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*Original Research Article*

# Anticancer and Antibacterial Activities of *Solanum aethiopicum* L., *Solanum macrocarpon* L. and *Garcinia kola* Heckel

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ABSTRACT

Cancer and infectious diseases are among the top ten leading causes of death in developing countries. The discovery and development of newer agents for combating these global health problems cannot be overemphasized. This study was designed to investigate the activities of extracts of *Solanum aethiopicum*, *Solanum macrocarpon* and *Garcinia kola* on cancer and antibacterial pathogens. The Agar well diffusion method was used to evaluate antibacterial activity of the extracts. *In vitro* anticancer activity against cervical cancer (HeLa), breast cancer (MCF-7) and epidermoid carcinoma of the larynx (HEp-2) was done by microscopic evaluation of morphology and by determination of 50% cytotoxic concentrations ($CC_{50}$). The $CC_{50}$ of ethyl acetate extracts of *Solanum aethiopicum* and *Solanum macrocarpon* against MCF-7 were 38.79 µg/mL and 41.30 µg/mL respectively, and were significantly lower ($p < 0.05$) compared to the $CC_{50}$ of the other extracts. Dichloromethane extract of *Garcinia kola* was significantly cytotoxic ($p<0.05$) on cervical cancer ($CC_{50}$ = 38.13 µg/mL) compared to DCM extracts from *Solanum aethiopicum* and *Solanum macrocarpon*. The minimum concentration of methanol extracts of *Solanum aethiopicum*, *Solanum macrocarpon* and *Garcinia kola* that inhibited the growth of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Klebsiella pneumoniae* was 1.56 mg/mL. *Solanum aethiopicum*, *Solanum macrocarpon* and *Garcinia kola* extracts demonstrated significant ($p < 0.05$) anticancer and antibacterial activities and as such are promising sources of novel plant-derived anticancer and antibacterial drugs.

***Keywords*:** Antimicrobial activity, Cancer, Cytotoxic, *Solanum aethiopicum*, *Solanum macrocarpon*, *Garcinia kola.*



## Introduction

Cancer, a global health challenge is characterised by rapid unregulated abnormal cell growth. [1] About 70% of cancer related-deaths occur in developing countries which are characterized by low and medium income.[1] Of these deaths, 25% are predominantly caused by cancer causing-infections notably, human papilloma virus that causes cervical cancer.[2] In Nigeria, the incidences of breast and cervical cancers are by far higher in comparison to other types of cancers.[3] Plant-derived compounds play important role in the discovery and development of a number of clinically useful drugs including anticancer agents. Typical examples of such drugs are; vincristine and vinblastine (vinca alkaloids), topotecan and irinotecan (camptothecin derivatives), etoposide and teniposide (podophyllotoxin derivatives) and paclitaxel a taxane alkaloid derivative.[4] However, the rising trend of multi-drug resistant cancers and bacteria necessitates intensified research to finding newer anticancer and antibacterial agents that are clinically effective, and possibly with novel mechanism of action. Preparations from the fruits and leaves of *Solanum aethiopicum* L. (*S. aethiopicum*) and *Solanum macrocarpon* L (*S. macrocarpon*) are used in traditional medicine as sedatives, antiulcer, anti-infective and anti-inflammatory agents.[5]

*Garcinia kola* found in parts of Nigeria is used in traditional medicinal for their antitumour, antimicrobial antiparasitic activities amongst several others.[6] However, there is paucity of scientific information on anticancer and antibacterial studies of these edible vegetables. It is on this note that this study was designed to investigate the activity of extracts of *Solanum aethiopicum*, *Solanum macrocarpon* and *Garcinia kola* on two cancers of significance in Nigeria; breast and cervical cancers, and epidermoid carcinoma of the larynx cancer, and to also evaluate their antibacterial activity.

## Materials and Methods

*Plant collection and extraction*

*Solanum aethiopicum* L., *Solanum macrocarpon* L. and *Garcinia kola* Heckel used for the study were obtained from a commercial market, at Bodija, Ibadan, Nigeria in August of 2019 and taken for authentication and identification at Forestry Research Institute of Nigeria (FRIN). The voucher numbers of the specimens deposited were; *Solanum aethiopicum* (112878), *Solanum macrocarpon* (112879) and *Garcinia kola* (112880). Air-dried pulverized plant materials (500 g each) were extracted by successive maceration in 3 L of n-hexane, dichloromethane, ethyl acetate and methanol for 72 h at room temperature. The extracts were filtered and concentrated using a rotary evaporator at 40ºC. Dried extracts were stored in the refrigerator (4ºC) until needed for bioassay.

*Qualitative phytochemical screening of extracts*

Phytochemical analysis of each of the extracts was carried out to determine the presence or otherwise of tannins, saponins, flavonoids, terpenoids, alkaloids, cardiac glycosides and anthraquinones as described by Oluremi *et al*.[7]

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*Preparation of cell culture for cytotoxicity assay*

Cytotoxicity on HeLa, HEP-2 and MCF-7 cells (CDC, Atlanta Georgia) provided by WHO polio laboratory, Department of Virology, University of Ibadan, Nigeria was investigated. Cells were grown in Eagle's MEM supplemented with 10% foetal bovine serum (FBS), 100 units/mL of penicillin, 100 units/mL of streptomycin, 2 mM/L glutamine, 0.07% $NaHCO_3$ and 1% non-essential amino acids and vitamin solution. For cytotoxicity assays, 10% or 2% of FBS was used in the growth and maintenance medium respectively. Cells were grown in sterile 96-well microplate and incubated at 37$^oC$ for 48 hour in a 5% $CO_2$ incubator to give 80% confluent monolayer.

*Determination of cytotoxicity by microscopy and 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) colorimetric assay*

Briefly, 100 µL of different concentrations of each extract prepared by ten-fold serial dilutions of the extract in the maintenance medium were separately added to 80% confluent cell lines, and then incubated at 37 $^oC$ for 48 hours in a humidified 5% $CO_2$ incubator. Six concentrations, 100-0.001 µg/mL were used to carry out the test in triplicate wells for each concentration. A row of untreated cells represented positive control to confirm cell viability. After incubation period, the morphology of the cells was observed by viewing under an inverted light microscope. Observation was recorded as graded scores representing 100%, 75%, 50% and 25% loss of cellular of morphology. Data generated was analyzed and presented graphically. Subsequently, the cells were washed with sterile phosphate buffered saline (PBS) and the anticancer activity of the extracts determined using MTT colorimetric assay. [8] A 25 µL volume of 2 mg/mL MTT (Sigma) solution in PBS was added into each well, and incubated for 2 h at 37$^oC$. Thereafter, 125 µL of dimethylsulfoxide (DMSO) was added to dissolve the formazan crystals. The plates were incubated on a bench-top shaker and gently shaken for about fifteen minutes. The optical density (OD) was read at a wavelength of 540 nm on a multiwell spectrophotometer (Multiscan 347, MTX lab) and the percentage cytotoxicity calculated by the expression= $[\frac{A-B}{A} x\ 100]$. A represents the mean optical density of untreated cells, while B is the mean optical density of cells treated with the extracts.

*Antimicrobial screening of extracts*

A modification of agar-well diffusion method was used to screen the extracts for antibacterial activity as described by Oluremi *et al*.[7] Pure cultures of selected bacteria strains were obtained from Pharmaceutical Microbiology laboratory, Faculty of Pharmacy, University of Ibadan, Nigeria. A 0.5 mL of a standardised overnight culture was used to inoculate a 19.5 mL molten nutrient agar, which was transferred into a sterile petri dish and allowed to set. Equidistant wells were made with a sterile cork-borer (6 mm diameter) in the agar plates and 0.1 mL of different concentrations of the extracts prepared by two-fold dilution from 200 mg/mL to 12.5 mg/mL was added to each well. Gentamicin at 10 µg/mL concentration and the solvent served as positive and negative controls, respectively. The plates were left on bench for 60 minutes to allow for diffusion of extracts after which they were incubated at 37 °C for 24 hours. Zones of bacterial growth inhibition by the extracts and the controls were measured and averages recorded**.** The test was carried out in duplicates.

*Determination of minimum inhibitory concentration (MIC) of extracts*

A modification of agar dilution method was used to determine the MIC of the extracts that showed significant antibacterial activity on the selected microorganisms. 7 A 2 mL volume of different concentrations of the extracts were added separately to universal bottles containing 18 mL of cooled molten Muller Hilton agar (60$^oC$) to give final concentrations of ranging from 1.563-50 mg/mL, prepared by doubling dilution. The mixture was shaken and poured into sterile petri dishes and allowed to set. The test organisms were swabbed on the surface of the prepared agar and the plates were then incubated at 37$^oC$ for 24 hours. Thereafter, the plates were examined for the presence or absence of microbial growth. The lowest concentration of the extracts that inhibited an observable growth of microorganisms was recorded as the MIC.

*Statistical analysis*

Data generated from the study was subjected to descriptive statistics and also analyzed for concentration at which 50% of the cell population was killed from dose-response inhibition curves using GraphPad prism version 6. Level of statistical significance, $\alpha$= 0.05.

## Results and Discussion

*Phytochemical profile of S. aethiopicum, S. macrocarpon* and *G. kola*

Phytochemical screening of extracts of *S. aethiopicum* and *S. macrocarpon* showed traces of anthraquinones, terpenoids, alkaloids and cardiac glycosides in the hexane and dichloromethane extracts. The secondary metabolites detected in the various extracts of *Solanum* species observed in this study corroborates with the findings of Eletta *et al*,[9] who reported similar chemical constituents in these species of Solanum. In this study, alkaloid was detected in methanol extract of *S. macrocarpon*, but not in *S. aethiopicum*. This observation differs from that of Ossamulu *et al*,[10] who detected the presence of alkaloids amongst other phytochemicals in methanol extracts of *S. aethiopicum* and *S. macrocarpon*. Environmental factors such as differences in growing condition, duration of sunshine and geography, annual mean rainfall and temperatures reported to influence the production of secondary metabolites may account for the variations in the phytochemicals detected in this study compared to those of other studies.[11] in addition, the methanol and ethyl acetate extracts of *G. kola* tested positive for saponins, tannins, flavonoids, alkaloids, terpenoids, cardiac glycosides and anthraquinones. The result in this study agrees with Ibedu *et al*, [12] who also reported the presence of these metabolites in aqueous extract of *G. kola*, suggestive of effects similarity of the polarity of solvents used for the extraction.

*Cytotoxic effects of S. aethiopicum, S. macrocarpon* and *G. kola*

In Nigeria, breast and cervical are the most common types of cancers, [3] and the discovery of new chemotherapeutic agents for the treatment of these cancers would be of great health benefit. The cytotoxic effects of hexane, dichloromethane, ethyl acetate and methanol extracts of *S. aethiopicum, S. macrocarpon* and *Garcinia kola* on breast, cervical cancers and epidermoid carcinoma of the larynx was investigated. All the extracts exhibited 100% anticancer activity on HeLa, HEp-2 and MCF-7, causing total inhibition of cell viability at 100 µg/mL observed as complete alteration of cell morphologically under the microscope is shown, Figures 1a,b and c. The control, 0.02% dimethyl sulphoxide (DMSO) was not cytotoxic to any of the cell lines at all, representing zero percent inhibition. Dead cells were observed as cells with abnormal morphology, comparing the morphology of the treated cancer cell cultures with the control. Methanol extract of *S. aethiopicum* and *S. macrocarpon* consistently inhibited MCF-7 and HEp-2 cells, compared to inhibition of HeLa cells, Figures 1a,b and c. The concentration of the extract that was cytotoxic to 50% ($CC_{50}$) of the cell lines calculated from the optical density of eluted MTT after incubation of confluent cell lines with or without the extracts is shown in Table 1. The $CC_{50}$ value of hexane extract of *S. aethiopicum* on HEp-2 cells was 47.97 µg/mL, and was not significantly different ($p>0.05$), compared to the $CC_{50}$ value of hexane extract of *S. macrocarpon*, 55.29 µg/mL. The $CC_{50}$ value of hexane extracts of the *S.* species on MCF-7 were also not significantly different ($p > 0.05$). The similarity in the magnitude of activity of hexane extract of *Solanum* species on epidermoid cancinoma and breast cancer cells lines suggests that the chemical constituents of the two *Solanum* species are similar. The ethyl acetate extracts of the two *Solanum* species exhibited similar magnitude of anti-breast cancer (MCF-7) activity with $CC_{50}$ of 38.79 and 41.30 µg/mL and significantly higher ($p<0.05$), compared to the $CC_{50}$ of extracts of the two *Solanum* species from other solvent systems, Table 1. Resistant human breast cancer cells, MCF-7 reported to be sensitive to aqueous extract of *Vernonia amygdalina*, [13] were also sensitive to ethyl acetate extracts of the two *Solanum* species used in this study. The phytochemical groups in methanol extracts of *V. Amygdalina*, saponins, tannins, alkaloids and glycosides are similar to those of the ethyl acetate extracts *S. aethiopicum* and *S. macrocarpon* used for this study which may account for the cytotoxic activity of the extracts against breast cancer

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cells. Dichloromethane and hexane extracts of *G. kola* were the most active extracts on cervical cancer cells with $CC_{50}$ of 38.13 and 46.12 µg/mL respectively, and significantly lower ($p < 0.05$) compared to $CC_{50}$ of extracts obtained from *S. aethiopicum* and *S. macrocarpon* using the same solvent systems. The significant ($p < 0.05$) cytotoxic activity of the dichloromethane and hexane extracts of *G. kola* on human papilloma virus-induced cervical cancer, a cancer of clinical importance in Nigeria,[3] suggests synergistic activity due to the presence of saponins in the mixture of alkaloids and anthraquinones.

Although mechanistic study was out of the scope of this study, however, flavonoids, terpenoids and anthraquinones are reported to exhibit anticancer activities by modulating ROS-scavenging enzyme activities, arresting the cell cycle, induction apoptosis, and suppress cancer cell proliferation and invasiveness.[14] The extracts used in this study are rich anthraquinones, alkaloids and terpenoids, suggesting that the observed anticancer activity of extracts might by similar mechanisms. Furthermore, such as vinblastine, vinorelbine, vincristine and vindesine act by arresting cell proliferation during mitosis,[15] thus suggesting another possible mechanism of action of the alkaloids containing extracts used in this study.

*Antimicrobial activities of S. aethiopicum, S. macrocarpon and G. kola*

Antimicrobial potentials of *S. aethiopicum*, *S. macrocarpon* and *G. kola* against bacterial and fungal pathogens have been previously reported. [23] However, validation of the antimicrobial activity and the minimum inhibitory concentrations is sacrosanct. In this study, methanol extracts of *S. aethiopicum* and *S. macrocarpon* showed significant ($p < 0.05$) concentration dependent activity against *S. aureus*, *E. coli*, *P. aeruginosa* and *Klebsiella spp*. Table 2. Gram-negative *E. coli* was sensitive to methanol extracts of *S. aethiopicum* and *S. macrocarpon* producing diameter of zones of inhibition, 10.0-12.0 mm at 12.5 mg/mL that was comparable to the diameter of zones of inhibition of gentamicin. However, inhibition of growth of *Klebsiella spp*. by methanol extract of *S. aethiopicum* and *S. macrocarpon* was significantly high ($p<0.05$), but a fold lower than inhibition by the gentamicin used as the positive control.

The spectrum of antibacterial activity of methanol extracts of *S. aethiopicum* and *S. macrocarpon* was found to include *S. aureus* and *E. coli* which agrees with the findings of Ilodiba *et al.*[16] who reported previously reported anti-staphylococcal and anti-*E. coli* activities of methanol extract from *S. macrocarpon*. Ethyl acetate extracts of *S. aethiopicum*, *S. macrocarpon* and *G. kola* did not inhibit the growth of any of the test bacteria strains at concentrations less than 50 µg/mL.

Gram-positive *Staphylococcus aureus* and Gram-negative *E. coli*, *S. typhi*, *K. pneumoniae* and *P. aeruginosa* were sensitive to 100 µg/mL of methanol extract of *G. kola* with diameter of inhibition of growth that was not significantly different ($p < 0.05$) from the control, gentamicin. These findings largely corroborate with previous observation of Ibedu and collaborators,[12] who previously reported that *S. aureus* and *E. coli* were sensitive to methanol extract of *G. kola* with the diameter of zone of inhibition 15 and 6 mm respectively.

The lowest concentration (MIC) of methanol extract of *S. aethiopicum*, *S. macrocarpon* and *G. kola* that inhibited the growth of *S. aureus*, *E. coli*, *Ps. aeruginosa* and *Klebsiella spp* was 1.56 mg/mL. However, the MIC of methanol extract of *S. aethiopicum* against *S. typhi* was 3.13 mg/mL, Table 3. However, the MICs of sensitive test bacterial pathogens in this study are 4-6-fold lower ($p < 0.05$) than those reported by other researchers for the same organisms,[17] suggesting that the extracts used for this study exhibited more superior antimicrobial activity or that the bacterial strains were different.

The vegetables, *S. aethiopicum*, *S. macrocarpon* and *G. kola* are rich in anthraquinones, alkaloids and polyphenols which are well reported to exhibit strong *in vitro* antibacterial activity against a wide range of pathogenic microorganism.[12, 16, 17,] Therefore, the antimicrobial activity of the various extracts of *S. aethiopicum*, *S. macrocarpon* and *G. kola* against susceptible bacterial in this study can be attributed to the presence of bioactive flavonoids, anthraquinones, alkaloids present in the vegetables.

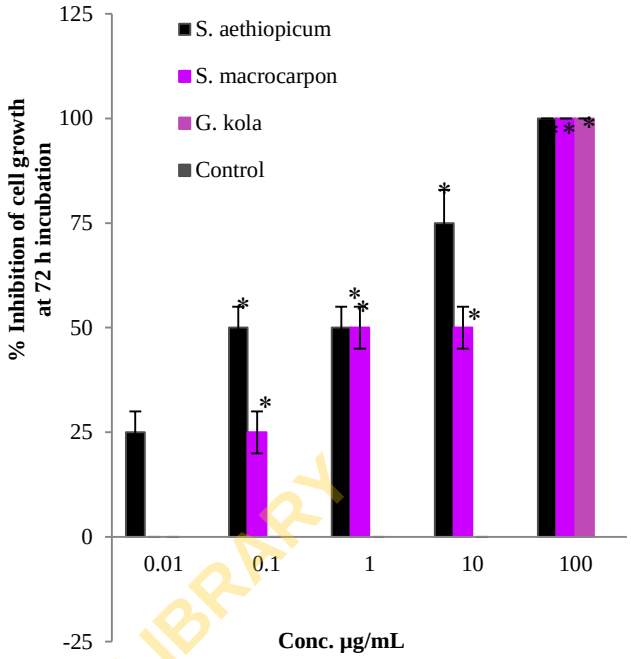


**Figure 1a:** Percentage inhibition of growth of MCF-7 treated with ethyl acetate extracts of *S. aethiopicum*, *S. macrocarpon* and *G. kola* observed under light microscope magnification x 100, error bars represent standard error of the mean, *=significantly ddifferent

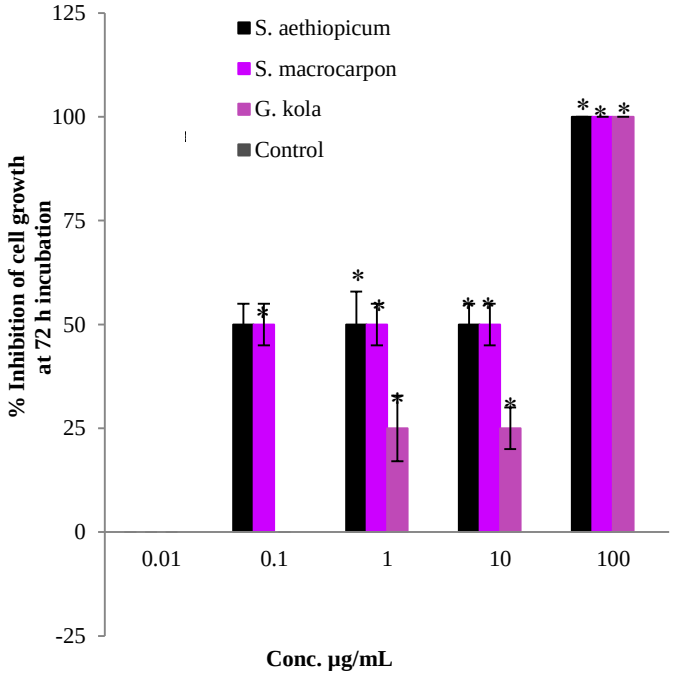


**Figure 1b**: Percentage inhibition of growth of HEp-2 cells treated with methanol extracts of *S. aethiopicum*, *S. macrocarpon* and *G. kola* observed under light microscope magnification x 100, error bars represent standard error of the mean,*= significantly different.

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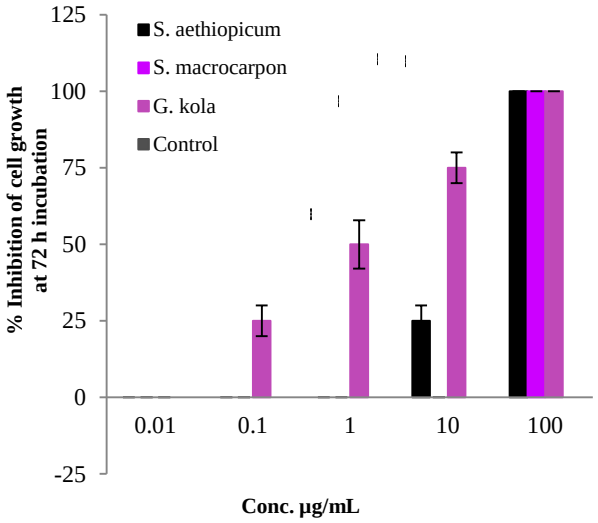


**Figure 1c:** Percentage inhibition of growth of HeLa cells treated with dichloromethane extracts of *S. aethiopicum*, *S. macrocarpon* and *G. kola* observed under light microscope magnification x 100, error bars represent standard error of the mean, *=significantly different.

**Table 1:** Cytotoxicity ($CC_{50}$) of *S. aethiopicum*, *S. macrocarpon* and *Garcinia kola* on HeLa, HEp-2 and MCF-7 cancer cells

| Plant | Extract | Concentration (µg/mL) | | |
|---|---|---|---|---|
| | | HeLa | HEp-2 | MCF-7 |
| *Solanum aethiopicum* | Hexane | 79.97 | 47.97 | 48.87 |
| | DCM | 83.03 | 56.79 | 56.86 |
| | EtoAc | 87.20 | 57.02 | 38.79 |
| | Methanol | 78.01 | 53.97 | 62.57 |
| *Solanum macrocarpon* | Hexane | 66.91 | 55.29 | 55.20 |
| | DCM | 81.56 | 52.19 | 52.18 |
| | EtoAc | 73.58 | 55.10 | 41.30 |
| | Methanol | 63.05 | 45.62 | 52.19 |
| *Garcinia kola* | Hexane | 46.12 | 62.17 | 59.08 |
| | DCM | 38.13 | 62.23 | 98.37 |
| | EtoAc | 69.60 | 60.22 | 50.49 |
| | Methanol | 65.95 | 63.95 | 46.26 |

Key: DCM = dichloromethane extract; EtoAc= ethyl acetat

**Table 2:** Zones of inhibition of bacterial growth by *S. aethiopicum*, *S. macrocarpon* and *Garcinia kola*

| Plant extracts | Microorganism | Diameter of zone of inhibition (mm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 200 (mg/mL) | 100 (mg/mL) | 50 (mg/mL) | 25 (mg/mL) | 12.5(mg/mL) | Gentamicin (10 µg/mL) |
| *Methanol S. aethiopicum* | *S. aureus* | 15.9 ± 013 | 14.0 ± 0.20 | 12.9 ± 0.25 | 11.8 ± 0.29 | 10 ± 0.09 | 16.0 ± 0.12 |
| | *E. coli* | 19.8 ± 0.17 | 18.0 ± 0.25 | 16.0 ± 0.21 | 14.9 ± 0.26 | 12.8 ± 0.21 | 11.8 ± 0.19 |
| | *P. aeruginosa* | 15.0 ± 0.23 | 13.9 ± 0.23 | 13.0 ± 0.21 | 12.0 ± 0.20 | 10.1 ± 0.09 | 15.7 ± 0.21 |
| | *Klebsiella spp.* | 15.1 ± 0.22 | 14.0 ± 0.45 | 13.2 ± 0.16 | 11.9 ± 0.23 | 10.0 ± 0.21 | 20.0 ± 0.14 |
| | *S. typhi* | 16.7 ± 0.17 | 16.0 ± 0.15 | 11.3 ± 0.22 | 10.0 ± 0.12 | NZ | 17.9 ± 0.37 |
| *Ethyl acetate S. aethiopicum* | *S. aureus* | 13 ± 0.25 | 10.0 ± 0.50 | 7.1 ± 0.17 | NZ | NZ | 15.0 ± 0.12 |
| | *E. coli* | 10 ± 0.25 | 7.9 ± 0.36 | NZ | NZ | NZ | 12.0 ± 0.29 |
| | *P. aeruginosa* | 12.9 ± 0.13 | 10.0 ± 0.50 | 7.9 ± 0.29 | NZ | NZ | 14.8 ± 0.24 |
| | *Klebsiella spp.* | 13.3 ± 0.67 | 12.0 ± 0.50 | 7.8 ± 0.22 | NZ | NZ | 20.7 ± 0.24 |
| | *S. typhi* | 12.0 ± 0.25 | 8.1 ± 0.31 | 7.0 ± 0.12 | NZ | NZ | 15.8 ± 0.24 |
| *Methanol S. macrocarpon* | *S. aureus* | 16.5 ± 0.25 | 16.0 ± 0.15 | 13.9 ± 0.08 | 10.2 ± 0.29 | 10.0 ± 0.21 | 17.0 ± 0.09 |
| | *E. coli* | 20.8 ± 0.15 | 16.0 ± 0.15 | 14.7 ± 0.21 | 11.9 ± 0.17 | 10.0 ± 0.09 | 10.0 ± 0.37 |
| | *P. aeruginosa* | 16.0 ± 0.13 | 13.8 ± 0.29 | 12.0 ± 0.12 | 11.8 ± 0.20 | 10.0 ± 0.16 | 15.0 ± 0.21 |
| | *Klebsiella spp.* | 19.9 ± 0.22 | 18.9 ± 0.32 | 13.8 ± 0.12 | 12.9 ± 0.23 | 12.0 ± 0.21 | 18.2 ± 0.24 |
| | *S. typhi* | 16.0 ± 0.38 | 15.0 ± 0.31 | 15.0 ± 0.12 | 10.3 ± 0.25 | NZ | 14.8 ± 0.28 |
| *Ethyl acetate S. macrocarpon* | *S. aureus* | 12.7 ± 0.17 | 10.0 ± 0.50 | 7.8 ± 0.17 | NZ | NZ | 16.8 ± 0.24 |
| | *E. coli* | 9.9 ± 0.20 | 7.9 ± 0.36 | NZ | NZ | NZ | 12.8 ± 0.16 |
| | *P. aeruginosa* | 12.0 ± 0.25 | 10.0 ± 0.50 | 9.0 ± 0.17 | NZ | NZ | 16.0 ± 0.16 |
| | *Klebsiella spp.* | 13.9 ± 0.13 | 10.9 ± 0.67 | 8.0 ± 0.12 | NZ | NZ | 19.0 ± 0.21 |
| | *S. typhi* | 12.0 ± 0.25 | 10.0 ± 0.50 | NZ | NZ | NZ | 14.0 ± 0.21 |
| *Methanol Garcinia kola* | *S. aureus* | 16.0 ± 0.13 | 14.0 ± 0.13 | 11.9 ± 0.09 | 12.2 ± 0.20 | 11.1 ± 0.17 | 16.8 ± 0.17 |
| | *E. coli* | 14.0 ± 0.07 | 12.0 ± 0.25 | 10.0 ± 0.21 | 10.0 ± 0.12 | NZ | 15.0 ± 0.29 |
| | *P. aeruginosa* | 20.0 ± 0.22 | 18.1 ± 0.60 | 16.0 ± 0.12 | 14.3 ± 0.30 | 12.0 ± 0.09 | 16.0 ± 0.29 |
| | *Klebsiella spp.* | 18.1 ± 0.32 | 14.8 ± 0.76 | 13.0 ± 0.16 | 11.2 ± 0.29 | 9.0 ± 0.14 | 15.0 ± 0.21 |
| | *S. typhi* | 16.1 ± 0.30 | 15.0 ± 0.12 | 13.0 ± 0.12 | 11.8 ± 0.15 | 11.2 ± 0.22 | 15.8 ± 0.12 |
| *Ethyl acetate Garcinia kola* | *S. aureus* | 10.0 ± 0.25 | 9.2 ± 0.29 | 6.9 ± 0.08 | NZ | NZ | 17.1 ± 0.17 |
| | *E. coli* | 9.3 ± 0.17 | 7.0 ± 0.50 | NZ | NZ | NZ | 15.2 ± 0.26 |
| | *P. aeruginosa* | 12.0 ± 0.25 | 10.5 ± 0.50 | 7.8 ± 0.17 | NZ | NZ | 16.0 ± 0.09 |
| | *Klebsiella spp.* | 11.7 ± 0.13 | 10.0 ± 0.50 | 8.1 ± 0.08 | NZ | NZ | 14.7 ± 0.21 |
| | *S. typhi* | 9.2 ± 0.17 | 7.0 ± 0.20 | NZ | NZ | NZ | 15.8 ± 0.16 |

Key: NZ = no zone of inhibition; data is presented as mean ±standard deviation

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**Table 3:** Minimum inhibitory concentration (MIC) of *S. aethiopicum*, *S. macrocarpon* and *G. kola* on bacterial pathogens

| Plant extract | Microorganisms | MIC (mg/mL) |
|---|---|---|
| Methanol *S. aethiopicum* | *S. aureus* | 1.56 |
| | *E. coli* | 1.56 |
| | *P. aeruginosa* | 1.56 |
| | *Klebsiella spp.* | 1.56 |
| | *S. typhi* | 3.13 |
| Methanol *S. macrocarpon* | *S. aureus* | 1.56 |
| | *E. coli* | 1.56 |
| | *P. aeruginosa* | 1.56 |
| | *Klebsiella spp.* | 1.56 |
| | *S. typhi* | 1.56 |
| Methanol *Garcinia kola* | *S. aureus* | 1.56 |
| | *E. coli* | 1.56 |
| | *P. aeruginosa* | 1.56 |
| | *Klebsiella spp.* | 1.56 |
| | *S. typhi* | 1.56 |

## Conclusion

Data generated from this study demonstrate that extracts of *S. aethiopicum* and *S. macrocarpon* and *G. kola* exhibited antibacterial activity and concentration-dependent kill on breast cancer and cervical cancer cells.

## Conflict of interest

The authors declare no conflict of interest.

## Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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