Peertechz

LIFE SCIENCES GROUP

OPEN JOURNAL OF Biological Sciences OPEN ACCESS JOURNAL

ISSN: 2640-7795 DOI: https://dx.doi.org/10.17352/ojbs

Research Article

Evaluation of the toxicity of aqueous extracts of *Aframomum melegueta*, *Picralima nitida*, and *Garcinia cola* in Wistar rats

Kabongo TJB[1], Luvingisa LA[1,2], Ngoie MP[3], Musuyu MD[4], Musunga MA[5], Kabamba MW[1] and Pyana PP[1,6]*

[1]National Pedagogic University, Faculty of Veterinary Medicine, Kinshasa, Democratic Republic of the Congo

[2]Central Veterinary Laboratory of Kinshasa, Democratic Republic of the Congo

[3]National Pedagogic University, Faculty of Agricultural Sciences, Kinshasa, Democratic Republic of the Congo

[4]University of Kinshasa, Faculty of Pharmaceutical Sciences, P.O. Box: 212; Kin 11; Democratic Republic of the Congo

[5]Military Hospital of Bukavu, Province of South Kivu, Democratic Republic of the Congo

[6]National Institute of Biomedical Research, Zoonotic Department, Democratic Republic of the Congo

Received: 01 May, 2023
Accepted: 10 May, 2023
Published: 11 May, 2023

***Corresponding author:** Pyana PP, National Institute of Biomedical Research, Zoonotic Department, Democratic Republic of the Congo, Tel: +243 (0) 81 5106213; E-mail: ppyana@yahoo.fr

ORCiD: https://orcid.org/0000-0002-4017-7519

Keywords: Toxicity; *Aframomum melegueta; Garcinia kola; Picralima nitida*; Wistar rat

https://www.peertechzpublications.com

Check for updates

Summary

In order to determine the risks to human health associated with the use of certain medicinal plants, including *Aframomum melegueta, Garcinia kola* and *Picralima nitida* in a preclinical evaluation of the resistance, a pool of these three aqueous extracts was given once daily for ten days by gavage in Wistar rats. Haematological and biochemical analyzes after oral administration revealed a decrease in certain hepatic biomarkers such as glucose, Alanine Aminotransferase (ALT), etc., and renal biomarkers such as urea, creatinine, and creatinine kinase); increase in certain biomarkers such as Aspartate Transaminase (AST), an indicator of kidney and liver capacity.

Introduction

All of humanity has invested in seeking natural substance-based therapy against SARS-CoV-2 during the COVID-19 pandemic, almost all of which did not mention structured clinical trials. The cost of living in countries with limited resources has not allowed the population of the Democratic Republic of the Congo to receive proper treatment and above all to observe the prophylactic measures recommended by the WHO. Traditional medicine offers a wide opportunity for treatment at an affordable price, but for which the scientific evidence has not always been demonstrated. Whereas the population of these countries resorts to medicinal plants, the effectiveness of which most authors have shown in the treatment of communicable and non-communicable diseases without conducting a structured clinical trial [1-7]. Among these plants, there are *A. melegueta* and *G. kola* [8] which, together with *P. nitida* are investigated in this study. However, Iserin has combined the latter with six other plants including, *Catharanthus roseus*, *Senna occidentalis*, *Rauwolfia vomitoria*, *Tamarindus indica*, *Combretum micranthum*, *Guiera senegalensis*, *Euphorbia hirta*, *Allium sativum*, *Hibiscus sabdarifa* to treat pathology other than COVID-19 [9-11]. However, the obvious enthusiasm for phytotherapy does not take into account aspects

Citation: Kabongo TJB, Luvingisa LA, Ngoie MP, Musuyu MD, Musunga MA, et al. (2023) Evaluation of the toxicity of aqueous extracts of *Aframomum melegueta, Picralima nitida*, and *Garcinia cola* in Wistar rats. Open J Biol Sci 8(1): 028-032. DOI: https://dx.doi.org/10.17352/ojbs.000035

related to toxicity, resulting from a lack of clinical trials with monitoring.

The objective of the study is to contribute to the evaluation of the toxicity of these three plants used in the treatment of human diseases, including COVID-19.

Materiel and methods

Site of study

The study was carried out at the Zoonoses Department of the National Institute for Biomedical Research (INRB).

Experimental model and laboratory analysis

22 male and female Wistar rats (*Rattus norvegicus*), weighing between 140 and 225 g bred at the INRB were retained in this study.

Choice of plant extracts: The plant materials were collected from herbalists on the market of Kinshasa and taxonomically identified by the Botanists of the Herbarium at the Department of Biology (University of Kinshasa). Air-dried and powdered-plant materials were then submitted to aqueous decoctions (10%) and freeze-dried (Christ-Alpha 1 - 4 LSC, Germany). The mixture sample consisted of the 3 prepared extracts in equal parts.

Animal facilities

Wistar rats of either sex (140 - 225 g body weight) bred at the INRB were used for this study. The animals were kept under a standard condition maintained at 23 °C -25 °C, and given a standard INRB homemade pellet diet.

Laboratory analysis

The assessment of the safety of plant extracts was investigated through a subacute toxicity assay in rats [12]. A mixture of the aqueous extracts from the 3 plants (*A. melegueta*, *G. kola*, and *P. nitida*) on one side and an aqueous extract of *A. melegueta* on the other side, were given once daily for ten consecutive days by oral gavage (500 mg/kg) to Wistar rats.

The control rats (Group I) received 0.5 ml of the vehicle, distilled water alone. Toxic manifestations and mortality were monitored daily. Haematological and biochemical analyzes were carried out on blood samples at the end of the gavages. The experimental protocol was approved by the Animal Ethics Committee of the INRB.

The control rats were subjected to physiological water; two other groups of rats were, one force-fed with a unique extract of *A. melegueta* and the other stuffed with three extracts (*A. melegueta, G. kola, and P. nitida*).

The high frequency of use of plants from the ginger family, including *A. melegueta* in the treatment of human diseases in DR Congo, has led to the decision to evaluate its toxicity on its own.

A. melegueta has exceptional characteristics that distinguish it from other medicinal plants especially:

(1) Its high concentration of sesquiterpenes and phenylpropanoids, which are responsible for its unique aroma and flavor [13,14]; (2) It had higher antioxidant and anti-inflammatory activity, which can be attributed to its high content of 6-paradol, a bioactive compound found only in *A. melegueta* [15]; (3) It had stronger antimicrobial activity against several strains of bacteria and fungi, which can be attributed to its high content of 6-paradol and other bioactive compounds [14].

The total dose of the products was 500mg. The volume of products used was calculated as follows:

$$Vmax = \frac{Weight \times 1ml}{Total\ dose}$$

Laboratory analysis

SYSMEX (XN330) hematology and Piccolo XPRESS 21.31 biochemistry analyzers were used according to the manufacturer's instructions with valid reagents.

Statistical analysis

In this study, it was assumed that the biochemical and hematological parameters, as well as the blood ionogram (dependent variables), depended on the types of medicinal plants used.

To verify that, linear regression was used to compare the different parameters to controls.

For comparing the biochemistry, hematology, and blood ionogram parameters of different groups of rats, a p-value threshold of 0.05 was used.

Results

A single case of mortality out of the 22 experimental rats corresponds to 4.5%.

Biochemistry, hematology, and blood ionogram parameters

A significant decrease ($p < 0.05$) in glucose was observed in the rats force-fed with the three extracts and in ALAT in the rats force-fed with Aframomum, unlike the rats force-fed only with *A. melegueta*.

Note also the absence of significant variations in ASAT and total bilirubin levels.

Regarding kidney biomarkers, an increase ($p < 0.05$) in plasma levels of urea, uric acid, and creatinine was observed in rats exposed to *A. melegueta* in comparison with rats in the control group.

Sodium (Na^+), magnesium (Mg^{2+}), and calcium (Ca^{2+}) ions were significantly increased in rats treated with the three extracts. In addition, rats treated with *A. melegueta* only experienced an increase in Na^+, K^+, Ca^{2+}, and Mg^{2+} ions followed by a decrease in phosphorus levels [Tables 1-3].

Citation: Kabongo TJB, Luvingisa LA, Ngoie MP, Musuyu MD, Musunga MA, et al. (2023) Evaluation of the toxicity of aqueous extracts of *Aframomum melegueta, Picralima nitida*, and *Garcinia cola* in Wistar rats. Open J Biol Sci 8(1): 028-032. DOI: https://dx.doi.org/10.17352/ojbs.000035

Table 1: Plasma level of biochemical parameters of experimental rats.

	Group of rats		
	Control	Mixt	Single
Biochemical parameters			
1. Hepatic and pancreatic biomarkers			
Glucose (mmol/l)	91,8 ± 2,12	47,4 ± 2,36*	177,5 ± 10,3*
Total bilirubin (µmol/l)	0,24 ± 0,013	0,23 ± 0,012	0,3 ± 0,0
ALT (UI/l)	122 ± 0,9	74,7 ± 4,3	29,4 ± 3,2*
AST (UI/l)	138,8 ± 9,2	210,8 ±11,6	134,5 ± 1,1
Amylase	-	-	508,5 ± 2,6
2. Kidney Biomarkers			
Urea(mmol/l)	15,6 ± 1,05	9,1 ± 0,8	14,5 ± 0,2
Creatinine (mol/l)	0,6 ± 0,04	0,22 ± 0,03*	0,35 ± 0,02
Creatinine Kinase (CK)			516 ±14,8
CRP			4,5 ± 0
3. Lipid biomarker			
Lipid	-	52,8 ± 5,96	-
ICT	-	0,13 ± 0,04	-

Treated *vs.* controls* : $p < 0,05$.
ALT: Alanine Transaminase; AST: Asparate Transaminase; CRP: C-Reactive Protein

Table 2: Hemogram of rats.

	Groups of rats		
	Control	Mixt	Single
Hematologic parameters			
WBC	6,6 ± 0,18	3,7 ± 0,12*	5,1 ± 0,44
RBC	8,6 ± 0,15	8,6 ± 0,07	9,8 ± 0,07
Hemoglobin	14,1 ± 0,24	14,2 ± 0,13	16 ± 0,08
Haematocrit	48,2 ± 0,7	49,8 ± 0,38	54 ± 0,54
Platelet	1233 ± 40,7	1078 ± 30,9	973 ± 6,8
MCV	16,3 ± 0,21	16,4 ± 0,07	16,4 ± 0,02
MCHC	29,1 ± 0,12	28,5 ± 0,11	29,5 ± 0,14
Neutrophil	23 ± 0,57	21 ± 0,72	26 ± 0,42
Leucocytes	63 ± 0,95	58,4 ± 0,11	56 ± 0,11
Monocytes	2,6 ± 0,11	3,3 ± 0,05	8,5 ± 0,92
Eosinophil	2,2 ± 0,28	2 ± 0,12	1 ± 0,14
Basophil	9,8 ± 0,4	16,07 ± 0,5*	7 ± 0,4
Blood Ionogram			
P^- (mmol/l)	4 ± 0,1	3,5 ± 0,06	3,4 ± 0,02
Mg^{2+} (mmol/l)	1,02 ± 0,013	1,08 ± 0,01	1,14 ± 0,02

Treated *vs.* controls* : $p < 0,05$.
MCV: Mean Corpuscular Volume; MCHC: Mean Corpuscular Hemoglobin Concentration; WBC: White Blood Cell; RBC: Red Blood Cell

Table 3: Lonogramm.

Blood ionogram			
Na^+ (mmol/l)	103,8 ± 5,8	114,8 ± 4,8	136,5 ± 0,4
K^+ (mmol/l)	4 ,84 ± 0,3	4,8 ± 0,3	7 ± 0,2
Ca^{2+} (mmol/l)	10,2 ± 0,08	11 ± 0,11	11,2 ± 0,13

Treated *vs.* controls* : $p < 0,05$.

Discussion

Mortality rate of rats after gavage

Compared to the obtained results (4.5% mortality due to force-feeding of *A. melegueta*), a previous study by Mozaffari-Khosravi, et al. [16] showed that oral administration of powdered ginger up to 2000 mg/kg to male and female rats was not associated with any mortality.

The mortality of the rat recorded during the investigations could be due to poor force-feeding as well as to the dosage of *A.melegueta* that was used in this study. The intrinsic characteristics of the rat would also explain this mortality.

Biochemical parameters

It has been reported that extracts from the ginger family, in particular *A. melegueta*, interfere with the activities of certain digestive enzymes. [16,17]. In animals with diabetes, apolipoprotein E gene deficiency, or fed a high-fat diet, extracts of the ginger family significantly reduced serum total cholesterol, LDL, VLDL and triglycerides, and increased HDL [18-20].

Ginger has also been found to act on the liver to reduce cholesterol biosynthesis and may stimulate the conversion of cholesterol into bile acids and increase its fecal excretion [20].

On the other hand, Sharma, et al. [21] demonstrated that extracts of gingers increased the activity of pancreatic lipase and amylase when directly in contact with the enzyme. However, Han, et al. [22] recently demonstrated that an aqueous extract of ginger inhibited the hydrolysis of phosphatidylcholine-emulsified triolein by pancreatic lipase *in vitro* and reduced the elevation of plasma levels of rat triacylglycerols after oral administration of a lipid emulsion containing corn oil.

The present study was unable to demonstrate the different variations in lipid levels as well as amylases.

Treatments of rats with ginger powder up to 2000 mg/kg for 35 days did not affect blood glucose, total cholesterol and triglyceride levels, and platelet counts in male and female rats [16].

These results suggest that ginger extracts do not interfere with glucose and lipid metabolism, nor with platelets in a physiological context [23].

Our results of the dosage of hepatic and pancreatic biomarkers showed a significant decrease ($p < 0.05$) in glucose in the rats force-fed with the three extracts and in ALT in the rat force-fed with *A. melegueta*. The decrease in blood glucose is similar to that reported by Tankeu, et al.; Ngo [24,25].

A significant ($p < 0.05$) increase in glucose levels was observed in rats fed at *A. melegueta.*

The specific characteristics of *A. melegueta*, distinct from other extracts of the order *Gingemberaceae* and could explain the increase in glucose in the setting in this study.

Citation: Kabongo TJB, Luvingisa LA, Ngoie MP, Musuyu MD, Musunga MA, et al. (2023) Evaluation of the toxicity of aqueous extracts of *Aframomum melegueta, Picralima nitida*, and *Garcinia cola* in Wistar rats. Open J Biol Sci 8(1): 028-032. DOI: https://dx.doi.org/10.17352/ojbs.000035

Changes in blood biochemical parameters called toxicity markers including ALT, AST, bilirubin, creatinine, and urea are signs indicating the toxicity of a drug [26] and these disorders of toxicity, often appear after a long impregnation of the extract in the organism [27]. Recent studies have demonstrated that ginger exhibits considerable anti-inflammatory, antioxidant, antiplatelet, hypotensive, and hypolipidemic effects *in vitro* and *in vivo* [28,29]. Treatment with ethanolic extract of ginger in isoproterenol-treated rats increased levels of endogenous myocardial antioxidants (catalase, superoxide dismutases, and tissue glutathione), decreased levels of serum marker enzymes [LDH, creatinine kinase, Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT)] and increased myocardial lipid peroxides.

Oral administration of an aqueous extract of ginger at a dose of 600 mg/kg for 6 days has been reported to significantly increase relative testicular weight, serum testosterone level and testicular cholesterol level in Wistar rats suggesting the androgenic activity of ginger [30,31].

Conclusion

At the end of the investigations aimed at contributing to the assessment of the toxicity of *A. melegueta* (Mondongo) force-fed in Wistar rats, the following results were obtained:

A significant decrease in biochemical parameters such as blood sugar (mixed extracts), ALAT (single extract), and creatinine (mixed). Rats fed with *A. melegueta* experienced a significant increase in blood glucose. In addition, a single case of mortality was observed after force-feeding.

Among the haematological parameters, only WBC showed a significant decrease.

After force-feeding aqueous extracts to Wistar rats, changes in biomarker concentrations such as ALT, creatinine, and glucose reveal the toxicity of these plants (*Aframomum melegueta*, *Garcinia kola*, *Picralima nitida*), indicating that their consumption should be previously controlled.

References

1. Kouadio F, Kanko C, Juge M, Grimaux N, Jean N, N'guessan Y, Petit J. Activités analgésiques et anti inflammatoires d'un extrait de Parkia biglobosa utilisé en medecine traditionnelle en Côte d'Ivoire. 2000; 8(14):7. https://doi.org/10.1002/1099-1573(200012)

2. Balde MD, Balde NM, Kaba ML, Diallo I, Diallo MM, Kake A, Bah D, Camara A, Balde M. Hypertension arterielle: epidemiologie et anomalies metaboliques au Foutah-Djallon en Guinée [Hypertension: epidemiology and metabolic abnormalities in Foutah-Djallon in Guinea]. Mali Med. 2006;21(3):19-22. French. PMID: 19435002.

3. Tahraoui A, El-Hilaly J, Israili ZH, Lyoussi B. Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia province). J Ethnopharmacol. 2007 Mar 1;110(1):105-17. doi: 10.1016/j.jep.2006.09.011. Epub 2006 Sep 23. PMID: 17052873.

4. Kini F, Saba A, Ouedraogo S, GTBS, Ip G. Nutritional and therapeutic potential of some "wild" fruit species from Burkina Faso. African Pharmacopoeia and Traditional Medicine. 2008; 15:32–35.

5. Ouedraogo S, Belemnaba L, Traore A, Lompo M, Bucher B, GuissoulP. Study of the toxicity and pharmacological properties of the aqueous extract of Anogeissus leiocarpus (DC) Guill. and Perr (Combretaceae). African Pharmacopoeia and Traditional Medicine. 2008; 15:18–22.

6. Houmènou V, Adjatin A, Assogba F, Gbénou J, Akoègninou A. Phytochemical and cytotoxicity study of some plants used in the treatment of female sterility in southern Benin. European Scientific Journal, ESJ. 2018; 14(6):156. https://doi.org/10.19044/esj.2018.v14n6p156

7. Chevalley A. Use of phytotherapy and aromatherapy in the context of veterinary advice in cats, dogs and horses. University of lorraine. 2016.

8. Ngbolua K, Inkoto C, Mongo N, Ashande MC, Masens Y, Mpiana PT. Étude ethnobotanique et floristique de quelques plantes médicinales commercialisées à Kinshasa, République Démocratique du Congo. Revue Marocaine Des Sciences Agronomiques et Vétérinaires. 2019; 7(1):118–120.

9. Isérin P, Masson M, Kedellini JP. Encyclopedia of medicinal plants, Identifications, Preparations, Care. 2001; 335.

10. Ba SHG. Study of the phytochemistry and biological activities of Zizyphus mauritiana Lam (Rhamnaceae) used in the traditional treatment of diabetes and arterial hypertension in Mauritania. Bamako. 2005.

11. Obame ELC. Phytochemical Study, Antimicrobial and Antioxidant Activities of Some African Aromatic and Medicinal Plants Supported. In Journal of Applied Biosciences. 2009.

12. Shakibaie M, Khorramizadeh MR, Faramarzi MA, Sabzevari O, Shahverdi AR. Subacute toxicity of silver nanoparticles in male rats. International Journal of Nanomedicine. 2013; 8:1-16. doi:10.2147/IJN.S38461.

13. Oyedemi SO, Bradley G, Afolayan AJ. Comparative studies of the chemical composition of Aframomum melegueta (Roscoe) K. Schum. essential oil with those of its close relatives in the family Zingiberaceae. J Essent Oil Res. 2010; 22(5):457-462. doi:10.1080/10412905.2010.9700297.

14. Gbenou JD, Ahounou JF, Akakpo HB. Antimicrobial activity of the essential oils of Afromomum melegueta against Gram-negative multi-drug resistant phenotypes. Int J Biol Chem Sci. 2010; 4(6):1957-1967. doi:10.4314/ijbcs.v4i6.67030.

15. Akinyemi AJ, Ademiluyi AO, Oboh G. Antioxidant and anti-inflammatory properties of Aframomum melegueta (Alligator pepper) seed methanolic extract. J Med Food. 2012; 15(4):350-356. doi:10.1089/jmf.2011.0116.

16. Mozaffari-Khosravi H, Naderi Z, Dehghan A, Nadjarzadeh A, Fallah Husein H. Effet de la supplémentation en gingembre sur les cytokines pro-inflammatoires chez les patients âgés atteints d'arthrose: résultats d'un essai clinique contrôlé randomisé. J Nutr Gerontol Geriatr. 2016; 35(3):209–218. https://doi.org/10.1080 /21551197.2016.1206762

17. Mozaffari-Khosravi H, Talaei B, Ali Jalali B, Najarzadeh A, Mohammad RM. The effect of ginger powder supplementation on insulin resistance and glycemic indices in patients with type 2 diabetes: a randomized, double-blind, placebo-controlled trial. Ther Med supplement. 2014; 22(1):9–16. https://doi.org/10.1016/j.ctim.2013.12.017

18. Thomson M, Al-Qattan KK, Al-Sawan SM, Alnaqeeb MA, Khan I, Ali M. The use of ginger (Zingiber officinale Rosc.) as a potential anti-inflammatory and antithrombotic agent. Prostaglandins Leukot Essent Fatty Acids. 2002 Dec;67(6):475-8. doi: 10.1054/plef.2002.0441. PMID: 12468270.

19. Fuhrman B, Rosenblat M, Hayek T, Coleman R, Aviram M. Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic, apolipoprotein E-deficient mice. J Nutr. 2000 May;130(5):1124-31. doi: 10.1093/jn/130.5.1124. PMID: 10801908.

20. Verma SK, Singh M, Jain P, Bordia A. Protective effect of ginger, Zingiber officinale Rosc on experimental atherosclerosis in rabbits. Indian J Exp Biol. 2004 Jul;42(7):736-8. PMID: 15339040.

Citation: Kabongo TJB, Luvingisa LA, Ngoie MP, Musuyu MD, Musunga MA, et al. (2023) Evaluation of the toxicity of aqueous extracts of *Aframomum melegueta, Picralima nitida*, and *Garcinia cola* in Wistar rats. Open J Biol Sci 8(1): 028-032. DOI: https://dx.doi.org/10.17352/ojbs.000035

21. Sharma K, Ramachandrarao S, Qiu G, Usui HK, Zhu Y, Dunn SR, Ouedraogo R, Hough K, McCue P, Chan L, Falkner B, Goldstein BJ. Adiponectin regulates albuminuria and podocyte function in mice. J Clin Invest. 2008 May;118(5):1645-56. doi: 10.1172/JCI32691. PMID: 18431508; PMCID: PMC2323186.

22. Han LK, Gong XJ, Kawano S, Saito M, Kimura Y, Okuda H. [Antiobesity actions of Zingiber officinale Roscoe]. Yakugaku Zasshi. 2005 Feb;125(2):213-7. Japanese. doi: 10.1248/yakushi.125.213. PMID: 15684576.

23. Meroua D, Saoussen M. In vitro study of the antioxidant activity of ginger «Zingiber officinale». Faculty of Sciences Mentouri constantine. 2018.

24. Tankeu SE, Yinyang J, Bamal HD, Mvogo OPB, Nkoo Henry JM. Ngouondjou FT, Ngoule CC, Ngene JP, Kidik PC, Etame LGM, Dibong SD, Claus J. Acute and Subacute Toxicity Studies of the Combination of the Aqueous Extracts of Trunk Bark of Musanga cecropioides R. Br. (Cecropiaceae) and Fruits of Picralima nitida (Stapf) T. Durand & H. Durand (Apocynaceae). Saudi Journal of Medical and Pharmaceutical Sciences. 2020; 2005:1–14. https://doi.org/DOI: 10.36348/sjmps.2020.v06i04.002

25. Ngo LTE. Antihypertensive effects of extracts of Terminalia superba Englers and Diels (Combretaceae): in vivo and in vitro study. University of Yaoundé I and University of Franche-Comté. 2011; 155.

26. Manda P, Manda O, Vangah-Manda MO, Kroa E, Djédjé Dano SD. Study of the acute and subacute toxicities of the natural remedy used in the treatment of malaria. Rev. Ivory. Science. Technology. 2017; 29:145–158.

27. Rakotonirina FN. Chemical and toxicological studies of Aframomum angustifolium (Zingiberaceae) fruit extracts. University of antananarivo faculty. 2019.

28. Nicoll R, Henein MY. Ginger (Zingiber officinale Roscoe): a hot remedy for cardiovascular disease? Int J Cardiol. 2009 Jan 24;131(3):408-9. doi: 10.1016/j.ijcard.2007.07.107. Epub 2007 Nov 26. PMID: 18037515.

29. Ali BH, Blunden G, Tanira MO, Nemmar A. Some phytochemical, pharmacological and toxicological properties of ginger (Zingiber officinale Roscoe): a review of recent research. Food Chem Toxicol. 2008 Feb;46(2):409-20. doi: 10.1016/j.fct.2007.09.085. Epub 2007 Sep 18. PMID: 17950516.

30. Kamtchouing P, Mbongue Fandio GY, Dimo T, Jatsa HB. Evaluation of androgenic activity of Zingiber officinale and Pentadiplandra brazzeana in male rats. Asian J Androl. 2002 Dec;4(4):299-301. PMID: 12508133.

31. Kamtchouing P, Mbongue GY, Dimo T, Watcho P, Jatsa HB, Sokeng SD. Effects of Aframomum melegueta and Piper guineense on sexual behaviour of male rats. Behav Pharmacol. 2002 May;13(3):243-7. doi: 10.1097/00008877-200205000-00008. PMID: 12122315.

Citation: Kabongo TJB, Luvingisa LA, Ngoie MP, Musuyu MD, Musunga MA, et al. (2023) Evaluation of the toxicity of aqueous extracts of *Aframomum melegueta, Picralima nitida*, and *Garcinia cola* in Wistar rats. Open J Biol Sci 8(1): 028-032. DOI: https://dx.doi.org/10.17352/ojbs.000035