Scholars Journal of Agriculture and Veterinary Sciences OPEN ACCESS
Abbreviated Key Title: Sch J Agric Vet Sci
ISSN 2348–8883 (Print) | ISSN 2348–1854 (Online)
Journal homepage: https://saspublishers.com

Effect of *Solenostemon monostachyus* on Antioxidant Biomarkers in Wistar Rats

Wariebi Koikoibo[1], Daniel Ewa Ikpi[2], John Nwolim Paul[3*], Mao Ebimobotei Bunu[4], Agona Odeh Obembe[2], Polycarp Unim Adie[2], Mercy Kelechi Azumah[5], Chioma Winifred Udeh[6], Barisuka Kofii Nwibana[7], Udo Orukwowu[5], Chimezunem Mandah[3]

[1]Department of Human Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria
[2]Department of Human Physiology, Faculty of Basic Medical Sciences, College of Medical Sciences, University of Calabar, Cross River State, Nigeria
[3]Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria
[4]Department of Human Physiology, Bayelsa Medical University, Yenagoa, Bayelsa State
[5]Department of Nursing Science, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria
[6]Department of Medical Biochemistry, Faculty of Basic Medical Sciences, University of Port Harcourt, Choba, Port Harcourt, Rivers State, Nigeria
[7]Rivers State College of Health Science and Management Technology, Oroworukwo, Port Harcourt, Rivers State, Nigeria

DOI: https://doi.org/10.36347/sjavs.2026.v13i02.001 | **Received:** 19.01.2026 | **Accepted:** 01.03.2026 | **Published:** 03.03.2026

***Corresponding author:** John Nwolim Paul
Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria

Abstract **Original Research Article**

Solenostemon monostachyus, SOM, has aroused overwhelming attention, in recent years. There is growing concern whether SOM expresses its effect via a particular phytoconstituent, a combination of fractions, or otherwise. This study investigated the effect of both the ethanol extract and alkaloid fraction of SOM on some antioxidant biomarkers. Twenty-five adult Wistar rats were randomly grouped into five batches (n=5). Group I (control) received rodent feeds and water; Group II had 200mg/kg body weight of ethanol extract of SOM; Group III (400mg/body weight of ethanol extract). While groups IV and V, respectively, received, 33mg and 66mg/kg body weight of SOM alkaloid fraction. Serum levels of Superoxide dismutase (SOD), malondialdehyde (MAD) and catalase (CAT) enzymes were evaluated. The results showed significant elevation of SOD and CAT activity, respectively, while MAD levels were reduced by the effect of crude extract and alkaloid fraction. This suggests SOM's potential in maintaining cellular integrity and preventing tissue damage via anti-oxidative activity and reducing liquid peroxidation.

Keywords: Superoxidase dismutase, Malondialdehyde, Catalase, *Solenostemon monostachyus,* antioxidation.

1.0 INTRODUCTION

The rapid increase in consumption of herbal remedies worldwide has been stimulated by several factors, including the notion that all herbal products are safe and effective. (Omoloye *et al., 2015*)

Solenostemon monostachyus, SOM, has aroused overwhelming attention, in recent years (Okokon *et al.,2015*). Its use in the ethno-medical treatment of sicknesses and diseases nearly cuts across all organ systems of the body. SOM is mainly administered orally, more so, in the form of a crude extract.

Like in any other herbal intake, adverse effects on the tissues and organ-systems cannot be ruled out. (Okaiyeto and Oguntibeju, 2021). There is growing concern whether SOM expresses its effect via a particular phytoconstituent, a combination of fractions, or otherwise (Okoko and Ere, 2015)

2.0 SOLENOSTEMON MONOSTACHYUS: A NOVEL HERB

Solenostemon monostachyus is an aromatic, medicinal plant that belongs to the family *Lamiaceae*. In English language, it is called Monkey potato. Its names among some ethnic groups in Nigeria include Ntorikwot (Ibibio) and Olojogbodu (Yoruba). The use of

Solenostemon monostachyus plant in traditional medicine by the people of Nigeria has been documented.(Okokon, *et al.,*2017) The aerial parts of the plant are used in various decoctions traditionally by the Ibibios of the Niger Delta of Nigeria to treat stomach ulcer, fever/malaria The plant has been reported to possess antioxidant (Okoko and Ere, 2012) antihypertensive (Fidele, Andre, Yao and Michel, 2012) and antimicrobial activities. Its anti-inflammatory and anti-nociceptive activities (Okokon, *et al.,*2020), and anti-microbial properties (Ekundayo *et al*., 2006) and anti-ulcer as well as screening of its phytochemical constituents had been documented in literatures. Apart from the *S. monostachyus*, some plants and herbs including the leaf extract of Carica papaya (English name: pawpaw) show potent antioxidant activity. The leaf essential oil of *S. monostachyus* has been reported to contain; β-pinene, oct-1-en-3-ol, β-caryophyllene, octan-3-ol and (E,E)-αfarnesene (Mvé-Mba *et al*., 1994) in abundance and some of these compounds are sesquiterpenes. The presence of bioactive compounds is an affirmation of the use of *Solenostemon monostachyus* leaves in the management of various ailments, and can serve as a potential source of useful drugs. (Obichi *et al*., 2015).

2.1 Origin and history of *Solenostemon monostachyus*

Solenostemon monostachyus which belongs to the family Lamiaceae (English name: Monkey potato; Ibibio name: Ntorikwot; Yoruba name: Olojogbodu) is an important edible herb which can be found mostly within the tropical countries (West and Central African). It's a valuable herb that thrives in both anthropogenic and rocky savannah environments. The plant is an erect, branched annual weed with a long inflorescence of violet flowers. It is slightly succulent, aromatic and grows up to 100 cm tall (Mye-Mba and Menut, 1994).

2.2 Scientific classification of *solenostemon monostachyus*

The genus *Solenostemon* is in the family Lamiaceae in the major group, Angiosperms (Flowering plants). It is classified as follows: Kingdom (Plantae), Phylum (Tracheophyta), Class (Magnoliopsida), Order (Lamiales), Family (Lamiaceae), Genus (*Solenostemon*), Species (*monostachyus*, P. Beauv.). (Paton *et al.,*2019).

2.3 Phytochemical composition of *Solenostemon monostachyus*

Fig. 1: Image of *Solenostemon monostachyus* in its natural habitat (Paton *et al*., 2019)

Phytochemicals are chemicals of plant origin The phytochemical screening of *S. monostachyus* leaf extract revealed the presence of saponins, tannins, cyanogenic glycosides, flavonoids and alkaloids (Obichi, *et al*., 2015).

Fig. 2: *Solenostemon monostachyus*
Source: Wikipedia, 2022

3.0 ENZYMATIC ANTIOXIDANT BIOMARKERS: SUPEROXIDE DISMUTASE, MALONDIALDEHYDE, CATALASE

These enzymes play crucial role in neutralizing free radicals, reducing oxidative stress, and protecting against cell damage. Superoxide Dismutase (SOD), EC 1.15.1.1, is a potent intracellular enzymatic antioxidant and it catalyzes the conversion of superoxide anions to dioxygen and hydrogen peroxide, as follows.

O_2-O_2-2H → $H_2O_2 + O_2$

Malondialdehyde (MDA) is a reactive aldehyde that is widely used as a biomarker of lipid peroxidation and oxidative stress. Because it contains two aldehyde groups, it can participate in several important chemical reactions, especially with nucleophiles like amines and thiols. Below are key reactions involving MDA:

1. Formation of MDA from Lipid Peroxidation

MDA is produced during the oxidative degradation of polyunsaturated fatty acids (PUFAs) in cell membranes.

Steps:

A. Initiation: Free radicals (•OH, $•O_2^-$) extract a hydrogen from PUFA.

B. Propagation: Lipid radicals react with oxygen → lipid peroxyl radicals.

C. Breakdown: Peroxyl radicals decompose → MDA + other aldehydes.

2. Reaction of MDA with Thiobarbituric Acid (TBA) — TBARS Assay

This is the most common method to measure MDA levels.

A. MDA reacts with 2-thiobarbituric acid (TBA) under acidic and high-temperature conditions.

B. This forms a pink chromogen that absorbs at 532–535 nm.

Malondialdehyde (MDA) assay is based on the reaction of MDA with thiobarbituric acid (TBA) forming an MDA-TBA_2 adduct that absorbs strongly at 532nm. This method is very relevant in estimating MDA levels in biological systems.

MDA + 2 TBA → MDA–TBA adduct (pink pigment)

On the other hand, catalase enzyme (CAT) catalyzes the quick breakdown of hydrogen peroxide, H_2O_2, to water and molecular oxygen. Catalase activity in a sample is measured as directly proportional to the rate of this reaction.

$2H_20_2 → 2H_2O + O_2$

3.0 EXPERIMENTAL PROTOCOL

3.1 Plant Procurement

Fresh leaves of *Solenostemon monostachyus* were obtained from a botanical garden in Calabar, Cross River, in the month of March, 2024. The sample of the plant specimen was identified and authenticated by a botanist expert from the Department of Botany, University of Calabar, Nigeria.

3.2 Preparation of Ethanolic Plant Extract of SOM

Specifically, the leaves were sorted to eliminate any dead matter and other unwanted particles (Harborne,1998). They were air dried under shade at room temperature for 14 days and the leaves were blended with a manual hand blender to a powdered form. 100g of the fine powder was extracted using 80% ethanol (600ml) and allowed to stand for three (3) hours. It was then refrigerated at 4^0C for three (3) days. A silk material was used to filter, and then a secondary filtration was done using Whatman's filter paper size number 2 was used to complete the process. The filtrate was then dried until a paste was formed which was stored (in a refrigerator) as a stock reference.

3.3. Acid-base extraction of alkaloid fraction of SOM.

Alkaloid constituents were selectively extracted with acid-base extraction approach (Harborne,1998), with minor modification (Anza, *et al.,*2022). Root powder (400 g) was extracted with 97 % ethanol (3 x 1.5L) for 24 h at room temperature by maceration while shaking by electronic shaker at a speed of 230 rpm at room temperature. The solution was filtered and concentrated using a vacuum rotary evaporator to yield a crude extract. The residue of ethanol extract was redissolved in chloroform (100 mL) and then extracted with aqueous H_2SO4 5% to pH 3-4 (3 x 50 mL) in a separatory funnel to remove lipids, acidic and neutral metabolites. The aqueous phases were combined and basified with NH_4OH 5% to pH 11 and extracted with chloroform (3 x 100 mL). The chloroform phases were combined, dehydrated with anhydrous Na_2SO4, filtered, and concentrated by using a rotary evaporator to afford 6.9 g of an alkaloid fraction. Finally, the presence of alkaloids was checked by Dragondroff and Mayer's reagent chemical test.

3.4 Animal Groupings

Twenty-five (25) Wistar rats (both sexes), 220 ± 40 grams body weight, were randomly assigned to five batches (n=5). Group I: Control (rat, chow, water *ad libitum*). Group II: 200 mg *SOM* / kg body weight (rat chow, water *ad libitum, ethanol extract*); low dose SOM {ETHANOL LD} Group III: 400 mg *SOM* /kg body weight (rat chow, water *ad libitum, ethanol extract*); high dose SOM {ETHANOL HD} Group IV: 33 mg alkaloid /kg body weight (rat chow, water *ad libitum, alkaloid fraction*); low dose alkaloid {ALKALOID LD}

Group V: 66 mg ALKALOID/kg body weight (rat chow, water *ad libitum, alkaloid fraction*); high dose alkaloid {ALKALOID LD}

4.0 ANTIOXIDANT ENZYME ACTIVITIES AND LIPID PEROXIDATION ASSAYS

4.1 Superoxide Dismutase (SOD) Activity

4.12 Principle:

Superoxide dismutase (SOD) activity was determined using a modified method of Marklund and Marklund (1974). The assay is based on the ability of SOD to inhibit the autoxidation of pyrogallol. SOD

catalyzes the dismutation of the superoxide radical (O2•−) into molecular oxygen and hydrogen peroxide.

4.13 Preparation of Tissue Homogenate:

Tissue homogenates were treated with the non-ionic detergent Triton X-100 (1% final concentration) and incubated on ice for 30 minutes to ensure complete release of the Cu–Zn SOD enzyme.

4.14 Assay Procedure:

The reaction mixture (final volume: 1 ml) consisted of 500 µl of 0.1 M sodium phosphate buffer (pH 8.0; 50 mM), 33 µl of 3.3 mM EDTA (0.1 mM), 60 µl of 8.1 mM pyrogallol (0.48 mM), and an appropriate volume of tissue homogenate containing 10 µg of protein. The increase in absorbance was monitored at 420 nm for 2 minutes at 25°C against a reagent blank lacking tissue homogenate.

4.15 Calculation of SOD Activity:

SOD activity was expressed as units per milligram of protein. One unit of SOD was defined as the amount of enzyme required to produce 50% inhibition of pyrogallol autoxidation.

4.2 Determination of Lipid Peroxidation (Malondialdehyde, MDA)

Lipid peroxidation was assessed by measuring malondialdehyde (MDA) levels using a modified method of Armstrong and Al-Awadi (1991).

4.21 Assay Procedure:

A 1 ml aliquot of sample or standard was mixed with 3 ml of TCA–TBA–HCl reagent and thoroughly vortexed. The mixture was heated in a boiling water bath for 15 minutes, cooled to room temperature, and centrifuged at 1000 × g for 10 minutes. The absorbance of the resulting supernatant was measured at 535 nm against a reference blank.

4.22 Calculation of MDA Concentration:

MDA concentration was calculated using a molar extinction coefficient of 1.56×10^4 M^{-1} cm^{-1} and expressed as units per gram of tissue.

4.3 Determination of Catalase Activity

Catalase activity was determined following the method described by Cohen et al. (1970). The assay is based on the decomposition of hydrogen peroxide (H2O2) by catalase and subsequent reaction of residual H_2O_2 with potassium permanganate (KMnO4).

4.31 Assay Procedure:

The rate of H_2O_2 decomposition was assessed spectrophotometrically by measuring the residual permanganate at 480 nm. Catalase activity was directly proportional to the rate of decrease in H2O2 concentration.

4.32 Preparation of Reagents:

Phosphate buffer (pH 7.4) was prepared by dissolving appropriate quantities of disodium phosphate and potassium dihydrogen phosphate in distilled water. The pH was adjusted using 0.1 M hydrochloric acid, and the final volume was made up to 1000 ml. A 6 M sulphuric acid solution was prepared by carefully adding 163.2 ml of concentrated sulphuric acid (98%) to distilled water with continuous stirring, followed by dilution to a final volume of 1000 ml. A 0.01 M potassium permanganate solution was prepared by dissolving 0.158 g of KMnO4 in 100 ml of distilled water.

Hydrogen peroxide (30 mM) was prepared fresh by adding 0.1 ml of 10% H2O2 to approximately 80 ml of 0.05 M phosphate buffer (pH 7.4), and then the volume was adjusted to 100 ml with the buffer solution.

4.33 Assay Protocol

To measure catalase activity, 0.5 ml of the sample was mixed with 5 ml of 30 mM H_2O_2 in an ice-cold test tube, and the reaction was stopped after 3 minutes by adding 1 ml of 6 M H_2SO_4 followed by mixing. The resulting solution was then measured for absorbance at 480 nm against distilled water within 30–60 seconds. A blank solution was prepared in the same way as the test but with 0.5 ml of distilled water instead of the sample. A spectrophotometric standard was also prepared by adding 1 ml of 0.01 M $KMnO_4$ to a tube containing 5.5 ml of 0.05 M phosphate buffer (pH 7.4) and 1 ml of 6 M H_2SO_4 solution, and its absorbance value was measured at 480 nm.

4.34 Calculation of Catalase Activity

The catalase activity was then calculated using the formula below:

Catalase Activity (Kc) = $\text{Log}_{10} \times 2.03$

Where:

So = Absorbance of standard − Absorbance of blank

Ss = Absorbance of standard − Absorbance of test

4.35 Statistical Analysis

All results are presented as mean ± standard error of mean. Data were analyzed using one way of variance (ANOVA), followed by the least significant difference (LSD) procedure for significant F values. A $p<0.05$ was considered significant. Computer Software (SPSS and Excel Analyzer) was used for the analysis.

5.0 RESULTS

5.1 Effect of *SOM* on Anti-oxidant Biomarkers

5. 12 Effect of *SOM* on Superoxidase Dismutase Enzyme (SOD), Fig. 3

The activity of SOD was assayed, and the values (pg/ml) were as follows: 61.00 ± 1.95, 308.20 ± 3.35, 459.00 ± 0.89, 465 ± 0.73 and 378 ± 1.47, respectively, for control, ELD, EHD, ALD and AHD.

(ELD= ethanol Extract low dose, 200mg/body weight; EHD= ethanol Extract high dose, 400mg/body weight; ALD= alkaloid fraction low dose, 33mg/body weight; alkaloid fraction high dose, 66mg/body weight)

5. 13 Effect of *SOM* on Catalase Enzyme (CAT), Fig. 4

The corresponding levels for CAT were 14.80 ± 0.37, 26.00 ± 0.71, 25.80 ± 0.37, 26.6 ± 0.65 and 24.7 ± 0.52 pg/ml for control, ELD, EHD, ALD and AHD, respectively.

5.14 Effect of *SOM* on Malondialdehyde (MDA) Fig. 5

The concentration of MDA was 543.00 ± 0.86, 183.40 ± 0.51, 96.80 ± 1.24, 101.2 ± 0.84 and 105.6 ± 0.57 pg/ml, respectively, for control, ELD, EHD, ALD and AHD groups.

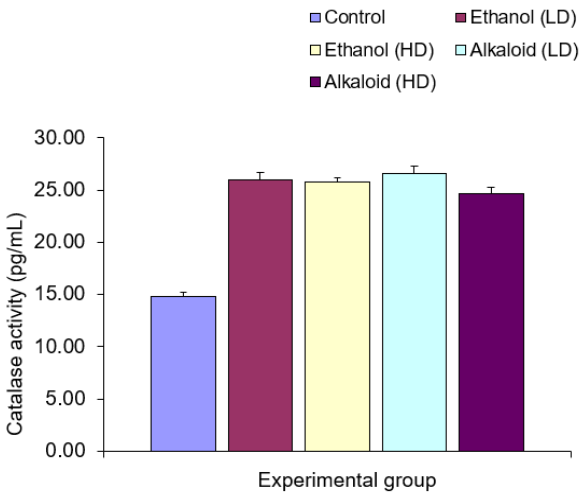

FIG.4 Catalase activity in the different experimental groups.
Ethanol=Ethanol extract; Alkaloid= Alkaloid Fraction;
LD=low Dose; HD=High Dose

Values are expressed as mean +SEM, n = 5.
* = p<0.05 vs control
a = p<0.05 vs Ethanol (LD)
b = p<0.05 vs Ethanol

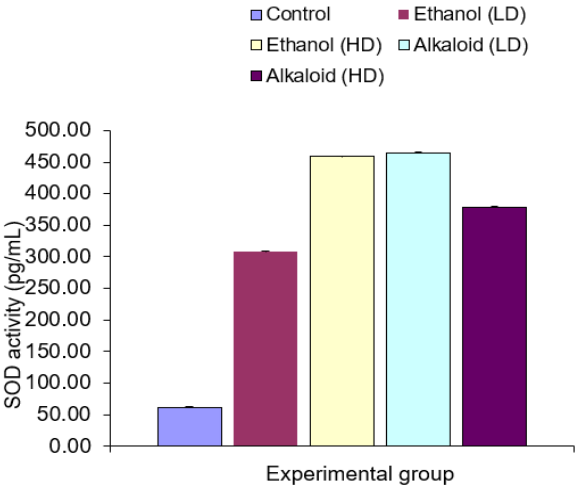

FIG. 3 Superoxide dismutase activity in the different experimental groups.
Ethanol=Ethanol extract; Alkaloid= Alkaloid Fraction;
LD=low Dose; HD=High Dose
Values are expressed as mean ± SEM, n = 5.
* = p<0.05 vs control
a = p<0.05 vs Ethanol (LD)
b = p<

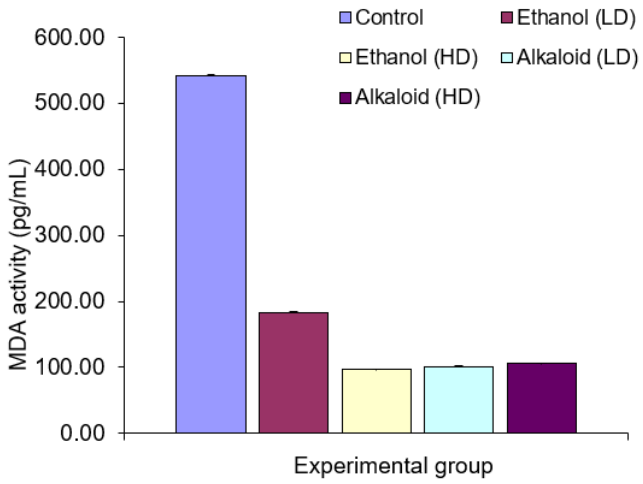

FIG. 5 Malondialdehyde activity in the different experimental groups.
Ethanol=Ethanol extract; Alkaloid= Alkaloid Fraction;
LD=low Dose; HD=High Dose
Values are expressed as mean ± SEM, n = 5.
* = p<0.05 vs control
a = p<0.05 vs Ethanol (LD)
b = p<0.05 vs

6.0 DISCUSSION

6.1 Effect on Antioxidant Biomarkers

Antioxidants are enzymatic or non-enzymatic agents that can prevent undesired oxidation through their reaction with reactive oxygen species (ROS) or oxidation intermediates (Sipoloni *et al.,* 2025). As highlighted earlier, enzymatic antioxidants include SOD, catalase, glutathione peroxidase and glutathione reductase. Non-enzymatic antioxidants include vitamins E and C, b-carotene, GSH and flavonoids.

In this study, both Extract and Alkaloid fraction of SOM raised the serum levels of superoxide dismutase (SOD) and catalase (CAT) enzyme, while decreasing the concentration of malondialdehyde (MDA). This is compatible with antioxidant activity of the plant. Phytoconstituent analysis (Koikoibo, 2024, Olohigbe, *et al.,* 2018) has shown the presence of ascorbic acid (12.6 %) and squalene (7.5%), bioactive compounds with high antioxidant activity. In 2024, Du, Ma and Gao reported that Squalene, an unsaturated triterpene compound, enhances antioxidant enzyme activity in intestinal mucosa, reduces the expression levels of inflammatory factors, decreases infiltration of inflammatory cells, repairs damaged intestinal epithelial barriers, and promotes colonic health by inhibiting NF-κB and Nrf-Keap1 signaling pathways.

SOM has been reported to possess anti-oxidative and anti-inflammatory bioactive compounds like flavonoids, polyphenols, and vitamins. Theses components are effective in scavenging free radicals and mitigating oxidative stress, contributing to tissue repair and preventing further damage (Akinmoladun, *et al.,*2021). This finding supports the therapeutic potential of SOM in managing oxidative tissue injury, as seen in various studies where plant-derived anti-oxidants reduced cellular injury and inflammation in hepatic tissues (Adedapo, *et al.,*2019). The antioxidant agents present in SOM may contribute to the maintenance of cellular integrity and help prevent oxidative damage, a thought similarly expressed by Okoro, *et al.,*2020.

Okoko and Ere (2012) showed that the extract of *S. monostatychus* possessed significant abilities to reduce lipid peroxidation and haemolysis in erythrocytes induced by hydrogen peroxide when compared with the ability of ascorbic acid to do the same. Some bioactive agents in the plant protect cells from oxidative stress and reduce the risk of chronic diseases (Adegbola *et al.,*2017) Oxidative stress may be due to reactive oxygen species (ROS) which can be modulated by either endogenous or exogenous antioxidant nutrients (Gekpe, *et al.,*2023).

6.2 Limitations

This report excludes the effect of SOM on specific organs like the liver, brain, lungs and heart. Neither does it involve histological and molecular basis of function.

7.0 CONCLUSION

SOM has antioxidant properties, with relatively better effect via the alkaloid fraction compared with the ethanol crude extract, in the Wistar rat. This might be a beneficial therapeutic use in the human biological system.

8.0 RECOMMENDATION

It is expedient to explore some relevant aspects of function at the molecular and tissue levels in further studies. SOM may be developed as a novel drug alternative in complementary medicinal therapeutics and diagnosis.

9.0 ETHICAL APPROVAL

Ethical approval was duly obtained from the Faculty Animal Research Ethics Committee (FAREC-FBMS) of the Faculty of Basic Medical Sciences, College of Medical Sciences, University of Calabar, Cross River State of Nigeria. The approval code was 302PHY3724 contained in a letter of approval with reference number, FAREC/PA/[UC/049].

All procedures used in this study were in accordance with the guidelines of the above committee, and also in compliance with the care and use of the laboratory, as outlined in the Helsinki (1964) declaration and adopted by Kurihara, *et al.,*2024.

AUTHORS' CONTRIBUTIONS

The trio of WK, IDE and OAO developed the concept, experimental design and laboratory protocol, as well as the manuscript. Other authors did procurements, literature review, collation of results, data analysis and editing/approval of the final write-up.

Conflict of Interest: The authors declare no conflict of intellectual property.

ACKNOWLEDGEMENT

We are very grateful to staff, postgraduate students and laboratory personnel of the Department of Physiology, Faculty of Basic Medical Sciences, University of Calabar, Calabar, Cross River State of Nigeria, for their invaluable support for this study. Thanks to all researchers and authors whose works have been cited herein.

REFERENCES

1. Adedapo A A, Adeoye A, Awoyinka A (2019). Hepatoprotective potential of *Musa paradisiaca* (plantain) on drug-induced liver damage. *African Journal of Medicine and Medical Sciences*, 48(4), 329-336
2. Adegbola P, Aderibigbe I, Hammed W and Omotayo T (2017) Antioxidant and anti-inflammatory medicinal plants have potential role in the treatment of cardiovascular disease: a review. *American Journal of Cardiovascular Diseases*; 7(2):19-32
3. Akinmoladun A C, Olaleye M T, Ogunyinka B I (2023). Antioxidant and anti-inflammatory potentials of unripe plantain (*Musa* spp): Implications for liver health. *Natural Product Research,* 35(10), 1587-1593, https://doi.org/10.1080/14786419.2020.1727090
4. Anza M, Endale M, Cardona L, Cortes D, Eswaramoorthy R, Cabedo N, Abarca B, Zueco J, Rico H, Ortí I D, Palomino-Schätzlein M (2022). Cytotoxicity, Antimicrobial Activity, Molecular Docking, Drug likeness and DFT Analysis of Benzo[c]phenanthridine Alkaloids from Roots of *Zanthoxylum chalybeum*. *Biointerface Research in Applied Chemistry,* 12(2),1569 - 1586 https://doi.org/10.33263/BRIAC122.15691586
5. Armstrong, D., & Al-Awadi, F. (1991). Lipid peroxidation and retinopathy in streptozotocin-induced diabetes. *Free Radical Biology and Medicine, 11*(4), 433–436. https://doi.org/10.1016/0891-5849(91)90161-U
6. 6. Cohen, G., Dembiec, D., & Marcus, J. (1970). Measurement of catalase activity in tissue extracts. *Analytical Biochemistry, 34*(1), 30–38. https://doi.org/10.1016/0003-2697(70)90083-7 doi: 10.17265/2328-2150/2015.08.005
7. Du X, Ma X and Gao Y (2024) The Physiological Function of Squalene and its application prospects in animal husbandry. *Frontiers in Veterinary Sciences*. 10:1284500. doi: 10.3389/fvets.2023.1284500
8. Ekundayo E O and Ezeogu L I (2006). Evaluation of Antimicrobial activities of extracts of five plants used in traditional medicine in Nigeria. International Journal of Tropical Medicine. 1:93-96
9. Fidele K Z, Andre K B, Yao D J, Michel O A. (2012). Action of hydroethanolic leaves extract of Solenostemon monostachyus (lamiaceae) on cardiovascular system of mammalians: blood pressure lowering effects *International Journal of Pharmacy and Biological Sciences,* 2(3):310-320.
10. Gekpe C G, Chukwu John A O, Ofem O E. (2023) Quercetin and Omega-3 fatty acid avert the deleterious effects of Cadmium on NO, NOS, anti-oxidants and MDA levels in rats. *Journal of Drug Delivery and Therapeutics,* 13(12):155-6. Available from: https://jddtonline.info/index.php/jddt/article/view/6143
11. Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis* (5th ed.). Chapman & Hall Ltd.
12. Koikoibo W, Ikpi D E, Obembe A O (2024). Effect of *Solenostemon monostachyus* on Gastrointestinal Function in Wistar Rats. A PhD Dissertation, Department of Human Physiology, Faculty of Basic Medical Sciences, University of Calabar, Calabar, Nigeria, pp 1-164
13. Kurihara C, Kerpel-Fronius S, Becker S, Chan A, Nagaty Y, Naseem S, Schenk J, Matsuyama K and Baroutsou V (2024). Declaration of Helsinki: ethical norm in pursuit of common global goals. *Frontiers in Medicine.* 11:1360653.
14. Lemmens, R.H.M.J., (2004). *Solenostemon monostachyus* (P.Beauv.) Briq. In: Grubben, G.J.H. & Denton, O.A. (Editors). *PROTA 2*: Vegetables/Légumes. [CD-Rom]. PROTA, Wageningen, Netherlands.

15. Marklund, S., & Marklund, G. (1974). Involvement of the superoxide anion radical in the autoxidation of pyrogallol and a convenient assay for superoxide dismutase. *European Journal of Biochemistry, 47*, 469–474
16. Mve-Mba, C.E., Menut, C., Lamaty, G., Zollo, P.H.A., Tchoumbougnang. (1994). Aromatic plants of tropical central Africa. Part XIX. Volatile components from leaves of two lamiaceae from Cameroon: Leucas deflexa Hook. and *Solenostemon monostachyus (P. Beauv.) Briq. Flav Frag J*., 9(6): 315-317.
17. Obichi E A, Monago C C, Belonwu D C. (2015). Nutritional qualities and phytochermical compositions of *Solenostemon monostachyus (Family Lamiaceae). Journal of Environment and. Earth Sciences*. 5(3):105-111
18. Okaiyeto, K.; Oguntibeju, O.O.(2021) African Herbal Medicines: Adverse Effects and Cytotoxic Potentials with Different Therapeutic Applications. *International Journal of. Environmental Research and Public Health*, 18, 5988. https://doi.org/10.3390/ijerph18115988
19. Okoko T, Ere D. (2012). Antioxidant activities of *Solenostemon monostachyus* leaf extract using in vitro methods. *Sci Res Essays* 7(6): 621-626.
20. Okokon J E, Oguamanam W N, and Umoh E E. (2017) Hepatoprotective and nephroprotective activities of Solenostemon monostachyus P. Beauv (Lamiaceae) leaf extract. *African Journal of Pharmacology and Therapeutics* Vol. 6 No. 3 Pages 123-
21. Okokon J E, Davies K, Augustine I. Bassey AI (2020). Psycopharmacological Study of Ethanol Leaf Extract of *Solenostemon monostachyus Nigerian Journal of Pharmaceutical and Applied Science Research, 9(3), 59-63;*
22. Olohigbe AB, Phlip O and Osaro I (2018) Evaluation of Phytoconstituents of *Solenostemon monostachyus* by FTIR, UV-VIS and GC-MS Spectroscopic Analysis. *Asian Journal of Physical and Chemical Sciences 5(1): 1-7*
23. Omoloye A A, Quasim K O, Johnson S O and Murtala A A (2015) Endocrine and Metabolic Effects of Hydroethanolic Extract of *Solenostemon monostachyus* on Haloperidol Induced Hyperprolactinemia. *Journal of Pharmacy and Pharmacology* 3, 391-399
24. Paton, A. J., Mwanyambo, M., Govaerts, R. H. A., Smitha, K., Suddee, S., Phillipson, P. B., Wilson, T. C., Forster, P. I., & Culham, A. (2019). Nomenclatural changes in Coleus and Plectranthus (Lamiaceae): a tale of more than two genera. *PhytoKeys,* 129, 1–158. https://doi.org/10.3897/phytokeys.129.34988
25. 26. Sipoloni V M, Bassicheto M C, de Oliveira M V, de Souza A B D S, Alves G M, Veiga T A M. (2025) Nonconventional Techniques in Plant Alkaloid Extraction: A Decade of Progress (2014-2023). *Chemistry and Biodiversity.* 22(8):e202403225. doi: 10.1002/cbdv.202403225. PMID: 40117174; PMCID: PMC12351439.