Evaluation of Acute and Sub-Chronic Toxicities and the Effect of Ointment Bases on the Antimicrobial Potency of the Ethanolic Extracts of *Alchornea cordifolia* Leaf and *Terminalia superba* Stem Bark

Nwamaka H. Igboke, Eneje P. Echezonachi, Chukwuemeka P. Azubuike, Abel O. Idowu

Department of Pharmaceutics and Pharmaceutical Technology, Faculty of Pharmacy, Idi-Araba, University of Lagos, Lagos, Nigeria.

**ABSTRACT**

The problem of resistance of dermatological infections to some antimicrobial agents available in the market has constrained man to search for newer compounds of natural origin with potent antimicrobials. *Alchornea cordifolia* leaf and *Terminalia superba* stem bark are used in African folkloric medicine and have been documented to have antimicrobial properties. It is important to ascertain the potency of their extracts against microorganisms, their toxicities and the type of ointment base most suitable for the formulation of these plant extracts into topical antimicrobials. This study was designed to evaluate the effect of ointment bases on the antimicrobial potency of the Ethanolic extracts of *A. cordifolia* leaf and *T. superba* stem bark. The in-vitro antimicrobial activity of the extracts and their minimum inhibitory concentration (MIC) were determined against *Pseudomonas aeruginosa* and *Staphylococcus aureus*. The MIC (mg/mL) of *A. cordifolia* extract against *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* were 12.8, 12.8, 25.6 and 12.8, respectively. The MIC (mg/mL) of *T. superba* extract against *B. subtilis*, *E. coli*, *P. aeruginosa* and *S. aureus* were 25.6, 25.6, > 25.6 and 25.6, respectively. The topical formulation prepared using the soft water washable base released antibacterial activity of the extracts better than the formulations prepared using other bases. The soft water washable base is the most suitable ointment base for topical antimicrobials formulation of the extracts.

**Keywords:** *Alchornea cordifolia*, *Terminalia superba*, Antimicrobial potency, Ointment bases.

**Introduction**

In developing countries, the major causes of diseases are the poor quality of accessible drinking water, contaminated food, poor standard of personal hygiene and lack of appropriate sanitation. Antimicrobials are the mainstay of extract treatment strategy of infectious diseases worldwide. Regardless of this fact, the problems of antimicrobial resistance and toxicity have triggered interest in research for newer antimicrobial compounds of natural origin and likely to be less toxic to man. Apart from the problem of resistance, environmental degradation, cost and pollution associated with irrational use of orthodox medicines have necessitated renewed interest in the use of medicinal plants as sources of effective and safer alternatives in the management of human infections. Plants occupy a very important place in modern medicine as they are used as either raw materials for drugs or as a template for discovery and synthesis of drugs. According to the World Health Organization, medicinal plants can provide the best alternative source for obtaining a variety of drugs, since they possess a variety of bioactive principles known as phytochemicals which make them potential sources of antimicrobial agents. These phytochemicals include alkaloids, flavonoids, terpenoids, glycosides, tannins and saponins. Topical antibiotics are the mainstay of the treatment of skin infections caused by bacterial, fungal and viral organisms and these agents are available as creams, ointments, powders and sprays.

*Alchornea cordifolia* Muell. Arg. belongs to Euphorbiaceae family and is a traditional medicinal plant widely distributed in West Africa including Nigeria. Its common English name is christmas bush. The plant is used for ethnomedical purposes against wounds, ulcers, and sores. *Terminalia superba* is of Combretaceae family. It is commonly called yellow pine and is a large tree which is native to tropical western Africa. The plants, *A. cordifolia* and *T. superba* are used traditionally against infections and various health conditions. Investigations have been carried out on the Phytochemical constituents and antimicrobial activities of *A. cordifolia* leaf extracts. Bits of information exist regarding its acute toxicities. Nevertheless, there had not been records of investigations regarding the phytochemical screening and acute toxicity evaluations of *T. superba* stem bark extract. There are no recorded exposures to acute toxicities and antimicrobial activities of the combination of *A. cordifolia* leaves and *T. superba* stem bark extract. Since studies have shown that the type of ointment base and formulation process affect topical drug bioavailability and potency of the preparations, the effect of various ointment bases on the antimicrobial potency of the extracts of *Alchornea cordifolia* leaf and *Terminalia superba* stem bark were investigated. Moreover, with the problem of increasing resistance, high cost and side effects associated with topical antibiotics available in the market, it is necessary to formulate an herbal ointment which would be affordable, potent and safe to use.
Materials and Methods

Plant material
Fresh leaves of *Alchornea cordifolia* were obtained from Ijegun, Lagos, while fresh stem barks of *Terminalia superba* were obtained from the Forestry Research Institute of Nigeria (FRIN) Ibadan, Oyo, Nigeria in 2017. *Alchornea cordifolia* was identified and authenticated by a taxonomist at the Herbarium of the Department of Botany and Microbiology, University of Lagos where Herbarium specimen assigned with Voucher number (LUH 7539) was deposited in the herbarium for future reference. *Terminalia superba* was identified and authenticated by a taxonomist at the Herbarium of the FRIN, Ibadan with the voucher specimen number (FHI 111222) deposited in the herbarium for future reference.

Microorganisms
Clinical isolates of bacterial strains of *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Bacillus subtilis* and fungal strains of *Candida albicans* and *Aspergillus niger* were obtained from the Lagos University Teaching Hospital (LUTH) and the Department of Pharmaceutical Microbiology Laboratory, Faculty of Pharmacy of the University of Lagos, Nigeria.

Laboratory animals
Swiss albino mice (20.0 – 25.0 g) were used for this study. They were obtained from the Laboratory animal Centre, College of Medicine, University of Lagos, Ibadan-Araba and kept under standard environmental conditions. They were kept in well spacious polypropylene cages (5 animals per cage) in full ventilated animal house with 12 h dark and light cycle and were fed on standard animal diet (Pfizer Feeds Ltd., Nigeria) and water *ad libitum*. They were acclimatized to the laboratory conditions for seven days prior to commencement of research. The use and care of the animals, and the experimental protocol were in strict compliance with the Institute of Laboratory Animal Research (ILAR) guidelines on the use and care of animals in experimental studies. The animals were distributed randomly into five groups of five animals each for acute toxicity.

Preparation of plant extracts
The leaves of *A. cordifolia* were oven dried at 40°C and milled to coarse powder with laboratory mill (Christy and Norris Ltd, Chelmsford, England). A total of 700 g of milled leaves was extracted with 7 L of 85% ethanol using cold maceration. The extract was filtered using a fine pored cloth. The maceration process was repeated after 7 days using 4 L of 85% ethanol. The extract was concentrated using a rotary evaporator (Buchi V-801) and dried in an oven at 37°C. The stem barks of *T. superba* were oven-dried at 40°C and pulverized using the grinding machine (Christy and Norris Ltd, Chelmsford, England). A portion of 700 g of the powdered bark was extracted with 6 L of 80 % ethanol using cold maceration method. The extract was filtered using a fine pored muslin cloth. The maceration process was repeated on the residue for the first 7 days using 4 L of 80 % ethanol. The extract was filtered and concentrated using a rotary evaporator (Buchi V-801) and dried in an oven at 37°C.

Phytochemical screening
The phytochemical screening for the presence of cardiac glycosides, anthraquinone glycosides, flavonoids, saponins, phytosterols (steroids), tannins, alkaloids, gums and mucilages, fixed oils in both extracts was carried out using standard procedures as described by Sofowora. The percentage yield of the ethanolic extract of *A. cordifolia* leaves was 28.57% while that of *T. superba* stem bark was 17.83%. It must be noted that extract yields from plants are influenced by plant strain, geographical location, extraction medium and procedure among other factors. According to Vogel et al., yields below 40% are poor. *A. cordifolia* and *T. superba* extracts therefore exhibited poor yield respectively which could be as a result of one or more of the factors stated above. *A. cordifolia* leaf had a better yield in comparison with *T. superba* stem bark.

Preparation and Evaluation of Ointments

The acute toxicity screening of the ethanolic extracts of *A. cordifolia* leaves and *T. superba* stem bark were carried out using the method described by Ogbonna et al. Swiss albino mice (25) of both sexes weighing 20.0 - 25.0 g were used. The animals were randomly distributed into one control group and four treated groups of five animals per group. After the overnight fasting, the control group received distilled water and 2% acacia orally. The test animals were fed orally with different doses (5.0, 10.0, 15.0 and 20.0 g/kg) of 80% (w/v) of the extracts, respectively. The 80 % (w/v) solution of the extract was prepared by dispersing 16 g of the extract in 7 mL distilled water in a 100 mL beaker and transferred to a 20 mL volumetric flask. The beaker was thoroughly rinsed with distilled water; the content added to the volumetric flask and the volume made to mark. The animals were observed continuously for the first 4 h and every hour for the next 12 h, then 6 hourly for 56 h (72 h acute toxicity) to observe any death or changes in general behavior and other physiological activities.

Preparation and Evaluation of Ointments Formulations Containing Ethanolic Extracts of *A. cordifolia* leaf and *T. superba* stem bark
Different ointment bases (4): White ointment base USP, Lanolin ointment base USP, Hydrous Lanolin Ointment base and Soft water washable ointment base were prepared using the fusion method and their various efficacies in the formulation of herbal ointment evaluated (Table 1). The white ointment base and the lanolin base were prepared using the fusion method described by Azubuike et al. The hydrous lanolin ointment base and soft water washable base were prepared by melting the respective phase separately in a melting pan at 70°C and heating the aqueous phase in another melting pan to 70°C. The aqueous portion was then added to the oleaginous phase with continuously stirring until congealed. When ready to use, the ointment bases were melted and maintained at 70°C. A concentration of 1 g each of the ethanolic extract of *A. cordifolia* and *T. superba* was incorporated into the bases with continuous stirring to get an even mix. The prepared *A. cordifolia* herbal ointments and *T. superba* herbal ointments were then filled into ointment jars and stored at room temperature.

Preparation of Ointment Formulations

The ointment formulations (A. cordifolia and T. superba ointments) were evaluated for the following parameters: physical appearance, colour, texture, phase separation, and homogeneity spread ability and irritant effect using the method of Azubuike et al. In-vitro antimicrobial efficacy of the formulated ointments was carried out using the agar diffusion method.

Statistical Analysis

Data were expressed as mean ± SEM. Significant difference were analysed by one-way ANOVA and P < 0.05 was regarded as significant.

Results and Discussion

The percentage yield of the ethanolic extract of *A. cordifolia* leaf was 28.57% while that of *T. superba* stem bark was 17.83%. It must be noted that extract yields from plants are influenced by plant strain, geographical location, extraction medium and procedure among other factors. According to Vogel et al., yields below 40% are poor. *A. cordifolia* and *T. superba* extracts therefore exhibited poor yield respectively which could be as a result of one or more of the factors stated above. *A. cordifolia* leaf had a better yield in comparison with *T. superba* stem bark.

The extracts were found rich in Phytochemical constituents. The ethanolic extract of the stem bark of *T. superba* revealed the presence of alkaloids, saponins, cardiac glycosides, tannins, flavonoids, gums and mucilages while the ethanolic extract of the leaves of *A. cordifolia* revealed the presence of saponins, anthraquinone and cardiac glycosides, tannins, flavonoids, and gums and mucilage. Antimicrobial Activity of Ethanolic Extracts of *A. cordifolia* leaf and *T. superba* stem bark.

One of the preliminary stages involved in the development and large-scale production of a new drug is the extraction of its active constituent. In Table 2, the *in-vitro* antimicrobial activity of the ethanolic extract of *A. cordifolia* leaf and *T. superba* stem bark are presented.
The result of the in-vitro antimicrobial activity of the ethanolic extract of A. cordifolia leaves implies, the extract has a concentration dependent antibacterial activity but no antifungal activity. These findings are in contrast with the findings of Kra et al\(^5\) which reported that T. superba was active against Candida albicans. The zones of inhibition of A. cordifolia leaf extract were remarkable for Staphylococcus aureus than the zones of inhibition of Ciprofloxacin. The significant \(p \leq 0.05\) antibacterial activity of the extract on S. aureus shows they can be employed in the treatment of skin disorder like impetigo and eczema caused by S. aureus. The mixture of the extracts showed reduced activity compared to each of the extracts. The mixture of A. cordifolia and T. superba extracts reduced zones of inhibition when compared with each of the extracts. This could be as a result of interaction between the extracts leading to the formulation of less active antimicrobial agent. These extracts therefore should not be used in combination as an antimicrobial agent. The antimicrobial activities of Ciprofloxacin BP (standard anti-bacterial) and Clotrimazole BP (standard anti-fungal) on the microorganisms are shown on Tables 3 and 4. The extracts compared favourably with the standards. The MIC values of A. cordifolia leaf extracts against the test organisms are: B. sub 1.8 mg/mL, E. coli 1.8 mg/mL, S. aureus 12.8 mg/mL, P. aeruginosa 25.6 mg/mL, while that of T. superba against the testorganisms 26.6 mg/L for the organisms respectively (Table 5). The mixture of A. cordifolia and T. superba extracts showed reduced zones of inhibition when compared with each of the extracts. This could be as a result of interaction between the extracts leading to the formulation of less active antimicrobial agent. These extracts therefore should not be used in combination as an antimicrobial agent.

### Acute Toxicity Screening of the Ethanolic Extracts of A. cordifolia and T. superba stem bark

The results of the acute toxicity evaluation of A. cordifolia, T. superba and the mixture of both extracts are shown in Figure 1. A 100% death was recorded for the animals fed with 20.0 g/kg body weight of the group of animals fed with 15.0 g/kg body weight of A. cordifolia, T. superba and the mixture of both extracts recorded 60 % and 20 % death respectively when fed with 15.0 g/kg body weight of the extracts. There was no death recorded in the group of animals that received 5.0 and 10.0 g/kg body weight of the extracts singly and in combination. The median lethal dose (LD\(_{50}\)) for the ethanolic extracts of A. cordifolia leaves, T. superba stem barks and the mixture of these extracts were 14.79 g/kg, 15.85 g/kg and 17.78 g/kg, respectively. Each of the extracts and their combination could be classified as nontoxic, since the LD\(_{50}\) by oral route were found to be 14.8 g/kg, 15.8 g/kg and 17.8 g/kg respectively which were much higher than the toxicity index of 2.0 g/kg body weight recommended by WHO. According to Ogbonnia et al, the LD\(_{50}\) of more than 15.0 g/kg body weight could be translated to 1050 g dose in an average adult man of 70 kg.

### Evaluation of A. cordifolia and T. superba ointments

The formulated ointments appeared to be uniformly mixed, non-greasy, homogenous and had no phase separation after 4 weeks. The white ointment base and the lanolin base were greasy while the hydrous lanolin and the soft water washable base were non-greasy to touch. The in-vitro antimicrobial screening of the formulated A. cordifolia and T. superba ointments revealed the soft water washable ointment base containing ointments possessed antibacterial activity against all the bacterial organisms (Tables 6 and 7). According to Shelke and Mahajan,\(^{30}\) an ideal ointment for medicinal purposes should be non-greasy, non-sticky, non-gritty (smooth), spreadable, homogenous and have no phase-separation. From the results it can be deduced that the herbal ointments formulated using hydrous lanolin and soft water washable bases passed the organoleptic tests because they possessed the properties of an ideal ointment.

From the results of the antimicrobial potency of the herbal ointments, only the topical formulation prepared using the soft water washable base effectively released the antibacterial extracts as it had zones of inhibition similar to that of the crude extract. The A. cordifolia ointment formulation prepared using hydrous lanolin base was potent only against P. aeruginosa. White ointment base and lanolin base had no activity.

### Table 1: Formulation of Ointment bases.

| Formulations | Ingredients | Concentration (% w/w) | Quantity used (g) |
|--------------|-------------|-----------------------|-------------------|
| Formulation I | White wax | 5% | 0.5 |
| | White petrolatum | 95% | 9.5 |
| Formulation II | Wool fat | 100% | 10 |
| Formulation III | Wool fat | 70% | 7 |
| | Distilled water | 30% | 3 |
| Formulation IV | Glycerin | 0.10% | 1 |
| | Mineral oil | 0.20% | 2 |
| | Triethanolamine | 0.02% | 0.2 |
| | Purified water to: | 100% | 10 |

Formulation I: White ointment, II: Lanolin, III: Hydrous and IV: Soft water washable base.

### Table 2: Zones of Inhibition (mm) of the Ethanolic Extract of A. cordifolia, T. superba and the Mixture of the Extracts.

| Organisms/Zones of Inhibition | Extract | Conc. | C. albicans | E. coli | S. aureus | P. aerugin | A. nig | B. subt |
|------------------------------|---------|-------|-------------|---------|-----------|------------|--------|--------|
| A. Cord | 50 | 15.5 ± 0.5 | 10.0 ± 0.0 | 16.5 ± 0.5 | 16.0 ± 1.0 | - | - |
| | 100 | 16.0 ± 0.0 | 16.5 ± 0.5 | 18.5 ± 1.5 | 20.5 ± 0.5 | - | - |
| | 200 | 17.0 ± 0.0 | 18.0 ± 0.0 | 20.0 ± 0.0 | 22.0 ± 0.0 | - | - |
| | 50 | 15.5 ± 0.5 | 10.0 ± 0.0 | 16.5 ± 0.5 | 16.0 ± 1.0 | - | - |
| T. sup | 100 | 16.0 ± 0.0 | 16.5 ± 0.5 | 18.5 ± 1.5 | 20.5 ± 0.5 | - | - |
| | 200 | 17.0 ± 0.0 | 18.0 ± 0.0 | 20.0 ± 0.0 | 22.0 ± 0.0 | - | - |
| | 50 | 16.5 ± 0.5 | 20.0 ± 0.0 | 16.5 ± 0.5 | 14.0 ± 1.0 | - | - |
| Mixture | 100 | 17.0 ± 1.0 | 20.0 ± 0.0 | 18.5 ± 1.5 | 18.5 ± 0.5 | - | - |
| | 200 | 20.0 ± 0.5 | 21.0 ± 0.0 | 20.0 ± 0.0 | 22.0 ± 0.0 | - | - |
| D. water | - | - | - | - | - | - | - | - |

- No zone of inhibition, Conc = concentration, P. aerugin = Pseudomonas aeruginosa, A. nig = Aspergillus niger, B. subst = Bacillus subtilis, A. cord = A. cordifolia, T. sup = T. superba, D. water = Distilled water.
Table 3: Zones of Inhibition (mm) Obtained with Ciprofloxacin (Positive Control for Anti-Bacterial Activity).

| Microorganism       | Concentration of ciprofloxacin (µg/mL) | 2.5 | 5   | 10  | 20  |
|---------------------|----------------------------------------|-----|-----|-----|-----|
| Bacillus subtilis   |                                        | 20  | 23  | 26  | 27  |
| Escherichia coli    |                                        | 15  | 19  | 21  | 21  |
| Staphylococcus aureus|                                        | 11.5| 15  | 20  | 23  |
| Pseudomonas aeruginosa |                                      | -   | 18  | 25  | 27  |

This result can be attributed to the properties of the ointment bases as explained by The Pharmaceutics and Compounding Laboratory. The white ointment base is an oleaginous base and oleaginous ointment bases are very occlusive and have poor drug release potential. The lanolin base is an absorption ointment base and absorption ointment bases are also occlusive, their drug release potential is also poor but it is better than that of the oleaginous ointment base. The hydrous base is a water in oil emulsion ointment base with HLB value ≤ 8, it is sometimes occlusive but has a fair drug release potential. The soft water washable base is an oil in water emulsion ointment base with HLB value 8, it is sometimes occlusive but has a fair drug release potential.

Table 4: Zones of Inhibition (mm) Obtained with Clotrimazole.

| Concentration of Clotrimazole (µg/mL) | Microorganism/Zones of inhibition (mm) |
|--------------------------------------|----------------------------------------|
|                                      | Aspergillus niger | Candida albicans |
| 20                                   | 28             | 25              |
| 40                                   | 27             | 23              |
| 80                                   | 25             | 22              |
| 160                                  | 22             | 21              |

Table 5: Minimum Inhibitory Concentration of the Ethanol Extracts of A. cordifolia Leaves and T. superba Stem Bark.

| Microorganisms | A. cordifolia Leaves | T. superba Stem barks |
|----------------|----------------------|-----------------------|
| B. subtilis    | 12.8                 | 25.6                  |
| E. coli        | 12.8                 | 25.6                  |
| S. aureus      | 12.8                 | 25.6                  |
| P. aeruginosa  | 25.6                 | > 25.6                |

Table 6: Zone of inhibition (mm) of A. cordifolia Topical Formulations on the Test Bacteria.

| Bases                      | MIC (mg/mL) | E. coli | B. subtilis | P. aeruginosa | S. aureus |
|----------------------------|-------------|---------|-------------|---------------|-----------|
| Petroleum jelly            | -           | -       | -           | 14.5 ± 0.5    |           |
| Lanolin base               | -           | -       | -           | 16.5 ± 0.5    |           |
| Hydrous lanolin base       | -           | -       | 10.0        | 18.0          |           |
| Soft water washable base   | -           | -       | -           | 18.0          |           |

- : No zone of inhibition.

Table 7: Zone of inhibition (mm) of T. superba Topical Formulations on the Test Bacterial Organisms.

| Bases/Zones of inhibition | MIC (mg/mL) | E. coli | B. subtilis | P. aeruginosa | S. aureus |
|----------------------------|-------------|---------|-------------|---------------|-----------|
| Petroleum jelly            | -           | -       | -           | 14.5 ± 0.5    |           |
| Lanolin base               | -           | -       | -           | 19.5 ± 0.5    |           |
| Hydrous lanolin base       | -           | -       | -           | 16.0 ± 0.0    |           |
| Soft water washable base   | -           | -       | -           | 21.5 ± 0.5    |           |

- : No zone of inhibition.
References

1. Igboke H, Bhattacharyya S, Gradus S, Khubbar M, Grieshold D, Reddy J, Igwilo C, Molajumiero D, Azenabor A. Preponderance of toxigenic Escherichia coli in stool pathogens correlates with toxin detection in accessible drinking-water sources. Jepidermiol = infect. (2014); 4(6):1-24.

2. WHO Media Centre, Antibiotic Resistance, Fact sheet, (2017); https://www.who.int/mediacentre/news/releases/2017/antibiotic-resistance-factsheet/en/.

3. Natarajan D, Srinivasan R, Shivakumar M, Phyllanthus W. A potential source for natural antimicrobial agents. Biomed Res Int Article. (2014); 135082.

4. Azubuike CP, Igboke NH, Essien GS, Elendu NJ. Evaluation of antimicrobial properties of herbal ointments formulated with ethanolic extract of Acylypha wilkesiana. J Tradit Biol Sci Opin. 1(2):41-44.

5. Onyeaka IP, Suleiman MM, Bako SP. Toxicity Effects of Methanolic Extract of Euphorbia hirta-Honey Mixture in Albino Rats. J Pharmacocon Nat Prod. (2018); 4: 147. doi:10.4172/2472-0792.1000147.

6. Nair R, Kalariya T, Chanda S. Antibacterial activity of some selected Indian medicinal flora. Turk J Biol. 2005; 29:41-47.

7. Abreu AC, Borges A, Simeo LC, Saavedra MJ, Simeo M. Antibacterial activity of phenyl isothiocyanate on Escherichia coli and Staphylococcus aureus. Med Chem. 2013; 9(7):75-76.

8. Okwu E and Ukanwa N. Isolation, Characterization and Antibacterial Activity Screening of Alchornea cordifolia (Schumach. and Thonn.) Mull. Arg. Leaves. E-J Chem. 2010; 7(1):41-48.

9. Vaghasiya Y, Dave R, Chanda S. Phytochemical analysis of some medicinal plants from western region of India. Res J Med Plant. 2011; 5:567-576.

10. Singal A and Thami G. Topical antibacterial agents in dermatology. J. Dermatol. 2003; 30(9):644-648.

11. Schwartz R A and Al-Muairi N. Topical antibiotics in dermatology: An update. GIDV. 2010; 17(1):1-19.

12. Adesina GO, Kule OF, Omoalo OA, Ehimidu JO, Odama LE. Antimicrobial activity of the aqueous and ethyl acetate sub-fractions of Alchornea cordifolia leaf. Eur J Med Plants 2011; 2(1):31-41.

13. Kimpouni V. Terminalia superba Engl. & Diels. [Internet] Record from PROTA4U. Lemmens RHJM, Louppe D, Oteng-Amoako AA (Ed.). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l’Afrique tropicale), Wageningen, Netherlands. <http://www.prota4u.org/search.asp>, Accessed 7 July 2018.

14. Ahmadu A, Agunu A, Abdurrahman E. Anti-Inflammatory Constituents of Alchornea cordifolia Leaves. Nig J Nat Prod Med. 2015; 19:60-64.

15. Mohammed RK, Ibrahim S, Atawodi SE, Eze ED, Suleiman JB. Anti-diabetic and haematological effects of n-butanol fraction of Alchornea cordifolia leaf extract in streptozotocin-induced diabetic wistar rats. Glob J Med Plant Res. 2012; 1(1):14-21.

16. Ngaha NM, Dahtna I, Massoma LD. Alchornea cordifolia, a special plant for traditional medicine.traditional medicine. A review. J Agroecol Nat Res Manag. 2016; 3(2):140-144.

17. Tarun G, Goutam R, Amit K. Comprehensive review on additives of topical dosage forms for drug delivery. Drug Deliv. 2015; 22(5):968.

18. Derrell CJ, Gerald FG, Janet CG, Micaele HE, Dennis FK, Author N. The 1996 Guide for the Care and Use of Laboratory Animals. ILAR J. 1997; 38(1):41-48.

19. Ogbonna SO, Mbaka GO, Igboke NH, Anyika EN, Ali P. Nwakakwa N. Antimicrobial evaluation, acute and subchronic toxicity studies of Leone Bitters, a Nigerian polyherbal formulation, in rodents. Agric Biol J N America. 2010; 1(3):366-376.

20. Ogbonna SO, Mbaka GO, Anyika EN, Ladiju O, Igboke NH, Emordi JE. Nwakakwa N. Evaluation of Anti-diabetics and Cardiovascular Effects of Parinari curatellifolia Seed Extract and Anthocysta vogelli Root Extract Individually and Combined on Postprandial and Alloxan-Induced Diabetic Albino Rats. Br J Med Res. 2011; 1(3):146-162.

21. Sofowora A. Medicinal plants and traditional medicine in Africa. 3rd ed. Spectrum books Ltd, Ibadan, Nigeria. 2008. 199-202 p.

22. Boyan B, James H, Judicael P. Principles of assessing bacterial susceptibility to antibiotics using the agar diffusion method. J Antimicrob Chemother. 2008; 61(6):1295-1301.

23. Alalor CA, Igwilo CI, Azubuike CP. Evaluation of the antibacterial activity of ethanolic extracts of selected Indian medicinal plants formulated with methanolic extract of Cassia alata. Asian J Biomed Pharm Sci. 2012; 2(13):15-19.

24. Ogbonna SO, Mbaka GO, Akinsande OE, Otah DA, Ayeni TA. Evaluation of acute toxicity, hygoglycaemic and hypolipidaemic effects of Cyathula prostate (Linn.) Blume weeds on adult rats. Br J Pharm Res. 2016; 9(5):1-11.

25. Cunha IB, Sawaya AC, Caetano FM, Shimizu M, Marucci MC, Drezza FT, Povia GS, Carvalho PD. Factors that influence the yield and composition of Brazilian propolis extracts. 2004; J. Braz. Chem. Soc. 15(6):964-970.

26. Vogel, AI, Tatchell AR, Furniss BS, Hanaford AJ, Smith PWG. Vogel's Textbook of Practical Organic Chemistry, 5th Edition. Prentice Hall, 1996. 1195-1204 p.

27. Shelke UV, Mahajan AA. Review on: an ointment. Int J Pharm Pharm Res. 2015; 4(2):170-192.

28. The Pharmaceutics and Compounding Laboratory, Estelman school of Pharmacy, Ointments: preparation and evaluation of drug release. Available from: https://pharmilabs.unc.edu/labs/ointments/prep.html. Accessed 03 March 2018.

29. Kra AK, Siaka S, Ahon GM, Kassi AB, Ouattara S, Sadat AW, Coulibaly A, Soro Y, Djaman AJ. Antifungal activity of Terminalia superba (combretaceae). J Exp Biol Agric Sci. 2015; 3(2):162-173.