

## Original Research Article

# The Effects of *Cymbopogon Citratus* (Lemon grass) on the Blood Sugar Level, Lipid Profiles and Hormonal Profiles of Wistar Albino Rats

Adegbegi J. Ademuyiwa<sup>\*1</sup>, Ogunyemi Y. Olamide<sup>2</sup> and Oyebiyi O. Oluwatosin<sup>3</sup>

### Abstract

<sup>1,2</sup>Department of Science Laboratory Technology, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria.

<sup>3</sup>Department of Chemical Sciences, Achievers University, Owo, Ondo State, Nigeria.

\*Corresponding Author's E-mail: [joshuajournals@gmail.com](mailto:joshuajournals@gmail.com)

The present study was undertaken to investigate the effect of extracts of *Cymbopogon citratus* on the blood sugar level, lipid profiles and hormonal profiles of normal rats. Oral administration of ethanolic and aqueous extract of *C. citratus* at a doses of 200 mg/kg body weight, for a period of 30 days, caused a significant ( $p < 0.05$ ) reduction in blood glucose levels. Effect on hormonal profile (TSH, T3, and T4) was also determined, and was found to be significantly higher in all the administered groups when compared with control. Lipid profiles levels; Total cholesterol, triglycerides, high density lipoprotein-cholesterol and low density lipoprotein-cholesterol were significantly ( $p > 0.05$ ) higher for all treated rats as compared against control. Findings in this study showed that this plant has hypoglycemic properties and did not exert oxidative damage to the heart and the various hormonal profiles as well as its relative safety and possible use for weight gain.

**Keywords:** Blood glucose, *Cymbopogon citrates*, Hypoglycaemic, Medicinal plants, Oxidative damage

## INTRODUCTION

*Cymbopogon citratus* commonly called lemon grass is an aromatic, perennial grass belonging to the family graminaceae (Ebomoyi, 1986). It is a tropical plant, grown as an ornamental in many temperate areas with maximum a height of about 1.8m and its leaves 1.9cm wide covered with a whitish bloom (Gbile, 1986). In certain medications, it is used for mental illness. It is an antifungal, antitoxicant and deodorizing agent. In combination with other herbs, it has large use as cure for Malaria (Gbile, 1986).

One of the main constituents of the many different species of lemongrass (genus *Cymbopogon*) is citral (3,7-dimethyl-2,6-octadien-1-al) (Balbaa and Johnson, 1955; Banthorpe *et al.*, 1976). Lemongrass oil has been found to contain up to 75-85% citral (Nhu-Trang *et al.*, 2006). Lemongrass also contains  $\alpha$ -citral, borneol, estragole, methyleugenol, geranyl acetate (3,7-dimethyl-2,6-octadiene-1-ol acetate), geraniol (some species higher in this compound than citral), beta-myrcene (MYR, 7-methyl-3-methylene-1,6 octadiene), limonene,

piperitone, citronellal, carene-2, alpha-terpineole, pinene, farnesol, proximadiol, and (+)-cymbodiacetal (Hegnauer, 1955). The volatile oil from the roots contains 56.67% longifolene-(V4) and 20.03% selina-6-en-4-ol (Li *et al.*, 2005). In particular, a study of *Cymbopogon martinii* isolated fatty acids, common sterols, and 16-hydroxypentacos-14(z)-enoic acid (Siddiqi and Misra, 2000).

The reactive oxygen species produced in cells include hydrogen peroxide ( $H_2O_2$ ), hypochlorous acid (HClO), and free radicals such as the hydroxyl radical ( $\cdot OH$ ) and the superoxide anion ( $O_2^-$ ) (Valko *et al.*, 2007). The hydroxyl radical is particularly unstable and will react rapidly and non-specifically with most biological molecules. These oxidants can damage cells by starting chemical chain reactions such as lipid peroxidation, or by oxidizing DNA or proteins (Sies *et al.*, 1997).

Triglycerides, as major components of very-low-density lipoprotein (VLDL) and chylomicrons, play an important role in metabolism as energy sources and

transporters of dietary fat. They contain more than twice as much energy (approximately 9 kcal/g or 38 kJ/g) as carbohydrates (approximately 4 kcal/g or 17 kJ/g) (Balch, 2006). In the human body, high levels of triglycerides in the bloodstream have been linked to atherosclerosis and, by extension, the risk of heart disease and stroke (Davidson *et al.*, 2008). Cholesterol is an organic molecule. It is a sterol (or modified steroid) (Olson, 1998), and an essential structural component of animal cell membranes that is required to establish proper membrane permeability and fluidity. Cholesterol is thus considered within the class of lipid molecules. In addition to its importance within cells, cholesterol also serves as a precursor for the biosynthesis of steroid hormones, bile acids, and vitamin D. Cholesterol is the principal sterol synthesized by animals. All kinds of cells in animals can produce it. In vertebrates, the hepatic cells typically produce greater amounts than other cells (Lecerf and de Lorgeril, 2011).

The purpose of this study, therefore, is to carry out the effects of *Cymbopogon citratus* (lemon grass) on the blood sugar level, lipid profiles and hormonal profiles using wistar albino rats.

## **MATERIALS AND METHODS**

*Cymbopogon citratus* was harvested and collected freshly from a native farms and authenticated in Environmental Biology Laboratory, Department of Science Laboratory Technology, Rufus Giwa Polytechnic, Owo.

### **Preparation of plant extract**

The fresh plant was washed, chopped into pieces and air-dried for four weeks at room temperature. The dried plant part was milled into powder and weighed. The Plant powder was divided into two groups. One portion was soaked in 90% absolute ethanol to obtain the ethanolic extract and the other group in distilled water to obtain the aqueous form separately in a container for 72 hours with intermittent shaking. Then, it was filtered through a muslin cloth and later Whatman No. 1 filter paper.

The resulting filtrate was evaporated under reduced pressure using a rotary evaporator and there after freeze dried to get powder form of both ethanolic and aqueous extracts. The yield was stored in a refrigerator (4°C) till when needed (Onoagbe and Esekheigbe, 1999).

### **Experimental animal**

Male albino rats (Wistar strain) weighing between 109-170g, purchased from the central animal house of University of Ibadan were used for the study.

Acclimatization: 15 days prior to dosing.  
Identification of animals: By cage number.

Diet: Pelleted feed

Water: Potable drinking water

Housing and Environment: 4 animals each in a group

Determination of the weight of animals

The weights of the animals were weighed using an electronic weighing balance every 7 days to verify and quantitate the change in weight over the period of administration.

### **Animal ethics**

All of the animals received humane care according to the criteria outline in the Guide for the Care and the Use of Laboratory Animals prepared by the National Academy Science and published by the National Institute of Health (USA). The ethic regulations have been followed in accordance with national and institutional guidelines for the protection of animals' welfare during experiments.

### **Experimental design**

To carry out this study, twelve male Albino rats were randomly, equally divided and assigned to either control or experimental groups. The control group received 2ml distilled water while the experimental rats group received oral doses of 200mg/kg for both the ethanolic and aqueous extracts of *Cymbopogon citratus* dissolved in 2ml distilled water through a stainless steel intra-gastric intubation and administered for 30 days. Here, the blood glucose levels and hormonal, were determined and recorded.

### **Chemicals and reagents preparation**

All chemicals were of an analytical grade and are supplied from sigma chemical co. USA. Distilled water was used in all biochemical assays.

### **Blood glucose determination**

The blood of the rat was drawn from the tail and measured the blood glucose levels by using Accucheck glucometer. The body weights of the rats were also recorded.

### **Hormonal Assays**

Blood samples were collected in glass tube from retro-orbital puncture to obtain haemolysis free clear serum for the analysis of hormonal assays (Rubenstein *et al.*, 1972).

**Table 1.** Effects of oral administration of ethanolic and aqueous extracts of *Cymbopogon citratus* on the weight of normal rats.

	Control	Ethanolic extract	Aqueous extract
Initial weight (g)	115 ± 1.92 <sup>a</sup>	130 ± 1.71 <sup>b</sup>	135 ± 1.50 <sup>c</sup>
Final weight (g)	129 ± 1.71 <sup>a</sup>	150 ± 1.50 <sup>b</sup>	149 ± 1.70 <sup>c</sup>

Values are expressed as means ± SEM of four independent experiments. Means in the same column not sharing the same letter(s) are significantly different ( $p < 0.05$ )

**Table 2.** Effects of oral administration of ethanolic and aqueous extracts of *Cymbopogon citratus* on Serum glucose in normal rats.

Group	Day 0(mg/dl)	Day 7(mg/dl)	Day 14 (mg/dl)	Day 21(mg/dl)	Day 28(mg/dl)	Day 30(mg/dl)
Control	91.5 ± 7.78 <sup>a</sup>	85.3 ± 3.78 <sup>a</sup>	87.0 ± 2.82 <sup>a</sup>	95.33 ± 4.93 <sup>a</sup>	97.7 ± 2.08 <sup>a</sup>	101.0 ± 4.00 <sup>a</sup>
Ethanolic extract (200mg/kg)	104.0 ± 8.49 <sup>b</sup>	94.5 ± 4.95 <sup>b</sup>	75.0 ± 10.61 <sup>b</sup>	80.0 ± 2.28 <sup>b</sup>	74.5 ± 9.19 <sup>b</sup>	79.48 ± 7.78 <sup>b</sup>
Aqueous extract (200mg/kg)	103.3 ± 6.81 <sup>b</sup>	98.5 ± 16.26 <sup>b</sup>	89.10 ± 2.83 <sup>b</sup>	84.50 ± 2.83 <sup>c</sup>	79.0 ± 2.12 <sup>c</sup>	81.0 ± 10.61 <sup>c</sup>

**Table 3.** Effects of oral administration of ethanolic and aqueous extracts of *Cymbopogon citratus* on Serum lipid profiles in normal rats.

Group	TotalCholesterol (mmol/l)	Triglycerides (mmol/l)	HDL (mmol/l)	LDL (mmol/l)
Control	30.54 ± 2.79 <sup>a</sup>	29.21 ± 6.09 <sup>a</sup>	36.18 ± 3.01 <sup>a</sup>	15.60 ± 1.34 <sup>a</sup>
Ethanolic extract (200mg/kg)	28.82 ± 4.83 <sup>a</sup>	19.89 ± 3.99 <sup>a</sup>	42.03 ± 0.27 <sup>a</sup>	14.91 ± 3.42 <sup>a</sup>
Aqueous extract (200mg/kg)	29.22 ± 2.41 <sup>a</sup>	21.05 ± 2.82 <sup>a</sup>	41.90 ± 0.63 <sup>a</sup>	16.11 ± 0.42 <sup>a</sup>

Values are expressed as means ± SEM of four independent experiments. Means in the same column not sharing the same letter(s) are significantly different ( $p < 0.05$ )

**HDL-** High Density Lipoprotein, **LDL-** Low Density Lipoprotein

**Table 4.** Effects of oral administration of ethanolic and aqueous extracts of lemon grass (*Cymbopogon citratus*) on Hormonal profiles in normal rats.

Group	TSH (µIU/ml)	T3 (ng/ml)	T4 (nmol/L)
Control	1.17 ± 0.11 <sup>a</sup>	0.69 ± 0.064 <sup>c</sup>	35.31 ± 1.07 <sup>a</sup>
Ethanolic extract (200mg/kg)	2.66 ± 0.44 <sup>b</sup>	1.01 ± 0.00 <sup>a</sup>	34.93 ± 1.62 <sup>a</sup>
Aqueous extract (200mg/kg)	2.19 ± 0.065 <sup>b</sup>	0.93 ± 0.025 <sup>b</sup>	35.89 ± 0.62 <sup>a</sup>

Values are expressed as means ± SEM of four independent experiments. Means in the same column not sharing the same letter(s) are significantly different ( $p < 0.05$ )

**TSH -** Thyroid-stimulating hormone (thyrotropin), **T3-** Triiodothyronine, **T4 –** thyroxine

## Lipid profile assay

Serum was used to assay for the following parameters: total cholesterol (Trinder, 1969), triglycerides (Tietz, 1990), high density lipoprotein cholesterol (Tietz, 1976), very low density lipoprotein cholesterol (triglycerides/5) and low density lipoprotein cholesterol (Friedewald et al., 1972).

## Blood sample preparation

At the end of the experiment, rats were fasted for 12 to 14 h. Blood were collected by cardiac puncture from the rats at fasting state after being anesthetized with chloroform. The blood samples were collected in plain tubes, allowed to coagulate at room temperature and centrifuged at 3500 rpm for 15 min at room temperature

for separation of serum. The clear, non-haemolysed supernatant was separated using clean dry Pasteur pipette and stored at -20°C. Serum was used to assay for the lipid profile levels of the rats.

### Statistical analysis

The experimental results were expressed as the mean  $\pm$  S.E.M. Statistical significance of difference in parameters amongst groups was determined by One way ANOVA followed by Duncan's multiple range test.  $P < 0.05$  was considered to be significant.

## RESULTS AND DISCUSSION

Values are expressed as means  $\pm$  SEM of four independent experiments. Means in the same column not sharing the same letter(s) are significantly different ( $p < 0.05$ ) (Table 1, 2)

Blood sugar level of the plant was determined and no significant ( $p < 0.05$ ) difference was observed rats in control and the ethanolic extract treated rats. Administration of single dose at 200mg/kg of the plant

ethanolic and aqueous extracts did not show any reduction in blood glucose level in normal rats with single dose administration study on day '7'. There was a significant increase in levels at intervals of 0 and 7 days.

Result showed that administration of both ethanolic and aqueous extracts of *Cymbopogon citratus* at a dose of 200 mg/kg body weight for a period of 30 days to the test animals caused a steady decrease in their blood glucose level. The significant ( $p < 0.05$ ) decrease in the blood glucose of the test animals as compared to the control is a reflection of the hypoglycemic effect of the plant. (Table 3)

The lipid profiles of rats treated with both ethanolic and aqueous extracts of lemon grass was also observed. The Total cholesterol, Triglycerides, High density lipoprotein (HDL) and low density lipoprotein (LDL) levels of the ethanolic extracts were observed to be significantly lowered when compared with the aqueous extract and the control normal rats. The results of the study also showed that the level of the LDL-Cholesterols in both ethanolic and aqueous extracts were significantly ( $p < 0.05$ ) lowered when compared with the control group and the level of the HDL-Cholesterol in the treated groups. Thus, blood serum cholesterol level was found to be down regulated in this study. (Table 4) The results of the hormonal assays showed that there is a significant ( $p > 0.05$ ) increase in the level of the Thyroid stimulating hormones (TSH) in the ethanolic extract treated rats and aqueous extract treated rats when compared with the normal control. In the same vein, the level of Triiodothyronine ( $T_3$ ) in both the ethanolic and aqueous extracts treated rats was significantly ( $p < 0.05$ ) higher as

compared with the control. And no significant ( $p < 0.05$ ) difference was observed in thyroxine ( $T_4$ ) level of both the ethanolic and aqueous extracts of *C. citratus* when compared with the normal control animal.

## DISCUSSION

Many indigenous medicinal plants have been reported by various authors to have hypoglycemic effects (Young and Maciejewski, 1997). Some of these hypoglycemic medicinal plants have been shown to significantly reduce blood glucose concentration in normal and diabetic animals. These plants, for example *C. citratus*, tend to participate in the tight regulation of blood glucose levels as a part of metabolic homeostasis.

The result in table 2 showed that administration of both ethanolic and aqueous extracts of *C. citratus* at a dose of 200 mg/kg body weight for a period of 30 days to the test animals caused a steady decrease in their blood glucose level. The significant decrease in the blood glucose of the test animals as compared to the control is a reflection of the hypoglycemic effect of the plant.

Recent Phytochemical studies have shown that the hypoglycaemic effect of any plants is due to presence of tannins and polyphenols singly or in combination having anti-oxidant property (Kumar, 1983). Tannic acid possesses glucose transport-stimulatory and adipocyte differentiation-inhibitory activity and induces GLUT 4 translocation (Hirosh *et al.*, 2004), while polyphenols inhibit  $\alpha$ -glucosidase enzyme from the intestine and initiate release of insulin from the beta cells of pancreas (Liu *et al.*, 2005). Based on increased insulin levels in rats treated with *C. citratus* extracts, it can be suggested that the possible mechanism of action of both ethanolic and aqueous extract from *C. citratus* could be related to anti-oxidant activity that aids to recovery from impaired glucose metabolism through release of insulin from the pancreas.

In diabetes, elevation of blood glucose is a consequence of increased hepatic glucose output along with reduced peripheral glucose utilization. Insulin deficiency is clearly associated with a change in hepatic metabolism (Consoli *et al.*, 1989). Moreover, a reduction in insulin-mediated glucose uptake caused by decreasing gene expression of GLUT-4 has been reported in skeletal muscle, a major site for glucose disposal, in diabetic rats (Berger *et al.*, 1989).

Mohammad *et al.*, (2007) has earlier reported the hypoglycemic activity of aqueous extract of *G. lucidum* in Wistar rats. Over 400 medicinal plants are available globally for the medication of *diabetes mellitus*, with a few having been subjected to scientific authentication to ascertain their effectiveness as anti-diabetic agents (Onoagbe and Esekheigbe, 1999). Substances with hypoglycemic properties would be effective in the management of diabetes mellitus (Young and

Maciejewski, 1997).

The lipid profiles: Total cholesterol, Triglycerides, High density lipoprotein (HDL) and low density lipoprotein (LDL) levels of the ethanolic extracts as indicated in table 3 were observed to be significantly lowered when compared with the aqueous extract and the control normal rats. The results of the study also showed that the level of the LDL-Cholesterols in both ethanolic and aqueous extracts were significantly ( $p < 0.05$ ) lowered when compared with the control group and the level of the HDL-Cholesterol in the treated groups. Thus, blood serum cholesterol level was found to be down regulated in this study. It is known that high blood cholesterol levels and hyper-lipidemia can be the consequence and frequently associated with diabetes (Ravi *et al.*, 2005, Emeka, *et al.*, 2011). The concomitant protein stabilization and the elevation in the serum cholesterol levels are considered an added value of this plant protective mechanism. These events and together with the hypoglycemic properties of this plant indicated that it can be considered as a preventive factor for long-term complications of diabetes. These findings are in agreement with other cholesterol modulating effects of several other plants (Momo *et al.*, 2006). The reduction of this lipid profile in rats after treatment can be attributed to their promotion in utilization glucose reflected by a decrease in blood glucose and elevated insulin levels and hence depressed mobilization of fat (Momo *et al.*, 2006).

Elevated blood triglyceride and cholesterol are some of the diabetic indicators and significant decreases of these parameters obtained in this study (Table 3) were indicative of the potentials of extracts of *C. citratus* to reduce plasma levels of these indicators to asymptomatic limit. These reductions of both cholesterol and triglyceride concentrations in the ethanolic extracts treated normal rats could be beneficial in preventing diabetic complications and improving lipid metabolism in diabetics (Cho *et al.*, 2002). Hypercholesterolemia plays an important role in the initiation and progression of atherosclerosis and is known to have a positive correlation with cardiovascular disease, largely depending on the oxidation of LDL, the main cholesterol carrier in plasma (Hsu, 2003). Flavonoid and saponin contents of extracts of *T. scleroxylon* may have also contributed to the reduction in the blood levels of triglyceride and cholesterol in experimental rats as has been widely reported by Prohp and Onoagbe (2012).

Increase in LDL (bad cholesterol) or lethally dangerous lipoprotein carry a lot of health risks as its accumulation could occlude major arteries causing myocardial infarction, atherosclerosis, heart attack, stroke and even high blood pressure. Thus, both extracts significantly reduced LDL.

Avci *et al.*, (2006) reported an increase in HDL in male Swiss albino mice by aqueous and ethanol extracts of *Agrostemmagithago*, *Potentilla reptans*, *Thymbra spicata*, *Urtica dioica* and *Viscum album*. HDL carries cholesterol

and cholesterol esters from the peripheral tissues and cells to the liver, where cholesterol is metabolised into bile acids. This pathway plays a very important role in reducing cholesterol levels in the blood and peripheral tissues and in inhibiting atherosclerotic plaque formation in the aorta (Karmarker, 2008; Kim *et al.*, 2008). The increased levels of HDL (good cholesterol) concentrations obtained in this study were indicative of potentials of extracts to protect against heart diseases.

For the hormonal assays, Uboh *et al.*, (2007) reported that exposure to gasoline vapours increased serum FSH, LH and testosterone in male rats and decreased serum FSH, LH and estradiol and progesterone in female rats. Testicular androgens (testosterone) are responsible for the growth and development of male urogenital system and the accessory sex organs. The prostate gland tissue is also known to be a testosterone dependent organ and when the testosterone level decreases as a result from an increasingly pronounced metabolic syndrome (Laaksonen *et al.*, 2003; Laaksonen *et al.*, 2004), the growth-stimulating effect on the prostate gland by other aberrations might possibly be reduced. Niu *et al.*, (2003) also stated that the hormonal anatomical and functional growth of the prostate is mainly controlled by androgens. The hormonal hypothesis seems to be one of the most important hypotheses in prostatic cancer etiology, and efforts are continuing to improve the understanding of androgen action in prostatic cancer (Imammoto *et al.*, 2009). Although evidence from epidemiological studies of an association between circulating levels of androgens and prostatic cancer risk has been inconsistent, the traditional view that higher testosterone represents a risk factor for prostatic cancer appears to have little evidentiary support (Morgentaler, 2007).

The increasing trend of blood hormones Thyroid stimulating Hormones and testosterone on oral administration of *Cymbopogon citratus* (table 4) was novel since no works has earlier reported these. Raji *et al.*, (2005) found the mean serum testosterone level of rats treated with 400 mg/kg of the *Morinda lucida* leaf extract for 4 and 13 weeks significantly increased ( $p < 0.01$ ) compared with the controls. He also stated that the extract caused an increase in the weight of the testes, which was accompanied by an increase in the serum levels of testosterone. Similar changes have been reported with the extract of *Zingiber officinale* and *Pentadiplendra brazzeana* in rats (Kamtchouing *et al.*, 2002). Others have reported testicular weight reduction accompanied by decreased serum testosterone levels in male rats treated with the extracts of *Quassia amara* (Kamtchouing *et al.*, 2002), *Azadirachta indica* (Raji *et al.*, 2005) and gossypol, a phenolic compound extracted from the cotton seed (Qian *et al.*, 1984). The MEPH treatment may lead to carcinogenesis. Thus, it can be inferred that *C. citratus* extracts has no negative effects on the various hormonal profiles tested for.

## CONCLUSION

In conclusion, *Cymbopogon citratus* are recommended cardiac glycoside and the cardiac glycosides serves as defence mechanisms against cardiovascular disease and digestive problems. Thus, *Cymbopogon citratus* (Lemon grass) whole plant materials are recommended to be taken because it has many beneficial effects in human health (Ozcan *et al.*, 2009).

## REFERENCES

- Avci G, Kupeli E, Eryavuz A, Yesilada E, Kucukkurt I (2006). Antihypercholesterolemic and antioxidant activity assessment of some plants used as remedy in Turkish folk medicine. *J. Ethno-Pharmacol.*, 107: 418-423.
- Balboa SI, Johnson CH (1955). The microscopic structure of lemongrass leaves. *J Am Pharm Assoc Am Pharm Assoc (Baltim)*; 44(2):89-98.
- Balch Phyllis A (2006). Prescription for nutritional healing. 4th ed. New York: Avery, Pp. 54
- Banthorpe DV, Duprey RJ, Hassan M, Janes JF, Modawi BM (1976). Chemistry of the Sudanese flora. I. Essential oils of some *Cymbopogon* species. *Planta Med.*; 29(1):10-25.
- Berger J, Biswas C, Vicario PP, Strout HV, Saperstein R, Pilch PF (1989). Decreased expression of the insulin-responsive glucose transporter in diabetes and fasting. *nature*; 340:70 –72
- Cho SY, Park JY, Park EM, Choi MS, Lee MY, Jeon SM, Jang MK, Kim MJ, Park YB (2002). Alternation of hepatic antioxidant enzyme activities and lipid profile in streptozotocin-induced diabetic rats by supplementation of dandelion water extract. *Clin. Chim. Acta.*, 317: 109 – 117.
- Consoli A, Nurjhan N, Capani F, Gerich J (1989). Predominant role of gluconeogenesis in increased hepatic glucose production in NIDDM. *Diabetes*38:550 –557
- Davidson MH, Toth PP, Maki KC (2008). *Therapeutic Lipidology*. Contemporary Cardiology. Cannon, Christopher P.; Armani, Annemarie M. Totowa, New Jersey: Humana Press, Inc. pp. 141–142.
- Ebomoyi O (2008). Traditional Medicine in Mental health care. *The Journal of American Science*; 4(4):21-25.
- Emeka EJI, Funmilayo DO (2011). Hypoglycemic effects, biochemical and histological changes of *Spondias mombin* linn and *Perinaria ployandra benth* seeds ethanolic extracts in alloxan induced rats. *Journal of pharm. Toxicol.*: 6 (2) 1001-102.
- Friedewald WT, Levy RI, Fredrickson DS (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without the use of preparative ultracentrifuge. *Clin. Chem.* 18:499-502.
- Gbile (1986). Ethnobotany, Taxonomy and Conservation of Medicinal Plants. Ibadan University press, Ibadan p. 126 – 130
- Hegnauer R (1955). Microscopical study of the leaves of *Cymbopogon flexuosus* Stapf (Lemon grass). *Pharm Weekbl*; 90(13):445-447.
- Hirosh T, Mitsuy I, Mi T, Jin EW, Tosiyasu S, Ikuko K (2004). Effect of green tea on blood glucose levels and serum proteomics patterns in diabetic mice and on glucose metabolism in healthy humans. *BMC Pharma*; 4:18–30.
- Hsu HHT (2003). In vitro effect of cholesterol on calcifying activity of vesicles isolated from rabbit aortas. *Biochimica et Biophysica Acta (BBA) - Molec. Basis Dis.*, 1638: 235-240.
- Imamoto T, Suzuki H, Yano M, Kawamura K, Kamiya N, Araki K (2009). Does presence of prostate cancer affect serum testosterone levels in clinically localized prostate?
- Kamtchoung P, Mbongue Fandio GY, Dimo T, HB Jatsa (2002). Evaluation of androgenic activity of *Zingiber officinale* and *Pentadiplandra brazzeana* in male rats. *Asian J.* 14 (2): 101-111.
- Karmarker B (2008). Polaxamers and their applications in Pharmacy student articles, <http://www.pharmainfo.net/>.
- Kim H, Jeong D, Jung H, Yokozawa T, Choi J (2008). Hypolipidemic effects of *Sophora flavescens* and its constituents in Poloxamer-407 induced hyperlipidemic and cholesterol-fed rats. *Biol. Pharm. Bull.* 31 (1): 73 – 78.
- Kumar R (1983). Chemical and biochemical nature of fodder tree tannins. *J Agriculture Food Chem*; 31: 1346–66.
- Laaksonen DE, Niskanen L, Punnonen K, Nyyssonen K, Tuomainen TP, Valkonen VP (2003). Sex hormones, inflammation and the metabolic syndrome: a population based study. *Eur. J. Endocrinol.* 149: 601–608.
- Laaksonen DE, Niskanen L, Punnonen K, Nyyssonen K, Tuomainen TP, Valkonen VP (2004). Testosterone and sex hormone-binding globulin predict the metabolic syndrome and diabetes in middle-aged men. *Diabetes Care.* 27: 1036 – 1041.
- Lecerf JM, de Lorgeril M (2011). "Dietary cholesterol: from physiology to cardiovascular risk". *Br J Nutr* 106 (1): 6–14.
- Li H, Huang J, Zhang X, Chen Y, Yang J, Hei L (2005). Allelopathic effects of *Cymbopogon citratus* volatile and its chemical components. *Ying Yong Sheng Tai Xue Bao*; 16(4):763-767.
- Liu PY, Pincus SM, Takahashi PY, Roebuck PD, Iranmanesh A, Keenan DM, Veldhuis JD (2006). "Aging attenuates both the regularity and joint synchrony of LH and testosterone secretion in normal men: analyses via a model of graded GnRH receptor blockade". *Am. J. Physiol. Endocrinol. Metab.* 290 (1): E34–E41.
- Mohammed A, Adelaiye AB, Abubakar MS, Abdurahman EM (2007). Effects of aqueous extract of *Ganoderma lucidum* on blood glucose levels of normoglycemic and Alloxan-induced diabetic Wistar rats. *J. Med. Plant Res.* 1(2): 34-37.
- Momo CEN, Oben JE, Tazoo D, Dongo E (2006). Antidiabetic and hypolipemic effects of *laportea ovalifolia* (urticaceae) in alloxan induced diabetic rats. *Afr. J. Trad. CAM*: 3 36-43.
- Morgentaler A (2007). Testosterone deficiency and prostate cancer: emerging recognition of an important and troubling relationship. *Eur. Urol.* 52: 623–625.
- Nhu-Trang TT, Casabianca H, Grenier-Loustalot MF (2006). Authenticity control of essential oils containing citronellal and citral by chiral and stable-isotope gas-chromatographic analysis. *Anal Bioanal Chem.*; 386(7-8):2141-2152
- Niu YJ, Ma TX, Zhang J, Xu Y, Han RF, Sun G (2003). Androgen and prostatic stroma. *Asian J. Androl. Mar.* 5(1): 19 – 26.
- Olson RE (1998). "Discovery of the lipoproteins, their role in fat transport and their significance as risk factors". *J. Nutr.* 128 (2 Suppl): 439S–443S.
- Onoagbe IO, Esekheigbe A (1999). Studies on the anti-diabetic properties of *Uvaria Chamae* in streptozotocin-induced diabetic rabbits. *Biokemistri.*; 9: 79-84.
- Prohp TP, Onoagbe IO (2012). Plasma Lipid Profile in Non-Diabetic Rats Treated with Extracts of *Triplochiton Scleroxylon* K. Schum. *J Phys Pharm Adv* 2012, 2(12): 389-399.
- Qian SZ, Wang ZG (1984). Gossypol: A potential antifertility agent for males. *Annu. Rev. Pharmacol. Toxicol.*24: 329–60.
- Raji Y, Akinsomiso OS, Salman TM (2005). Antispermatic activity of *Morinda lucida* extract in male rats. *Asian J. Androl.* 7 (4): 405–410.
- Ravi K, Rajasekaran S, Subramanian S (2005). Antihyperlipidemic effect of *Eugenia jambolana* seed kernel on streptozotocin-induced diabetes in rats. *Food Chem. Toxicol.*: 43 1433-1439.
- Rubenstein KE, Schneider RS, Ullman EF (1972). "Homogenous enzyme immunoassay". New immunochemical technique". *Biochem. Biophys. Res commun.* 47: 846-851.
- Siddiqi SA, Misra L (2000). Fatty acids and sterols from *Cymbopogon martinii* var. *motia* roots. *Z Naturforsch [C]*; 55(9-10):843-845.
- Sies H (1997). "Oxidative stress: Oxidants and antioxidants". *Experimental physiology* 82 (2): 291–5
- Tietz N.W. (1976). Fundamentals of Clinical Chemistry. 2nd edn., W.B. Saunders Company, Philadelphia, USA pp. 878-878.
- Trinder P (1969). Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. *Ann. Clin. Biochem.* 6: 24-27.
- Uboh FE, Akpanabiatu MI, Atangwho IJ, Ebong PE, Umoh IB (2007). Effect of gasoline vapours on serum lipid profile and oxidative

stress in hepatocyte of male and female *J. reproductive toxicol.* 3, 354-358.

Valko M, Izakovic M, Mazur M, Rhodes CJ, Telser J (2004). "Role of oxygen radicals in DNA damage and cancer incidence". *Molecular and Cellular Biochemistry* 266 (1-2): 37-56.

Young NS, Maciejewski J (1997). The pathophysiology of Acquired Aplastic anemia. *N. Eng. J. Med.* 336: 1365-1371.