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Comparative Study of The Antioxidant Activities of Monodora Myristica And A. Sceptrum on Protein And Lipid Levels of Diabetic-Induced Rats.

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Abstract: *Diabetes is known to involve oxidative stress and changes in lipid metabolism. Many secondary plant metabolites have been shown to possess antioxidant activities improving the effects of oxidative stress on diabetes. Wistar albino rats (male and female) weighing 160g – 200g were induced with diabetes by administration of streptozotocin (50mg/kg body weight) intraperitoneally. This study evaluated the antihyperlipidaemic effect of methanolic extracts of Aframomum sceptrum and Monodora myristica in comparison with vitamin E (a known antioxidant) in the streptozotocin-induced diabetic rats. Marked increase in plasma and liver levels of total protein, triacylglycerol, total cholesterol, low density lipoprotein cholesterol and decreased level of high density lipoprotein cholesterol were observed in the streptozotocin-induced diabetic rats. Oral administration of plant extracts of 200mg/kg of the body weight daily for three (3) weeks to both normal and diabetic rats resulted in significant ($P<0.05$) reduction in plasma and liver levels of total protein, total cholesterol, triacylglycerol, low density lipoprotein cholesterol and increase in the level of high density lipoprotein cholesterol. The efficacy of the extracts as antidyslipidaemic and antioxidant agents was found to be, Monodora myristica > Vitamin E > Aframomum sceptrum. This can be attributed to the higher level of flavonoids in M. myristica than in A. sceptrum. These results clearly show that the methanolic extracts of M. myristica and A. sceptrum may enhance the protection against dyslipidaemia in streptozotocin-induced diabetic rats without possible damage to hepatic tissues.*

Keywords: *Antioxidant activity , diabetes, phytochemicals, plant extracts, spices.*

I. Introduction

Diabetes mellitus is one of the most common chronic diseases, associated with hyperlipidemia, obesity, hypertension and hyperglycaemia [1]. Diabetes is a syndrome initially characterized by a loss of glucose homeostasis resulting from defects in insulin secretion, insulin action or both, resulting in impaired metabolism of glucose and other energy-yielding fuels such as lipids and proteins [2].

Lipid abnormalities due to diabetes include potentially atherogenic, qualitative (increased triglyceride levels and decreased high-density lipoprotein cholesterol levels) and quantitative abnormalities of lipoproteins (changes in lipoprotein size, increase in triglyceride content of low density lipoprotein (LDL), and high density lipoprotien (HDL) [3], glycation of apoproteins and increased susceptibility of LDL to oxidation [4]. A second etiology of diabetic hypertriglyceridemia is a reduction in the activity of lipoprotein lipase [3].

The increasing number of ageing populations, consumption of calorie rich diets, obesity and sedentary life style have led to a tremendous increase in the number of patients with diabetes worldwide [5].

Besides the orthodox medicine used for the treatment of diabetes, plant extracts such as spices, herbs, etc have also been employed. The curative properties of these plants are due to the presence of various complex phytochemical substances of different composition which occur as secondary metabolites, grouped as alkaloids, glycosides, flavonoids, saponins, tannins, phenols, essential oils, etc. These phytochemicals produce various antioxidative compounds to counteract reactive oxygen species [6]. Besides their antioxidative properties, spices have been found to give taste and aroma to foods, and also useful in industries. The attributed antihyperglycaemic effect of these plants is due to their ability to restore the function of pancreatic tissues by causing an increase in insulin output or inhibit the intestinal absorption of glucose or to the facilitation of metabolites in insulin dependent processes ([7]; [8]). Hence treatment with herbal drugs has an effect on protecting the beta cells of the pancreas and smoothing out fluctuation in glucose levels [7]).

In this study, the seed extracts of Aframomumsceptrum of the family of Zingiberaceae, (commonly called bear berry orgrains of paradise) and Monodora myristica of the family of Annonaceae (commonly called African nutmeg) were used in the management of the levels of proteins and lipid profile of the streptozotocin-induced (STZ) diabetic rats.

II. Materials And Methods

2.1 Materials

2.1.1 Source Of Spices And Reagents

The spices (Aframomumsceptrum and Monodoramyristica) were purchased from the local market in Agbor, Delta State, Nigeria. They were identified at the Department of Botany, Faculty of Science, Delta State University, Abraka, Nigeria. Most of the reagents and chemicals used were from E. Merck or Sigma-Aldrich Chemical Co. Ltd, USA. All other unlabelled chemicals and reagents were of analytical grade.

2.1.2 Preparation of extracts

The spices were sun-dried for two weeks and subsequently reduced to fine powder using warren blender. The powder (100g) was exhaustively extracted with methanol in the ratio of 1:5 (w/v) for 24 hours using Soxhlet apparatus. The extract was completely evaporated to dryness using rotary flash evaporator (Buchi type). Different concentrations of extracts were prepared from the resultant crude methanol and aqueous extracts to determine invitro antioxidant activity. The extracts were stored frozen in a deep freezer until used.

2.1.3 Animals Used

Wister Albino rats (male and female) weighing about 160 – 200g were obtained from the Faculty of Basic Medical Sciences, Delta State University, Abraka. The animals were maintained on standard growers marsh for rats obtained from Top-feeds, Sapele, Delta State, and water adlibitum. The animals were housed in metal cage under controlled conditions of 12 hours light/ 12 hours dark.

2.2 Methods

2.2.1 Induction Of Diabetes In Experimental Animals [2]

Diabetes was induced by intraperitoneal injection of streptozotocin (STZ) dissolved in O.1M citrate buffer, pH 4.5, at a dose of 50mg/kg body weight. After 48 hours of STZ administration, diabetic state was confirmed by detecting the presence of glucosuria using glucose-test strips (URS – 10, Teco diagnostics, Anaham, (A).

2.2.2 Experimental Procedure

A total of 32 rats (16 diabetic rats and 16 normal rats) were used for the experiments. The rats were divided into 8 groups of 4 rats in each group as follows:
The 16 diabetic rats were divided into 4 groups of 4 rats each.

Diabetic control (DC), Diabetic treated with A. sceptrum extract (DPS^1), Diabetic treated with Monodoramyristica (DSP^2) and Diabetic treated with vitamin E (DV).

The 16 normal rats were divided into 4 groups of 4 rats each as follows: Normal control (NC), Normal treated with A.sceptrum (NSP^1), Normal treated with M. myristica extract (NSP^2) and Normal treated with Vitamin E (NV). The extracts were dissolved in tween 80 [9] before administration.

Group 1: Normal Control (NC): Control rats given tween 80 (200mg/kg body weight) Group 2: Diabetic control (DC): Control rats given tween 80 (200mg/kg body weight)

Group 3: Diabetic spice -1 (DSP^1): 200mg/kg b.wt of A. sceptrum extract was administered to this group

Group 4: Diabetic spice-2 (DSP^2): 200mg/kg b. wt. of M. myristica extract was administered to this group.

Group 5: Diabetic vitamin E (DV): 200mg/kg b. wt. of vitamin E was administered to this group. Group 6: Normal Spice -1 (NSP^1): 200mg/kg of b. wt. of A. sceptrum extract was administered to this group.

Group 7: Normal Spice -2 (NSP^2): 200mg/kg b. wt. of M. myristica extract was administered to this group.

Group 8: Normal vitamin E (NV): 200mg/kg.b.wt.of vitamin E was administered to this group.

The administration of the extract, vitamin E. and tween 80 was carried out using an intragastric tube for a period of 23 days. On the last day rats were fasted overnight, sacrificed by decapitation, and the blood and liver were collected for various biochemical estimations.

Physical properties of the seeds of A. sceptrum and M. myristica were identified. Phytochemical screenings were performed on the powdered specimens using standard procedures to qualitatively identify the constituents such as tests for saponin [10], tannins [11], Flavonoids [12], alkaloidal salts [13] and Carbohydrates [14].

Biochemical analysis of the blood and liver of experimental animals were also investigated which include: determination of albumin [15], total protein [15], triacylglycerol [16] total cholesterol [17], HDL – Cholesterol [18] and LDL-cholesterol [19].

III. Statistical Analysis

Data obtained from the evaluation of antioxidant activities at different concentrations using changes in peroxide values with time were subjected to statistical analysis, and results were tested for significant difference at 5% level using analysis of variance (ANOVA). The means were separated using Turkey test [20].

IV. Results

The results of physical examination and various analysis conducted are detailed in TABLES 1 to 10 below.

Table 1: Physical properties of Aframomum sceptrum (spice 1) and Monodora myristica (spice 2)

Physical Properties	Aframomumsceptrum	Monodoramyristica
Form	Seed	Seed
Colour	Black	Brown
Odour	Aromatic	Aromatic
Taste	Bitter, hot & spicy	Hot and spicy
Solubility		
Cold water	Insoluble	Insoluble
Hot water	Slightly soluble	Slightly soluble

Table 2: Phytochemical compositions of A. sceptrum and M. myristica

Physical Properties	Aframomumsceptrum	Monodoramyristica
Family	Zingiberaceae	Annonaceae
English names	Grains of paradise	African nutmeg
Local names	Atariko or Atako	Eworhe, Abo lakoshe
Tannins	-	-
Saponins	+	++
Alkaloidal salts	++	++
Flavonoids	++	+++
Carbohydrate	++	+++
Phenol	++	+++

Key: + = presence of. - = absence of

Table 3: Levels of liver TAG, total cholesterol, HDL-cholesterol and LDL- cholesterol in control and experimental rats given A. sceptrum (200mg/kg body weight)

Group	Triacylglycerol (TAG) (mg/dl)	Total cholesterol (mg/dl)	HDL cholesterol (mg/dl)	LDL cholesterol (mg/dl)
Normal Control (NC)	180.22±11.55^{a}	204.43±9.24^{a}	134.58±5.60^{a}	36.31±4.44^{a}
Normal + A. sceptrum (200mg/kg) (NPS[1])	190.51±13.79^{a}	229.32±4.14^{c}	161.67±9.89^{c}	29.55±7.08
Normal +Vitamin E (200mg/kg (NV)	188.23±4.38^{a}	207.62±12.81^{a}	140.86±19.66^{a}	28.90±12.80^{a}
Diabetic Control (DC)	181.19±63.44^{a}	279.48±33.04^{b}	166.83±23.68^{c}	76.41±12.98^{c}
Diabetic + A. sceptrum (200mg/kg) (DSP[1])	196.05±22.82^{a}	286.14±17.54^{b}	189.00±14.92^{c}	58.92±6.43^{b}
Diabetic + Vitamin E (200mg/kg) (DV)	188.27±5.67^{a}	247.08±5.80^{a}	156.61±15.79^{b}	51.33±11.17^{b}

Values are given as mean±SD, n= 4. Values not showing a common superscript letter differ significantly at $P<0.05$.

Table 4: Changes in levels of total protein and albumin in liver of control and experimental rats given A. sceptrum (spice 1) at 200 mg/kg body weight.

Group	Total protein (mg/dl)	Albumin (mg/dl)
Normal Control (NC)	0.58±0.38[a]	0.96±0.54[a]
Normal + A. sceptrum (200mg/kg) (NPS[1])	0.82±0.32[b]	1.20±0.48[b]
Normal +Vitamin E (200mg/kg (NV)	0.71±0.33[c]	0.99±0.30[a]
Diabetic Control (DC)	0.45±0.28[a]	0.52±0.31[c]
Diabetic + A. sceptrum (200mg/kg) (DSP[1])	0.79±0.33[b]	0.98±0.34[a]
Diabetic + Vitamin E (200mg/kg) (DV)	0.65±0.35[c]	0.70±0.29[a]

Values are given as mean±SD, n= 4. Values not showing a common superscript letter differ significantly at P<0.05.

Table 5: Changes in levels of triacylglycerol (TAG), total cholesterol, high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL) in plasma of normal and experimental animals given A. sceptrum (200mg/kg body weight)

Group	Triacylglycerol (TAG) (mg/dl)	Total cholesterol (mg/dl)	HDL cholesterol (mg/dl)	LDL cholesterol (mg/dl)
Normal Control (NC)	188.15±7.49[a]	164.55±5.60[a]	106.75±5.60[a]	32.87±10.06[a]
Normal + A. sceptrum (200mg/kg) (NPS[1])	112.71±17.75[a]	163.25±8.71[a]	109.16±8.71[a]	32.05±4.39 [a]
Normal +Vitamin E (200mg/kg (NV)	123.05±8.65[a]	169.31±3.33[a]	113.75±3.33[a]	30.95±10.86[a]
Diabetic Control (DC)	117.01±16.79[a]	181.31±7.66[b]	112.39±7.66[a]	45.69±7.24[b]
Diabetic + A. sceptrum (200mg/kg) (DSP[1])	128.78±16.99[a]	178.50±8.81[b]	118.87±8.81[a]	33.88±6.08[a]
Diabetic + Vitamin E (200mg/kg) (DV)	117.99±9.61[a]	169.49±13.73[a]	115.82±13.73[a]	30.09±4.10[a]

Values are given as mean±SD, n= 4. Values not showing a common superscript letter differ significantly at P<0.05.

Table 6: Changes in levels of total protein and albumin in plasma of normal and experimental animals given A. sceptrum (200mg/kg body weight)

Group	Total protein (mg/dl)	Albumin (mg/dl)
Normal Control (NC)	4.04±0.32[a]	2.51±0.53[a]
Normal + A. sceptrum (200mg/kg) (NPS[1])	5.02±0.39[b]	3.20±0.11[b]
Normal +Vitamin E (200mg/kg (NV)	4.52±0.28[c]	2.84±0.48[a]
Diabetic Control (DC)	3.89±0.31[d]	1.81±0.32[d]
Diabetic + A. sceptrum (200mg/kg) (DSP[1])	4.86±0.21[b]	3.15±0.34[b]
Diabetic + Vitamin E (200mg/kg) (DV)	4.00±0.16[a]	2.95±0.41[a]

Values are given as mean±SD, n= 4. Values not sharing a common superscript letter differ significantly at P<0.05.

Table 7: Changes in level of triacylglycerol (TAG), total cholesterol, high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL) in the liver of normal and experimental rats given M.myristica (200mg/kg body weight)

Group	Triacylglycerol (TAG) (mg/dl)	Total cholesterol (mg/dl)	HDL cholesterol (mg/dl)	LDL cholesterol (mg/dl)
Normal Control (NC)	180.22±6.67[a]	204.43±5.34[a]	134.58±3.23[a]	36.31±2.56[a]
Normal + M. myristica (200mg/kg) (NPS^2)	114.42±7.90[b]	208.20±2.34[a]	150.92±5.70[b]	34.40±4.09 [a]
Normal + vitamin E (200mg/kg (NV)	188.23±8.30[a]	207.62±7.40[a]	140.86±11.35[a]	28.90±7.39[a]
Diabetic Control (DC)	181.19±36.63[a]	279.48±19.07[b]	166.83±13.67[b]	76.41±7.49[b]
Diabetic + M. myristica (DSP^2)	169.14±13.18[c]	237.47±10.13[c]	189.70±8.61[c]	63.92±3.71[c]
Diabetic + Vitamin E (200mg/kg) (DV)	188.27±3.28[a]	247.08±3.35[c]	156.61±9.12[b]	51.33±6.45[d]

Values are given as mean±SD, n= 4. Values not sharing a common superscript letter differ significantly at P<0.05.

Table 8: Changes in levels of total protein and albumin in liver of normal and experimental animals given M. myristica (200 mg/kg body weight)

Group	Total protein (mg/dl)	Albumin (mg/dl)
Normal Control (NC)	0.58±0.38[a]	0.96±0.54[a]
Normal + M. myristica (200mg/kg) (NPS^2)	0.95±2.31[b]	1.39±0.44[b]
Normal + Vitamin E (200mg/kg (NV)	0.71±0.33[c]	0.99±0.30[a]
Diabetic Control (DC)	0.45±0.28[a]	0.52±0.31[d]
Diabetic + M. myristica (200mg/kg) (DSP^2)	0.80±0.32[b]	1.11±0.17[b]
Diabetic + Vitamin E (200mg/kg) (DV)	0.65±0.35[c]	0.70±0.29[a]

Values are given as mean±SD, n= 4. Values not sharing a common superscript letter differ significantly at P<0.05.

Table 9: Levels of plasma triacylglycerol (TAG), total cholesterol, high density lipoprotein cholesterol (HDL) and low density lipoprotein cholesterol (LDL) in normal and experimental animals given M. myristica, (200mg/kg body weight).

Group	Triacylglycerol (TAG) (mg/dl)	Total cholesterol (mg/dl)	HDL cholesterol (mg/dl)	LDL cholesterol (mg/dl)
Normal Control (NC)	116.15±4.32[a]	164.55±3.23[a]	106.75±3.23[a]	32.67±5.81[a]
Normal + M. myristica(200mg/kg) (NPS^2)	116.31±10.25[a]	167.65±5.03[a]	109.91±5.03[b]	34.48±2.53 [a]
Normal + Vitamin E (200mg/kg (NV)	123.05±4.99[b]	169.31±1.92[a]	113.75±1.92[a]	30.95±6.27[a]
Diabetic Control (DC)	117.01±9.69[a]	181.31±4.42[b]	112.39±4.42[a]	45.69±4.18[b]
Diabetic + M. myristica (DSP^2)	129.95±9.81[b]	180.83±5.09[b]	123.32±5.09[b]	33.52±3.51[a]
Diabetic + Vitamin E (200mg/kg) (DV)	117.99±5.55[a]	169.49±7.92[a]	115.82±7.92[a]	30.09±2.36[a]

Values are given as mean±SD, n= 4. Values not sharing a common superscript letter differ significantly at P<0.05.

Table 10: Changes in levels of total protein and albumin in plasma of normal and experimental animals given M. myristica (spice 2) (200mg/kg body weight).

Group	Total protein (mg/dl)	Albumin (mg/dl)
Normal Control (NC)	4.04 ± 0.32^{a}	2.51 ± 0.53^{a}
Normal + M. myristica (200mg/kg) (NPS^2)	6.52 ± 0.48^{b}	3.95 ± 0.31^{c}
Normal + Vitamin E (200mg/kg (NV)	4.52 ± 0.28^{c}	2.84 ± 0.48^{b}
Diabetic Control (DC)	3.89 ± 0.31^{a}	1.81 ± 0.32^{d}
Diabetic + M. myristica (200mg/kg) (DSP^2)	5.31 ± 0.28^{d}	3.56 ± 0.21^{c}
Diabetic + Vitamin E (200mg/kg) (DV)	4.00 ± 0.16^{a}	2.95 ± 0.41^{b}

Values are given as mean±SD, n= 4. Values not sharing a common superscript letter differ significantly at $P<0.05$

V. Discussions And Conclusion

TABLE 1 shows the physical properties of Aframomum sceptrum (spice 1) and Monodora myristica (spice 2). Both are seeds, aromatic, hot and spicy and are also both insoluble in cold water. TABLE 2 shows the phyto-chemical compostions of A. scepturrm and M.myristica. Levels of saponins, flavonoids, and carbohydrates are higher in M. myristica compared to A. sceptrum, which may be responsible for a higher antioxidative activity observed with M. myristica. There was absence of tannins in both spices and equal levels of alkaloidal salts.

TABLE 3 shows levels of liver triacylglycerol (TAG), total cholesterol, HDL-cholesterol and LDL-cholesterol in control and experimental rats given A. sceptrum (200 mg/kg body weight). The results showed that the TAG level in the liver of experimental animals were not affected by A. sceptrum and vitamin E. HDL level of diabetic rats and normal rats given A. sceptrum (DSP^1) was higher compared to diabetic control and untreated normal control respectively. LDL cholesterol was lower in the liver of diabetic rats treated with A. sceptrum compared to untreated diabetic control.

TABLE 4 shows changes in levels of total protein and albumin in liver of control and experimental rats given A. sceptrum (spice 1) at 200mg/kg body weight. The result showed that diabetic rats and normal rats given spice 1 extract and vitamin E showed increased protein and albumin levels compared to untreated diabetic control and normal control.

In TABLE 5 is presented the lipid profile in the plasma of experimental and control rats given A. sceptrum (spice 1). The results showed that the HDL cholesterol level in the plasma of diabetic rats treated with A. sceptrum extract was higher compared to the other groups, while the LDL cholesterol (assumed to be the "bad cholesterol") level of the plasma of diabetic rat treated with A. sceptrum was significantly reduced compared to that of the untreated diabetic control. Neither the spice extract nor vitamin E affected the level of TAG in the plasma of experimental animals.

TABLE 6 shows the changes in the levels of total protein and albumin in plasma of normal and experimental animals given A. sceptrum (200mg/kg body weight). The results showed that the levels of total protein and albumin were significantly lower in diabetic control compared to the normal control and diabetic rats treated with spice 1 extract. Also total protein level in normal rats given spice 1 was significantly higher compared to the normal control.

TABLE 7 shows changes in levels of triacylglycerol (TAG), total cholesterol, high density lipoprotein (HDL), low density lipoprotein cholesterol (LDL) in the liver of normal and experimental rats given Monodora myristica (spice 2), (200mg/kg body weight). The results showed that the levels of TAG, total cholesterol and LDL in the liver of diabetic rats given M. myristica were significantly lower compared to the untreated diabetic control. Total cholesterol level in untreated diabetic control was significantly higher compared to the normal control. HDL cholesterol level of diabetic rats treated with M. myristica was significantly higher compared to diabetic control. LDL cholesterol levels in the normal rats (NC, NSP^2 and NV) were similar and do not differ significantly.

TABLE 8 shows changes in levels of total protein and albumin in liver of normal and experimental animals given M. myristica (200mg/kg body weight). The results showed that the total albumin and protein levels of diabetic rats and normal rats given M. myristica and vitamin E were significantly higher compared to the untreated diabetic control and normal control, with M. myristica producing higher and more consisted result than vitamin E.

TABLE 9 shows levels of plasma TAG, total cholesterol, high density lipoprotein and low density lipoprotein in normal and experimental animals given M. myristica (200mg/kg body weight). The result showed

that levels of TAG, total cholesterol and LDL were significantly lowered in experimental animals treated with M. myristica extract compared to the untreated ones. However, the levels of HDL cholesterol in the treated animals were significantly higher than untreated ones.

In TABLE 10 is presented the total protein and albumin in the plasma of experimental and control rats given M. myristica. The results showed that total albumin and protein levels in the plasma of untreated diabetic rats and normal rats were significantly lower compared to the treated ones. Results also showed that total albumin and protein levels of diabetic rats given M. myristica extract were higher compared to the diabetic rats given vitamin E.

In this study, levels of triacylglycerol, total cholesterol and low density lipoprotein were increased significantly, while high density lipoprotein cholesterol level was decreased in the diabetic animals. These increased levels were lower significantly in the diabetic animals given extracts from both spices as well as vitamin E. Also HDL cholesterol levels were increased in the experimental animals treated with both spices and vitamin E respectively. However, results showed that the extracts of M. myristica produced a more consistent effect than both the vitamin E and A. sceptrum extract.

These reductions could be beneficial in preventing diabetic complications as well as improving lipid metabolism in diabetics [21].

However, it was observed from the study that high density lipoprotein cholesterol level increased on administration of extracts as shown in the normal as well as the diabetic rats. These findings are in agreement with the previous studies that reported the hypolipidemic actions of Cleome drosofolia shoot extact and Tinosporacordifolia root extract respectively ([22]; [23]). The increased level of cholesterol in the liver is due to the decreased level of high density lipoprotein cholesterol [24], which in turn resulted in the decreased removal of cholesterol from extra hepatic tissues by the high density lipoprotein cholesterol.

The increased level of triacylglycerol in streptozotocin-induced diabetes observed in our study may be due to lack of insulin, which normally activates the enzyme lipoprotein lipase.

The antihyperlipidemic effect of the extracts can be explained as a direct result of the reduction in blood glucose. Diabetes induced hyperlipidemia is attributable to excess mobilization of fat from adipose tissue due to the under utilization of glucose. Regression of the diabetic condition following the administration of the spices increases the utilization of glucose, thereby depressing the mobilization of fats [25].

Enhanced vitamin E concentration has been observed in the plasma and liver tissue of the streptozotocin induced diabetic rats [26]. STZ-released nitric oxide in isolated pancreatic islets was suppressed by vitamin E in vivo [27]. Investigation conducted in diabetic patients led to heterogeneous results. Indeed, unchanged elevated or decreased plasma vitamin E concentrations have been reported, independently of the type of diabetes [28] and the data in this investigation showed heterogeneous results on administration of vitamin E to the experimental animals.

The study also revealed that the total protein level of the diabetic rats decreased significantly at $P < 0.05$ as compared to normal control, and increased on treatment with the spices and also with vitamin E. Further mechanistic investigation showed that the increased protein improves GLUT4 translocation to skeletal muscle T-tubules, but not to the plasma membrane [29]. Increased protein resulted in an increase in circulating insulin, and a modest increase in the rate of glucose disappearance [30].

Increased level of albumin was observed in this investigation following treatment with spices and vitamin E at $P<0.05$ with M. myristica showing more consistent results. Albumin is a primary defence against reactive oxygen metabolites [31]. Such metabolites have been implicated in the damage brought about by ionizing radiation, as well as in the effects of several cytostatic compounds [32]. The decreased activity of antioxidant molecules along with elevated lipid peroxide levels in diabetic rats could probably be associated with oxidative stress and /or decreased antioxidant defence potential [31]. The reversal in their content following treatment may be due to decreased oxidative load.

Elevated albumin levels in the groups given extracts may probably be due to the anabolic role of this proteinous hormone [33]. The herbal hypoglycaemic agents may also act by either directly scavenging the reactive oxygen metabolite due to the presence of various antioxidant compounds or by increasing the synthesis of antioxidant molecules [34]. The antioxidant effect on albumin and other proteins have been shown to decrease at very low concentration [35], and it has been suggested that this is because protein carbonyl radical can abstract an electron from a polyunsaturated fatty acid to initiate the process of lipid peroxidation, a reaction that can be inhibited by ascorbate or retinol [35].

The primary identification of the previously mentioned phytochemical constituents of the spices (flavonoids, saponins, alkaloids, phenolic compounds, etc) may explain in part some of the antidiabetic and antioxidative properties of these extracts observed in this study in agreement with that reported by Farombi and Owoeye, [36].

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