Journal of Experimental Research

DECEMBER 2023, Vol 11 No 4

Email: editorinchief.erjournal@gmail.com
editorialsecretary.erjournal@gmail.com

***Received*:** Oct., 2023
***Accepted for Publication*:** Dec., 2023

EFFECTS OF ETHANOL EXTRACT OF RHIZOMES OF *Zingiber Officinale* (GINGER) ON SOME METABOLIC SYNDROME INDICES OF ALBINO WISTAR RATS FED HIGH-FAT HIGH-SUCROSE DIET

Chukwu O.O[1*], Christian E. Odo[1], and Eze-Steven P.E[2].

[1]Department of Biochemistry, College of Natural Sciences, Micheal Okpara University of Agriculture, PMB 7267, Umudike, Abia State, Nigeria.
[2]Department of Applied Biochemistry, Faculty of Applied Natural Sciences, Enugu State University of Science and Technology, Enugu State, Nigeria.

***Author for Correspondence:** onyiichuks94@gmail.com

ABSTRACT

Zingiber officinale rhizome, known commonly as ginger, is extensively used in traditional system of medicine in many countries for the treatment of various disorders. The study was aimed at determining the effects of the ethanol extract of the rhizomes of *Z. officinale* on some metabolic syndrome indices in albino Wistar rats fed high-fat high-sucrose diet. The design consisted of 6 groups. Group 1 received standard feed(vital finisher's mash) and distilled water, group 2 received high-fat high-sucrose diet only, group 3 received high-fat high-sucrose diet + metformin, groups 4,5 and 6 received high-fat high-sucrose diet + ethanol extract of rhizomes of *Zingiber Officinale* (200, 400 and 800mg/kg body weight respectively). The experiment lasted for 10 weeks. At the end of the experiment, the rats of different groups were sacrificed; the parameters of lipid profile(Total cholesterol, HDL-C, TAG, LDL-C and VLDL-C), antioxidant status SOD and catalase activities as well as GSH and MDA concentrations) and using standard methods. Administration with the ethanol extract of *Z. officinale* rhizomes at doses of 200, 400 and 800mg/kg body weight showed significant reduction of body weight in treated groups, improved lipid profile and HDL-cholesterol levels in the rats of the treated groups compared to the rats in the group fed high-fat high-sucrose diet alone. Inhibition of lipid peroxidation, and improvement of GSH, GPx, SOD, MDA and catalase activity were also observed in the rats of the treated groups. In conclusion, this study reveals that the ethanol extract of the rhizome of *Z. officinale* improved the indices of metabolic syndrome and therefore, justifies its use in the amelioration of metabolic syndrome.

Keywords: HFHS diet (high-fat high-sucrose diet), MetS (metabolic syndrome), *Zingiber officinale* (Ginger)

INTRODUCTION

Metabolic syndrome including the presence of obesity, insulin resistance and dyslipidaemia that predisposes one to type 2 diabetes mellitus is becoming more prevalent in recent years (Alberti *et al.* 2018; Bergman *et al.* 2018). The modern lifestyle of increased intake of high-fat high-sucrose cafeteria fast food associated with decreased energy expenditure also contributes to the current rising prevalence of obesity and type 2 diabetes (Aude *et al.* 2017). Therefore, new medicinal agents with dual properties on controlling both blood glucose and lipids are in great demand. *Z. officinale* commonly known as ginger, a well-known food spice, has been used traditionally in a wide variety of ailments (Afzal *et al.*2015; Park *et al.*2021).In laboratory experiments, ethanol extract of *Z. officinale* has been shown to reduce plasma lipids in cholesterol-fed hyperlipidaemic rabbits **(**Verma *et al.* 2014; Bhandari *et al.* 2018). Hence, this study was aimed at evaluating the effects of the ethanol extract of rhizomes of *Z. officinale* on some metabolic syndrome indices in rats fed high-fat high-sucrose diet.

MATERIALS AND METHODS

Plant Material and extraction:

Fresh rhizomes of *Z. officinale* were obtained from a local vegetable market (Ubani) in Umuahia

North Local Government Area, Abia State and were authenticated by a taxonomist Mr. Ibe K. Ndukwe of the Herbarium Unit of Forestry and Environmental Management Department of Michael Okpara University of Agriculture, Umudike, Abia State.

Extracts from these rhizomes were prepared according to the Soxhlet method described by Jensen (2017).

Animals

A total of 30 adult male albino rats aged 8-10 weeks and weighing 80 to 120g. The animals were obtained from the Animal House of the Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, housed in Aluminium cages (6 rats per cage) The study was conducted in the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike.

Experimental Design

Thirty (30) adult albino rats assigned to 6 groups of 5 rats each were treated according to the order below:

Group 1: Normal control
Group 2: Negative control (high-fat high-sucrose diet only)
Group 3: High-fat high-sucrose diet + metformin (100 mg/kg body weight)
Group 4: High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (200 mg/kg body weight)
Group 5: High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (400 mg/kg body weight)
Group 6: High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (800 mg/kg body weight)

Determination of Total Cholesterol Concentration

The determination of serum concentrations of total cholesterol was carried out using enzymatic colorimetric endpoint method as described by Allain *et al.* (1974).

Determination of High Density Lipoprotein Cholesterol Concentration

The determination of serum concentrations of total cholesterol was carried out using enzymatic colorimetric endpoint method as described by Allain *et al.* (1974).

Determination of Triacylglycerol Concentration

This was determined by the method described by Tietz (1990).

Determination of Malondialdehyde Concentration

Lipid peroxidation was determined by measuring thiobarbituric acid reactive substances (TBARS) in the tissues using the method Wallin *et al.* (1993).

The pink chromogen produced by the reaction of secondary products of lipid peroxidation such as malondialdehyde (MDA) with thiobarbituric acid was estimated at 532 nm.

Determination of antioxidant enzymes

SOD was assayed according to the method of Arthur and Boyne (1985). The assay was based on the 50% inhibition of the formation of NADH-phenazine methosulfate nitroblue tetrazolium formazan at 520 nm. The activity of catalase was assayed according to the method of Sinha (1972), based on the conversion of dichromate in acetic acid to perchromic acid and then to chromic acetate, when heated in the presence of H_2O_2. The chromic acetate formed was measured at 620 nm. Reduced glutathione (GSH) in the tissue was assayed according to the method of Exner *et al.* (2000).GSH estimation was based on the development of yellow colour when 5.5-dithiobisnitro benzoic acid was added to compounds containing sulfydryl groups. Hepatic GST activity was assayed according to the method of Habig *et al.*(1984) with some modifications. GPx activity was determined by measuring the decrease in GSH content after incubating the sample in the presence of H_2O_2 and NaN_3 (Hafemann *et al.*1974).

Statistical Analysis

Data obtained were presented as mean ± standard error of mean and analyzed using Oneway Analysis of Variance of SPSS software. The variant mean was separated by least significant difference of the different groups. Significance was accepted at the level of $P < 0.05$.

Table 1: Lipid profile

Parameters	Normal control	High-fat high-sucrose diet only	High-fat high-sucrose diet + Metformin (100 mg/kg)	High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (200 mg/kg BW)	High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale*(400 mg/kg BW)	High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale*(800 mg/kg BW)
Total cholesterol (mg/dl)	103.17±2.12^{a}	185.65±9.05^{d}	133.37±6.58^{b,c}	133.88±8.44^{b,c}	137.49±3.37^{c}	128.13±5.06^{b}
HDL-C (mg/dl)	64.16±1.20^{a}	69.95±2.59^{b,c}	67.58±2.38^{a,b}	70.76±2.80^{b,c}	71.15±4.77^{b,c}	72.58±2.51^{c}
TAG (mg/dl)	116.80±4.77^{a}	191.55±8.66^{d}	177.54±05.25^{c}	171.71±7.84^{c}	155.16±5.29^{b}	153.84±7.34^{b}
LDL-C (mg/dl)	15.65±2.44^{a}	77.40±8.72^{d}	30.28±7.66^{b,c}	28.78±5.93^{b,c}	35.31±6.72^{c}	24.78±4.59^{b}
VLDL-C (mg/dl)	23.36±0.95^{a}	38.31±1.73^{d}	35.51±1.05^{c}	34.34±1.57^{c}	31.03±1.06^{b}	30.77±1.47^{b}

Values were presented as mean ± standard deviation (n = 5); and values with different letter superscripts are significantly different from any paired mean across the row.

Table 2: Antioxidant parameters

Parameters	Normal control	High-fat high-sucrose diet only	High-fat high-sucrose diet + Metformin (100 mg/kg)	High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (200 mg/kg BW)	High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (400 mg/kg BW))	High-fat high-sucrose diet + ethanol extract of the rhizomes of *Z. officinale* (800 mg/kg BW)
GSH (u/l)	65.35±3.22^{d}	54.69±3.85^{a}	59.24±2.10^{b,c}	57.60±1.20^{a,b}	61.00±2.59^{b,c}	61.81±1.98^{c}
GPx (u/l)	53.55±2.98^{c,d}	46.64±1.73^{a}	50.39±0.70^{b}	50.80±2.26^{b,c}	53.75±2.17^{d}	52.42±1.86^{b,c,d}
SOD (u/l)	42.47±2.67^{c}	32.75±2.26^{a}	36.86±1.33^{b}	40.13±1.82^{c}	40.86±1.52^{c}	42.04±1.55^{c}
CAT (u/l)	31.04±1.08^{a,b}	28.92±1.45^{a}	30.84±1.06^{a,b}	30.34±2.24^{a,b}	30.23±2.01^{a,b}	31.71±1.21^{b}
MDA (mmol/L)	0.43±0.05^{a}	1.89±0.12^{d}	1.34±0.05^{c}	1.23±0.10^{c}	1.05±0.11^{b}	1.00±0.12^{b}

Values were presented as mean ± standard deviation (n = 5); and values with different letter superscripts are significantly different from any paired mean across the row.

RESULT AND DISCUSSION

Alteration in lipid profile is an indication of pathological conditions relative of plaques formation in the arterial walls may cause atherosclerosis and this may be obtained with an increase on LDL-C and decrease level of HDL-C (Superko *et al.* 2022). Exposure of the experimental albino rats to HFHS diet in this present study elicited an increase in the concentration of total cholesterol, TAGs, LDL-C and VLDL-C but reduction in the concentration of HDL-C. Treatment with the graded doses of the ethanol extract of the rhizomes of *Z. officinale* significantly attenuated all the alterations in the lipid profile (Table 1). The results agree with the previous report of Bello *et al*. (2017), who documented protective effects of plant extract against atherosclerosis and other cardiovascular disorders. The ethanol extract of rhizomes of *Z. officinale* may haveinterfered with cholesterol uptake in intestine (Oladele *et al.*2017).

In the result of antioxidant (Figure 4.3 to 4.7), the activities of GSH,CAT,GPx and SOD show marked elevation at the end of the experiment in all ethanol extract of rhizomes of *Z. officinale* treated groups compared to the control. Ajith *et al*. (2017) suggested that the hepatoprotective effect of ethanol extract of rhizomes *Z. officinale* may be mediated either by enhancing hepatic antioxidant (GSH and SOD) or due to its direct radical scavenging capacity. It appeared that the ethanol extract of rhizomes *Z. officinale* reduced the oxidative stress as revealed from the increased activity of antioxidant biomarkers like CAT, SOD, GPx, and GSH in the extract treated groups.

Lipid peroxidation may lead to the formation of several toxic products, such as malondialdehyde (MDA). Malondialdehyde level was significantly decreased in the groups treated with different doses of ethanol extract of rhizomes of *Z. officinale* compared to the control. This result agrees with Stoilova *et al.* (2017) whom confirmed that, the ethanol extract of rhizomes of *Z. officnale* is a powerful free hydroxyl (OH^-) scavenger, resulting in inhibiting lipid peroxidation in linoleic acid model system. These bioactive components have antioxidative and antiproliferative activities are also constituents of the *Z. officinale* extract used in the present study. Metformin is effective in reducing the level of oxidative stress factors by regulating the antioxidant system of the cell (Amin *et al.*2020). Al-Hasani *et al*. (2015) confirmed that metformin attenuates the generation of oxygen reactive species and inhibits the opening of the mitochondrial membrane permeability transition pore activated by cytosolic Ca^{2+}, thereby preventing necrotic processes.

CONCLUSION

Z. officinale used as whole plant supplement in HFHS diet ameliorated the studied bio-indicators of metabolic syndrome brought about by the high-fat high-sucrose diets and supports the local application of the ethanol extract of the rhizomes of *Z. officinale* in the management of metabolic syndrome and possibly the incorporation of ginger an integral part of our diets.

REFERENCES

Afzal M, Al-Haddi D, Menon M, Pesek M, Dharmi MS. (2015). Ginger: an ethno medical, chemical and pharmacological review. *Drug Metabolism and Drug Interactions.*18:159–90.

Ajith TA, Hema U, Aswathy MS.(2017). *Zingiber officinale Roscoe* prevents acetaminophen induced acute hepatotoxicity by enhancing hepatic antioxidant status. *Food and Chemical Toxicology.*45: 2267–2272.

Alberti KG, Zimmet P, Shaw J. (2018). Metabolic syndrome – a new world-wide definition. A consensus statement from the international diabetes federation. *Diabetic Medicine*.23:469–480.

Al-Hasani H, Kunamneni RK, Dawson K, HinckCS, Muller-Wieland D, Cushman SW. (2015). Roles of the N- and C-termini of GLUT4 in endocytosis. *Journal of Cell Science*. *115*(1):131-140.

Allain CC, Poon LS, Chan CSG, Richmond WFPC, Fu PC. (1974). Enzymatic determination of total serum cholesterol. *Clinical Chemistry*.*20*(4): 470-475.

Amin KA, Abdel HH, Abd Elsttar AH. (2020). Effect of food azo dyes Tartrazine and carmoisine on biochemical parameters related to renal, hepatic function and oxidative stress biomarkers in young male rats. *Food and Chemical Toxicology*.48: 2994–2999.

Arthur JR, Boyne R. (1985). Superoxide dismutase and glutathione peroxidase activities in neutrophils from selenium deficient and copper deficient cattle. *Life Sciences*.*36*(16):1569-1575.

Aude YW, Mego P, Mehta JL. (2017). Metabolic syndrome: dietary interventions. *Current Opinion in*

Cardiology.*19*(5): 473-479.

Bello I, Zoph B, Vasudevan V, Le QV. (2017). Neural optimizer search with reinforcement learning. In *International Conference on Machine Learning*. 459-468.

Bergman RN, Kim SP, Catalano KJ, Hsu IR, Chiu JD, Kabir M, Ader M. (2018). Why visceral fat is bad: mechanisms of the metabolic syndrome. *Obesity*.*14*(2S):16S.

Bhandari U, Sharma JN, Zafar R. (2018). The protective action of ethanolic ginger (*Zingiber officinale*) extract in cholesterol fed rabbits. *Journal of Ethnopharmacology*. *61*(2):167-171.

Bray GA, Bellanger T. (2016). Epidemiology, trends, and morbidities of obesity and the metabolic syndrome. *Endocrine*.*29*:109-117.

Exner R, Wessner B, Manhart N, Roth E. (2000). Therapeutic potential of glutathione. *Wiener. Klinishe Wochenschr.*112: 610–616.

Habig WH, Pabst MJ, Jakoby, WR. (1974). Glutathione S-transferase.The first enzymatic step in mercapturic acid formation.*J Biol Chem*. 249: 7130-7139.

Hafemann DG, Sunde RA, Houestra WG. (1974). Effect of dietary selenium on erythrocyte and liver glutathione peroxidase in the rat.*J. Nutr*. 104: 580-584.

Kahn E, Hull RL, Utzschneider KM. (2016). Mechanisms linking obesity to insulin resistance and type2 diabetes. *Nature.*444:840–846.

Oladele JO, Oyewole OI, Bello OK, Oladele OT. (2017). Hepatoprotective effect of aqueous extract of *Telfairia occidentalis* on cadmium chloride-induced oxidative stress and hepatotoxicity in rats. *Journal of Drug Design and Medicinal Chemistry*. *3*(3):32-36.

Singh AB, Akanksha J, Singh N, Maurya R, Srivastava AK. (2019). Anti-hyperglycaemic, lipid lowering and anti-oxidant proper- ties of [6]-gingerol in db/db mice. *International Journal of Medicine and Medical Sciences*.1(12): 536–544.

Sinha AK. (1972). Colourimetric assay of catalase. *Analytical Biochemistry.*47:389–394.

Superko HR, Nejedly M, Garrett B. (2002). Small LDL and its clinical importance as a new CAD risk factor: a female case study. *Progress in Cardiovascular Nursing*. *17*(4):167-173.

Tietz NW. (1990). Colorimetric method of triglyceride estimation. *Clinical Guide to Laboratory Tests, 2nd ed.; WB Saunders Company: Philadelphia, PA, USA*, 554-556.

Verma SK, Singh M, Jain P, Bordia A. (2014). Protective effect of ginger, *Zingiber officinale* Rosc on experimental atherosclerosis in rabbits. *Indian Journal of ExperimentalBiology.*42:736–738.

Wallin B, Rosengren B, Shertzer HG, Camelo G. (1993). Lipoprotein oxidation and measurement of TBARS formation in a single microliter plate: Its use for evaluation of antioxidants. *Analytical Biochemistry*.208:10-15.