

# Phytochemical, Antimicrobial and Cytotoxic Activities of *Strophanthus sarmentosus* DC

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## Abstract

*Strophanthus sarmentosus* DC is used traditionally in the management of snake-bite, arthritis, eye infection, rheumatism, emetic and venereal diseases. Freshly collected mature *Strophanthus sarmentosus* plant parts were air-dried at room temperature. Each of the plant parts (leaf, stem and roots) was successively extracted by cold extraction method using hexane, ethyl acetate and methanol respectively. The crude extracts were subjected to phytochemical, antimicrobial and cytotoxicity analysis by employing chemical tests, agar diffusion and brine shrimps methods. The phytochemical screening showed the presence of tannins, saponins, glycosides, flavonoids, phenols, steroids, terpenoids and carbohydrates in all the extracts. The extracts demonstrated broad spectrum activities against both gram-positive and gram-negative bacteria and the fungi tested. The MIC and MMC of ethyl acetate and methanol extracts of the *S. sarmentosus* (stem) is between 0.3 and 5.0 mg/mL. The cytotoxic activity (LC<sub>50</sub>) of the *S. sarmentosus* extracts (leaf, stem and root) ranged between 117 µg/mL and 270 µg/mL, showing that the extracts are within the medium toxic level according to Clarkson's toxicity index.

**Keywords:** Antimicrobial activity; Cytotoxic activity; *Strophanthus sarmentosus* DC; Apocynaceae; phytochemicals.

**Abbreviations:** Met; Methanol, EA; Ethyl-acetate, Hex; Hexane, DZI; Diameter of Zone of Inhibition, S. a. ; *Staphylococcus aureus*, S. t.; *Staphylococcus typhimonium*, B. s. ; *Bacillus subtilis*, E. c. ; *Escherichia coli*, K. p. ; *Klebsiella pneumonia*, P. a. ; *Pseudomonas aeruginosa*, A. n. ; *Aspergillus niger*, C. a. ; *Candida albicans*, G; Gentamycin, K; Ketoconazole, SHLH; *Strophanthus hispidus* leaves hexane, SHLE; *Strophanthus hispidus* leaves ethyl acetate, SHLM; *Strophanthus hispidus* leaves methanol, SHSH; *Strophanthus hispidus* stem hexane, SHSE; *Strophanthus hispidus* stem ethyl acetate, SHSM; *Strophanthus hispidus* stem methanol, LC; Lethal Concentration, CYCLO P; Cyclophosphamide.

## INTRODUCTION

Plant extracts and essential oils are considered to be the potential sources of compounds with anticancer, antimicrobial and antioxidant properties. Several medicinal plants and their bioactive components have been reported to be very important in the management of health through the regulation of biological processes (Rahmani & Aly, 2015). Compounds like tannins, steroids, flavonoids and phenols possess strong biological properties and have found use in many fields, including medicine, pharmacy, food production, beauty care and agriculture (Behidj-Benyounes et al., 2014). Infectious diseases are the world's leading human and animal agents of death. The situation is further complicated by the rapid development of multi-drug resistance to available antimicrobial agents (Alalor et al., 2012), thus, plants still remain the most effective and cheapest alternative sources of drugs for management of diseases.

*Strophanthus sarmentosus* DC (Apocynaceae), is commonly found in tropical Africa. Many species of

*Strophanthus* possess anti-venom, anti-arthritis, anti-pyretic, emetics, anti-rheumatism and diuretic properties (Onotu et al., 2014). One of the active constituents of *Strophanthus* species is strophanthin which is used as a cardiac stimulant and is comparable to and recommended as a therapeutic substitute of digitalis (Agbaje and Ajidahun, 2011).

Bioassay-guided fractionation of an ethanol extract of *Strophanthus boivinii* afforded six cardenolide glycosides-boivinides, as well as four known cardenolide glycosides, digitoxigenin 3-*O*-[β-D-glucopyrananosyl-(1,4)-α-L-acofriopyranoside], corotoxigenin 3-*O*-β-D-boivinoside, 17 α-corotoxigenin 3-*O*-β-D-sarmentoside, and uzarigenin 3-*O*-α-L-rhamnoside. The structures of these compounds were elucidated by various 1D and 2D NMR techniques. All the compounds showed significant antiproliferative activity against the A2780 human ovarian cancer cell line, with boivinide A being the most active at IC<sub>50</sub> of 0.17 mM (Karkare et al., 2007).

There is limited information in the literature on the biological activities and chemical constituents of

*Strophanthus sarmentosus*, hence, this study was aimed at investigating the phytochemical constituents, antimicrobial and cytotoxic activity of the leaf, stem and root extracts of the plant against some pathogenic bacteria and fungi as well as determine its cytotoxic level.

## MATERIAL AND METHODS

### Plant Collection and Identification

*Strophanthus sarmentosus* (leaf, stem and root) was collected from the premises of Forestry Research Institute, Ibadan, Oyo State, South-west, Nigeria (7°39'11"N, 3°85'82"E). The plant samples were identified and authenticated by Mr. D. P. O. Esimekhuie at the Herbarium of the Botany Department, University of Ibadan and voucher specimen (UIH 23178) of the plant was deposited at the herbarium of the Department for further reference.

### Plant preparation and extraction

The plant samples were air-dried for two weeks and ground. The powdered plant materials were weighed and then soaked in the solvents for at least 72 hours. The extractions were carried out successively with *n*-hexane, ethyl acetate and methanol and the extracts were recovered by filtering the solvents and concentrating on a rotator evaporator at 40°C. The concentrated extracts were kept in the desiccators for further drying.

### Phytochemical Analysis

The freshly prepared extracts were subjected to standard phytochemical tests to determine the chemical constituents such as tannins, alkaloids, flavonoids, glycosides, saponins and phenols (Hetty Manurung et al., 2019, Labiad et al., 2017).

**Test for Glycosides:** To 1 mL of the extract was added 2ml of acetic acid and then cooled in an ice bath at 40°C. To this mixture 1 mL of concentrated tetraoxosulphate (VI) acid (H<sub>2</sub>SO<sub>4</sub>) was added dropwise. The formation of an oil layer on top of solution indicated the presence of glycosides.

**Test for Alkaloides:** To 3 mL of the extract was added 1 mL of 1% HCl. This resulting mixture was then treated with few drops of Meyer's reagent. The appearance of a creamy white precipitate confirmed the presence of alkaloids.

**Test for Saponins:** Five drops of olive oil was added to 2mL of the plant extract and the mixture shaken vigorously. The formation of a stable emulsion indicated the presence of saponins (Trease and Evans, 2009)

**Test for Tannins:** Two drops of 5% FeCl<sub>3</sub> was added to 1 mL of the plant extract. The appearance of a dirty-green precipitate indicated the presence of tannins (Trease and Evans, 2009)

**Test for Flavonoids:** To 1 mL of the extract was added 3 drops of ammonia solution (NH<sub>3</sub>) followed by

0.5 mL of concentrated HCl. The resultant pale brown colouration of the entire mixture indicated the presence of flavonoids.

**Test for Steroids and Terpenoids:** To 1 mL of the plant extract was added 1 mL of concentrated tetraoxosulphate (VI) acid (H<sub>2</sub>SO<sub>4</sub>). A red coloration confirmed the presence of steroids (Trease and Evans, 2009).

### Test organisms for Antimicrobial Assay

The microorganisms used for the assay consists of three gram- positive bacteria: *Staphylococcus aureus* ATCC 29213, *Staphylococcus typhimonium* ATCC 14028 and *Bacillus subtilis* ATCC 23775: three gram- negative bacteria: *Escherichia coli* ATCC 11175, *Klebsiella pneumonia* ATCC 700303, *Pseudomonas aeruginosa* ATCC 27853 and two fungi: *Aspergillus niger* and *Candida albicans*. They were obtained from the Department of Pharmaceutical Microbiology, Faculty of Pharmacy, University of Ibadan, Nigeria.

### Determination of antimicrobial activity

Antimicrobial activity of the plant extracts was evaluated by the cup plate agar diffusion method. Bacterial cultures were adjusted to 0.5 McFarland's turbidity standard and inoculated onto MHA (Mueller Hinton Agar) plates (diameter 15 cm). Cultures of *Candida albicans* were suspended in sterile solution of 0.9% normal saline and the spores of the other filamentous fungi were suspended in tanguay buffer and then inoculated onto PDA (Potato Dextrose Agar) plates. A sterile cork borer was used to make wells of 6 mm diameter on the MHA and PDA. In each of the wells in the culture plates previously seeded with the test organisms, 100µL aliquots of extract dilutions reconstituted in minimum amount of solvent at concentrations of 50 and 100 mg/mL were applied. Methanol (50%) was used as a negative control. Wells containing 20µL aliquots of gentamicin (10 µg/mL), ketoconazole (1%) served as positive controls. Bacterial cultures were incubated at 37°C for 24 hr while the filamentous fungal cultures were incubated at 30°C for 36 hr. After incubation, antimicrobial activity was determined by measurement of the diameter of the zones of inhibition. For all the extracts, the tests were carried out in triplicates (Frempong et al., 2021).

### Determination of minimum inhibitory concentration (MICs) & minimum microbicidal concentration (MMC)

The minimum inhibitory concentration (MIC) of the methanol, ethyl acetate and hexane extracts were determined for each of the test organisms in triplicate at concentrations of 0.3125, 0.625, 1.25, 2.5, and 5 mg/mL. To obtain these concentrations, 2mL of each of the dilution from 6.25, 12.5, 25, 50, 100 mg/mL of extracts were seeded into 18 mL of molten MHA to achieve

concentrations of 0.3125, 0.625, 1.25, 2.5, and 5 mg/mL and poured into petri dishes. After the solidification of the aliquot (diluted extracts) and MHA, different test micro-organisms (isolates) were streaked on the plates of different concentration. The procedure was repeated using the standards for the control. A petri dish containing nutrient broth only was seeded with the test organisms to serve as a negative control. Petri dishes containing bacterial cultures were then incubated at 37°C for 24 hr while petri dishes containing fungal spore cultures were incubated at 30°C for 36 hr. After incubation the petri dishes were examined for microbial growth by observing for turbidity.

To determine the minimum microbicidal concentration (MMC), which includes minimum bactericidal (MBC) and minimum fungicidal concentrations (MFC), a loopful of broth was collected from those petri dishes which did not show any growth in the MIC determination and inoculated on sterile nutrient agar (NA) for bacteria and Sabouraud Dextrose agar (SDA) for fungi by streaking. To serve as a control, NA and SDA only were streaked with the respective test organisms. Plates inoculated with bacteria were then incubated at 37°C for 24 hr, while those inoculated with fungi were incubated at 30°C for 36 hr. After incubation, the concentration at which no visible growth was seen was recorded as the MBC and MFC respectively, (Taiwo et al., 2022).

### Cytotoxicity Assay

**Brine shrimp lethality** bioassay was carried out to investigate the cytotoxicity of methanol, ethyl acetate and hexane extracts of *Strophanthus sarmentosus*. Brine shrimps (*Artemia salina*) were hatched using brine eggs in a vessel filled with simulated sterile artificial sea water (brine solution) made up of sea salt (38g) in 1000mL of distilled water with the pH adjusted to 8.5 using 1 N NaOH under constant aeration for 48hr. The active shrimps were collected and used for the assay (Krishnaraju et al., 2005, Osamudiamen et al., 2020).

Brine solution (4.5 mL) was taken into each test tube. Suitable dilution of the extracts was made to give concentration from 1000, 500, 250, 125 and 62.5 µg/mL. The 0.5 mL of diluted test solution was added to each of the test tubes. Ten shrimps were added into each test tube by drawing them with glass capillary tube. The surviving shrimps were counted after 24 hr and lethality concentration LC<sub>50</sub> was assessed.

The mortality endpoint of this bioassay is defined as the absence of controlled forward motion during 30 seconds of observation. The percentage lethality of the nauplii for each concentration and control was calculated (Apu et al., 2012).

$$\% \text{ Death} = \frac{\text{Number of dead Nauplii}}{\text{Number of dead nauplii} + \text{Number of live nauplii}} \times 100$$

### Toxicity testing criteria

The toxicity of plant extracts of medicinal values expressed as LC<sub>50</sub> values is commonly valorized either by comparison to Meyer's or to Clarkson's toxicity index.

According to Meyer's toxicity index, substance with LC<sub>50</sub><1000 µg/mL are considered as toxic, while substance with LC<sub>50</sub>>1000 µg/mL are considered as non-toxic (Meyer et al., 1982). While Clarkson's toxicity criterion for the toxicity assessment of plant extracts are as follows, extract with LC<sub>50</sub> above 1000 µg/mL are non-toxic, extract with LC<sub>50</sub> between 500-1000 µg/mL are low toxic, extract with LC<sub>50</sub> between 100-500 µg/mL are medium toxic, and extract with LC<sub>50</sub> between 0-100 µg/mL are highly toxic (Clarkson et al., 2004).

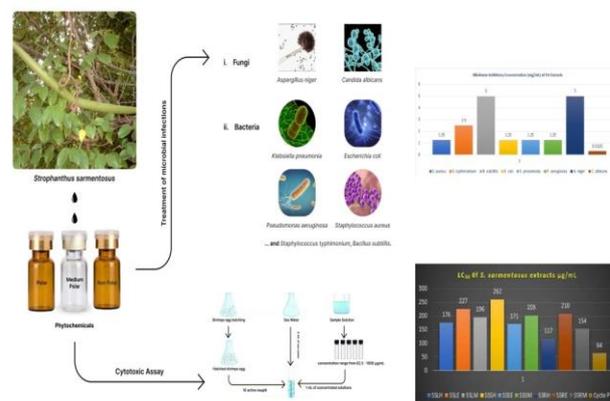


Figure 1. Research summary.

## RESULT AND DISCUSSION

### Phytochemical composition of the Extracts

The yield extracts for all the three plant parts (leaf, stem and root) are presented in Table 1. The highest (142 g) and lowest (12.4 g) yields were recorded for leaf methanol and stem hexane extracts respectively.

Table 1. Yield of Extracts of *Strophanthus sarmentosus*.

| Extracts   | Leaves (1000 g) |       |        | Stem (1600 g) |       |       | Root (1600 g) |       |       |
|------------|-----------------|-------|--------|---------------|-------|-------|---------------|-------|-------|
|            | Hex             | EA    | Met    | Hex           | EA    | Met   | Hex           | EA    | Met   |
| Weight (g) | 15.46           | 36.36 | 142.45 | 12.43         | 32.46 | 47.71 | 20.84         | 20.91 | 72.62 |
| Yield (%)  | 1.546           | 3.636 | 14.245 | 0.777         | 2.029 | 2.982 | 1.303         | 1.307 | 4.539 |

The results for the phytochemical screening are presented in Table 2. The extracts showed the presence of tannins, carbohydrates, saponins, steroids, glycosides, terpenoids, flavonoids and phenols. Bioactive compounds like tannins, steroids, flavonoids and

phenols have been reported to be used by plants for protection against bacterial and fungal infections and other pests, hence they may also be responsible for antimicrobial activity (Falodun et al., 2006).

**Table 2.** Phytochemical Screening of *Strophanthus sarmentosus* extracts.

|               | Leaves |      |      |      | Stem |      |      | Root |      |
|---------------|--------|------|------|------|------|------|------|------|------|
|               | SSLH   | SSLE | SSLM | SSSH | SSSE | SSSM | SSRH | SSRE | SSRM |
| Flavonoids    | +      | --   | --   | +    | --   | +    | +    | --   | +    |
| Saponins      | --     | --   | +    | --   | --   | ++   | -    | -    | +    |
| Phenolics     | +      | +    | --   | --   | +    | +    | --   | +    | ++   |
| Tannins       | +      | +    | --   | --   | +    | +    | --   | +    | ++   |
| Carbohydrates | +      | +    | +    | +    | +    | +    | +    | +    | +    |
| Glycosides    | --     | +    | +    | --   | +    | +    | --   | -    | +    |
| Alkaloids     | +      | +    | +    | --   | +    | +    | +    | ++   | ++   |
| Steroids      | +      | +    | +    | +    | +    | +    | +    | +    | +    |
| Terpenoids    | +      | +    | --   | +    | +    | +    | +    | +    | --   |

**Legend:** SSLH: *Strophanthus sarmentosus* leaves hexane, SSLE: *Strophanthus sarmentosus* leaves ethyl acetate, SSLM: *Strophanthus sarmentosus* leaves methanol, SSSH: *Strophanthus sarmentosus* stem hexane, SSSE: *Strophanthus sarmentosus* stem ethyl acetate, SSSM: *Strophanthus sarmentosus* stem methanol, SSRH: *Strophanthus sarmentosus* root hexane, SSRE: *Strophanthus sarmentosus* root ethyl acetate, SSRM: *Strophanthus sarmentosus* root methanol, +: Mildly present, ++: Highly present.

### Antimicrobial activities

The *in-vitro* antimicrobial activity of the *Strophanthus sarmentosus* extracts (leaf, stem and root) are presented in Table 3. The highest susceptible pathogenic microorganisms against the extracts were *Candida albicans*, *Staphylococcus typhimonium*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* while the least susceptible were *Klebsiella pneumonia* and *Bacillus subtilis*. All the extracts demonstrated considerable activity against both gram negative and gram positive bacteria and the fungi tested. The MIC and MMC of the extracts ranged between 0.3 and >5 mg/mL as shown in Table 3. The stem methanol (SSSM) and root ethyl acetate (SSRE) extracts were the most active of all the extracts and their activity are comparable to the standard antimicrobial agents used (Table 3). Secondary metabolites present in plants have been reported to be responsible for their therapeutic activity (Fabry et al., 1998). Flavonoids and other phytochemical constituents of the plant also have antimicrobial properties and this is in agreement with Singh and Bhat, (2003), which reported that flavonoids are responsible for the antimicrobial activity associated with some

ethnomedicinal plants. The results highlight the fact that the methanol and ethyl acetate extracts exhibited greater antimicrobial activity because the antimicrobial principles were either polar or moderately-polar compounds. This observation agrees with the report in the literature that organic solvents are more suitable for extraction of phytochemicals (Singh and Singh, 2000). Low MIC is an indication of high efficacy of the plant extract while high MIC may indicate low efficacy or possible development of resistance by the microorganisms (Shanmugam et al., 2008). The presence of glycosides and alkaloids in the plant extracts may be attributed to their use by traditional medicine practitioners in healthcare systems in the treatment of some bacterial infections such as, venereal diseases, and other diseases (Onotu et al., 2014; Agbaje and Ajidahun, 2011). Despite the significant progress made in the development of antimicrobial drugs and the control of microorganisms, high level of epidemics due to drug resistant microorganisms still pose an enormous threat to public health. Thus, the use of medicinal plants for antimicrobial activities needs to be given more attention.

**Table 3.** Antimicrobial activities of extracts (DZI, mm) of *Strophanthus sarmentosus* extracts.

| Extracts  | Test Pathogens / Concentration (mg/mL) / Zone of Inhibition (mm) |    |             |    |             |    |             |    |             |    |             |    |             |    |             |    |
|-----------|--|----|-------------|----|-------------|----|-------------|----|-------------|----|-------------|----|-------------|----|-------------|----|
|           | <i>S. a</i>  |    | <i>S. t</i> |    | <i>B. s</i> |    | <i>E. c</i> |    | <i>K. p</i> |    | <i>P. a</i> |    | <i>A. n</i> |    | <i>C. a</i> |    |
|           | 100  | 50 | 100         | 50 | 100         | 50 | 100         | 50 | 100         | 50 | 100         | 50 | 100         | 50 | 100         | 50 |
| SSLH      | 12   | 10 | 14          | 12 | -           | -  | -           | -  | -           | -  | 16          | 12 | -           | -  | -           | -  |
| SSLE      | 12   | 10 | 12          | 10 | 14          | 12 | -           | -  | -           | -  | 16          | 14 | 14          | 12 | 16          | 14 |
| SSLM      | 10   | 10 | 12          | 10 | 14          | 10 | 10          | 10 | 18          | 16 | -           | -  | 14          | 10 | 18          | 16 |
| SSSH      | 14   | 10 | 14          | 12 | 10          | -  | 16          | 12 | 10          | 10 | 14          | 10 | 18          | 12 | 16          | 14 |
| SSSE      | 16   | 12 | 12          | 10 | 12          | 10 | 14          | 10 | 12          | 10 | 14          | 12 | 14          | 12 | 14          | 12 |
| SSSM      | 14   | 12 | 18          | 14 | 16          | 14 | 18          | 16 | 14          | 12 | 20          | 14 | 20          | 14 | 18          | 16 |
| SSRH      | 10   | -  | -           | -  | -           | -  | 10          | 10 | 12          | 10 | -           | -  | -           | -  | 14          | 12 |
| SSRE      | 12   | 10 | 16          | 10 | 14          | 10 | 12          | 10 | 12          | 10 | 14          | 12 | 18          | 12 | 20          | 16 |
| SSRM      | -  | -  | 12          | -  | 14          | 12 | 14          | 10 | 12          | 10 | -           | -  | 14          | 10 | 16          | 12 |
| Met (50%) | -  | -  | -           | -  | -           | -  | -           | -  | -           | -  | -           | -  | -           | -  | -           | -  |
| Standards | Gent.  | 18 | 18          | 20 | 16          | 22 | 14          | NA | NA          | NA | NA          | NA | NA          | NA | NA          | NA |
|           | Ket.   | NA | NA          | NA | 16          | 14 | NA          | NA |

**Legend:** DZI: Diameter of Zone of Inhibition, **SSLH:** *Strophanthus sarmentosus* leaves hexane, **SSLE:** *Strophanthus sarmentosus* leaves ethyl acetate, **SSLM:** *Strophanthus sarmentosus* leaves methanol, **SSSH:** *Strophanthus sarmentosus* stem hexane, **SSSE:** *Strophanthus sarmentosus* stem ethyl acetate, **SSSM:** *Strophanthus sarmentosus* stem methanol, **SSRH:** *Strophanthus sarmentosus* root hexane, **SSRE:** *Strophanthus sarmentosus* root ethyl acetate, **SSRM:** *Strophanthus sarmentosus* root methanol, -Ve Control (Met 50%): Methanol 50%, +Ve Control = Gent.: Gentamycin (10 µg/mL), Ket.: Ketoconazole (1%), NA: Not Applicable, -- = No zone of inhibition.

**Table 4.** Minimum Inhibitory Concentration (MIC) (mg/mL) of *Strophanthus sarmentosus* extracts.

| Extracts | Test Pathogens |             |             |             |             |             |             |             |
|----------|----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|          | <i>S. a</i>    | <i>S. t</i> | <i>B. s</i> | <i>E. c</i> | <i>K. p</i> | <i>P. a</i> | <i>A. n</i> | <i>C. a</i> |
| SSLH     | 0.625          | >5.0        | >5.0        | 1.3125      | 2.50        | 0.625       | 5.0         | 0.625       |
| SSLE     | 2.50           | 2.50        | 2.50        | 0.3125      | 2.5         | 2.5         | 2.5         | 2.5         |
| SSLM     | 2.50           | 2.50        | 5.0         | 0.3125      | 5.0         | 5.0         | 1.3         | 5.0         |
| SSSH     | 2.50           | 5.0         | 5.0         | 2.50        | 1.25        | 1.25        | 5.0         | 5.0         |
| SSSE     | 2.50           | 2.50        | 2.50        | 2.50        | 2.50        | 2.50        | 2.50        | 2.50        |
| SSSM     | 0.3125         | 0.625       | 0.3125      | 0.6125      | <0.3125     | <0.3125     | 0.3125      | 0.3125      |
| SSRH     | 2.50           | 5.0         | >5.0        | 1.25        | 1.25        | 0.3125      | >5.0        | 2.5         |
| SSRE     | 1.25           | 2.50        | 5.0         | 1.25        | 1.25        | 1.25        | 5.0         | 0.3125      |
| SSRM     | 2.50           | 5.0         | >5.0        | 2.50        | 2.50        | 2.50        | 5.0         | 5.0         |

**Legend:** **SSLH:** *Strophanthus sarmentosus* leaves hexane, **SSLE:** *Strophanthus sarmentosus* leaves ethyl acetate, **SSLM:** *Strophanthus sarmentosus* leaves methanol, **SSSH:** *Strophanthus sarmentosus* stem hexane, **SSSE:** *Strophanthus sarmentosus* stem ethyl acetate, **SSSM:** *Strophanthus sarmentosus* stem methanol, **SSRH:** *Strophanthus sarmentosus* root hexane, **SSRE:** *Strophanthus sarmentosus* root ethyl acetate, **SSRM:** *Strophanthus sarmentosus* root methanol,

**Table 5.** Minimum Microbicidal Concentration (MMC) (mg/mL) of *Strophanthus sarmentosus* extracts.

| Extracts    | Test Pathogens |             |             |             |             |             |             |             |
|-------------|----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|             | <i>S. a</i>    | <i>S. t</i> | <i>B. s</i> | <i>E. c</i> | <i>K. p</i> | <i>P. a</i> | <i>A. n</i> | <i>C. a</i> |
| <b>SSLH</b> | 0.625          | >5.0        | >5.0        | 1.25        | 2.50        | 2.50        | >5.0        | >5.0        |
| <b>SSLE</b> | 5.0            | 5.0         | 5.0         | 5.0         | 5.0         | 2.50        | 5.0         | 5.0         |
| <b>SSLM</b> | 5.0            | 5.0         | 5.0         | 1.25        | 5.0         | 5.0         | 5.0         | 5.0         |
| <b>SSSH</b> | 5.0            | 5.0         | 5.0         | 2.50        | 1.25        | 5.0         | 5.0         | 5.0         |
| <b>SSSE</b> | 2.50           | 2.50        | 2.50        | 2.50        | 2.50        | 5.0         | 5.0         | 2.50        |
| <b>SSSM</b> | 0.3125         | 5.0         | 0.3125      | 2.50        | 0.3125      | 0.625       | 0.625       | 1.25        |
| <b>SSRH</b> | 2.50           | 5.0         | >5.0        | 5.0         | 2.50        | 1.25        | >5.0        | 2.50        |
| <b>SSRE</b> | 5.0            | 2.50        | 5.0         | 1.25        | 1.25        | 1.25        | 5.0         | 0.625       |
| <b>SSRM</b> | 5.0            | 5.0         | >5.0        | 5.0         | 2.50        | 5.0         | 5.0         | 5.0         |

**Legend:** **SSLH:** *Strophanthus sarmentosus* leaves hexane, **SSLE:** *Strophanthus sarmentosus* leaves ethyl acetate, **SSLM:** *Strophanthus sarmentosus* leaves methanol, **SSSH:** *Strophanthus sarmentosus* stem hexane, **SSSE:** *Strophanthus sarmentosus* stem ethyl acetate, **SSSM:** *Strophanthus sarmentosus* stem methanol, **SSRH:** *Strophanthus sarmentosus* root hexane, **SSRE:** *Strophanthus sarmentosus* root ethyl acetate, **SSRM:** *Strophanthus sarmentosus* root methanol,

### Cytotoxic activities

The cytotoxic activities of the plant extracts are presented in Table 6. This study determined that the extent of lethality was proportional to the concentration of the extract. After 24 hr all the shrimps survived in the control and maximum mortalities were recorded at a concentration of 1000 µg/mL for all the extracts while at 62.5 µg/mL, zero percent death are recorded in the extracts except for stem hexane extract (SSSH) and root ethyl acetate extract of (SSRE) which were 24% and 27% respectively. However, It was observed that in higher concentrations of the extracts the shrimps were

dying after 10 hr and most of all the shrimps died after 24 hr. Also, the LC<sub>50</sub> is presented in Table 7. All the extracts had LC<sub>50</sub> values between 117 µg/mL and 270 µg/mL, which show that the LC<sub>50</sub> of all the extracts are within the medium toxic level according to Clarkson's toxicity index (Clarkson et al., 2004). The presence of alkaloids, tannins and flavonoids could be responsible for their cytotoxic properties (Osamudiamen et al., 2020). However, the standard drug, cylophosphamide used for the treatment of cancer diseases, had a LC<sub>50</sub> value of 64 µg/mL. Thus, the plant extracts demonstrated moderate cytotoxic activities.

**Table 6.** Cytotoxic Activity of *Strophanthus sarmentosus* against Nauplii.

| Plant extracts | Concentration (µg/mL) | Number of Surviving Nauplii (After 24 hr) |    |    | Total Number of Nauplii Survivors | % Mortality | LC <sub>50</sub> (µg/mL) |
|----------------|-----------------------|---|----|----|-----------------------------------|-------------|--------------------------|
|                |                       | T1  | T2 | T3 |                                   |             |                          |
| SSLH           | 62.5                  | 9   | 10 | 9  | 28                                | 0±0.333     | 176.1±0.54               |
|                | 125                   | 8   | 7  | 7  | 22                                | 31.58±0.33  |                          |
|                | 250                   | 5   | 6  | 6  | 17                                | 73.68±0.89  |                          |
|                | 500                   | 3   | 4  | 5  | 12                                | 84.21±0.58  |                          |
|                | 1000                  | 1   | 0  | 2  | 3                                 | 100±0.58    |                          |
| SSLE           | 62.5                  | 9   | 10 | 9  | 28                                | 0±0.333     | 226.9±0.48               |
|                | 125                   | 8   | 9  | 7  | 24                                | 19.05±0.58  |                          |
|                | 250                   | 4   | 5  | 6  | 15                                | 61.91±0.58  |                          |
|                | 500                   | 4   | 3  | 5  | 12                                | 76.19±0.58  |                          |
|                | 1000                  | 2   | 2  | 2  | 6                                 | 100±0.58    |                          |
| SSLM           | 62.5                  | 7   | 7  | 8  | 22                                | 0±0.333     | 195.7±0.27               |
|                | 125                   | 5   | 6  | 6  | 17                                | 23.81±0.33  |                          |
|                | 250                   | 3   | 3  | 3  | 9                                 | 66.67±0.33  |                          |
|                | 500                   | 1   | 2  | 1  | 4                                 | 90.48±0.00  |                          |
|                | 1000                  | 0   | 1  | 1  | 2                                 | 100±0.33    |                          |
| SSSH           | 62.5                  | 8   | 9  | 8  | 25                                | 23.81±0.33  | 261.6±0.33               |
|                | 125                   | 7   | 6  | 6  | 19                                | 40±0.33     |                          |
|                | 250                   | 5   | 4  | 5  | 14                                | 52.38±0.33  |                          |
|                | 500                   | 4   | 3  | 4  | 11                                | 66.67±0.33  |                          |
|                | 1000                  | 0   | 1  | 1  | 2                                 | 100±0.33    |                          |
| SSSE           | 62.5                  | 10  | 9  | 9  | 28                                | 0±0.33      | 170.9±0.27               |
|                | 125                   | 5   | 5  | 6  | 16                                | 40±0.33     |                          |
|                | 250                   | 3   | 3  | 4  | 10                                | 68±0.33     |                          |
|                | 500                   | 1   | 1  | 2  | 4                                 | 88±0.33     |                          |
|                | 1000                  | 0   | 0  | 1  | 1                                 | 100±0.33    |                          |
| SSSM           | 62.5                  | 6   | 8  | 8  | 22                                | 0±0.33      | 202.8±0.33               |
|                | 125                   | 4   | 3  | 3  | 10                                | 30.77±0.33  |                          |
|                | 250                   | 2   | 2  | 1  | 5                                 | 69.23±0.33  |                          |
|                | 500                   | 2   | 2  | 1  | 5                                 | 69.23±0.33  |                          |
|                | 1000                  | 0   | 1  | 0  | 1                                 | 100±0.33    |                          |
| SSRH           | 62.5                  | 8   | 9  | 9  | 27                                | 0±0.33      | 117.4±0.33               |
|                | 125                   | 5   | 9  | 5  | 24                                | 27.27±0.33  |                          |
|                | 250                   | 3   | 4  | 4  | 11                                | 63.64±0.33  |                          |
|                | 500                   | 3   | 2  | 3  | 8                                 | 77.27±0.33  |                          |
|                | 1000                  | 0   | 1  | 0  | 1                                 | 100±0.33    |                          |
| SSRE           | 62.5                  | 7   | 8  | 9  | 24                                | 27.27±0.58  | 209.5±0.50               |
|                | 125                   | 6   | 5  | 7  | 18                                | 42.11±0.58  |                          |
|                | 250                   | 4   | 2  | 4  | 10                                | 63.64±0.67  |                          |
|                | 500                   | 3   | 2  | 2  | 7                                 | 77.27±0.33  |                          |
|                | 1000                  | 0   | 1  | 1  | 2                                 | 100±0.33    |                          |

|                 |                |      |   |   |    |            |            |            |
|-----------------|----------------|------|---|---|----|------------|------------|------------|
|                 | 62.5           | 7    | 5 | 7 | 17 | 0±0.33     |            |            |
| <b>SSRM</b>     | 125            | 4    | 4 | 3 | 11 | 42.11±0.58 | 153.5±0.27 |            |
|                 | 250            | 2    | 2 | 1 | 5  | 73.68±0.33 |            |            |
|                 | 500            | 0    | 0 | 0 | 0  | 100±0.33   |            |            |
|                 | 1000           | 0    | 0 | 0 | 0  | 100±0.33   |            |            |
| <b>Standard</b> | 62.5           | 6    | 6 | 7 | 19 | 40±0.02    |            |            |
|                 | <b>CYCLO P</b> | 125  | 4 | 6 | 5  | 15         | 60±0.02    | 63.82±0.33 |
|                 |                | 250  | 3 | 3 | 3  | 9          | 70.68±0.02 |            |
|                 |                | 500  | 2 | 2 | 3  | 7          | 75±0.05    |            |
|                 |                | 1000 | 2 | 2 | 1  | 5          | 80±0.01    |            |

**Legend:** **SSLH:** *Strophanthus sarmentosus* leaves hexane, **SSLE:** *Strophanthus sarmentosus* leaves ethyl acetate, **SSLM:** *Strophanthus sarmentosus* leaves methanol, **SSSH:** *Strophanthus sarmentosus* stem hexane, **SSSE:** *Strophanthus sarmentosus* stem ethyl acetate, **SSSM:** *Strophanthus sarmentosus* stem methanol, **SSRH:** *Strophanthus sarmentosus* root hexane, **SSRE:** *Strophanthus sarmentosus* root ethyl acetate, **SSRM:** *Strophanthus sarmentosus* root methanol, **CYCLO:** Cyclophosphamide.

**Table 7.** Cytotoxic Activity (LC50) of *Strophanthus sarmentosus* extracts.

| Samples | LC <sub>50</sub> |
|---------|------------------|
| SSLH    | 176.1±0.54       |
| SSLE    | 226.9±0.479      |
| SSLM    | 195.7±0.266      |
| SSSH    | 261.6±0.333      |
| SSSE    | 170.9±0.266      |
| SSSM    | 202.8±0.333      |
| SSRH    | 117.4±0.333      |
| SSRE    | 209.5±0.497      |
| SSRM    | 153.5±0.267      |
| CYCLO P | 63.82±0.02       |

**Legend:** **SSLH:** *Strophanthus sarmentosus* leaves hexane, **SSLE:** *Strophanthus sarmentosus* leaves ethyl acetate, **SSLM:** *Strophanthus sarmentosus* leaves methanol, **SSSH:** *Strophanthus sarmentosus* stem hexane, **SSSE:** *Strophanthus sarmentosus* stem ethyl acetate, **SSSM:** *Strophanthus sarmentosus* stem methanol, **SSRH:** *Strophanthus sarmentosus* root hexane, **SSRE:** *Strophanthus sarmentosus* root ethyl acetate, **SSRM:** *Strophanthus sarmentosus* root methanol, **LC:** Lethal Concentration, **CYCLOP:** Cyclophosphamide

## CONCLUSION

The inhabitants of sub-sahara Africa have been using numerous herbs for therapeutic purpose since time immemorial to cure all forms of diseases like diarrhea, jaundice, rheumatism, dyspepsia, asthma, diabetes, dysentery, gonorrhoea and skin infections. The current investigation evaluated for the first time antimicrobial and cytotoxic potentials of *Strophanthus sarmentosus*. The plant extracts showed potent antimicrobial and moderate cytotoxic activities with ethyl acetate and methanol extracts of the stem and root of the plant displaying higher activities than the other extracts. These results authenticate the traditional use of *Strophanthus sarmentosus* for the treatment of various diseases (Onotu et al., 2014; Agbaje and Ajidahun, 2011). Further studies to characterize the bioactive constituents of *Strophanthus sarmentosus* responsible for its biological activities are in progress.

**Conflict of interest:** The authors declare that there is no conflict of interest.

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