resistance in normal and diabetic animal subjects using homeostatic model (HOMAIR). The research compared the effectiveness of natural plants extract (ginger and aloe vera) source with and without two anti-insulin resistant drugs (Glimepiride and Metformin) and one anti-insulin resistant herb (Cinnamon) after inducement of insulin resistance by dexamethasone and high fat diet (25% lard, 7% egg, and 15% sucrose). The study evaluate dyslipidaemia and hyperinsulinaemia in sampled subjects Eighty four wistar albino rats were used in this study, being divided into fourteen groups of six rats each and fed with high fat diet, inducted with dexamethasone, and treated with Glimepiride, Metformin, Cinnamon, Ginger, and Aloe vera in various doses with the exception of the normal and negative controls. Each sample of blood serum and plasma was analyzed using Randox kits to test for various biochemical parameters. Compared with the normal control, the mean values of the parameters were significantly different ($p<0.05$) from each other with few exceptions. Compared with the animal controls, the results showed a significant difference ($p<0.05$). Groups fed with high fat diet showed an increase in LDL, CHOL and TG levels where the LDL and CHOL and TG levels of the induced and untreated and even the treated groups were much higher than that of the normal control groups. The groups treated with Glimepiride, Metformin, and Cinnamon showed improvement. The various doses of Ginger, Aloe vera, and their mixture, showed improvement with an increase in the level as the dose increased. Conclusively, the assessment of insulin resistance studied using the models proved that insulin resistance can be managed when appropriate lifestyle is adopted.

***Keywords*: Ginger, Aloe vera, Type 2 diabetes, Dexamethasone, high fat diet, synergetic, Insulin resistance.**

I. INTRODUCTION

Medicinal herbs prepared using various parts of the plantsare being used all over the world as remedy to cure human diseases. It is well known that the medicinal property of plants or plant extracts is due to the phytochemical substances present in them[1]. The World Health Organization estimates that up to 80% of the world's populations depend on the herbal medicinal system for some aspects of primary health care. However, these plant parts may cause toxic effect on some tissues and organs of individuals consuming them as herbal medicine, hence the need for evaluation[2].

Several animal researches have proven the antiinflamatory potentials of ginger. Ginger and its extract helps in lowering blood cholesterol and pressure. The effectiveness of ginger against rheumatic disease, vomiting during pregnancy and antiemetic agent was also proved in several studies [3]. Research showed the antioxidant ability of ginger extract as it suppresslipooxygenase enzymes. The hormonal activity of ginger was also reported in animal models[4-5].Aloe vera has been the subject of much scientific study over the last few years, regarding several claimed therapeutic properties. Aloe vera is a popular medicinal plant that is used in the cosmetic, pharmaceutical and food industries. Its leaves are full of a gel-like substance that contains numerous beneficial compounds. Aloe vera gel contains powerful antioxidants, which belong to a large family of substances known as polyphenols [6-7]. These polyphenols, along with several other compounds in Aloe vera, help suppress the growth rate of certain bacteria that can cause infections in humans. Aloe vera have often been used as a traditional diabetes remedy. It is said to facilitate insulin sensitivity and help improve blood sugar management. Several animal and human studies in type 2 diabetics have showed promising results from consuming Aloe vera extract. Though, there have been some cases of liver damage reported with long-term ingestion of Aloe vera supplements [6-7].The administration of ginger or aloe veraor the combination of these two ethno medicinal plants (Ginger and Aloe vera) were investigated in this study against the type 2 diabetes mellitus in wistar rats.

Insulin resistance (IR) in humans has been shown to be present in conditions like non-insulin dependent diabetes mellitus (NIDDM) and dyslipidemia. Thus interventions to decrease insulin resistance may postpone the development of NIDDM and its complications. Insulin resistance condition is usually associated with excess release of insulin to lower plasma glucose levels. This hyperinsulinemia accounts for the peripheral reduction of insulin sensitivity[8].It is associated with various conditions such as type 2 diabetes, obesity, septicemia, poly cystic ovarysyndrome and excess glucocorticoids[9].

IR is one of the main problems in type 2 diabetes mellitus (T2DM). Treatment with natural herbs is likely to be fraught with lesser side effects compared to the presently used synthetic oral antidiabetic agents. Dexamethasone (Dex) is a synthetic glucocorticoid. Dex, dueto its anti-inflammatory and immunosuppressant properties have got wide therapeutic applications. But, the major drawback with this, it may cause glucose intolerance and reduce insulin sensitivity in some vulnerable patients, depending upon the dose and frequency of administration which could cause diabetes mellitus [10].

Apart from its clinical uses, it is widely used in research for induction of insulin resistance in animals and human beings [11-14]. Dexamethasone increases triglyceride levels, causing an imbalance in lipid metabolism leading to hyperlipidemia and an increase in glucose levels leading to hyperglycemia [15].

Insulin resistance can be assessed by using fasting insulin levels, butto obtain a more accurate idea, euglycemic hyperinsuline micclamp technique was employed as it is considered as the gold standard method to measure insulin resistance[16]. However, the use of this method was discouraged due to tedious work and restricted to small scale of samples. To overcome this, other methods were developed. Among them, Homeostatic assessment method (HOMA) was developed which is a calculative method based on fasting glucose and insulin levels. Later on, several other indices were developed [16].

Lipids are organic compounds that occur naturally. They are derivatives of fatty acid and functionally or biosynthetically substances related to fatty acid. Lipids are usually considered as fats and oil. Fats are solids while oil is liquid. Around seventy percent (70%) of a human's dry nervous system consist of lipid [17].A body mass index (BMI) ≥25 kg/m2 was defined as the presence of obesity [18], and the cutoffs of abdominal obesity were defined as waist circumference (WC) ≥90 cm in men or ≥85 cm in women [19].Insulin resistance is generally accepted to be a major risk factor in the etiology of type 2 diabetes mellitus [20]. Several risk factors (e.g. obesity, physical inactivity, body fat distribution, age and hyperinsulinemia) may be considered markers of insulin resistance. Insulin resistance is a predictor for the development of Type 2 diabetes mellitus even in individuals with normal glucose tolerance. Therefore, it is important to recognize insulin resistance in the pre-disease stage when therapeutic intervention is likely to be more successful than in manifest disease [21].

Likewise, insulin resistance, the reciprocal of insulin sensitivity, is a continuous variable. This makes it difficult to define cut-off levels for insulin resistance and, rather than attempting to label individuals as 'insulin resistant' or 'insulin sensitive', it is more appropriate to consider each individual as lying somewhere along the continuum between very high and very low insulin sensitivity. This concept should be borne in mind when considering techniques used to assess insulin sensitivity[22].

The common form of insulin resistance is associated with high levels of triglyceride (TG), increased waist circumference (visceral adiposity),hypertension, hyperglycaemia and dyslipidaemia involving a decreased serum high density lipoprotein (HDL) cholesterol concentration and a preponderence of small dense low density lipoprotein (LDL) particles [22,23].

Aim and Objectives of the Study

Aim: The aim of this study is to assess the effects of the extracts of ginger and aloe vera on wistarrats model of type 2 diabetes induced with dexamethasone and high fat diet.

Objectives: The objectives of the study include to:

I. Compare the effectiveness of natural plants extract (ginger and aloe vera) source with and without twoanti-insulin resistant drugs (Glimepiride and Metformin) and one anti-insulin resistant herb (Cinnamon) after inducement of insulin resistance by dexamethasone and high fat diet (25% lard, 7% egg, and 15% sucrose), all known for their effectiveness in the assessment of insulin resistance, and management of diabetes.

II. Evaluate dyslipidaemia and hyperinsulinaemia in sampled subjects.

III. Assess the risk of developing cardiovascular disease (CVD) and other complications of DM with Insulinaemia; to monitor and assist treatment.

IV. Monitor subject progress and prognosis in diabetes.

Significance of the Study

Over the years, ginger and aloe vera have been used as spice and drink respectively, which have generated lots of interest throughout human existence as a medicinal panacea. This study would be particularly beneficial in our society where the essence of aloe vera as drink and ginger as food supplement is undermined and their cultivations is considered not essential [24].

Base-line data could be provided for physicians in the assessment of insulin resistance, and management of diabetes. This study intends to make available some scientific information on lipid profile, Glucose, insulin, TG/HDL cholesterol index or ratio, TyG index, HOMA-IR index statuses of normal and diabetic rat subjects. Subjects with high TyG index have a high risk of diabetes. Insulin resistance (IR) is associated with an increased risk of hyperglycemia, hypertension, and dyslipidemia, which increases the risk of inflammation, altered coagulation, and atherosclerosis.

Many studies have demonstrated that IR is one of the most important contributing factors to CVD [25-26]. Furthermore, given that insulin resistance is an important risk factor for development of type 2 diabetes and incident cardiovascular diseases, identification of subjects with insulin resistance is a

strategy for identifying high-risk peoplefor targeted preventive interventions [25,27].

II. MATERIALS AND METHODS

The extracts used were those of aloe vera, ginger, and cinnamon.

Methods

Collection of Test materials

The test materials (Aloe vera and ginger) were purchased from Mile 3 Diobu and Choba markets in Port Harcourt City and Obio/Akpor Local Government Areas respectively of Rivers State, Nigeria. The aloe vera sample was identified in the herbarium unit of the Department of Plant Science and Biotechnology, University of Port Harcourt and deposited in the Departmental herbarium with the voucher number UPH/P/184.

Preparation of Extracts:

Preparation of Ginger extract

Ginger rhizomes were washed with clean sterile distilled water and allowed to air-dry for one hour, then the outer covering of the ginger was manually peeled off and the ginger washed again and extracted. Aqueous ginger extract was prepared according to methods previously reported by Onyeagba *et al*., [28] in which one hundred gram (100 g) of fresh, washed gingercloves was macerated in a sterile, ceramic mortar. The homogenate was then filtered off with a sterile, muslin cloth and used.

The plant material (ginger) was finely ground to powder with a blender. 100g of the ground ginger was mixed with one liter of sterile deionized water and kept in a water bath at 60ºC for five hours, then filtered through sterile filter paper "Whatman, UK". The filtrate was exposed at 40 ºC to a hot air oven for evaporation of water. The filtrate was then kept in a refrigerator at 4 ºC until use [29].

Preparation of Aloe vera extract

Aloe veracrude extract was prepared by washing the leaves with tap water and thereafter weighed. Care was taken not to tear the green rind that could contaminate the fillet with leaf exudates. A traditional hand filleting method of processing Aloeleaves was used. In this method, the lower leaf base, the tapering point at the leaf top and the short spines located along the leaf margins were removed by sharp blades. The blade was then introduced into the mucilage layer below the green rind avoiding the vascular bundles, and the top rind was removed. The epidermis of the leaves was peeled off, and the parenchymatous tissue was collected. The colourless, solid mucilaginous gel was cut into pieces. The gel was lyophilized and ground. The lyophilized gel powder was then packed into soxhlet apparatus and extracted with 90% ethanol at 90° C for four (4) hours. The ethanol containing the extract was filtered and concentrated using rotary evaporator and was stored at 90°C.

Experimental Animals

A total of eighty four (84) male Wistar albino rats (*Rattusnorvegicusdomesticus*) were used for the study. The Wistar albino rats were purchased from the animal house of the Department of Biochemistry, University of Port Harcourt, Rivers State. They were weighed and housed in standard cages. The weight of the Wistar albino rats ranged from one hundred and fifty to two hundred gram (150-200g). Habituation conditions were 25–32°C and relative humidity of 45±5% with twelve (12) hours light and dark cycle. The animals were allowed to feed with standard diet and water *ad libitium*, and to acclimatize with the new housing condition within fourteen (14) days. The experiment was based on approved guidelines for the use of laboratory animals.

Experimental Animal Design

The following approach was employed in grouping the animals; the animals were grouped into two major groups: control Group A, and test Groups B, C, and D.

Group A: The control group consisted of six (6) rats each, and was subdivided into:

(a) Normal control: This sub-group was treated with just distilled water aside the general feed and serve as normal control.
(b) Negative control: This sub-group was treated with diet and with dexamethasone to induce insulin resistance which could result in type 2 diabetes but not treated.

Group B: This test group was divided into 4 sub-groups which consisted of 6 rats each.

Table 3.1 Test Group B

S/N	TREATMENT		INDUCTION			
			DEXAMETHASONE AND HIGH FAT DIET			
		GROUP	B1	B2	B3	B4
1	ANTI-INSULIN RESISTANT DRUG (GLIMEPIRIDE 0.032mg/kg)		YES			
2	100mg/kg ginger extract			YES		
3	100mg/kg aloe vera extract				YES	
4	100mg/kg ginger and aloe vera extract (50:50)					YES

Group C: This test group was divided into 4 sub-groups which consisted of 6 rats each.

Table 3.2 Test Group C

S/N	TREATMENT		INDUCTION			
			DEXAMETHASONE AND HIGH FAT DIET			
		GROUP	B1	B2	B3	B4
1	ANTI-INSULIN RESISTANT DRUG (METFORMIN 8mg/kg)		YES			
2	300mg/kg ginger extract			YES		
3	300mg/kg aloe vera extract				YES	
4	300mg/kg ginger and aloe vera extract (50:50)					YES

Group D: This test group was divided into 4 sub-groups which consisted of 6 rats each.

Table 3.3 Test Group D

S/N	TREATMENT		INDUCTION			
			DEXAMETHASONE AND HIGH FAT DIET			
		GROUP	B1	B2	B3	B4
1	ANTI-INSULIN RESISTANT HERB (CINNAMON 500mg/kg)		YES			
2	500mg/kg ginger extract			YES		
3	500mg/kg aloe vera extract				YES	
4	500 ginger and aloe vera extract (50:50)					YES

Blood Sample Collection and Preparation

Whole Blood Sample Collection

Whole blood sample collection was by cardiac puncture and the samples were collected into plain and heparinized bottles respectively, which were allowed to stand for 30 minutes to clot, centrifuged at 3,000 rpm for 10min for proper separation, separated into plain bottles and labeled accordingly. This was stored frozen, until when needed for biochemical analysis.

III. ANALYSIS

Biochemical Analysis

The Lipid Profile and Blood Glucose were analysed using Randox Kits (RANDOX, USA). Insulin was analysed using Calbiotech Inc., enzyme-linked immunosorbent assay (ELISA) Kit.

Lipid profile

Determination of Total Cholesterol (CHOL)

The quantitative *in vitro* determination of CHOL in serum and plasma was done on the Rx Monza analyser.

IV. RESULTS

Lipid profile of the rats

Table 4.7below reveals the lipid profile results for the animal subjects. The results showed a significant difference ($p \leq 0.05$) in the biochemical parameters for the test groups relative to the control groups. The negative control group (untreated) did not show any improvement while the test groups treated with standard drugs and herb (Glimepiride, Metformin, and Cinnamon) showed improvement. The 100mg/kg, 300mg/kg, and 500mg/kg doses of the plants extract (Ginger, Aloe Vera, and their mixtures) also showed improvement with an increase in the level of improvement as the dose increased.

Table 4.1 Lipid profile of rats from the different groups

GROUP	CHOL (mmol/l)	TG (mmol/l)	HDL (mmol/l)	LDL (mmol/l)
NORMAL CONTROL	$4.17\pm0.07^{b,c,d,e}$	$1.43\pm0.10^{b,c,d,e}$	$1.40\pm0.06^{b,c,d,e}$	$2.08\pm0.07^{b,c,d,e}$
NEGATIVE CONTROL	$7.20\pm0.47^{a,c,d,e}$	$3.38\pm0.25^{a,c,d,e}$	$0.90\pm0.04^{a,c,d,e}$	$4.73\pm0.51^{a,c,d}$
GLIMEPIRIDE	$5.28\pm0.08^{a,b,d,e}$	$2.18\pm0.09^{a,b,d,e}$	$0.98\pm0.03^{a,d,e}$	$3.08\pm0.10^{a,b,d,e}$
METFORMIN	$5.55\pm0.27^{a,b,c,e}$	$2.28\pm0.12^{a,b,c,e}$	$1.10\pm0.04^{a,b,c}$	$2.83\pm0.33^{a,b,c,e}$
CINNAMON	$5.98\pm0.37^{a,b,c,d}$	$2.53\pm0.11^{a,b,c,d}$	$1.24\pm0.04^{a,b,c,d}$	$2.73\pm0.30^{a,b,c}$
100mg/kg GINGER	$6.48\pm0.09^{a,b,c,e}$	$2.70\pm0.15^{a,b,c,d,e}$	$1.08\pm0.05^{a,b,e}$	$3.88\pm0.25^{a,b,c,d,e}$
100mg/kg ALOE VERA	$5.88\pm0.21^{a,b,c,d,}$	$2.88\pm0.09^{a,b,c,d}$	$1.05\pm0.06^{a,b,e}$	$3.80\pm0.27^{a,b,c,d,e}$
100mg/kg GINGER + ALOE VERA	$5.73\pm0.31^{a,b,c}$	$2.55\pm0.08^{a,b,c}$	$1.08\pm0.05^{a,b,e}$	$3.63\pm0.29^{a,c,d,e}$
300mg/kg GINGER	$6.12\pm0.21^{a,b,c,d}$	$2.68\pm0.06^{a,b,c}$	$1.10\pm0.04^{a,b,e}$	$3.39\pm0.17^{a,b,c,d,e}$
300mg/kg ALOE VERA	$5.78\pm0.16^{a,b,c,d}$	$2.72\pm0.10^{a,b,c,d}$	$1.15\pm0.04^{a,b,e}$	$3.48\pm0.16^{a,b,c,d,e}$
300mg/kg GINGER + ALOE VERA	$5.60\pm0.25^{a,b}$	$2.38\pm0.16^{a,b}$	$1.18\pm0.05^{a,b}$	$3.44\pm0.31^{a,b,c,d,e}$
500mg/kg GINGER	$6.02\pm0.25^{a,b,c,d,}$	$2.43\pm0.07^{a,b}$	$1.20\pm0.07^{a,b,c,d}$	$3.15\pm0.23^{a,b,c,d,e}$
500mg/kg ALOE VERA	$5.70\pm0.24^{a,b,c}$	$2.40\pm0.23^{a,b}$	$1.22\pm0.06^{a,b,c,d}$	$3.32\pm0.23^{a,b,c,d,e}$
500mg/kg GINGER + ALOE VERA	$5.54\pm0.11^{a,b,e}$	$2.23\pm0.06^{a,b}$	$1.22\pm0.05^{a,b,c,d}$	$3.25\pm0.11^{a,b,c,d,e}$

Data are expressed as Mean ± Standard error of mean (SEM), n=84 where n represents the number of animal subjects. Values found in a column with common superscript letter a, are significantly different ($p \leq 0.05$) when compared to the normal control. Values with the superscript b, are significantly different ($p \leq 0.05$) relative to the negative control. Values with

the superscript c, are significantly different ($p \leq 0.05$) compared to the Glimepiride group. Values with the superscript d, are significantly different ($p \leq 0.05$) compared to the Metformin group while values with the superscript e, are significantly different ($p \leq 0.05$) compared to the Cinnamon group.

Where:

CHOL – Cholesterol (Total cholesterol), TG – Triglyceride

HDL – High density lipoprotein, LDL – Low density lipoprotein

Key: Normal control = non-inducted and untreated group; Negative control = inducted but untreated; Glimepiride, Metformin, and Cinnamon = inducted and treated with Glimepiride, Metformin, and Cinnamon respectively.

Biochemical indices of the rats
Glucose and Lipid profile of rats on day 0 and day 14

Table 4.2below reveals the Glucose (GLU) and Lipid profile levels for animal subjects on Day 0 and 14. The results showed a significant difference ($p \leq 0.05$).The groups treated with the standard drugs and herb showed improvement. The doses of Ginger, Aloe vera, and a mixture of both, showed improvement with a decrease in the levels as the dose increased.

Table 4.2 Glu and Lipid profile of rats on day 0 and 14 from the different groups

GROUP	GLU (mmol/l)	CHOL (mmol/l)	TG (mmol/l)
DAYS	0 14	0 14	0 14
NORMAL CONTROL	5.32±0.39[d] 5.00±0.24[e]	4.11±0.27 4.23±0.10[a]	1.47±0.08 1.50±0.09[b]
NEGATIVE CONTROL	10.50±0.20[c]11. 55±0.45	7.00±0.20 7.32±0.45	2.88±0.20 3.07±0.21
GLIMEPIRIDE	7.18±0.41 7.22±0.40	5.73±0.20 5.30±0.18	2.35±4.03 2.52±0.15[a]
METFORMIN	7.10±0.40 7.03±0.25[d,e]	5.25±0.19[b] 5.63±0.18	2.37±0.15 2.52±0.10[b]
CINNAMON	7.85±14.03[a] 7.40±0.32	5.72±0.39[c]5.40± 0.29[d,e]	2.35±0.15 2.48±0.14[d]
100mg/kg GINGER	9.12±0.49 9.02±0.38	6.83±0.23 6.80±0.14	2.68±0.14[d] 2.87±0.13
100mg/kg ALOE VERA	9.77±0.43[c] 8.90±0.34	6.87±0.27[c,d]6.40 ±0.13[d]	2.70±0.18 2.82±0.08[a]
100mg/kg GINGER + ALOE VERA	9.65±0.56 9.07±0.43	6.70±0.32 6.42±0.20	2.68±0.09[e] 2.80±0.15
300mg/kg GINGER	9.03±0.44 8.53±0.31	6.68±0.37 6.63±0.23	2.67±0.19 2.78±0.11
300mg/kg ALOE VERA	9.48±0.49[a] 8.63±0.21	6.75±0.31[a] 6.30±0.21	2.65±0.16 2.75±0.15[e]
300mg/kg GINGER + ALOE VERA	9.17±0.64 8.68±0.21	6.57±0.31 6.32±0.41	2.63±0.16 2.73±0.09
500mg/kg GINGER	8.25±0.33[b] 8.33±0.58	6.45±13.35 6.55±0.21	2.63±0.19 2.60±0.14
500mg/kg ALOE VERA	9.15±1.07 8.37±0.36[d]	6.40±10.32[b] 6.15±0.18	2.55±0.15[c] 2.70±0.16
500mg/kg GINGER + ALOE VERA	8.20±0.28[b] 8.47±0.33	6.27±0.23 6.23±0.26	2.60±0.12 2.65±0.15

Data are expressed as Mean ± Standard error of mean (SEM), n=168 where n represents the number of animal subjects for two (2) separate days (Days 0 and 14). Values with the superscripts a, b, c, d, e are significantly different ($p \leq 0.05$) compared to the normal control, negative control, Glimepiride, Metformin, and Cinnamon groups respectively.

Where:
GLU – Glucose
CHOL – Cholesterol (Total cholesterol)
TG – Triglyceride

V. DISCUSSION

obesity is believed to account for 80 to 85% of the risk of developing type 2 diabetes while recent research suggests that obese people are up to 80 times more likely to develop type 2 diabetes than those with a BMI of <22 [30]. Insulin sensitivity is a continuous variable. Thus young, lean, physically fit individuals are likely to be highly insulin sensitive whereas obese subjects with type 2 diabetes will have poor insulin sensitivity [23]. Type 2 diabetes has a direct correlation with an increased risk of visceral fat deposition [31]. This is in line with our research. Groups fed with high fat diet showed an increase in LDL, CHOL and TG levels where the LDL and CHOL and TG levels of the induced and untreated and even the treated groups were much higher than that of the normal control groups. Low insulin as well as unresponsive insulin will promote gluconeogenesis (breakdown of various substrates to release glucose), glycogenolysis (the breakdown of glycogen to release glucose), glycolysis, lipolysis (breakdown of lipids to release glucose), and proteolysis (breakdown of proteins to release glucose). With increased glucose production, reverse feedback mechanism occurs leading to increase in the lipid profile parameters. HDL levels were lower in the diabetic rats than the normal rats but increased as treatment proceeded, the HDL concentration levels increased as the doses increased. There are a number of factors which can contribute to becoming obese such as eating a high calorie diet (high fat diet), not getting enough physical exercise, genetics, medical conditions and being on medications. Loss of body weight has been shown to improve blood glucose levels [30], and has allowed people with type 2 diabetes to come off or avoid going onto insulin resistance. Obesity is also thought to trigger changes to the metabolism of the body. These changes cause adipose tissue to release fat molecules into the blood which can affect insulin responsiveness in cells and lead to reduced insulin sensitivity. Obesity causes pre-diabetes, a metabolic condition that usually results in type 2 diabetes [20].

Cinnamon has been known to increase insulin sensitivity while Glimepiride and Metformin have been known to decrease insulin resistance and the risk of type 2 diabetes [23].

Metformin ameliorated the condition. Cinnamon also had a similar effect as the standard drugs. There was also an improvement with the extracts of Ginger and Aloe Vera in different concentrations though to a lesser degree. This is

expected and in line with other studies as it is known that insulin resistance is a major risk factor and predicts Type 2 diabetes [20]. The hall-mark of Type 2 diabetes is an abnormally high glucose that is unresponsive or only slightly responsive to insulin regulation. Treatment with the standard drugs Glimepiride and Metformin led to improvement in all indices. The herb, Cinnamon faired very well as the standard drugs in improving the indices. Treatment with the extracts of Ginger and Aloe Vera and their mixture also led to improvements in the indices albeit to a less degree. This also resulted in an improvement in the adverse effects of the disease condition as shown by the improvement in the Lipid profiles parameters. Treatment with the plant extracts also led to mild improvements in these indices.

VI. CONCLUSIONS

Based on our findings, the assessment of insulin resistance studied using the animal model proved that insulin resistance can be managed when appropriate lifestyle is adopted. This can be deduced from the result obtained by administration of varying doses of Ginger, Aloe Vera, and mixture of both plant extracts to the animal test subjects. This increased the insulin sensitivity and ameliorated the effect of insulin resistance as seen by the return of some of the diabetic markers assayed. Recognition and monitoring of insulin resistance in the normal and diabetic patient will likely lead to a more successful preventive approach and a better therapeutic intervention measure and management of the diabetic patient. The use of natural herbs especially ginger and aloe vera and its synergetic effects against insulin resistance which is the root cause of type 2 diabetes is therefore established.-

VII. RECOMMENDATIONS

On the basis of the findings of this survey, the following are recommended:

1. Further work should be done to ascertain the use of these plants in preventive type 2 insulin resistance diabetic therapy.
2. The plants should be used in combination with other plants with known anti-diabetic activity to understand how this synergy can boost the antidiabetic properties of these plants.
3. Also, further research should be carried out on this plant extracts and their effects not only as it relates to diabetes but also their involvement in some of the intermediary metabolic pathways.
4. Attempts should be made to isolate the active substance responsible for specific therapeutic action.

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