Journal of Complementary and Alternative Medical Research

Volume 20, Issue 2, Page 11-21, 2022; Article no.JOCAMR.86551
ISSN: 2456-6276

Multicellular Effects from Aqueous Stem Bark Extract of *Cadaba farinosa Forsk* on Selective Internal Organs of Wistar Rats

Solomon Matthias Gamde [a*], Abubakar Amali Muhammad [b], Mohammed Umar [c], Ovie Godwin Avwioro [d], Ahmed Aminu Biambo [e], Eugene Samuel Bwede [f], Egbujo Ejike Amina [a] and Emmanuel Mshelia Halilu [g]

[a] Department of Medical Laboratory Science, Bingham University Karu, Nigeria.
[b] Department of Pharmacology and Toxicology, Usmanu Danfodiyo University Sokoto, Nigeria.
[c] Department of Anatomy and Forensic Medicine, Usmanu Danfodiyo University Sokoto, Nigeria.
[d] Department of Science Laboratory Technology, Delta State University, Abraka, Nigeria.
[e] Department of Clinical Pharmacy and Pharmacy Practice, Usmanu Danfodiyo University Sokoto, Nigeria.
[f] National Reference Laboratory, Nigeria Centre for Disease Control, Gaduwa, Abuja, FCT, Nigeria.
[g] Department of Pharmacognosy and Ethnopharmacy, Faculty of Pharmaceutical Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author SMG conceive, experimented, and wrote the manuscript. Author AAB analyzed the data. Author OGA designed the experiment, supervised, and revised the manuscript. Author AAM analyzed the data and reviewed the manuscript. Author MU participated in the experiment and revised the manuscript. Authors EEA, ESB and EMH participated in the experiment and reviewed the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JOCAMR/2022/v20i2411

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86551

**Corresponding author: E-mail: solomonmatthias85@gmail.com;*

Original Research Article

Received: 14/10/2022
Accepted: 22/12/2022
Published: 23/12/2022

ABSTRACT

Introduction: *Cadaba farinosa Forsk* belongs to the family Cappariraceae used in the treatments of snakebite, breast cancer, and retained placenta in African traditional medicine. However, information about the plant toxicity profile and risk awareness are largely unknown.
Aim: To determine the histopathological, biochemical, and hematological effects from aqueous stem bark extract of *Cadaba farinosa Forsk* on selective internal organs of Wistar rats.
Methods: Twenty (20) Wistar rats were randomly divided into five (5) groups of four rats each. The extract was administered by oral gavage in doses of 100, 200, 300, and 400 mg/kg body weight for 28 days. Blood samples were collected for hematological and biochemical analyses, while the liver, kidney, spleen, lung, brain, and stomach were harvested and processed histopathologically using standard methods.
Results: Oral administration of the aqueous stem bark extract from *Cadaba farinosa Forsk* caused a significant increase in hematocrit (*P*=0.044) and hemoglobin (*P*=0.046). However, the white blood cell was significantly (*P*=0.011) reduced at doses of 300 and 400 mg/kg compared to control. The serum albumin of treated animals was also significantly (*P*=0.017) reduced in a dose-dependent manner compared to control. In addition, histopathological sections of treated animals showed pulmonary hemorrhage, stomach edema, vacuolation in the spleen, and necrosed hepatocytes.
Conclusion: Oral administration of the aqueous stem bark extract from *Cadaba farinosa Forsk* for 28 days is toxic to the liver, spleen, stomach, and lung. Reducing the therapeutic dose and period of exposure may minimize the deleterious effects of plant drugs.

Keywords: Cadaba farinosa forks; leukocytopenia; fatty changes; hypoalbuminemia; liver cell damage; apoptotic changes.

1. INTRODUCTION

Since ancient times, people in different parts of the world have developed ways to maintain health as well as prevent and treat diseases [1]. Ethnomedicinal studies documented that about 80% of the population in developing countries depend on medicinal plants for their healthcare needs [2]. The limited accessibility and affordability of modern healthcare in most developing countries have necessitated the extensive use of plant [3,4]. However, the toxicity study for most medicinal plants are unevaluated [5,6].

Cadaba farinosa Forsk (*C. farinosa*) belongs to the family Cappariraceae (capparaceae), a slender, evergreen woody shrub growing up to 5 meters tall and rarely trees with 45 genera and about 600 species found throughout the world, mostly in tropical and subtropical regions [7]. The leaf extracts are used for the treatments of diabetes [8], snakebite [9], haemorrhage [10], parasitic worms [8], Mastitis, and breast cancer [11]. The flowers are used as stimulant, purgative, anthelmintic, and antiphlogistic agents [7]. The stem bark is reported to be antimicrobial [12], anti-ulcerative [13] and hepatoprotective [7]. The roots are used for retained placenta [11], breast cancer [14] and female infertility [12]. The plant posses secondary metabolites such as flavonoid, alkaloid [8], amino acid, saponin, steroid [12], tannin, phenol, and diterpenes [15], new spermidine alkaloid Cadabicine, L-Stachydrine, 3- hydroxystachydrine [10], spermidine alkaloids, capparisine, cadibicilone, and ά, β-Dihydroferulic acid [16]. Other phytochemicals include isoorientin, quercetin, hydroxybenzoic acid, vanillic acid, syringic acid, and 2-hydroxy-4-methoxy benzoic acid [17]. These secondary metabolites may explain the anti-oxidative, anti-diabetic, anti-inflammatory, anti-tumor, and antimicrobial effects [8,14,18].

In Northern Nigeria, *C. farinosa* sprouts are used to spice foods [19]. The leaves are scorched with cereals to make pudding (cake) called Farsa, Tigiraganda, or Balambo [20]. The chocolate-colored cake (Farsa) appears common in the markets for consumption [19] without considering the body's physiological state. In Maiduguri [21] and Jigawa States [22], the decoctions are

documented to be treatments for breast and skin cancers. "One of the interviewed respondents claimed that there is no type of cancer the plant cannot cure and he was ready to bet the authors in case they doubted his submission" [8]. However, information about the plant toxicity profile and risk awareness are largely unknown. This study aimed to determine the multicellular effects from aqueous stem bark extract of *C. farinosa Forsk* on selective internal organs of Wistar rats.

2. MATERIALS AND METHODS

2.1 Plant Material

The fresh plant was collected from The Faculty of Pharmaceutical Sciences and authenticated by Dr. H.E Mshelia, Department of Pharmacognosy, Usmanu Danfodiyo University Sokoto, Nigeria. A voucher specimen (Ref. No. PCG/UDUS/CAPP/0002) was deposited for future reference.

2.2 Preparation of Extracts

The aqueous extract was prepared using the standard procedure as outlined by Gamde et al. [23] to yield 10.67% with few modifications. Plant remains from the aqueous extract were resuspended in methanol and allowed to stay for 24 hours. Both the aqueous and methanol extracts were stored in air-tight containers in a refrigerator below 10°C. The suspensions of aqueous and methanol extracts for phytochemical screening tests were prepared by using distilled water as the solvent and for the oral administration of the aqueous extract to the experimental animals.

2.3 Determination of Aqueous Extract Yield

The percentage yield of the aqueous extract (dry weight) was calculated from the equation:

$$\text{Percentage yield (g/g)} = W_1 / W_2 \times 100.$$

Where W_1 signifies the dry extract weight (22.4 g) following solvent evaporation of the aqueous extract and W_2 signifies the powder weight of plant material (210 g) before maceration.

2.4 Phytochemical Tests

Both the aqueous and methanol stem bark extracts of *Cadaba farinosa* were characterized by color reactions indicating the presence or absence of alkaloids, glycosides, tannins, saponins, terpenoids, flavonoids, saponins, cardiac glycosides, anthraquinones following standard methods [12,15].

2.5 Animals Used

Twenty Wistar rats of both sexes weighing 160±10g were procured from The Animal House, Faculty of Pharmaceutical Sciences, Usmanu Danfodiyo University Sokoto Nigeria. Animals were fed with standard chow and water ad libitum. Animals were maintained in standard environmental conditions of temperature (25±2°C), relative humidity, and 12 hours of dark/light cycle before and during the experiment. All experimental procedures were approved by the Animal Ethics Committee, Usmanu Danfodiyo University Sokoto Nigeria.

2.6 Experiment Design

The experiment followed the 'Guide for Care and Use of Laboratory Animals of Laboratory Animal Centre at the Animal House, Usmanu Danfodiyo University Sokoto Nigeria. Animals were randomly divided into five groups (n = 4). The first group received distilled water (control) and the treated groups received a new formulation of *C. farinosa* extract administered orally at doses equivalent to 100, 200, 300, and 400 mg/kg body weight extracts. Under partial anesthesia using chloroform, blood (about 8 mL) was withdrawn by cardiac puncture and the target organs were excised from rats 24 h post-dosing for analysis.

2.7 Sample Collection

Within 24 hours of the last dose being administered, all animals were weighed and anesthetized with chloroform. Animal blood samples were collected by cardiac puncture. The blood samples for hematological analysis were collected in EDTA bottles and we used plain sample bottles for biochemical analysis following standard procedures. The fresh stomach, brain, kidney, spleen, liver, and lung tissue samples were excised from the animals, weighed, washed, and fixed with 10% formal saline for histopathological studies.

2.7.1 Haematological assessment

Blood samples were collected into tubes containing ethylene diamine tetraacetic acid (EDTA) for the determination of red blood cell

(RBC), total leukocyte count (WBC), platelet count (PLT), hematocrit (HCT), and hemoglobin (Hgb) concentration using an autoanalyzer (Sysmex XK-21N, USA).

2.7.2 Biochemical assessment

Blood samples collected for the liver and kidney function tests were allowed to clot, spun, and analyzed for serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), total protein (TP), albumin (ALB), bilirubin (BIL), and electrolytes; potassium (k^+), sodium (Na^+), and chloride (Cl^-) using an auto-analyzer (Raytochemray 120, Germany).

2.7.3 Histopathological assessment

Tissue sections measuring 3 mm thick were processed by the paraffin wax method and the paraffin sections were cut at 3 µm using Rotary Microtome (Surgcare Microtome, Model 335A USA) and stained with hematoxylin and eosin (H&E) for the demonstration of general tissue structures.

2.8 Statistical Data Analysis

All statistical values were expressed as Mean ± SD and analyzed using the one-way ANOVA (SPSS, 23.0 version, Chicago, IL, USA) followed by the Bonferroni post hoc test. A statistically significant difference between experimental groups was accepted at $P \leq 0.05$.

3. RESULTS

3.1 Phytochemical Analysis

The phytochemical tests for both aqueous and methanolic stem bark extracts of *C. farinosa* showed the presence of carbohydrate, phenol, flavonoid, tannin, saponin, protein, diterpene, cardiac glycoside, and triterpene (Table 1).

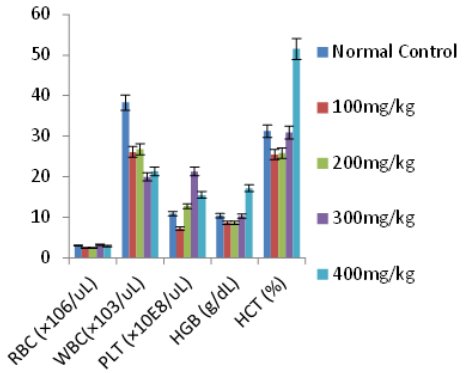

Fig. 1. Effects of extract on some haematological parameter. Analysed by ANOVA and Bonferroni post hoc. Significant at *$P \leq 0.05$

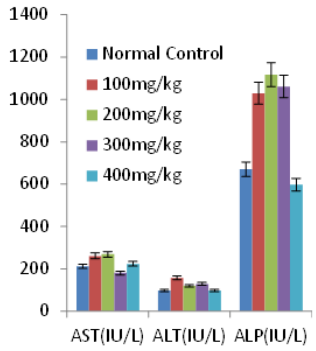

Fig. 2. Effects of extract on serum aminotransferases. Analysed by ANOVA and Bonferroni post hoc. Significant at *$P \leq 0.05$

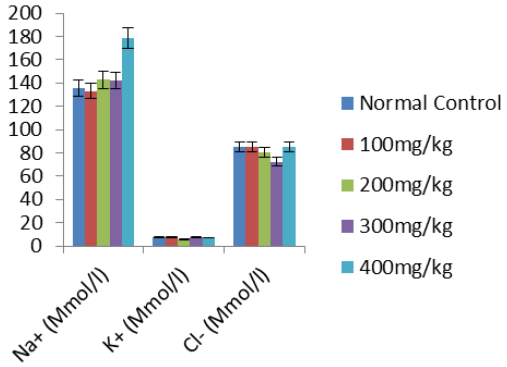

Fig. 3. Effects of extract on electrolytes. Analysed by ANOVA and Bonferroni post hoc. Significant at *$P \leq 0.05$

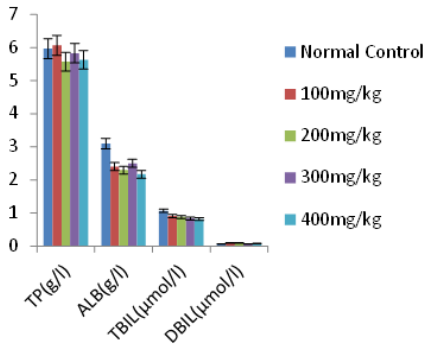

Fig. 4. Effects of extract on liver functions. Analysed by ANOVA and Bonferroni post hoc. Significant at *$P \leq 0.05$

Table 1. Phytochemical Analysis of *C. farinosa* aqueous and methanolic stem bark extracts

Selected Phytochemical	Test Methodology	Observation	Aqueous Inference	Methanol Inference
Flavonoids	Shinoda's test	The intermediate orange color formed	present	present
	Ferric chloride test	A Blue-black color was formed	present	present
Phenols	FeCl3 reagent	A Blue-black color was formed	present	present
Carbohydrates	Molisch test	Golden interphase was formed	present	present
	Fehling's solution	The orange color was formed	present	present
Alkaloids	Mayer reagents	The brown precipitate was formed	present	present
	Wagner's reagents	The brown precipitate was formed	present	present
	Dragendorff's reagent	Red precipitate was formed	present	absent
Protein/amino acid	Million's test	The yellow color was formed	present	present
Saponins	frothing test	Frothing formed remains	present	present
Diterpenes	Copper acetate test	An Emerald green color was formed	present	present
Tannins	FeCl3 reagent	A Blue-black color was formed	present	present
	Lead sub- acetate test	The conspicuous precipitate was formed	absent	present
Cardiac glycosides	Keller-Killiani's test	Brown interphase was formed	present	absent
Triterpenoids	Salkwaski's test	The golden yellow color was formed	present	present

Table 2. Effect of *C. farinosa* extract on the hematological parameter

Parameter	Unit	Control	100 mg/kg	200 mg/kg	300 mg/kg	400 mg/kg	P-value
Platelet	109/L	1081.7±297.3	721.0±103.00	1270.3±327.52	2128.7±841.69	1551.7±106.49	0.232
Haematocrit	%	31.233±0.284	25.500±4.957	25.800±5.100	30.900±0.000	51.500±10.300*	0.044
Haemoglobin	g/dL	10.400±0.100	8.600±1.700	8.600±1.700	10.300±0.000	17.167±3.433*	0.046
Red blood cells	109/L	3.003±0.467	2.473±0.353	2.473±0.353	3.180±0.000	2.827±0.353	0.529
White blood cells	109/L	38.297±6.020	26.100±0.907	26.800±1.000	19.933±2.239*	21.300±1.234*	0.011

*Statistical data are expressed as Mean ± SD and analyzed by ANOVA followed by Bonferroni Post Hoc Test. A statistically significant difference was accepted at *P≤ 0.05*

Table 3. Effect of *C. farinosa aqueous* stem bark extract on the biochemical parameter

Parameters	Units	Control	100 mg/kg	200 mg/kg	300 mg/kg	400 mg/kg	*P*-value
Albumin	g/L	3.100±0.28	2.400±0.12*	2.300±0.00*	2.500±0.10*	2.167±0.15*	0.017
Total protein	g/L	5.967±0.6	6.067±0.18	5.567±0.04	5.833±0.66	5.633±0.47	0.941
Total bilirubin	µmol/L	1.067±0.06	0.913±0.09	0.877±0.19	0.837±0.08	0.817±0.04	0.544
Dir. Bilirubin	µmol/L	0.067±0.00	0.090±0.02	0.097±0.01	0.067±0.01	0.083±0.01	0.203
ALP	UI/L	670.6±109.4	1029.0±92.31	1117.3±196.5	1060.7±153.7	597.6±99.9	0.064
ALT	UI/L	97.6±8.41	158.3±17.0	119.6±23.0	129.3±19.3	197.6±5.2	0.113
AST	UI/L	12.6±21.07	261.3±17.9	269.0±42.1	180.6±38.5	223.6±22.0	0.285
Chloride (Cl-)	mmol/L	84.667±1.453	85.000±1.732	80.667±5.238	72.33±5.239	84.67±3.283	0.162
Sodium (Na^+)	mmol/L	135.67±1.453	133.00±0.577	142.67±16.384	142.33±15.026	178.67±4.910	0.058
Potassium (K^+)	mmol/L	7.2667±0.376	7.6000±0.322	5.5333±1.656	7.2667±0.607	7.000±0.116	0.462

Statistical data are expressed as Mean ± SD and analyzed by ANOVA followed by Bonferroni Post Hoc Test. A statistically significant difference was accepted at $^*P \leq 0.05$

3.2 Physical Observation and Mortality

No obvious signs of toxicity and mortality were observed in the treated animals as compared to the normal control.

3.3 Effect of Extract on the Haematological Parameter

The effect of the extract on hematological Parameters is presented in Table 2. Oral administration of aqueous stem bark extract of *C. farinosa* for 28 days caused a significant (P<0.05) increase in hemoglobin (P=0.046) and hematocrit (P=0.044), while white blood cell count (leukocyte) significantly (P<0.05, P=0.011) reduced at 300 and 400 mg/kg. No significant differences were observed in the platelet and red blood cell count of treated animals.

3.4 Effect of Extract on the Biochemical Parameter

The effect of the extract on the biochemical parameter is presented in Table 3. Oral administration of aqueous stem bark extract of *C. farinosa* on the biochemical parameter for 28 days significantly (P<0.05, P=0.017) reduced serum albumin compared to control. Other biochemical changes were not statistically different from the control.

3.5 Histopathology Effect

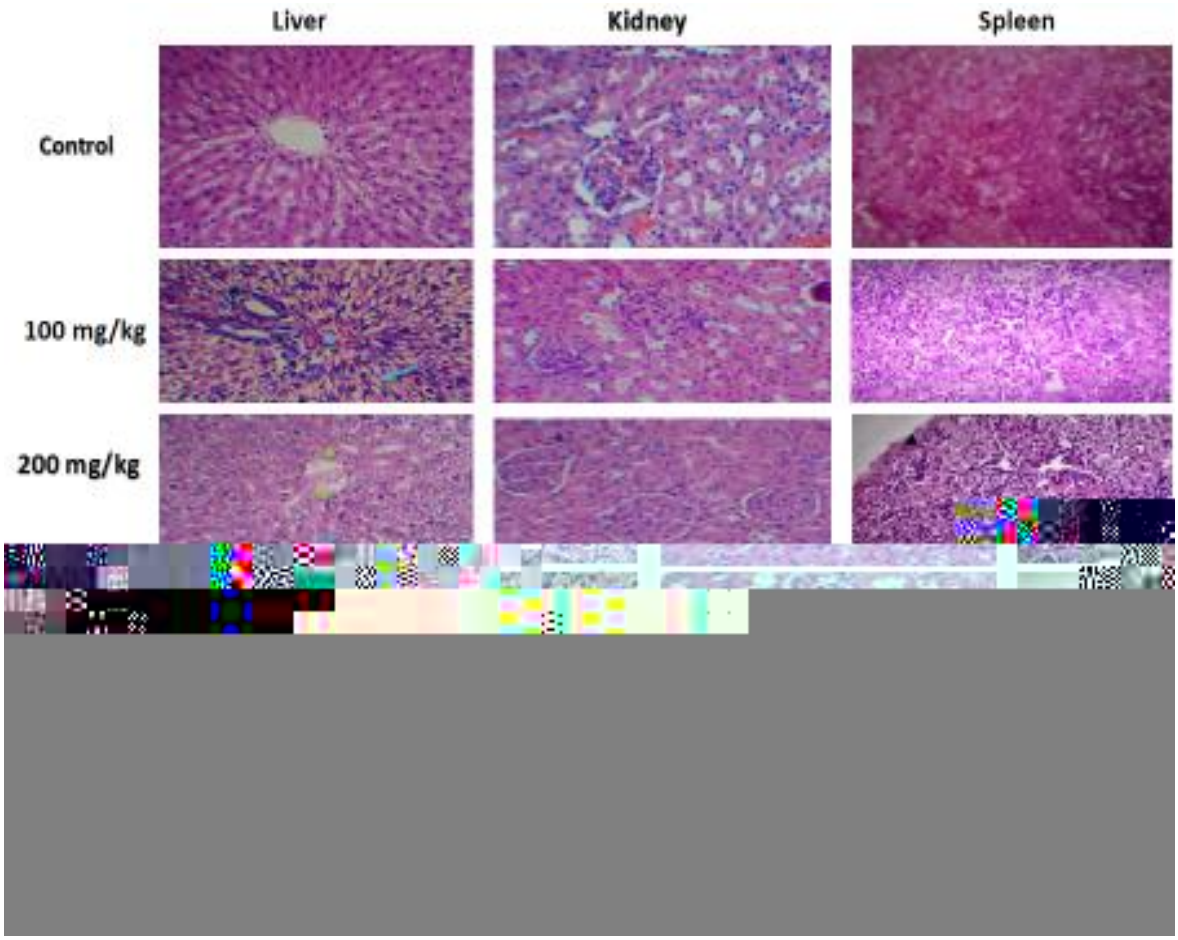

Fig. 5. The representative liver sections of animals administered extract of *C. farinosa* showed morphological characteristics of vacuolated degeneration of hepatocytes (green arrow), piecemeal necrosis (green arrowhead), inflammatory cells (blue arrowhead), and fatty changes (blue arrow). The spleen showed apoptotic changes (black arrow) and thickened capsule (black arrowhead). No histopathological changes were observed in the kidney parenchyma. (H&E. X 400)

dysfunction [32,33]. furthermore, the histopathological sections of the liver showed morphological characteristics of cell death which models hepatocyte apoptosis (Fig. 5). The significance of apoptosis is appreciated to be the main mode of cell death in liver diseases [34].

The functional integrity of the kidney is to maintain the body's homeostatic functions through the excretion of metabolic waste products and in the regulation of intracellular fluid volume, electrolyte compositions, and acid-base balance [35]. The electrolyte result showed that the extract of *C. farinosa* has no statistically significant effect on the kidney (Table. 3). This biochemical result was further supported by the normal histological sections of the kidney (Fig. 5).

Further histopathological studies showed morphological characteristics of apoptosis in the spleen (Fig. 5). A similar trend to this model of apoptosis was caused by the chronic consumption of Chili pepper [36]. Apoptosis is a mode of cell death characterized by specific morphological and biochemical features [34]. For the reason that spleen is the body's filter against foreign substances from the circulatory system, some neutrophils wander from the peripheral blood into the splenic parenchyma to be contributing to the humoral immunological responses [37]. This may perhaps explain the neutrophils in the spleen (Fig. 5). This trend is in agreement with the number of effete erythrocytes in the hematological parameters (Table. 2).

In addition, extract induced interstitial hemorrhage in the lungs of treated animals compared to control (Fig. 6). A similar finding was documented from the aerial parts of *Caralluma dalzielii* [38]. Furthermore, drug-induced gastrointestinal injury is a common medical problem [39]. We studied animals treated with *Cadaba farinosa* extract and model the characteristic features of stomach edema with mild inflammatory cell presentation (Fig. 6). The representative sections of stomach edema were further justified by the reduced serum albumin (hypoalbuminemia) in all treated animals (Table. 3). However, the extract did not cause any pathological changes in the brain cells (Fig. 6). This trend is also in agreement with the report of Kaid et al. [6], where oral administration of Goniothalamus extract had no remarkable pathology on the brain.

5. CONCLUSION

Oral administration of the aqueous stem bark extract of *Cadaba farinosa Forsk* for 28 days is toxic to the liver, spleen, stomach, and lung. Reducing the therapeutic dose and period of exposure may minimize the deleterious effects.

CONSENT

Consent was obtained from all authors.

ETHICAL APPROVAL

Approved by the Animal Ethics Committee, Usmanu Danfodiyo University Sokoto Nigeria.

DATA AVAILABILITY

Data are available from the corresponding author upon request.

ACKNOWLEDGEMENTS

The authors extend their appreciation to the Head of Pharmacognosy and Ethnomedicine, Dr. H.E Mshelia at the Usman Danfodiyo University Sokoto for the plant identification and extraction.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1 Shewamene N, Dune T, and Smith C.A. The use of traditional medicine in maternity care among African women in Africa and the diaspora: A systematic review. BMC Complementary and Alternative Medicine. 2017;17:382.

2 Taek M, Prajogo B, Agil M. Plants used in traditional medicine for the treatment of malaria by the Tetun ethnic people in West Timor Indonesia. Asian Pac. J. Trop. Med. 2018;11 (11):630-637.

3 Philpott J, Abera A, Hadgu K. Livelihood/Emergency Assessment in Afar Region. Oxfam International. 2005; 1-50.

4 Zeynu A, Wondimu T, Demissew *S.* Herbal medicine is used by the community of Koneba district in Afar Regional State, Northeastern Ethiopia*.* Afri. Health Sci. 2021;21(1):410-7.

5 Ugwah OM, Ugwah-Oguejiofor CJ, Etuk EU, Bello SO, Aliero AA. Evaluation of acute and chronic toxicities of aqueous stem bark extract of *Balanites aegyptiaca L delile*. African Journal of Pharmaceutical Research & Development. 2016;8(2): 93-99.

6 Fahmi Kaid, AM. Alabsi, Nashwan Alafifi, Rola Ali-Saeed, May Ameen Al-koshab, Anand Ramanathan, and A. M. Ali. Histological, Biochemical, and Hematological Effects of Goniothalamin on Selective Internal Organs of Male *Sprague-Dawley* Rats. Hindawi. Journal of Toxicology. 2019;13.

7 Umesh T, Vaibhav U. Phyto-pharmacological Perspective of *Cadaba farinosa Forsk*. American Journal of Phytomedicine and Clinical Therapeutics. 2013;1:011-022.

8 Ezekiel J., and Kadam T. Phytochemical Analysis and Biological Assay of the Methanolic Leaf Extract of *Cadaba farinosa Forsk* (Capparidaceae). International Journal of Advanced Research. 2015;3:1368-1375.

9 Dramane Pare, AdamaHilou, Noufou Ouedraogo, and Samson Guenne. Ethnobotanical Study of Medicinal Plants Used as Anti-Obesity Remedies in the Nomad and Hunter Communities of Burkina Faso. Medicines. 2016;3:9.

10 Ahmad, Viqar UA, Rahman A, Chen, Marie HM, Clardy. Cadabicine, an alkaloid from *Cadaba farinosa*. Phytochem. 1985; 24(11):2709-271.

11 Tilahun Teklehaymanot. An ethnobotanical survey of medicine and edible plants of Yalo Woreda in Afar Regional State, Ethiopia. Journal of Ethnobiology and Ethnomedicine, 2017;13:40.

12 Umesh T, Anuj M, Vaibhav U, Avinash G, Hemalatha GD. Hepatoprotective and Antioxidant Activity of Root of *Cadaba farinosa Forsk* against CCl4 Induced Hepatotoxicity in Rats. Journal of Pharmaceutical Resources, 2010;3:1-5.

13 Solomon Matthias Gamde, Amali Abubakar Muhammad, Mohemmed Umar, Abdulrahman Musa, Godwin Avwioro. Histological Effects of Aqueous Stem Bark Extract of *Cadaba farinosa* on Gastrointestinal Tract of Wistar rats, Global Journal of Medical Research. 2020; 18(1):41-47.

14 Moshi J Mainen, Zakaria H Mwambo; Appolinary Kamuhabwa; Modest C Kaipingu; Pascal Thomas; Marco Richard. African Journal of Traditional, Complementary and Alternative Medicines. 2006;3(3):48-58.

15 Perede A, Aisha A, Musa A, Khadijat K Hauwa, Solomon MatthiasGamde. Protective Effects of Aqueous Leaf Extract of *Cadabafarinosa* on the Gastrointestinal Tract of Adult Wistar Rats. *European* Journal of Biology and Medical Science Research. 2019;7(3):49-56.

16 Yousif G, Iskander GM, Eisa EB. Alkaloid components of the Sudan Flora. II. Alkaloid *Cadaba farinosa* and C. rotundifolia. Fitoterapia, 1984;55(2):117-118.

17 Khare CP. Indian Medicinal Plants: An Illustrated Dictionary. (Springer-VerlagBerlin/Heidelberg publication. New York- USA); 2006:107.

18 Nadkarni AK. Indian Materia Medica- 1, 3rd ed., Popular Prakashan, Bombay; 2002:225- 26.

19 Ken F. Useful Tropical Plants Database; 2014. Available:http://tropical.theferns.info/viewtropical.php?.

20 Burkill HM. The useful plants of West Tropical Africa. 1st Edition, (Families M-R), Royal Botanic Gardens, Kew. 1985;1.

21 Mohammed Z, Daja A, Hamza H, Gidado A, Hussaini I. Ethnobotanical Survey of Folkloric Plants Used in Managing Breast Cancer by the Traditional Medical Practitioners of North-East Nigeria. Journal of Medical and Applied Biosciences. 2014; 6:29-43.

22 Ibrahim SI, Ameh DA. Atawodi SE, Umar IA. Jajere U. M. A, Mohammed SY. In vitro Inhibitory Effect of Methanol Leaf Extract of *Cadaba farinosa* on Carbonic Anhydrase Activity, IJBCRR. 2016;11(4): 1-8.

23 Solomon Matthias Gamde, HauwaKabiru, Aisha Abubakar, KhadijatAbubakar, Abdurahman Musa, and Anthony Perede. Histopathological and Biochemical Effects of Aqueous Leaf Extract of Cadabafarinosa on Liver of Adult Wistar Rats. International Journal of Research in Medical Sciences. 2019;7(3):3716-3721.

24 Ibrahim EE. Phytochemical, antioxidant activity, and cytotoxicity of methanolic extract of *Balanites aegyptiaca* (L.) DELILE. Pharmacie Globale. 2016;7(1):1.

25 Ibegbulem CO, Eyong EU., and Essien ET. Biochemical effects of drinking *Terminalia catappa*Lin. Decoction in Wistar rats. *Afri.* J. Biochem. Res. 2011;5:237-243.

26 Nugroho RA, Manurung H, Saraswati D, Ladyescha D, Nur FM. The Effects of *Terminalia catappa* L. Leaves Extract on the Water Quality Proper-ties, Survival and Blood Profile of Ornamental fish (*Betta sp*) Cultured. *Biosaintifika.* Journal of Biology & Biology Education. 2016;8(2):241-248.

27 Bin Cheng, Ai-Zhen Zhou, Wen Ge, Xiao-Min Yao, and Juan Wang. Mechanism of Huo-Xue-Qu-Yu Formula in Treating Nonalcoholic

28 Hepatic Steatosis by Regulating Lipid Metabolism and Oxidative Stress in Rats. Hindawi. Evidence-Based Complementary and Alternative Medicine. 2021;13.

29 Amit A. Lugade, Paul N. Bogner, Thomas H. Thatcher, Patricia J. Sime, Richard P. Phipps and Yasmin Thanavala. Cigarette Smoke Exposure Exacerbates Lung Inflammation and Compromises Immunity to Bacterial Infection. 2021;7(192):5226-5235.

30 Ram A, Laura P, Gupta R, Kumar P, Sharma VN. Hypocholesterolemic effects of Terminalia arguna tree bark. J. Ethnopharmacol. 1997;55(3):165-169.

31 Rej R. Aminotransferases in disease. Clin. Lab. Med. 1989;9:667-687.

32 Wang JH, Hwang SJ, Son CG. Comparative Analysis of the Antioxidative and Hepatoprotective Activities of Dimethyl Diphenyl Bicarboxylate in Four Animal Models of Hepatic Injury. Antioxidants. 2021;10:1508.

33 Suckow M, Stevens K, Wilson R. The Laboratory Rabbit, Guinea Pig, Hamster, and Other Rodents. London; Waltham MA: Academic Press/Elsevier; 2012.

34 Lima IR, Silva IB, Lima RM, Silva TM, Maria B. Arguivos de gastroenterologia. 2019;56:333-338.

35 Marc Bilodeau. Liver cell death: Update on apoptosis. Can J Gastroenterol. 2003;17 (8):501-506.

36 Ukoha UU, Mbagwu SI, Ndukwe GU, and Obiagbo C. Histological and Biochemical Evaluation of the Kidney following Chronic Consumption of *Hibiscus sabdariffa*. Hindawi Publishing Corporation. Advances in Biology. 2015;1-5.

37 Badr Al-Dahmesh, Mohamed A. Dkhil, and Saleh Al-Quraishy. Chili pepper-induced injury to splenic tissue of rabbit. Journal of Medicinal Plants Research. 2011;5(10): 2015-2020.

38 Fawcett MD. A textbook of Histology. 11th ed. Saunders WB. The company, Igaku-Shoin, Sounders; 1986.

39 Chinenye Jane Ugwah-Oguejiofor, Charles Ogbonna Okoli, Michael Oguejiofor Ugwah, Millicent Ladi Umaru, Chiedozie Smart Ogbulie, Halilu Emmanuel Mshelia, Mohammed Umar, and Anoka Ayembe Njan. Acute and sub-acute toxicity of aqueous extract of aerial parts of *Caralluma dalzielii N. E.* Brown in mice and rats. Heliyon 2018;5 2019: e01179.

© 2022 Gamde et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86551

View publication stats