British Journal of Pharmaceutical Research
7(4): 236-246, 2015, Article no.BJPR.2015.106
ISSN: 2231-2919

SCIENCEDOMAIN *international*
www.sciencedomain.org

In-vitro Antimicrobial Potential of *Cassia* Genus – An Overview

Vinay Kumar Gupta[1*], Amit Singh[2], Asha Pathak[1], Rajesh Verma[2], Seema Dayal[3], Atul Jain[1] and Manoj Gahlot[4]

[1]Department of Pharmacology, UP Rural Institute of Medical Sciences & Research, Saifai, Etawah, India.
[2]Department of Microbiology, UP Rural Institute of Medical Sciences & Research, Saifai, Etawah, India.
[3]Department of Pathology, UP Rural Institute of Medical Sciences & Research, Saifai, Etawah, India.
[4]Department of Pharmaceutical Sciences, SGRR Institute of Science and Technology, Dehradun, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJPR/2015/17506
Editor(s):
(1) George D. Geromichalos, Department Cell Culture, Molecular Modeling and Drug Design, Symeonidion Research Center, Theagenion Cancer Hospital, Greece.
Reviewers:
(1) Anonymous, University of Naples, Italy.
(2) Ary Fernandes Junior, Microbiology and Immunology Department, São Paulo State University, Brazil.
(3) Anonymous, The University of Texas, USA.
Complete Peer review History: http://sciencedomain.org/review-history/9808

Review Article

Received 17th March 2015
Accepted 18th May 2015
Published 18th June 2015

ABSTRACT

Antibiotics are one of the most important weapons in fighting bacterial infections and have greatly benefited the health-related quality of human life since their introduction. Infectious diseases caused by microorganism are still a major threat to health, despite the tremendous progress in human medicine. Dramatic increase in microbial resistance to antimicrobial agents is well known. Such situation leads the necessity for development of new anti-microbial agents in order to treat the infectious disease in an effective manner. The Medicinal plants are considerably useful and are rich in a wide variety of secondary metabolites such as tannins, alkaloids and flavonoids, which have been found *in vitro* to have antimicrobial properties. Several attempts are continued to identify the potential antimicrobial agent from the natural resources.

**Corresponding author: Email: vinay.pharma@yahoo.co.in;*

Considering the enormous potentiality of plants as sources for antimicrobial drugs with reference to antibacterial agents, a systematic review was undertaken in the present article for antimicrobial potential of *Cassia* genus.

Keywords: Cassia; extract; MIC; antibacterial activities; antifungal.

1. INTRODUCTION

The wide use of antibiotics in the treatment of bacterial infections has led to the emergence and spread of resistant strains [1]. Increasing development of drug resistance in human pathogens as well as the appearance of side effect of synthetic drugs needs to develop new antimicrobial drugs from natural sources. Infections are increasing alarmingly and have emerged as a critical issue in hospital care outcome. Opportunistic microorganisms primarily cause nosocomial infections; and multidrug-resistant pathogens that are commonly involved in nosocomial infections are difficult to treat. Multidrug resistant infectious diseases of bacterial and fungal origin are leading killers and account for approximately 25% of global deaths [2]. There are reports of antibiotics resistance of human pathogens, to available antibiotic [3,4] .

This situation has forced to search for new antimicrobial sources like medicinal plants [5]. The bio molecules of these plants origin appears as alternative for the control of human pathogen [6]and their uses have been shown to have scientific basis, chemicals compounds found in the various species have different medicinal effects. The use of plant extracts and phytochemical with known antimicrobial properties are of great significance. In the past few years, a number of investigations have been conducted worldwide to prove antimicrobial activities from medicinal plants.

Today medicinal plants are important to the global economy, as approximately 85% of traditional medicine preparations involve the use of plants or plant extracts [7]. A large proportion of the world's population depends on traditional medicine because of the scarcity and high costs of orthodox medicine [8]. Medicinal plants have provided the modern medicine with numerous plant-derived therapeutic agents [9]. Although in traditional medicine *Cassia* species have been well known for their laxative and purgative properties and for the treatment of skin diseases, Still *Cassia* invites attention of researchers worldwide for its phytochemistry and pharmacological activities ranging from antidiabetic to antiviral.

Cassia is a large genus of around 500 species of flowering plants in the family *Leguminosae* [10]. *Senna* is a large genus of flowering plants in the family *Fabaceae,* subfamily *Caesalpiniaceae* which is often treated as a sub-family *Caesalpinioideae* of the large family *Leguminosae*. It is closely related to *Mimosaceae* and *Papilionaceae*, but can be distinguished by few stamens and five free petals. *Caesalpinioideae* consist of trees, shrubs and a few woody herbs found in the tropics.

They are well known in folk medicine for their laxative and purgative uses [11,12]. Besides, they have been found to exhibit anti-inflammatory [13], antioxidant [14], hypoglycaemic [15], hyperglycaemic [13], antiplasmodial [16], larvicidal [17], antimutagenic [18] and anticancer activities [19]. They are also widely used for the treatment of wounds [20], skin diseases such as ringworm, scabies and eczema, gastro-intestinal disorders like ulcers, uterus disorders [21], rheumatism, anorexia and jaundice [22].

2. *Cassia alta*

2.1 Leaf Extract

Leaf, stem and root were extracted with chloroform, acetone, methanol and water. The clinical isolates *viz*., *Bacillus subtilis*, *Bacillus cereus*, *Esherichia coli, Klebsiella pneumoniae, Proteus vulgaris, Staphylococcus aureus, Staphylococcus epidermidis* and MTCC isolates *viz*., *Bacillus cereus* (MTCC-430)*, Bacillus subtilis* (MTCC-441), *Staphylococcus aureus* (MTCC-96), *Staphylococcus epidermidis* (MTCC-435), *Proteus vulgaris* (MTCC-744)*, Escherichia coli* (MTCC-1687)*, Klebsiella pneumoniae* (MTCC-3384)*, Psuedomonas aeruginosa* (MTCC-741) were taken for study. The antibacterial assay of the extracts was performed using agar well diffusion method.

The antimicrobial activity of acetone root extract was found highest in *P. vulgaris* with zone of inhibition of 28.0±0.5 mm and in *B. subtilis* (MTCC 441) with zone of inhibition of 22.3±0.3 mm. The lowest activity was found with acetone stem extract against *S. aureus* with zone of

inhibition of 8.0±0.5 mm. Acetone root extract gave a zone of inhibition of 8.3±0.6 mm against *K. pneumoniae* (MTCC 3384). No significant antimicrobial activity was seen in the aqueous extracts [23].

2.2 Leaf and Root Extract

Leaves and roots were extracted with hot water, acetone and methanol. Bacterial isolates of *E. coli, P. mirabilis, P. aeruginosa, S.* Typhi*, Shigella flexneri, S. Aureus, Streptococcus pyogenes* and the fungal isolates of *Aspergillus flavus, Aspergillus niger, Candida albicans and Cryptococcus neoformans* used for this study. Antimicrobial activity of the aqueous and organic extracts of the plant sample was evaluated by cup plate agar diffusion method. 100 µl aliquots of extract dilutions reconstituted in minimum amount of solvent at concentrations of 50 and 100 mg/ml were applied.

S. pyogenes and *S. aureus* were the most susceptible bacteria to all the extracts followed by *S.* Typhi and *E. coli*. The most susceptible fungi species were *C. neoformans* and *C. albicans* while the least susceptible was *A. flavus*. The highest activity of the plant (roots and leaves) was demonstrated by methanol extract [24].

3. *Cassia angustifolia* LEAF EXTRACT

Alcoholic leaf extract was taken in study. For evaluation of antibacterial activity Gram-negative bacteria [*E. coli* (ATCC8739), *Shigella shiga* (ATCC1013), *K. pneumoniae* (ATCC1318)] were taken. The broth microdilution method was used to determine MIC and MBC. All tests were performed in Mueller Hinton broth supplemented with Tween 80 at a final concentration of 0.5% (v/v). Briefly serial doubling dilutions of the extract were prepared in a 96-well microtiter plate ranged from 0.3 mg/ml to 10.00 mg/ml. To each well, 10 µl of indicator solution (prepared by dissolving a 10-mg extract in 2 ml of DMSO) and 10 µl of Mueller Hinton Broth were added. Finally, 10 µl of bacterial suspension (106 CFU/ml) was added to each well to achieve a concentration of 104 CFU/ml.

The MIC concentrations ranged between 0.62 to 1.25 mg/ml for methanol extract and concentrations ranged between 1.25 to 2.5 mg/ml for ethanol extract. The MIC value of leaf methanol extract of *C. angustifolia* exhibited stronger activity against *K. pneumoniae* (MIC: 0.62 mg/ml). The leaf extracts exhibited comparatively better activity displaying their zone of inhibitions 10-19 mm and largest zone was shown against *S. dysenteriae* (19 mm) [25].

4. *Cassia arereh* ROOT AND STEM BARK EXTRACT

Root and stem bark of plant was extracted with ethanol, acetone and water. The bacterial species *E. coli, S. aureus, S. pyogenes, S.* Typhi, *K. pneumoniae* and *C. albicans* were taken in study. The disc diffusion method was used for screening of antimicrobial activity.

The acetone and ethanol extracts of the root and stem barks for *C. arereh* showed the highest antimicrobial activity against *E. coli* followed by *K. pneumoniae*, *S. aureus* and *S.* Typhi. Aqueous extracts of both root and stem barks did not show measurable zone of inhibition against the tested organisms [26].

5. *Cassia auriculata*

5.1 Leaf Extract

Leaves were extracted using hexane, chloroform, ethyl acetate, acetone and methanol. Two Gram-positive (*E. faecalis* and *S. aureus*) and eight Gram-negative (*E. coli, K. pneumoniae, P. vulgaris, P. aeruginosa, S.* Typhi*, S. paratyphi, S. boydii* and *V. cholerae*) bacterial stains were used in the study. Aqueous extract inhibited *S. aureus*, *P. aeruginosa* and *E. coli* at concentrations of 100 µg/ml, 200 µg/ml and 250 µg/ml respectively but did not inhibit the growth of *B. subtilis* at any of the concentrations tested. Ethanol extract inhibited only *B. subtilis*, where as it was not effective against the other bacteria tested.

Methanol extract was effective against two of the tested organisms i.e., *S. aureus* and *E. coli* both at the concentration of 64 mg/ml. Pet-ether did not inhibit the growth of any of the bacteria. In the present study, ethyl acetate, acetone and methanol extracts were showed significant zone of inhibition against *E. faecalis*, *S.* Paratyphi and *S. boydii* but other Gram-negative bacteria were less inhibited. The results indicated that the tested crude extracts showed antibacterial activity towards the Gram-positive bacteria [27].

5.2 Flower Extract

Grounded plant materials were extracted with dichloromethane and methanol (1:1). *E. coli, S.*

aureus, B. subtilis, P. aeruginosa, C. albicans, C. tropicalis and *A. niger* cultures of the microorganism were used in the study. The MIC was determined by the micro dilution method using liquid nutrient media with different aliquots of the test materials. 10 ml of sterilized double strength nutrient media was poured into sterilized test tube. MIC was determined by the lowest concentration of sample that inhibits the development of turbidity.

Plant extracts produced outstanding antibacterial activity against Gram-positive with the greater zone of inhibition than the Gram-negative bacteria. Considering in this study the Gram-positive bacteria are more susceptible than Gram- negatives. Result showed that *C. auriculata L* had potential inhibitory action against fungal strains than bacterial strains tested and it also showed strong antifungal properties than Fluconazole (the standard antifungal drug used), as it shown greater zone of inhibition against *C. albicans, C. tropicalis* and *A. niger* [28].

5.3 Aerial Parts Extract

The plant material was extracted successively with petroleum ether, chloroform, ethyl acetate and methanol. The microorganisms used in this experiment were *B. subtilis*, *S. aureus*, *P. aeruginosa*, *E. coli* and fungus culture *C. albicans* and *A. niger.* The antimicrobial activity of the *C. auriculata* extracts were determined by using disc diffusion method. Two Gram-positive bacteria and two Gram-negative bacteria were used for this study. The tests were conducted at three different concentrations at 100,200 and 300 µg /ml respectively of the crude extract. Fungus culture *C. albicans and A. niger* were used for this study.

The *in vitro* antibacterial activities of chloroform extract were found to have maximum activity against all organisms except *P. aeruginosa*. The extract showed antibacterial activity at all concentrations selected. The extract with the concentration of 300 µg/ml showed maximum antibacterial activity against the organisms which are comparable with the standard control Amikacin [29].

6. *Cassia fistula*

6.1 Flower Extract

Alcoholic extracts of flowers was extracted using alcohol (ethanol or methanol)-distilled water solution (8:2 v/v). A total of 8 bacterial species were tested including 3 Gram-positive, *B. cereus, S. aureus* and *S. epidermidis* and 5 Gram-negative, *S.* Typhi*, K. pneumoniae, E. coli, P. aeruginosa* and *P. mirabilis*. Antibacterial activities of the ethanolic and methanolic extracts of the plant were studied by standard paper disc-diffusion method. Five concentrations of ethanolic and methanolic extracts were prepared as follows 0.05, 0.1, 0.2, 0.4 and 0.6 g/ml. Both alcoholic extracts of *C. fistula* exhibited antibacterial activity against Gram-positive and Gram-negative species. As a result, both alcoholic extracts efficiently inhibited three Gram-positive species including *S. aureus*, *S. epidermidis* and *B. cereus* and two Gram-negative bacteria including *E. coli* and *K. pneumoniae*.

The highest antibacterial was demonstrated in case of ethanolic extract against *E. coli* while the lowest activity was demonstrated against *B. cereus* and *S. aureus* and methanolic extract against *B. cereus* and *S. epidermidis*. On the other hand, the ethanolic and methanolic extracts were not active against *S.* Typhi*, P. aeruginosa, K. pneumoniae* and *P. mirabilis* [30].

6.2 Leaf Extract

Hydro alcoholic and chloroform extracts of flowers were taken for study. The tested bacterial strains *S. aureus*, *S. pyogenes*, *E. coli*, *P. aeruginosa* and fungal strains were *A. niger*, *A. clavatus*, *C. albicans* were chosen based on their clinical and pharmacological importance. *In vitro* antibacterial and antifungal activities were examined for hydroalcoholic extracts. Antibacterial and antifungal activities of plant extracts against four pathogenic bacteria (two Gram-positive and two Gram-negative) and three pathogenic fungi were investigated by agar disc diffusion method. For the determination of zone of inhibition, pure Gram-positive, Gram-negative and fungal strains were taken as a standard antibiotic for comparison of the results. The sets of five dilutions (5, 25, 50, 100, and 250 µg/ml) of *C. fistula* extract and standard drugs were prepared in double-distilled water using nutrient agar tubes.

As compared with standard drugs, the results revealed that in the extracts for bacterial activity, *S. pyogenes and S. aureus* were more sensitive as compared with *E. coli* and *P. aeruginosa*. The growth inhibition zone measured ranged from 11 to 20 mm for all the sensitive bacteria. The results showed that the

extracts of *C. fistula* were found to be more effective against all the microbes tested [31].

6.3 Leaf and Bark Extracts

Leaf and bark were extracted with Petroleum ether, Chloroform, Ethyl acetate, Methanol and 40% methanol, separately. Fungal and bacterial strains of *A. niger, C. albicans, E. coli, S. aureus,* and *Lactobacillus* were taken for study. MIC determination of the extracts was carried out by serial dilution method. Media used was Mueller-Hinton broth and Potato dextrose broth for bacteria and fungi respectively. Organisms used were *C. albicans, E. coli,* and *S. aureus.* The bark extracts of *C. fistula* showed considerable antimicrobial activity in terms of good zones of inhibition.

The leaf extracts of *C. fistula* showed no inhibition zones. Results showed that the ethyl acetate and methanolic extracts of *C. fistula* showed MIC values in the range of 0.5 mg/ml. The results of zones of inhibition of extracts against resistant strains were comparatively significant. The methanolic bark extract of *C. fistula* showed maximum zones of inhibition against resistant strains (*E. coli*=16 mm*, S. aureus*=14 mm) [32].

6.4 Seed Extract

The methanol extract of *C. fistula* seeds was investigated for potential antimicrobial activity. The following Gram-positive and Gram-negative bacteria, yeasts and moulds were used for antimicrobial activities studies: bacteria *included S. aureus, B. thuringiensis, E. coli, Salmonella* sp*, Micrococcus* sp. and *B. subtilis;* yeast included *C. albicans;* molds included *A. niger*. For determination of MIC a serial dilution was carried out to give final concentration between 0.10-100.00 mg crude extract per ml. The disk diffusion assay result of *C. fistula* seed extract with the inhibition zones formed by standard antibiotic disks showed good response *in vitro* potential of antimicrobial activities against all the tested bacterial strains.

Maximum activity was observed against *Micrococcus* sp (29 mm), followed by *Salmonella* sp. (25 mm), *B. subtilis* (24 mm), *B. thuringienesis* (22 mm), *S. aureus* (18 mm). *E. coli* exhibited weak inhibition zones (16 mm). The antimicrobial activity of this extract was also observed on the yeast *C. albicans* (21 mm) but it failed to inhibit the growth of filamentous fungi *A. niger*. In contrast, the inhibition zone of solvent control methanol (negative control) was zero so that it was not active against all of the tested microorganisms. However, the 2 antibiotics 30 µg/ml of Chloramphenicol and Miconazole nitrate (positive control) were more effective than the seeds extract of *C. fistula* with the diameter of zone inhibition ranging between 28 and 31 mm [33].

7. *Cassia glauca* SEED EXTRACTS

The Seeds were extracted with different solvents of increasing polarity viz. Petroleum ether, Chloroform, Acetone and Methanol. The bacterial cultures used in the study were *E. coli, K. pneumoniae, B. subtilus, S.* Typhi*, S. aureus.* The antifungal activity was studied against the microorganism viz. *A. niger. P. chrysogenum. S. cerevisiae*, *C. albicans.* Antibacterial studies revealed that only two extracts methanol and acetone showed antibacterial activity against all bacterial culture. Acetone extract showed maximum antibacterial activity with inhibition zone 13 mm against *E. coli*, 26 mm against *K. pneumoniae*, 13 mm against *B. subtilus*, 12 mm against *S.* Typhi, and 18 mm against *S. aureus*. Methanol extract showed inhibition zone 12 mm against *E. coli*, 10 mm against *K. pneumoniae*, 11 mm against *B. subtilus*, 18 mm against *S.* Typhi, and 25 mm against *S. aureus*. Standard drug Chloramphenicol showed antibacterial activity against *E. coli, K. pneumoniae, B. subtilus, S.* Typhi and *S. aureus*. The inhibition zone of Chloramphenicol was 30 mm against *E. coli*, 40 mm against *K. pneumoniae*, 28 mm against *B. subtilus*, 28 mm against *S.* Typhi, and 26 mm against *S. aureus*.

Antifungal studies revealed that only methanol and acetone extracts showed antifungal activity against all fungal cultures. Acetone extract showed inhibition zone 22 mm against *A. niger,* 27 mm against *P. chrysogenum*, 25 mm against *S. cerevisiae* and 27 mm against *C. albicans*. Methanol extract showed inhibition zone 24 mm against *A. niger*, 22 mm against *S. cerevisiae* and 23 mm against *P. chrysogenum* and 21 mm against *C. albicans*. Standard drug Ketoconazole showed antifungal activity inhibition zone 30 mm against *A. niger*, 27 mm against *S. cerevisiae* and 26 mm against *P. chrysogenum.* From the above study it was concluded that the methanol and acetone extracts showed the maximum antimicrobial activity in comparison to other extracts [34].

8. *Cassia occidentalis*

8.1 Leaf Extract

Leaves were extracted with ethanol, methanol and water. Bacterial species for test microorganisms in the present study include *S. aureus, S.* Typhi*, E. coli, Shigella* sp. and *P. aeruginosa.* Antibacterial activities were carried out by using agar well diffusion method. The results showed that these extracts were effective against all of the test organisms. The highest activity (zone of inhibition in diameter was about 18 mm) was demonstrated by the ethanolic extract of leaves against *S.* Typhi while the lowest activity was 7 mm by the water extract against *Shigella* sp. On the other hand the ethanol and water extract were not active against *E. coli* at all concentrations. The water extract showed inhibition at lower concentration (30 and 60 mg/ml) against *E. coli* and *S.* Typhi.

These results suggested that antibacterial activity of *C. occidentalis* leaves of ethanolic and water extract against test-organism were increased when used in higher concentration [35].

8.1.1 Leaf extract

The plant material was extracted with petroleum ether, benzene, chloroform, methanol and water. Antimicrobial activity was investigated against two Gram-positive bacteria including *Staphylococcus aureus* (MTCC96), *S. epidermidis* (MTCC435)*,* five Gram-negative bacteria *P. vulgaris* (MTCC426), *P. aeruginosa* (MTCC424), *K. pneumoniae* (MTCC3384), *P. mirabilis* (MTCC425) and *E. coli* (MTCC433) *and* fungi *A. fumigatus* (MTCC343) and *C. albicans* (MTCC227). The tested microorganisms were cultured on Nutrient agar.

Among all tested extracts, methanol and water extracts were found to be most active than corresponding organic extracts. Methanol extract was found to be active against six tested bacteria (*P. aeruginosa, K. pneumoniae, P. mirabilis, E. coli, S. aureus, S. epidermidis*). On the other hand, the aqueous extract was effective against three out of seven tested bacteria (*P. vulgaris, K. pneumoniae* and *P. aeruginosa*) and fungus (*C. albicans*). Aqueous extract was found to have maximum zone of inhibition against *P. aeruginosa* (18 mm) while the minimum zone of inhibition was against *K. pneumoniae* (3 mm). The benzene and petroleum ether extracts of the leaves of *C. occidentalis* were effective against *P. mirabilis* and *E. coli* respectively while chloroform extract was found to be inactive against all tested bacterial and fungal and yeast strains. Similarly, activity index of the plant extracts varied from maximum 0.72 for aqueous (*P. aeruginosa*) to the minimum 0.13 for methanol (*K. pneumoniae*) extract [36].

8.1.2 Leaf extract

Leaves were extracted with n-hexane and ethanol using cold maceration. The ethanol portion of the extract was suspended in water and sequentially partition with Chloroform, Ethyl acetate and n- Butanol. Bacteria used for the work include *S. aureus, P. aeruginosa*, *Klebsiella* sp, *E. coli*, *B. subtilis* and the fungi used for the research work was *C. albicans.* The antimicrobial activities of the extracts were determined by the Kirby-Bauer agar diffusion method according to NCCLS standards. The sterile discs were impregnated with different concentration (400, 200, 100 & 50 mg/ml). Streptomycin of (40 mg/ml) was used as positive control.

Present study revealed that the petroleum ether and ethanolic extract were effective against *E. coli* at concentration of 400 mg/ml. The inhibition activities were not observed in the chloroform and aqueous extracts against *E. coli.* The growth of *P. aeruginosa* was remarkably inhibited by the aqueous extract [37].

8.2 Whole Plant Extract

Whole plant was extracted successively with hexane, ethyl acetate and methanol. Another crude extract of aqueous methanol was also carried out. The zones of inhibition, MIC, minimum bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) were determined. The organisms used for antimicrobial screening include standard strains, *S. aureus NCTC 6571, B. subtilis NCTC 8236, E. coli NCTC 10418, P. aeruginosa NCTC 6750, S.* Typhimurium *ATCC 9184, K. pneumoniae ATCC 10031* and *S. aureus ATCC 13704,* and clinical isolates, *S. aureus, Methicilin Resistant S. aureus, S. pyogenes, E. faecalis, C. ulcerans L. monocytogenes, B. subtilis, B. cereus, E. coli, K. pneumoniae, K. ozaenae, P. mirabilis, P. vulgaris, P. aeruginosa, P. fluorescens, S.* Typhimurium*, S. dysenteriae, A. fumigatus, C. albicans, M. gypseum and T. rubrum.*

The extracts were selectively active against food pathogens like the *S. aureus* and enteric organisms like *E. faecalis*, *S. dysenteriae* and *Bacillus sp.* The methanolic and ethyl acetate extract showed some activity against *Candida, Microsporum* and *Trichophyton* [38].

8.3 Root Extract

Petroleum ether (60-80ºC), chloroform, and methanol root extract were taken in study. Microorganism *B. polymyxa*, *S. faecalis*, *S. aureus*, *B. subtilis*, *S.* Typhi, *V. cholerae*, *S. dysenteriae*, *E. coli*, *P. notatum* and *C. albicans* were taken. MIC of the extracts was determined by broth dilution method at concentrations of the extract ranging from 25 µg/ml to 500 µg/ml in DMSO. The zone of inhibition of the extract was performed by agar disc diffusion method at concentrations of 10 mg/ml of the extract in DMSO. Ciprofloxacin (5 µg/ml) and Cotrimazole (25 µg/ml) were used as standards for the antibacterial and antifungal studies respectively.

The pet-ether extract and chloroform extract had almost similar action on all types of micro-organisms but the methanol extract possess higher activity than other two. The result also revealed that the pet-ether extract has no action on some of the tested micro-organisms. The results of zone of inhibition study revealed that the extracts posses antimicrobial activity, more susceptible to Gram-positive bacteria than Gram-negative bacteria in a concentration dependent manner and were comparable with the standard drugs [39].

9. *Cassia roxburghii* FLOWER EXTRACT

Antimicrobial properties of methanol, chloroform and petroleum ether extracts were evaluated. The antimicrobial assay was performed by two methods viz. agar disc diffusion method and agar well diffusion method in different concentrations (25, 50, 75 and 100 µg/ml) against three bacterial strain (*E. coli*, *S. aureus, Vibrio* sp.) and three fungal strain (*E. flocossum, M. gypseum and T. mentagrophytes).*

Methanol extract was found most active against *(E. coli, S. aureus, Vibrio, M. gypseum* and *T. mentagrophytes*). Chloroform extract showed moderate activity against *E. coli* and *M. gypseum.* Petroleum ether extracts was not active against most of the bacterial and fungal strains [40].

10. *Cassia senna* LEAVES

In the present study fractions of the leaves like n-hexane, ethyl acetate and chloroform were tested along with the methanol extracts of the whole plants of *C. seena* for antimicrobial activity by using standard disc diffusion method. In this study, 16 microorganisms were taken. The study showed that the methanol extract at a concentration of 300 µg/disc has no zone of inhibition produced in case of 13 bacterial strains and 3 fungal strains where standard Kanamycin (30 µg/disc) showed zone of inhibition of 32-39 mm. The study was repeated two times for the confirmation of no inhibitory effect and in case of n-hexane fraction of whole plant it showed a moderate antibacterial activity for two Gram-positive bacteria like *B. cereus* (12 mm) & *S. aureus* (14 mm) & two Gram-negative strains *E. coli* (18 mm) and *V. mimicus* (16 mm) where *P. aeruginosa* (10 mm) possess less effect in-contrast to standard Kanamycin. The experiments also revealed that n-hexane extract possess a very less antifungal activity for *C. albicans* (8 mm) & *S. cerevisiae* (7 mm). The study revealed that the ethyl acetate fractions have no antifungal activity among the three fungi used in experiment. However, lower potentiality is seen as antibacterial agent against *S. aureus*, *E. coli*, *S. boydii* &*V. mimicus* [41].

11. *Cassia tora*

11.1 Seed Extract

Dried seeds were extracted by pet ether, methanol, ethanol and water successively. Micro-organisms *S. aureus* (ATCC 2267), *B. subtilis* (ATCC 6633), *P. aeruginosa* (ATCC 25619) and *E. coli* (ATCC 10536) were used for study. Aqueous extract inhibited *S. aureus*, *P. aeruginosa* and *E. coli* at concentrations of 100 µg/ml, 200 µg/ml and 250 µg/ml respectively but did not inhibit the growth of *B. subtilis* at any of the concentrations tested. Ethanolic extract inhibited only *B. subtilis*, where as it was not effective against the other bacteria tested. Methanolic extract was effective against two of the tested organisms i.e., *S. aureus* and *E. coli* both at the concentration of 64mg/ml. Pet ether did not inhibit the growth of any of the bacteria. Among the various extracts aqueous extracts exhibited high antibacterial activity in terms of zone of inhibition on all the organisms except *B. subtilis*. *S. aureus* was the most susceptible among the organisms tested [42].

11.2 Leaf and Stems Crude Extract

The leaves and stem was extracted with methanol. The bacterial species selected were *S. aureus* ATCC 96*, B. subtilis* MTCC 441, *B. cereus* ATCC 9372, *K. pneumoniae* MTCC 109*, E. coli* ATCC 8739*, S.* Paratyphi ATCC 4420. Whereas fungal cultures used were *A. niger* ATCC 9763*, C. albicans* ATCC 7596. The anti-bacterial activity of methanolic extracts of leaves and stem exhibited significant inhibitory effect towards various tested organisms. Among Gram-positive and negative strains, *S. aureus* and *K. pneumoniae* produced highest inhibitory zones 12, 15, 12, 20, and 13, 15, 17, 23 at100 and 200 µg/ml of leaves and stem methanolic extracts, respectively. The anti-fungal activity of both extracts also produced significant inhibitory zone against *A. niger* and *C. albicans*. The inhibitory zones of *A. niger* and *C. albicans* are 20, 13 and 7, 5 which are noticed at 100 and 200 µ/ml towards leaves and stem methanolic extracts, respectively. The antibacterial and anti-fungal activities were compared with known standards such as Gentamycin and Nystatin. The inhibitory zones which were obtained with standards are 25, 29 and 23, 18 towards *S. aureus*, *K. pneumoniae* and *A. niger* and *C. albicans* respectively.

The investigation reports revealed that the stem extract noticed highest anti-bacterial and anti-fungal activity than the leaves. The leaf methanolic extract fails to produce inhibitory effect on *S.* Paratyphi whereas, the methanolic stem extract exhibited significant inhibitory effect against *S.* Paratyphi [43].

11.3 Leaf Extract

Ethanolic and aqueous extracts were investigated for their antibacterial activity against *P. aeruginosa, Lactobacillus, S.* Typhi*, P. vulgaris, B. subtilis, S. aureus, S. pneumoniae, E. coli, Enterobacter* bacterias. The filter paper disc method was taken for study.

Maximum activity was exhibited by aqueous extract against *S. aureus, Lactobacillus* and show moderate activity against *P. aeruginosa, P. vulgaris* and *Enterobacter* and showed less activity against *B. subtilis* and *E. coli. A*queous extract did not show any activity against *S.* Typhi. Ethanolic extract show less activity as compared to aqueous extract but show maximum activity against *S. aureus* and *Lactobacillus* [44].

12. CONCLUSION

This review article comprised of antimicrobial potential of *Cassia species* various plant extracts against a diverse range of organisms. An extensive survey of literature revealed that *Cassia* is an important source of many pharmacologically and antimicrobial importance. Although many studies have claimed the use of some species of *Cassia* for the treatment of various diseases but still the pharmacological potential of the other species of the genus are required to be explored.

Further future research should be focused on the phytochemical, isolation of active compounds with screening of more antimicrobial activity rather than simply screening the plant crude extracts. In addition researches should attempt to establish the possible mechanism of action of drug so that it is beneficial for drug discovery and development.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nihal Dogruoz, Zuhal Zeybek, Ali Karagoz. Antibacterial activity of some plant extracts; Istanbul University Faculty of Science Journal of Biology. 2008;67(1):17-22.
2. Mondal S, Kolhapure SA. Evaluation of the antimicrobial efficacy and safety of Pure Hands herbal hand sanitizer in hand hygene and on inanimate objects. The Antisep. 2004;101(2):55-57.
3. Hugo S.M and Russel A.O. Antimicrobial activities of some African medicinal plants. Journal Chemical Society of Nigeria. 1984; 15(2):351-360.
4. Kubmarawa D. Ajoku, Enwerem M, Okorie, D. Preliminary phytochemical and antimicrobial screening of 50 medicinal

plant from Nigeria. Africa Journal of Biotechnology. 2007;6(14):1690-1696.

5. Doshi GM, Supriya S. Shidhaye, Gayatri V. Aggarwal, Preeja P. Pillai Abhijeet B. Bhalerao, Sandhya K. Desai. Antibacterial potential of Cassia auriculata flowers, J. Microbiol. Biotech. Res. 2011;1(3):15-19.
6. Kubmarawa D, Khan ME, Mtswenem M, Uwemedimo A, Timi PG, Hassan M, Atiko R. The phytochemistry and chemotherapeutic effects of some African Medicinal plants. Book of proceedings, chemical society of Nigeria. 2008;6(1):154-159.
7. Vieira RF, Skorupa LA. Brazilian medicinal plants gene bank. Acta Hort. 1993;330:51-58.
8. Hudaib M, Mohammad M, Bustanji Y, Tayyem R, Yousef M, Abuirjeie M, Talal A. Ethno pharmacological survey of medicinal plants in Jordan, Mujib Nature Reserve and surrounding area. J. Ethnopharmacol. 2008;120:63-71.
9. Oladunmoye MK, Adetuyi FC, Akinyosoye FA. Effect of *Cassia hirsuta* (L) extract on DNA profile of some microorganisms. Afr. J. Biotechnol. 2009;8(3):447-450.
10. Lodha SR, Joshi SV, Vyas BA, Upadhye MC, Kirve MS, Salunke SS, Kadu SK, Rogye MV. Assessment of the antidiabetic potential of *Cassia grandis* using an *in vivo* model. J Adv Pharm Technol Res. 2010; 1(3):330-333.
11. Hennebelle T, Weniger B, Joseph H, Sahpaz S, Bailleul F. *Senna alata*. Fitoterapia. 2009;80:385-393.
12. Verma L, Khatri A, Kaushik B, Patil UK, Pawar RS. Antidiabetic activity of *Cassia occidentalis* (Linn) in normal and alloxan-induced diabetic rats. Indian Journal of Pharmacology. 2010;42:224-228.
13. Soamchit MN, Reezal I, Elysha Nur, Mutalib AR. *In vitro* antimicrobial activity of ethanol and water extracts of *Cassia alata*. Journal of Ethnopharmacol. 2003;84(1):1-4.
14. Yen GC, Chuang DY. Antioxidant properties of water extracts from *Cassia tora* L. in relation to the degree of roasting. J. Agric. Food Chem. 2000;48:2760-2765.
15. Jalalpure SS, Patil MB, Pai A, Shah BN, Salahuddin MD. Antidiabetic activity of *Cassia auriculata* seeds in alloxan induced diabetic rats. Nig. J. Nat. Prod. Med. 2004; 8:22-23.
16. Iwalewa EO, Lege-Oguntoye L, Rai PP, Iyaniwura TT. *In vivo* and *in vitro* antimalarial activity of two crude extracts of *Cassia occidentalis* leaf. Nig. J. Pharm. Sci. 1997;5:23-28.
17. Yang Y, Lim M, Lee H. Emodin isolated from *Cassia obtusifolia* (Leguminosae) seed shows larvicidal activity against three mosquito species. J. Agric. Food Chem. 2003;51:7629-7631.
18. Silva CR, Monteiro MR, Rocha HM, Ribeiro AF, Caldeira-de-Araujo A, Leitao AC, Padula M. Assessment of antimutagenic and genotoxic potential of senna (*Cassia angustifolia* Vahl) aqueous extract using *in vitro* assays. Toxicol. *In vitro.* 2008;22:212-218.
19. Prasanna R, Harish CC, Pichai R, Sakthisekaran D, Gunasekaran P. Anticancer effect of *Cassia auriculata* leaf extract *In vitro* through cell cycle arrest and induction of apoptosis in human breast and larynx cancer cell lines. Cell Biol. Int. 2009; 33:127-134.
20. Joshi SG. *Caesalpiniaceae-Cassia auriculata*, Textbook of Medicinal Plants. 3rd Edn., India Book House, Bangalore, India; 2000.
21. Elujoba AA, Abere AT, Adelusi SA. Laxative activities of *Cassia* pods sourced from Nigeria. Nig. J. Nat. Prod. Med. 1999; 3:51-53.
22. Pieme CA, Penlap VN, Nkegoum B, Taziebou CL, Tekwu EM, Etoa FX, Ngongang J. Evaluation of acute and subacute toxicities of aqueous ethanolic extract of leaves of *Senna alata* (L.) Roxb (Ceasalpiniaceae). Afr. J. Biotechnol. 2006;5(3):283-289.
23. Pranita Sharma, Dhananjay Pandey, Rizvi AF, Gupta AK. Antimicrobial activity of *Cassia alata* from Raipur region against clinical and MTCC isolates. Int. J. Curr. Microbiol. App. Sci. 2015;4(1):330-339.
24. Ehiowemwenguan, G., Inetianbor, J.E. And Yakubu JM. Antimicrobial qualities of *Senna alata*. IOSR Journal of Pharmacy and Biological Sciences. 2014;9(2):47-52.
25. Zakaria Bameri, Negar Amini-Boroujeni, Saeide Saeidi, Saphora Bazi. Antibacterial activity of *Cassia angustifolia* extract against some human pathogenic bacteria.

Journal of Novel Applied Sciences. 2013; 2(11):584-586.

26. De N, Maori L, Ardo H. A study on antimicrobial effect of extracts of *Cassia arereh* (Del.) on some clinical isolates. Journal of Medicinal Plants Research. 2009;3(3):16-119.
27. Anushia C, Sampathkumar P, Ramkumar L. Antibacterial and antioxidant activities in *Cassia auriculata.* Global Journal of Pharmacology. 2009;3(3):127-130.
28. Muthukumaran P, Elayarani M, Shanmuganathan P, Cholarajan A. Antimicrobial activities of *Cassia auriculata* L and *Morinda tinctoria Roxb.* International Journal of Research in Pure and Applied Microbiology. 2011;1(2):9-12.
29. Devados Kumarasamy Raja, Nattanmai Sundararaman Jeganathan, Rajappan Manavalan. *In vitro* antimicrobial activity and phytochemical analysis of *Cassia auriculata* Linn. International Current Pharmaceutical Journal. 2013;2(6):105-108.
30. Seyyed Mansour Seyyednejad, Hossein Motamedi, Mouzhan Vafei, Ameneh Bakhtiari. The antibacterial activity of *Cassia fistula* organic extracts. Jundishapur J Microbiol. 2014;7(1):e8921.
31. Nayan R. Bhalodia, Shukla VJ. Antibacterial and antifungal activities from leaf extracts of *Cassia fistula* L.: An ethnomedicinal plant. J Adv Pharm Technol Res. 2011;2(2):104–109.
32. Zeeshan Afsar, Salma Khanam. Antimicrobial activity of the extracts of *Cassia fistula* and *Milletia pinnata* against ampicillin resistant strains of clinical origin. Asian Journal of Phytomedicine and Clinical Research. 2014;2(1):22-29.
33. Subramanion Jo Thy Lachumy, Zakaria Zuraini, Sreenivasan Sasidharan. Antimicrobial activity and toxicity of methanol extract of *Cassia fistula* seeds. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2010; 1(4):391-398.
34. Deepak Kumar, Shefali Arora, Ankit Verma. Fatty acid composition and Antimicrobial and Antioxidant activity of *Cassia glauca* seed extracts. International Journal of Phytopharmacology. 2013;4(2): 113-118.
35. Sadiq IS, Shuaibu M, Bello AB, Tureta SG, Isah A, Izuagie T, Nasiru S, Kamaru MB. Phytochemistry and antimicrobial activities of *Cassia occidentalis* used for herbal remedies. Journal of Chemical Engineering. 2012;1(1):38-41.
36. Vedpriya Arya, Sanjay Yadav, Sandeep Kumar, JP Yadav. Antimicrobial activity of *Cassia occidentalis* L (Leaf) against various human pathogenic microbes. Life Sciences and Medicine Research. 2010; LSMR-9:1-11.
37. Mohammed M, Aboki MA, Saidu HM, Victor O, Tawakalitu A, Maikano SA. Phytochemical and some antmicrobial activity of *Cassia occidentalis* L. (Caesalpiniaceae). International Journal of Science and Technology. 2012;2(4):2224-3577.
38. Egharevba, Henry Omoregie; Odigwe Anselem C, Abdullahi, Makailu Sabo, Okwute, Simon Koma, Okogun, Joseph Ibumeh. Phytochemical analysis and broad spectrum antimicrobial activity of *Cassia occidentalis* L. (whole plant). New York Science Journal. 2010;3(10).
39. Chinnala KM, Jithendra Debtha, Vidya Sagar Jenugu, Srinivas Ampati. Evaluation of Anti bacterial and antifungal activities of *Cassia occidentalis* Linn root extracts. Annals of Biological Research. 2010;1(3): 81-84.
40. Selvi V, Isaivani Indrakumar, Gomathi R, Karpagam S. Phytochemical analysis and antimicrobial activity of the flower extract of *Cassia roxburghii* Linn. Journal of Chemical and Pharmaceutical Research. 2014;6(11):105-107.
41. Md. Kamal Hossain, Md. Musfizur Hassan, Most. Nazma Parvin, Md. Mahmudul Hasan, Md. Siddiqul Islam, Md. Ahsanul Haque. Antimicrobial, cytotoxic and thrombolytic activity of *Cassia senna* leaves (family: Fabaceae). Journal of Applied Pharmaceutical Science. 2012; 02(06):186-190.
42. Roopashree TS, Raman Dang, Shobha Rani RH, Narendra C. Antibacterial activity of antipsoriatic herbs: *Cassia tora, Momordica charantia* and *Calendula officinalis.* International Journal of Applied Research in Natural Products. 2008;1(3): 20-28.

43. Murali Krishna T, Nilamani Venisetty. Anti-microbial activity of *Cassia tora* leaves and stems crude extract. Helix. 2012;4:202-205.

44. Sarika Sharma, Man Singh Dangi, Shailendra Wadhwa, Vivek Daniel, Akhilesh Tiwari. Antibacterial activity of *Cassia tora* leaves. International Journal of Pharmaceutical & Biological Archives. 2010;1(1):84–86.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/9808