Review

Antimicrobial activities and phytochemical composition of extracts of *Ficus* species: An over view

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Accepted 6 August, 2013

This paper reviews the antimicrobial research undertaken on *Ficus* species. Antimicrobial methods [disc and well diffusion, minimum inhibitory concentration (MIC), minimum bacterial concentration (MBC)] were used to evaluate the different extracts. The majority of published articles use MIC assays for antimicrobial determination. An overview is given on the activities; extracts, compounds or oils from the publication. Phytochemical screenings as well as some bioactive compounds are given with empirical data. Preliminary results of antimicrobial activity supported the traditional use of *Ficus* in folk medicine. These findings suggest a new pathway in elucidating a potent antimicrobial agent from *Ficus* species.

Key words: Antimicrobial activities, phytochemical composition, extracts, *Ficus*.

INTRODUCTION

Medicinal higher plants have been used extensively as a source for numerous active constituents for treating human diseases and they, as well, have high contain of therapeutic value (Nostro et al., 2000). The *in vitro* antibacterial or antifungal assay is the first aim to evaluate the importance of these plants since the antibiotic resistance has become a global concern (Westh et al., 2004).

*Ficus* is a genus of about 800 species and 2000 varieties of *Ficus* of woody trees, shrubs and vines in the family Moraceae occurring in most tropical and subtropical forests worldwide (Hamed, 2011). It is collectively known as fig trees and the most well-known species in the genus is the common Fig (*Ficus carica* L.), which produce commercial fruit called fig. Phytochemical investigations of some *Ficus* species revealed that phenolic compounds as their major components (Abdel-Hameed, 2009; Veberic et al., 2008; Basudan et al., 2005; Sheu et al., 2005; Salem, 2005; Lee et al., 2002). Considering the enormous potentiality of plants as sources for antimicrobial drugs with reference to antibacterial agents, a systematic investigation was undertaken to screen the antibacterial activity of different *Ficus* species. As to screening, the antimicrobial (bacteria and fungi) activity was determined by measuring the diameter of the zone of inhibitions (ZIs), minimum inhibitory concentrations (MICs) and also reported for many (MBC). On the other hand, the antiviral activity was also reported for

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many species of Ficus (Aref et al., 2011; Mahmoud et al., 2010). In recent years, researchers examined and identified phytochemicals with unknown pharmacological activities having adequate antibacterial, antifungal and antiviral effects. Many Ficus species have long been used in folk medicine and various pharmacological actions (Trivedi et al., 1969).

In Egypt, many Ficus species are found in streets, gardens, parks and outside the canal banks. The fruits of F. carica L. and F. sycomorus L. are two of the most favorable fruits eaten by Egyptian peoples. Mousa et al. (1994) approved and supported the traditional uses of certain Egyptian Ficus species in folk medicine for respiratory disorders and certain skin diseases.

Mosa et al. (1994) reported that there are about 20 species of Ficus native to Egypt; most of them are cultivated as street trees for providing shade (F. retusa L.) as in Alexandria city, other are cultivated for their edible fruits (F. sycomorus and F. carica) while others as ornamental plants (F. religiosa). Edlin and Nimmo (1978) investigated that the latex (source of rubber) has been found in large quantity in the wood of Ficus genus, representing one of the largest economical uses of Ficus in Egypt.

So far, few studies have been carried out to clarify their use in traditional folk medicine in Egypt. Since those Ficus species mentioned earlier have promising pharmacological activities and are indigenous to Egypt, the present review was initiated to delineate the antibacterial, antifungal and antiviral activities of Ficus species growing in Egypt as well around the world. Additionally, phytochemical screenings of some Ficus species were presented.

ANTIMICROBIAL ACTIVITY OF FICUS SPECIES

Screening the published work with potential antimicrobial activity of Ficus species is initially the first choice of investigation for further study. A summary of certain screening studies related to the antimicrobial activity of Ficus species is presented in Table 1.

Antimicrobial activity of F. retusa

Extracts from F. retusa (wood, bark, leaves) showed a moderate activity against some selected bacteria and the methanol (MeOH) extract showed good activity (ZIs) against some studied bacteria (Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Serratia marcescens and Agrobacterium tumefaciens) (Salem, 2005). The bark, fruits, and leaves of F. microcarpa extracted with MeOH contained high antibacterial properties towards gram-positive and gram-negative bacteria (Ao et al., 2008). Sarg et al. (2011) found that the extracts and the identified compounds of the aerial parts of F. retusa L. “variegata” showed mild antimicrobial activity against Candida albicans, Mucor spp. Salmonella typhi, E. coli and Bacillus spp. Mahmoud et al. (2010) reported that F. nitida had a significant inhibitory activity when mixed with virus inoculum or applied 48 h before challenge. On the other hand, no such inhibition was observed when latex was applied 48 h after virus challenge in either squash or broad bean inoculated with Zucchini Yellow Mosaic Virus (ZYMV) or Bean Yellow Mosaic Virus (BYMV), respectively.

Antimicrobial activity of F. religiosa L.

F. religiosa has been extensively used in traditional medicine for a wide range of ailments. Its bark, fruits, leaves, roots, latex and seeds are medicinally used in different forms, sometimes in combination with other herbs (Aiyegoro and Okoh, 2009). The aqueous (Aq) extract was evaluated by Preeti et al. (2010) and showed high antimicrobial activity against B. subtilis and P. aeruginosa (multi-drug resistant). The ethanolic leaves extracts at 25 mg/ml was active against B. subtilis, S. aureus, E. coli and P. aeruginosa and nearly not active against two fungi C. albicans and Aspergillus niger (Farrukh and Ahmad, 2003; Valsaraj et al., 1997). The fruit extracts had significant antibacterial activity but no antifungal activity (Mousa et al., 1994). Seventy per cent Aq-ethanol extracts completely inhibited the growth of Helicobacter pylori at 500 μg/ml in all strains and demonstrate anti-H. pylori activity with MBC value that ranged from 125 to 250 μg/ml (Zaidi et al., 2009). Chloroform (CHCl₃) extracts showed a strong inhibitory activity against the growth of infective S. typhi, S. typhimurium and P. vulgaris at a MIC of 39, 5 and 20 μg/ml, respectively (Hemaiswarya et al., 2009). According to another study, different extracts (MeOH, Aq, CHCl₃) of the bark of F. religiosa has inhibitory effect on the growth of three enterogenic H. coli, isolated from the patients suffering from diarrhoea (Uma et al., 2009). The acetone (AC), MeOH, ethyl acetate (EtOAc) of bark extracts showed moderate antibacterial activity against P. aeruginosa, E. coli, P. vulgaris, B. subtilis and S. aureus (Manimozhi et al., 2012).

The ethanol leaf extracts of F. binjamina inhibited all studied viruses, Herpes Simplex Virus-1 and -2 (HSV-1 and HSV-2) and Varicella-Zoster Virus (VZV), while its fruit extracts inhibited only VZV. None of the extracts showed significant cytotoxic effect on uninfected Vero cells even at 250 μg/mL. There was indirect evidence for strong interactions between the plant extracts and the viruses and weak interactions with the cell surface (Yarmolinsky et al., 2009).

Antimicrobial activity of F. benghalensis L.

The bark of F. benghalensis exhibited significant anti-
Table 1. The biological activities of some *Ficus* species.

<table>
<thead>
<tr>
<th>Part used</th>
<th>Extracts tested</th>
<th>Bioassay</th>
<th>Range</th>
<th>Biological activities investigated</th>
<th>Bioactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood, leaves</td>
<td>Me, EtOAc, n-BuOH, Aq, CHCl_3</td>
<td>Disc-diffusion, 96-well microplate.</td>
<td>5-200 μg/ml</td>
<td>Antibacterial activity (Salem, 2005)</td>
<td>MeOH extract from wood showed good inhibition.</td>
</tr>
<tr>
<td>Leaves</td>
<td>Hex, CHCl_3, MeOH</td>
<td>Well diffusion, broth dilution.</td>
<td>100-300 mg/ml</td>
<td>Antibacterial activity (Koona and Rao, 2012)</td>
<td>Hex extract showed less activity; CHCl_3 extract showed moderate activity; MeOH extract showed the high antibacterial activity against all tested bacteria.</td>
</tr>
<tr>
<td>Bark</td>
<td>Aq</td>
<td>Well diffusion, micro dilution.</td>
<td></td>
<td>Antibacterial activity (Gayathri and Kannabiran, 2009)</td>
<td>Extracts exhibited moderate inhibition with the MIC ranging from 0.04 mg to 0.1 mg against tested bacteria.</td>
</tr>
<tr>
<td>Bark</td>
<td>hydro alcoholic</td>
<td>Cup plate diffusion, Broth dilution.</td>
<td>0.01-0.1 mg/ml</td>
<td>Antibacterial (Bhangale et al., 2010)</td>
<td>The extract of 0.08mg/ml to 0.1 mg/ml have better antibacterial activity against <em>Actinomycets viscosus</em>.</td>
</tr>
<tr>
<td>Bark</td>
<td>AC, MeOH, EtOAc</td>
<td>Disc diffusion.</td>
<td>25-100 μg/ml</td>
<td>Antibacterial activity (Manimozhi et al., 2012)</td>
<td>The most resistance was <em>P. aeruginosa</em>.</td>
</tr>
<tr>
<td>Aerial roots</td>
<td>Hex, Aq</td>
<td>Disc-diffusion.</td>
<td>25-75 mg/ml</td>
<td>Antibacterial activity (Singh and Watla, 2010)</td>
<td>The highest activity was observed against <em>S. aureus</em>.</td>
</tr>
<tr>
<td>Bark</td>
<td>Aq, MeOH, CHCl_3, PTE, Hex</td>
<td>Disc diffusion.</td>
<td></td>
<td>Antibacterial activity (Uma et al., 2009)</td>
<td>MeOH extract found to be more active against all the Enterotoxigenic <em>E. coli</em>.</td>
</tr>
<tr>
<td>Fruits</td>
<td>CHCl_3</td>
<td>Disc-diffusion.</td>
<td></td>
<td>Antibacterial, and antifungal activities (Mousa et al. 1994)</td>
<td>Extracts had significant antibacterial activity but no antifungal activity.</td>
</tr>
<tr>
<td>Roots</td>
<td>Aq, EtOH</td>
<td>Disc-diffusion.</td>
<td>25-75 mg/ml</td>
<td>Antibacterial activity (Murti and Kumar, 2011)</td>
<td>EtOH extract of both the plants were having good antimicrobial activity towards <em>S. aureus</em>.</td>
</tr>
<tr>
<td>Bark</td>
<td>AC, MeOH, EtOAc</td>
<td>Disc diffusion.</td>
<td>25-100 μg/ml</td>
<td>Antibacterial activity (Manimozhi et al., 2012)</td>
<td>The most resistance was <em>P. aeruginosa</em>.</td>
</tr>
<tr>
<td>F. auriculata</td>
<td>EtOH, EtOAc, PTE, CHCl_3</td>
<td>Well diffusion.</td>
<td>50-250 μg/ml</td>
<td>Antibacterial activity (El-Fishawy et al., 2011)</td>
<td>250μg/ml extracts showed most activities. The extract of leaves showed more antibacterial activities than the extract of fruits except in case of <em>B. subtilis</em>.</td>
</tr>
<tr>
<td>Table 1. Contd.</td>
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</tr>
<tr>
<td><strong>F. recemosa</strong></td>
<td>Bark</td>
<td>AC, MeOH, EtOAc</td>
<td>Disc diffusion.</td>
<td>25-100 µg/ml</td>
<td>Antibacterial activity (Manimozhi et al., 2012)</td>
</tr>
<tr>
<td></td>
<td>Bark</td>
<td>MeOH, Isopropanol, CHCl₃, Diethyl Ether, Hex</td>
<td>Well diffusion, micro broth dilution.</td>
<td>0.5-4 mg/ml</td>
<td>Antibacterial activity (Suresh et al., 2012)</td>
</tr>
<tr>
<td></td>
<td>Roots</td>
<td>Aq, EtOH</td>
<td>Disc-diffusion.</td>
<td>25-75 mg/ml</td>
<td>Antibacterial activity (Murti and Kumar, 2011)</td>
</tr>
<tr>
<td></td>
<td>Bark</td>
<td>AC, MeOH, EtOAc</td>
<td>Disc diffusion.</td>
<td>25-100 µg/ml</td>
<td>Antibacterial activity (Manimozhi et al., 2012)</td>
</tr>
<tr>
<td><strong>F. religiosa</strong></td>
<td>Leaves</td>
<td>EtOH</td>
<td>Well diffusion.</td>
<td>0.15-75 mg/ml</td>
<td>Antibacterial activity (Jahan et al., 2011)</td>
</tr>
<tr>
<td></td>
<td>Bark</td>
<td>Aq, MeOH, CHCl₃, PTE, Hex</td>
<td>Disc diffusion.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F. glomerata</strong></td>
<td>Bark</td>
<td>PTE, MeOH</td>
<td>Cup-plate diffusion.</td>
<td>25-250 mg/ml</td>
<td>Antibacterial activity (Jagtap et al., 2012)</td>
</tr>
<tr>
<td><strong>F. elastica</strong></td>
<td>Young stems</td>
<td>latex serum</td>
<td>MMELI.</td>
<td>0.25-1 75 mg/ml</td>
<td>Antiviral activity (Mahmoud et al., 2010)</td>
</tr>
<tr>
<td><strong>F. nitida</strong></td>
<td>Wood, bark, leaves</td>
<td>MeOH, EtOAc, n-BuOH, Aq, CHCl₃</td>
<td>Disc-diffusion, 96-well microplate.</td>
<td>5-200 µg/ml</td>
<td>Antibacterial activity (Salem, 2005)</td>
</tr>
<tr>
<td></td>
<td>Young stems</td>
<td>latex Serum</td>
<td>MMELI.</td>
<td>0.25-1 75 mg/ml</td>
<td>Antiviral activity (Mahmoud et al., 2010)</td>
</tr>
<tr>
<td></td>
<td>Wood, bark, leaves</td>
<td>Me, EtOAc, n-BuOH, Aq, CHCl₃</td>
<td>Disc-diffusion, 96-well microplate.</td>
<td>5-200 µg/ml</td>
<td>Antibacterial activity (Salem, 2005)</td>
</tr>
<tr>
<td><strong>F. retusa &quot;variegata&quot;</strong></td>
<td>Aerial parts</td>
<td>EtOH, PTE, CHCl₃, EtOAc</td>
<td>Disk diffusion, dilution.</td>
<td></td>
<td>Antibacterial, and antifungal activities (Sarg et al., 2011)</td>
</tr>
<tr>
<td><strong>F. asperifolia</strong></td>
<td>Young stems</td>
<td>Latex</td>
<td>Disc-diffusion.</td>
<td></td>
<td>Antibacterial activity (Ajayi, 2008)</td>
</tr>
</tbody>
</table>

The most resistance was *S. aureus*. The extracts showed antibacterial activity against standard strains and clinical isolates. The EtOH extract having good antimicrobial activity towards *S. aureus*. The EtOH extract found to be more active against all the Enterotoxigenic *E. coli*. Latex only showed significant inhibitory activity when mixed with virus inoculum (ZYMV or BYMV) or applied 48 h before virus challenge.
Table 1. Contd.

<table>
<thead>
<tr>
<th>Species</th>
<th>Plant Part</th>
<th>Solvent(s)</th>
<th>Method</th>
<th>MIC or MBC (μg/ml)</th>
<th>Activity Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>F. polita</em></td>
<td>Roots</td>
<td>MeOH</td>
<td>96-well microplate</td>
<td>4-512</td>
<td>Antibacterial, antifungal</td>
<td>Kuete et al., 2011</td>
</tr>
<tr>
<td><em>F. tsiela</em></td>
<td>Leaves</td>
<td>diethyl ether, EtOH, AC</td>
<td>Disc diffusion.</td>
<td>100-500</td>
<td>Antibacterial</td>
<td>Shamila et al., 2012</td>
</tr>
<tr>
<td><em>F. exasperata</em></td>
<td>Leaves</td>
<td>EtOH</td>
<td>Well diffusion</td>
<td>100-1000</td>
<td>Antibacterial</td>
<td>Odunbaku et al., 2008</td>
</tr>
<tr>
<td><em>F. carica</em></td>
<td>Fruit latex</td>
<td>MeOH, Hex, CHCl₃, EtOAc</td>
<td>Disc-diffusion, 96-well microplate (B) inhibition percentage (F)</td>
<td>Antibacterial, antifungal</td>
<td>Aref et al., 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leaves</td>
<td>MeOH</td>
<td>Broth dilution</td>
<td></td>
<td>Antibacterial</td>
<td>Jeong et al., 2009</td>
</tr>
<tr>
<td></td>
<td>Fruit latex</td>
<td>MeOH, Hex, CHCl₃, EtOAc</td>
<td>Adsorption and penetration, intracellular inhibition and virucidal activity.</td>
<td>Antibacterial, antifungal</td>
<td>Aref et al., 2011</td>
<td></td>
</tr>
<tr>
<td><em>F. lyrata</em></td>
<td>Leaves</td>
<td>Aq, EtOH</td>
<td>Disc-diffusion, two fold serial dilution.</td>
<td>Antibacterial</td>
<td>Rizvi et al., 2010</td>
<td></td>
</tr>
<tr>
<td><em>F. deltoidea</em></td>
<td>Leaves</td>
<td>CHCl₃, MeOH, Aq</td>
<td>Disc-diffusion, 96-well microplate (B) inhibition percentage (F).</td>
<td>10-50</td>
<td>Antibacterial, antifungal</td>
<td>Abdsamah et al., 2012</td>
</tr>
</tbody>
</table>

The MIC values recorded with (E)-3,5,4′-trihydroxy-stilbene-3,5-O-b-D-glucopyranoside on the resistant *P. aeruginosa* PA01 strain was equal to chloramphenicol.

diethyl ether extract was found to be higher than that of other extracts.

The satisfactory MIC of the plant extract against *E. coli* is 300 mg/mL while that of *S. albus* is 700 mg/mL.

The MeOH extract (MICs, 0.156 to 5 mg/mL; MBCs, 0.313 to 5 mg/ml) showed a strong antibacterial activity against oral bacteria.

The Hex and Hex-EtOAc (v/v) extracts inhibited at 78 μg/ml.

The Aq extract was more potent than EtOH extract.

The MeOH extract exhibited good antibacterial and antifungal activities against the test organisms.
### Table 1. Contd.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Extracts Used</th>
<th>Method</th>
<th>MIC (μg/ml)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F. capensis</strong></td>
<td>Leaves and stem bark</td>
<td>MeOH, Aq</td>
<td>500-2000</td>
<td>Antibacterial (Oyeleke et al., 2008)</td>
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<tr>
<td></td>
<td></td>
<td>Disk-diffusion, agar</td>
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<td></td>
<td></td>
<td>dilution, agar</td>
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<td></td>
<td></td>
<td>0.5-2.5 ml/10 ml</td>
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<td></td>
<td></td>
<td>Antimicrobial activity</td>
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<tr>
<td></td>
<td></td>
<td>against E. coli</td>
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<tr>
<td></td>
<td></td>
<td>and Shigella sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F. palmata</strong></td>
<td>Fruit, bark, root, leaf</td>
<td>PTE, CHCl₃, MeOH, Aq</td>
<td>10 mg/ml and</td>
<td>Antibacterial, antifungal (Saklani and Chandra, 2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disc diffusion</td>
<td>50 mg/ml</td>
<td></td>
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<td>technique</td>
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<tr>
<td></td>
<td></td>
<td>0.05-2.5 mg/ml</td>
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<td>Antimicrobial activity</td>
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<tr>
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<td>against E. coli</td>
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<tr>
<td></td>
<td></td>
<td>and B. subtilis</td>
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</tr>
</tbody>
</table>

MeOH, methanol; Aq, aqueous; CHCl₃, chloroform; Hex, hexane; ETOAc, ethyl acetate; AC, acetone; EO, essential oil; EIOH, ethanol; butanol, BuOH; PTE, petroleum ether; MMELI, Microplate method of enzyme-linked immunosorbent; MIC, minimum inhibitory concentration.

Bacterial activity against *S. aureus*, *P. aeruginosa* and *Klebsiella pneumoniae* (Gayathri et al., 1998). Concentrations of 25, 50 and 75 mg/ml of Aq and hexane (Hex) aerial root extracts of *F. bengalensis* showed sustained activity against all bacterial strains and the highest activity was observed against *S. aureus* (Singh and Watal, 2010). The MeOH extract showed good antimicrobial activity at 100 mg/ml and was more potent towards *B. subtilis* (Jagtap et al., 2012). Mousa et al. (1994) reported the fruit extracts had significant antibacterial activity but no antifungal activity. The Aq or alcoholic extracts of various parts of this plant were found to have antibacterial activity (Ahmad et al., 2011). Murti and Kumar (2011) reported that the ethanolic extract at different concentrations (25, 50 and 75 mg/ml) of roots showed moderate antibacterial activity against *S. aureus*, *P. aeruginosa* and *K. pneumonia.* Other study (Koona and Rao, 2012) revealed that Hex leaves extract was found to be resistance against *K. pneumoniae*, *P. aeruginosa* and *Micrococcus luteus* for low concentration, while *K. pneumoniae* showed intermediate activity to its high concentration. *E. coli*, *P. vulgaris*, *B. subtilis* and *Enterococcus faecalis* did not show any inhibition zones. CHCl₃ extract was found effective against *K. pneumoniae* and *M. luteus* showed intermediate activity against *P. aeruginosa* irrespective of its concentrations whereas *E. coli*, *P. vulgaris* and *Enterococcus faecalis* were resistance to low concentration and evinced intermediate activity to high concentration. *B. subtilis* did not show inhibition zone. MeOH extract exhibited promising activity against all tested bacteria for both concentrations. The AC, MeOH and ETOAc bark extracts showed good antibacterial activity against *P. aeruginosa*, *E. coli*, *P. vulgaris*, *B. subtilis*, and *S. aureus* (Manimozhi et al., 2012).
Antimicrobial activity of *F. racemosa* L.

Mahato and Chudary (2005) reported that the stem bark extracts had an activity against *B. subtilis*. The maximum inhibition against *S. aureus* was observed from ethanolic extract solutions of the roots (Murti and Kumar, 2011). The MeOH, isopropanol, CHCl₃, diethyl ether and Hex extracts were evaluated against the growth of multi-drug resistant of five strains of *S. aureus, K. pneumoniae, P. aeruginosa*, and *Enterococcus faecalis* (Suresh et al., 2012). The zone of inhibition of various extracts for diabetic foot ulcer isolates is as follows: MeOH (21 mm) and Aq (19 mm) for *P. aeruginosa*; MeOH (21 mm) for *S. aureus*; MeOH (20 mm), Aq (20 mm) and isopropanol (19 mm) for *Enterococcus faecalis*; isopropanol (21 mm), MeOH (20 mm) and Aq (20 mm) for *K. pneumoniae*. The AC, MeOH, EtOAc of bark extracts showed moderate antibacterial activity against *P. aeruginosa, E. coli, P. vulgaris, B. subtilis* and *S. aureus* (Manimozhi et al., 2012).

Antimicrobial activity of *F. polita* Vahl.

The results of the MIC determination showed that the crude extract, fractions and the compound (E)-3,5,4’-trihydroxy-stilbene-3,5-O-b-D-diglucopyranoside were able to prevent the growth of the eight tested microorganisms (*Providencia smartii, P. aeruginosa, K. pneumoniae, S. aureus, S. typhi, E. coli and C. albicans*) (Kuete et al., 2011). The lowest MIC value of 64 μg/ml (crude extract) was recorded on 50% of the studied microbial species. The corresponding value for fractions of 32 μg/ml was obtained on *S. typhi, E. coli* and *C. albicans*. Compounds such as betulonic acid (Mbaveng et al., 2008), ursolic acid (Collins and Charles, 1987), b-sitosterol, sitosterol-3-O-b-D-glucopyranoside (Kuete et al., 2007), had antimicrobial activities. However, lupeol exhibited moderate inhibitory effect against *E. coli* and *Mycobacterium smegmatis* (Kuete et al., 2008). Water extract showed anti-HIV activity through the inhibition of HIV-1 reverse transcriptase activity (Ayisi and Nyadzedor, 2003). Extracts from the leaves exhibited antimalarial action against *Plasmodium falciparum* (Gbeassor et al., 1990).

Antimicrobial activity of *F. carica*

*F. carica* is commonly referred to as “Fig”. Various parts of the plant like bark, leaves, tender shoots, fruits, seeds, and latex are medicinally important (Joseph and Justin, 2011). In a study by Jeong et al. (2009), the antibacterial activity of the leaves MeOH extract showed strong activities against *S. gordonii, S. anginosus, P. intermedia, A. actinomycetemcomitans*, and *P. gingivalis* (MIC, 0.156 to 0.625 mg/ml; MBC, 0.313 to 0.625 mg/ml). Some phenolic compounds isolated from plants exhibit anticaries activity either due to growth inhibition against *Streptococcus mutans* or due to the inhibition of glucosyltransferases and the antibacterial effects may be related to the presence of flavonoids (Hada et al., 1989). Leaves water extract and EtOAc and Hex fractions from MeOH extracts have been demonstrated as anti-HSV-1 effect (Wang et al., 2004).

MeOH, hexanoic, CHCl₃ and EtOAc extracts from green fruit latex were investigated by Aref et al. (2010) for their in vitro antimicrobial proprieties against five bacteria species and seven strains of fungi. The MeOH extract had no effect against bacteria except for *P. mirabilis* while the EtOAc extract had inhibition effect on the multiplication of five bacteria species (*Enterococcus fecalis, Citobacter freudei, P. aeruginosa, E. coli* and *P. mirabilis*). For the opportunistic pathogenic yeasts, EtOAc and chlorophormic fractions showed a very strong inhibition (100%); MeOH fraction had a total inhibition against *C. albicans* (100%) at 500 μg/ml and a negative effect against *Cryptococcus neoformans*. *Microsporum canis* was strongly inhibited with MeOH extract (75%) and totally with EtOAc extract at 750 μg/ml. Hexanoic extract showed medium results. The same extracts were evaluated for their antiviral activity (Aref et al., 2011) against herpes simplex type 1 (HSV-1), echovirus type 11 (ECV-11) and adenovirus (ADV). The Hex and Hex-EtOAc (v/v) extracts inhibited multiplication of viruses by tested techniques at 78 μg/ml. All extracts had no cytotoxic effect on Vero cells at all tested concentrations. The leaves AC extracts showed antibacterial activity against *Staphylococcus* species, but were not effective against *P. syringae*. The extract possessed antifungal activity against *Fusarium solani, F. larenitum, F. roseum, Daporute nonurai* and *Bipolaris leersiae* (Shirata and Takabashi, 1982).

Antimicrobial activity of *F. ilyrata*

The antibacterial potential of Aq and ethanol extracts of leaves and two pure compounds, Urosolic acid and Acacetin-7-O-neohesperidoside, were tested against several standard bacterial strains (Rizvi et al., 2010). The plant showed potent antibacterial activity against *P. aeruginosa, S. aureus, Shigella dysenteriae, Shigella boydii, Citrobacter freundii, P. vulgaris, P. mirabilis, Klebsiella*. The Aq extract was more potent than alcoholic extract (Rizvi et al., 2010). Glycosides and saponins extracted from leaves using alcohol had biological effects but they had no effects on *C. albicans, S. aureus* and *E. coli* (Ahmad et al., 2001). Compared to the study of Bidarigh et al. (2011), latex extract are more active on human pathogenic yeasts and standard strains. The Zls for Nystatin was between 16 to 20 mm and 21 to 24 mm for standard strain and clinical isolates of *C. albicans*, respectively (Bidarigh et al., 2011). Based on the data
analysis, the best MIC EtOAc latex extract on clinical isolates and type strain of C. albicans were 25 and 2.5 mg/ml, respectively. The best MIC of Nystatin on clinical isolates and type strain of C. albicans were 36 mg/ml but MIC of combination of both showed more potency than Nystatin alone (0.05 mg/ml), which is a synergistic effect.

### Antimicrobial activity of some other Ficus species

Among the different leaf extracts of F. tsiela, diethyl ether extract exhibited better inhibitory effect against K. pneumoniae (20 mm) followed by E. coli (12 mm), P. aeruginosa (12 mm) and least activity was noted against S. aureus (10 mm) (Shamila et al., 2012). The maximum ZIs (10 mm) were observed in E. coli, P. aeruginosa and K. pneumoniae when ethanol was used as an extract (Shamila et al., 2012). The AC extract showed maximum inhibitory activity (11 mm) against S. aureus, P. aeruginosa and K. pneumoniae. Moderate activity (9 mm) has been recorded against E. coli (Shamila et al., 2012). F. elastica latices did not have any antiviral activity (Mahmoud et al., 2010). The fruit extracts of F. sycomorus L., F. benjamina L., had significant antibacterial activity but no antifungal activity (Mousa et al., 1994). EL-Fishawy et al. (2011) reported that the petroleum ether, CHCl₃ and EtOAc fractions of alcoholic extracts of the leaves and fruits were effective against S. aureus, B. aureus, B. subtilis, E. coli and P. aeruginosa.

All the extracts of F. deltoidea showed inhibitory activity on the fungus, gram-positive and gram-negative bacteria strains tested except for the CHCl₃ and Aq extracts on B. subtilis, E. coli, and P. aeruginosa (Abdsamah et al., 2012). The MeOH extract exhibited good antibacterial and anti-fungal activities against the test organisms (Abdsamah et al., 2012).

Adeshina et al. (2010) found that the Zls by F. sycomorus ranged between 11.5 - 21.5 mm while that of F. platyphtypha was from 17.0 - 22.0 mm. The values of the MIC and MBC of F. sycomorus were 1.95, 31.3 and 3.91, 250 mg/ml, respectively. Similarly, F. platyphtypha displayed 1.95 and 7.81 mg/ml MIC values and 3.91 to 62.5 mg/ml MBC values against the test organisms (S. aureus and S. typhi). Thus, the difference observed in the antimicrobial activities of F. sycomorus and F. platyphtypha stem bark extracts against S. aureus when compared to the reports of Kubmarawa et al. (2007) on the same plants against the same organism might be attributed to difference in geographical location.

The leaf extracts of F. thonningii, F. saussureana, F. exasperata and F. sur were screened for antimicrobial properties on eight fungal species and two bacterial species. The extracts had low antimicrobial effect at 25 and 50 mg/ml concentrations while a significant arrest of mycelia growth was observed at 75 and 100 mg/ml concentrations. The presence of alkaloids, flavonoids and cardiac glycosides in the leaves of these species may have conferred the antimicrobial properties on these species. The extracts from all the four Ficus species exerted significant antimicrobial effect on all the test organisms at 75 and 100 mg/ml (Oyelana et al., 2011).

### PHYTOCHEMICAL ELUCIDATION OF FICUS EXTRACTS

Most of the studies of the Ficus species revealed the presence of phenolic compounds as major components from different parts (leaves, stem wood, branches, stem bark, roots, root bark, fruits, and seeds) (Abdel-Hameed, 2009; Sultana and Anwar, 2008; Veberic et al., 2008; Basudan et al., 2005; Sheu et al., 2005; Salem, 2005; Lee et al., 2002).

#### Phytochemical constitution of F. benghalensis

Previous studies on the phytochemical screening of F. benghalensis revealed the presence of saponins, tannins and flavonoids in aqueous and MeOH extract (Aswar et al., 2008). Levels of total phenolics, total flavonol and total flavonoid compounds in aerial roots in 70 mg/g of extract, 3 mg/g quercetin equivalent and 5 mg quercetin equivalent/g extract have also been reported (Sharma et al., 2009).

The Aq extracts revealed the presence of tannins, saponins, flavonoids, glycosides, phenolic compounds, carbohydrates and proteins (Gayathri and Kannabiran, 2009). Some natural compounds, viz. glucoside, 20-tetratriacontahene-2-one, 6-heptatriacontene-10-one, pentatriacontan-5-one, β-sitosterol-α-D-glucose and meso-inositol have been isolated from the bark (Subramanian and Misra, 1978). Table 2 presents phytochemical constituents of Ficus species.

#### Phytochemical constitution of F. religiosa

The fruit of F. religiosa contained appreciable amounts of total phenolic contents, total flavonoid, and percent inhibition of linoleic acid (Swami and Bishit, 1996). The MeOH extract of bark showed the presence of flavonoids, saponins, steroids, wax, terpenoids, cardiac glycosides and tannins (Babu et al., 2010; Uma et al., 2009). The findings showed that quercetin was most abundant flavonol (Tasaki et al., 2009). Additionally, the bark extracts contain bergapten, bergaptil, lanosterol, stigmasterol, lupen-3-one, β-sitosterol-α-D-glucoside (phytosterolin), vitamin k1, β-sitosterol, leucocyanidin-3-0-β-D-glucopyranoside, leucopelargonidin-3-0-α-L-rhamnopyranoside, lupeol, ceryl behenate, lupeol acetate, α-amyrin acetate, leucoanthocyanidin and leucoanthocyanin (Joseph and Justin, 2010; Margareth and Miranda, 2009; Swami and Bishit, 1996; Swami et al., 1989).

Leaves yielded campestrol, stigmasterol, isofucosterol, α-amyrin, lupeol, tannic acid, arginine, serine, aspartic acid, glycine, threonine, alanine, proline, tryptophan, tryosine, methionine, valine, isoleucine, leucine, nnonacosane,
n-hentrientanen, hexa-cosanol and n-octacosan (Suryawanshi et al., 2011). The fruit contains asparagine, tyrosine, undecane, tridecane, tetradecane, (e)-β-ocimene, α-thujene, α-pine, β-pine, α-terpine, limonene, δ-dendrolasine, δ-dendrolasine δ-ylangene, α-copaene, β-bourbonene, β-caryophyllene, α-trans bergamotene, aromadendrene, α-humulene, aloaromadendrene, germacrene, bicycle-germacrene, γ-cadinene and δ-cadinene (Grison et al., 2002). Alanine, threonine and tyrosine have been reported in the seeds and the crude latex shows the presence of a serine protease, named religiosin (Ali and Qadry, 1987).

### Phytochemical constitution of F. retusa (F. microcarpa)

Aly et al. (2013) found that the main compounds presented in EtOAc fraction from MeOH crude extract of the leaves, were 1, 2-benzenedicarboxylic acid-dibutyl ester (15.19%); this components showed good antibacterial activity against certain grame-positive and gram-negative bacteria (Beese et al., 2002), phenol, 4-(2-aminopropyl) (9.27%) and R-(2,2,3,3-2H4) butyro lactone (13.24%).

Sarg et al. (2011) reported that new polyphenolic compounds named retusaphen 2-[hydroxy-4-methoxy-1,3-phenylene-bis-(4-hydroxy-benzoate)] and (−)-retusa azfelechin [azfelechin-(4α→8)-azfelechin-(4α→8)-azfelechin] together with ten known compounds: luteolin, (+)-azfelechin, (−)-catechin, vitexin, β-sitosterol acetate, β-amyrin acetate, moretenone, friedelenol, β-amyrin and β-sitosterol were isolated for the first time from the ethanolic extract of the aerial parts of F. retusa, “variegata”.

### Phytochemical constitution of F. auriculata

Flavonoids contents (kaempferol, quercetin, myricetin) were identified by Sultana and Anwar (2008). Additionally, betulinic acid, lupeol, stigmasterol, bergapten, scopoletin, β-sitosterol-3-O-β-D-glucopyranoside, myricetin and quercetin-3-O-β-D-glucopyranoside were isolated from the petroleum ether, CHCl₃ and EtOAc fractions of alcoholic extracts of the leaves and fruits (El-Fishawy et al., 2011).

### Phytochemical constitution of F. sycomorus

MeOH extract of the leaves was fractionated using CHCl₃, EtOAc and n-butanol (n-BuOH) and each EtOAc and n-BuOH was subjected to chromatographic separation and purification (Mohamed El-Sayed et al., 2010). The following compounds were isolated from EtOAc and n-BuOH fractions; quercetin, gallic acid, quercetin 3-O-L-rhamnopyranosyl (1→6)-β-D-glucopyranoside (Rutin), quercetin 3-O-β-D-glucopyranoside (Isoquercitrin), quercetin 3,7-O-α-L-dirhamnoside, quercetin 3-O-β-D-galactopyranosyl(1→6)-glucopyranoside and β-sitosterol-3β-D-glucopyranoside.

### Phytochemical constitution of F. carica

The phytochemical analysis reveals that the Aq extract of ripe dried fruit contains alkaloids, flavonoids, coumarins, saponins, and terpenes (Vaya and Mahmood; 2006, 2009).

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<table>
<thead>
<tr>
<th>Part</th>
<th>Phytochemical group</th>
<th>Elucidated compounds</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bark</td>
<td>Ketones</td>
<td>20-tetraactacontene-2-one, pentatracontan-5-one</td>
<td>Vikas and Vijay (2010)</td>
</tr>
<tr>
<td>Leaves</td>
<td>Flavonols</td>
<td>quercetin-3-galactoside and rutin</td>
<td>Vikas and Vijay (2010)</td>
</tr>
<tr>
<td>Stem bark</td>
<td>glycosides or flavonoids</td>
<td>Bengalenosides, 5, 7 Dimethyl ether of Leucoperagonidin-3-0-α-L-rhamnoside and 5, 3 dimethyl ether of leucocyanidin 3-O-β-D-glucopyranosyl cellulose, and 5, 7, 3 trimethoxy leucodelphinidin 3-O-α-L-Rhamnoside</td>
<td>Vikas and Vijay (2010)</td>
</tr>
<tr>
<td>Leaves</td>
<td>Pentacyclic triterpenes and triterpenoids</td>
<td>Friedelin, 3-friedelanol, beta sitosterol, 20-traxasten-3-ol, Lupeol or Betulinic acid and β-amyrin</td>
<td>Vikas and Vijay (2010)</td>
</tr>
<tr>
<td>Seeds</td>
<td>Coumarins (furcoumarins)</td>
<td>Psoralen derivative of umbelliferone, Bergapten (5-methoxypsoralen)</td>
<td>Ahmad et al. (2011)</td>
</tr>
<tr>
<td>Heartwood</td>
<td>Ester</td>
<td>Tiglic acid nester of ψ-traxasterol</td>
<td>Mohammad et al. (2010)</td>
</tr>
<tr>
<td>Bark</td>
<td>Ester</td>
<td>KETO-n-cosanyl stearate, Hydroxypentacosanyl palmitate and Phenyln tetradecanol oleate</td>
<td>Mohammad et al. (2010)</td>
</tr>
<tr>
<td>Seeds, fruits</td>
<td>Carbohydrates</td>
<td>Galactose specific lectin</td>
<td>Biswajit et al. (2007)</td>
</tr>
<tr>
<td>Bark</td>
<td>Carbohydrates</td>
<td>α-D-glucose and meso-inositol</td>
<td>Vikas and Vijay (2010)</td>
</tr>
<tr>
<td>Latex</td>
<td>Serine protease</td>
<td>Bengalensin</td>
<td>Anurag et al. (2009)</td>
</tr>
</tbody>
</table>
Some phenolic compounds, with reported pharmacological properties have already been isolated from fig leaves, namely furanocoumarins like psoralen and bergapten, flavonoids like rutin, quercetin, and luteolin, phenolic acids like ferrulic acid, and also phytosterols like taraxasterol (Vaya and Mahmood; 2006, Ross and Kasum, 2002). The plant has been reported to have numerous bioactive compounds such as arabinose, β-amyrins, β-carotines, glycosides, β-sitosterols and xanthotoxol (Gilani et al., 2008; Vaya and Mahmood, 2006). Latex contains caoutchouc, resin, albumin, cerin, sugar and malic acid, rennin, proteolytic enzymes, diasstase, esterase, lipase, catalase, and peroxidase (Joseph and Raj, 2011).

**Phytochemical screening of F. polita Vahl**

The phytochemical investigation of this plant (Kamga et al., 2010) revealed the presence of a cerebroside named pollitamide, sitosterol 3-O-B-D-glucopyranoside, betulinic acid, stigmasterol and lupeol. The compounds isolated from the roots of F. polita were identified as euphol-3-O-cinnaminate (Gewali et al., 1990), lupeol (Kamga et al., 2010; Chian and Ku, 2002), taraxar-14-ene (Kuo and Chaiang, 1999), ursoic acid (Kamga et al., 2010; Seebacher et al., 2003), β-sitosterol (Xu et al., 2006), betulinic acid (Kamga et al., 2010; Simo et al., 2008), sitosterol 3-O-B-D-glucopyranoside (Kamga et al., 2010; Xu et al., 2006) and (E)-3,5,4′-trihydroxy-stilbene-3,5-O-b-D-diglucopyranoside (Xu et al., 2006).

**Phytochemical screening of F. capensis**

Leaves and stem bark extracts of F. capensis have revealed the presence of alkaloids, balsams, carbohydrates, flavonoids, free anthraquinones, tannins, glycosides, tepenes, resins, sterols and saponins (Oyeleke et al., 2008). François et al. (2010) reported that the major compounds in essential oils were carvacrol (65.78%), α-caryophyllene (29.81%), caryophyllene oxide (25.70%), linalool (3.97%), 3-tetradecanone (2.90%), geranylacetone (1.20%), 3,7,11-trimethyl-3-hydroxy-6,10-dodecadiene-1-yl acetate (1.53%), hexahydrofarnesyl acetone (1.21%), α-caryophyllene (0.81%), 2-methyl-3-hexyne (0.69%) and scytalone (0.69%). Quercetin dihydrate (4.48 mg/ml) and protocatechuic acid (1.46 mg/ml) were the major compounds identified. Glycosides were not present in the leaf but present in the stem bark (Eban et al., 1991).

**Phytochemical screening of other some species**

The bark of F. racemosa showed the presence of phytochemical constituents namely alkaloids, carbohydrates, flavonoids, glycosides, saponins, steroids, tannins, phenols, triterpenoid, fixed oils and fats and the absence of anthraquinones, and amino acids (Poongothai et al., 2011). Benjamminamide: A new ceramide from the twigs of F. benjamina was identified (Simon et al., 2008). The EtOAc of F. barteri fruits has led to the isolation and characterization of 3,5,4′-trihydroxystilbene (trans-resveratrol), 3,5,3′,4′-tetrahydroxystilbene and catechin. The main antibacterial compound was 3,5,3′,4′-tetrahydroxystilbene with MIC values of 25 µg/ml for S. aureus, 50 µg/ml for B. subtilis and > 400 µg/ml for E. coli and P. aeruginosa (Ongubamila et al., 1997).

A triterpene, conrauidienol, and dihydroflavonol, conrauflavonol, along with β-amyrin acetate, betulinic acid, ursoic acid, 6β-hydroxystigmasta-4,22-dien-3-one, 8-prenylapigenin, β-sitosterol glucoside, and 3,4′,5-trihydroxy-6″,6″-dimethylpyrano-flavone were isolated from the stem barks of F. conraui and the Hex. EtOAc and MeOH extracts, as well as the new isolated compounds that exhibited selective antimicrobial activities varying from weak to moderate (Kengap et al., 2011).

Hakiman et al. (2012) reported that the total polyphenol content of hot and cold Aq extracts of F. deltoidea accessions ranged from 0.49 to 0.88 mg Gallic Acid Equivalent (GAE) fresh weight and 0.47 to 0.79 mg GAE/g fresh weight, respectively. The compound 3, β-hydroksilup-20(29)-en, (lupeol) was identified from the leaves and this compound showed antibacterial activities against E. coli, B. subtilis and S. aureus. The MIC against E. coli, B. subtilis and S. aureus were 150, 220 and 130 µg/ml, respectively (Suryati et al., 2011). Phytochemical screening of F. tsiela shows the presence of carbohydrates, glycosides, flavonoids, tannins, saponins, resins, fat and phenolic compounds. However, alkaloids and steroid were absent (Shamila et al., 2012). The phytochemical analysis of F. sycomorus and F. platyphyllea revealed the presence of tannins, anthraquinones, flavonoid, saponins, steroids, alkaloids (Adeshina et al., 2009), which have been previously reported for their antimicrobial activities (Ahmadu et al., 2007; Kubmarawa et al., 2007; Hassan et al., 2006).

The flavonoid content of the leaf extract of F. platyphyllea was higher than the F. sycomorus investigated, hence had better antibacterial activity in the leaf extracts of F. platyphyllea than F. sycomorus leaf extract (Adeshina et al., 2010). The presence of flavonoid in all the plant extracts tested, could probably be responsible for the observed antibacterial activity. The higher flavonoid contents in the leaf than the stem bark extracts probably account for high antibacterial activity of the Ficus spp tested (Adeshina et al., 2010). Flavonoids have been reported to display strong antimicrobial activity (Özcelik et al., 2008; Cushnie, 2005). Similarly, they have been reported to inhibit S. mutans and other bacteria (Koo et al., 2002). Thus, these test plants present a potential novel and cheap source of potent antimicrobial agents against ciprofloxacin resistant S. typhi which could justify them been claimed for ethno medicinal uses. Phenolic compounds constitute an important class of phytochemi-
cals which possess diverse biological activities like antibacterial activity (Vaya and Mahmood, 2006). Phytochemical screening of crude extract showed the occurrence of alkaloids, flavonoids, phenols, tannins, terpenoids. In this study, it was found that EtOAc latex extract contains substances which have anticanical effects. Jeong et al. (2009) showed some flavonoids compounds.

**CONCLUSION**

This review article comprised of antibacterial, antifungal, antiviral activities and phytochemical constitution studies of different species of *Ficus* (Moraceae). These species have great medicinal values as it has been reported to have enormous phytochemical constituents including tannins, flavonols and flavonoids, terpenoids, coumarins, glycosides, esters, carbohydrates, serine protease, etc. Thus, these plants have great medicinal potential for the therapy of infection.

**REFERENCES**


