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Review

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

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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* anti-bacterial 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 ($CHCl_3$) extracts showed a strong inhibitory activity against the growth of infectious *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, $CHCl_3$) of the bark of *F. religiosa* has inhibitory effect on the growth of three enteroxigenic *E. 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.

Ficus specie	Part used	Extracts tested	Bioassay	Range	Biological activities investigated	Bioactivity
F. benghalensis	Wood, bark, leaves	Me, EtOAc, *n*-BuOH, Aq, $CHCl_3$	Disc-diffusion, 96-well microplate.	5-200 µg/ml	Antibacterial activity (Salem, 2005)	MeOH extract from wood showed good inhibition.
	Leaves	Hex, $CHCl_3$, MeOH	Well diffusion, broth dilution.	100-300 mg/ ml	Antibacterial activity (Koona and Rao, 2012)	Hex extract showed less activity; $CHCl_3$ extract showed moderate activity; MeOH extract showed the high antibacterial activity against all tested bacteria.
	Bark	Aq	Well diffusion, micro dilution.		Antibacterial activity (Gayathri and Kannabiran, 2009)	Extracts exhibited moderate inhibition with the MIC ranging from 0.04 mg to 0.1 mg against tested bacterial .
	Bark	hydro alcoholic	Cup plate diffusion, Broth dilution.	0.01-0.1 mg/ ml	Antibacterial (Bhangale et al., 2010)	The extract of 0.08mg/ml to 0.1 mg/ml have better antibacterial activity against *Actinomycets viscosus.*
	Bark	AC, MeOH, EtOAc	Disc diffusion.	25-100 µg/ml	Antibacterial activity (Manimozhi *et al.*, 2012	The most resistance was *P. aeruginosa.*
	Aerial roots	Hex, Aq	Disc-diffusion.	25-75 mg/ml	Antibacterial activity (singh and watla, 2010)	The highest activity was observed against *S. aureus*
	Bark	Aq, MeOH, $CHCl_3$, PTE, Hex	Disc diffusion.		Antibacterial activity (Uma et al., 2009)	MeOH extract found to be more active against all the Enterotoxigenic *E. coli.*
F. sycomorus L., F. benjamina L., F. bengo/ens;s L. and F. religiosa L.	Fruits	$CHCl_3$	Disc-diffusion.		Antibacterial, and antifungal activities (Mousa et al. 1994)	Extracts had significant antibacterial activity but no antifungal activity.
F. benghalensis and F. racemosa	Roots	Aq, EtOH	Disc-diffusion.	25-75 mg/ml	Antibacterial activity (Murti and Kumar, 2011)	EtOH extract of both the plants were having good antimicrobial activity towards *S. aureus*.
F. religiosa	Bark	AC, MeOH, EtOAc	Disc diffusion.	25-100 µg/ml	Antibacterial activity (Manimozhi et al., 2012)	The most resistance was *P. aeruginosa.*
F. auriculata	Leave, fruits	EtOH, PTE, $CHCl_3$, EtOAc	Well diffusion.	50-250 µg/ml	Antibacterial activity (El-Fishawy et al., 2011)	250µg/ml extracts showed most activities. The extract of leaves showed more antibacterial activities than the extract of fruits except in case of *B. subtilis*.

Table 1. Contd.

	Bark	AC, MeOH, EtOAc	Disc diffusion.	25-100 µg/ml	Antibacterial activity (Manimozhi et al., 2012	The most resistance was *S. aureus.*
F. recemosa	Bark	MeOH, Isopropanol, $CHCl_3$, Diethyl Ether, Hex	Well diffusion, micro broth dilution.	0.5-4 mg/ml	Antibacterial activity (Suresh et al., 2012)	The extracts showed antibacterial activity against standard strains and clinical isolates.
	Roots	Aq, EtOH	Disc-diffusion.	25-75 mg/ml	Antibacterial activity (Murti and Kumar, 2011)	The EtOH extract having good antimicrobial activity towards *S. aureus.*
	Bark	AC, MeOH, EtOAc	Disc diffusion.	25-100 µg/ml	Antibacterial activity (Manimozhi et al., 2012	moderate activity.
F. religiosa	Leaves	EtOH	Well diffusion.	0.15- 75 mg/ml	Antibacterial activity (Jahan et al., 2011)	moderate activity.
	Bark	Aq, MeOH, $CHCl_3$, PTE, Hex	Disc diffusion.		Antibacterial activity (Uma et al., 2009)	MeOH extract found to be more active against all the Enterotoxigenic *E. coli.*
F. glomerata	Bark	PTE, MeOH	Cup-plate diffusion.	25-250 mg/ml	Antibacterial activity (Jagtap et al., 2012)	MeOH extract shows good antimicrobial activity at 100 mg/ml.
F. elastica	Young stems	latex serum	MMELI.	0.25-1 75 mg/ml	Antiviral activity (Mahmoud et al., 2010)	The latix did not have any antiviral activity.
F. nitida	Wood, bark, leaves	MeOH, EtOAc, *n*-BuOH, Aq, $CHCl_3$	Disc-diffusion, 96-well microplate.	5-200 µg/ml	Antibacterial activity (Salem, 2005)	Moderate antibacterial.
	Young stems	latex Serum	MMELI.	0.25-1 75 mg/ml	Antiviral activity (Mahmoud et al., 2010)	Latex only showed significant inhibitory activity when mixed with virus inoculum (ZYMV or BYMV) or applied 48 h before virus challenge.
	Wood, bark, leaves	Me, EtOAc, *n*-BuOH, Aq, $CHCl_3$	Disc-diffusion, 96-well microplate.	5-200 µg/ml	Antibacterial activity (Salem, 2005)	Moderate antibacterial.
F. retusa "variegata"	Aerial parts	EtOH, PTE, $CHCl_3$, EtOAc	Disk diffusion, dilution.		Antibacterial, and antifungal activities (Sarg et al., 2011)	the four extracts showed mild antimicrobial activity against *C. albicans, Mucor* spp. *S. typhi*, *E. coli* and *Bacillus* spp.
F. asperifolia	Young stems	Latex	Disc-diffusion.		Antibacterial activity (Ajayi, 2008)	Moderate antibacterial.

Table 1. Contd.

F. polita	Roots	MeOH	96-well microplate.	4-512 µg/ml	Antibacterial, antifungal (Kuete et al., 2011)	The MIC values recorded with (E)-3,5,4'-trihydroxy-stilbene-3,5-O-b-D-diglucopyranoside on the resistant *P. aeruginosa* PA01 strain was equal to chloramphenicol
F. tsiela	Leaves	diethyl ether, EtOH, AC	Disc diffusion.	100-500 µg/ml	Antibacterial (Shamila et al., 2012)	diethyl ether extract was found to be higher than that of other extracts
F. exasperata	Leaves	EtOH	Well diffusion.	100-1000 mg/ml	Antibacterial (Odunbaku et al., 2008)	The satisfactory MIC of the plant extract against *E. coli* is 300 mg/mL while that of *S. albus* is 700 mg/ml.
F. carica	Fruit latex	MeOH, Hex, $CHCl_3$, EtOAc	Disc-diffusion, 96-well microplate (B) inhibition percentage (F)		Antibacterial, antifungal (Aref et al., 2010)	EtOAc extract showed good activity
	Leaves	MeOH	Broth dilution.		Antibacterial (Jeong et al., 2009)	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.
	Fruit latex	MeOH, Hex, $CHCl_3$, EtOAc	Adsorption and penetration, intracellular inhibition and virucidal activity.		Antibacterial, antifungal (Aref et al., 2011)	The Hex and Hex-EtOAc (v/v) extracts inhibited at 78 µg/ml
F. lyrata	Leaves	Aq, EtOH	Disc-diffusion, two fold serial dilution.		Antibacterial (Rizvi et al., 2010)	The Aq extract was more potent than EtOH extract
F. deltoidea	Leaves	$CHCl_3$, MeOH, Aq	Disc-diffusion, 96-well microplate (B) inhibition percentage (F).	10-50 mg/ml	Antibacterial, antifungal (Abdsamah et al., 2012)	The MeOH extract exhibited good antibacterial and antifungal activities against the test organisms.

Table 1. Contd.

	Leaves	Hex, EtOAc, MeOH	Disc-diffusion, micro broth dilution.	0.25-2 µg/ml (isolated lupeol)	Antibacterial (Suryati et al., 2011)	lupenol showed antibacterial activities against *E. coli*, *B. subtilis* and *S. aureus*. The MIC against *E. coli*, *B. subtilis* and *S. aureus* are 150, 220 and 130 µg/ml, respectively.
F. capensis	Leaves and stem bark	MeOH, Aq	Disc-diffusion, agar dilution.	500-2000 µg/ml	Antibacterial (Oyeleke et al., 2008)	The crude extract inhibited the growth of *E. coli* and *Shigella* sp. but no activity against *S. typhi*.
	Leaves	EO, (MeOH – Aq), Aq	Disk diffusion, agar diffusion technique.	0.05-2.5 ml/10ml	Antibacterial, antifungal (François et al., 2010)	The antimicrobial activity against *E. coli* and *B. subtillis.*
F. palmata	Fruit, bark, root, leaf	PTE, $CHCl_3$, EtOAc, AC, MeOH, EtOH, Aq	Disc diffusion.	10 mg/ml and 50 mg/ml	Antibacterial, antifungal (Saklani and Chandra, 2011)	The EtOH showed significant activity against *S. aureus.*

MeOH, methanol; Aq, aqueous; $CHCl_3$, chloroform; Hex, hexane; EtOAc, ethyl acetate; AC, acetone; EO, essential oil; EtOH, 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. $CHCl_3$ 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, $CHCl_3$, 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 betulinic 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 Nyadedzor, 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, $CHCl_3$ 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 freundei*, *P. aeruginosa*, *E. coli* and *P. mirabilis*). For the opportunist 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. lareritium, F. roseum, Daporuthe nonurai* and *Bipolaris leersiae* (Shirata and Takabashi, 1982).

Antimicrobial activity of *F. lyrata*

The antibacterial potential of Aq and ethanol extracts of leaves and two pure compounds, Ursolic 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 ZIs 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 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, $CHCl_3$ 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 $CHCl_3$ and Aq extracts on *B. subtilis*, *E. coli*, and *P. aeroginosa* (Abdsamah et al., 2012). The MeOH extract exhibited good antibacterial and antifungal activities against the test organisms (Abdsamah et al., 2012).

Adeshina et al. (2010) found that the ZIs by *F. sycomorus* ranged between 11.5 - 21.5 mm while that of *F. platyphylla* 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. platyphylla* 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. platyphylla* 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 aqeous 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-tetratriaconthene-2-one, 6-heptatriacontene-10-one, pentariacontan-5-one, ß-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 Bisht, 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 (Taskeen et al., 2009). Additionally, the bark extracts contain bergapten, bergaptol, lanosterol, stigmasterol, lupen-3-one, *β*-sitosterol-d-glucoside (phytosterolin), vitamin k1, *β*-sitosterol, leucocyanidin-3-*0*-*β*-D-glucopyrancoside, 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 Bisht, 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,

Table 2. Phytochemical constitution of *F. benghalensis.*

Part	Phytochemical group	Elucidated compounds	Reference
Bark	Ketones	20-tetratriacontene-2-one, 6-heptatriacontene-10-one, pentatriacontan-5-one	Vikas and Vijay (2010)
Leaves	Flavonols	quercetin-3-galactoside and rutin	Vikas and Vijay (2010)
Stem bark	glycosides or flavonoids	Bengalenosides, 5, 7 Dimethyl ether of Leucoperalgonidin-3-0-α-L-rhamnoside and 5, 3 dimethyl ether of leucocyanidin 3-O-β-Dgalactosyl cellobioside, and 5, 7, 3 trimethoxy leucodelphinidin 3-O-α-L-Rhamnoside	Vikas and Vijay (2010)
Leaves	Pentacyclic triterpenes and triterpenoids	Friedelin, 3-friedelanol, beta sitosterol, 20-traxasten-3-ol, Lupeol or Betulinic acid and β-amyrin	Vikas and Vijay (2010)
Seeds	Coumarins (furocoumarins)	Psoralen derivative of umbelliferone, Bergapten (5-methoxypsoralen)	Ahmad et al. (2011)
Heartwood	Esters	Tiglic acid ester of ψ-traxasterol	Mohammad et al. (2010)
Bark	Esters	Keto-n-cosanyl stearate, Hydroxypentacosanyl palmitate and Phenyl tetradecanyl oleiate	Mohammad et al. (2010)
Seeds, fruits	Carbohydrates	Galactose specific lectin	Biswajit et al. (2007)
Bark	Carbohydrates	α-D-glucose and meso-inositol	Vikas and Vijay (2010)
Latex	Serine protease	Benghalensin	Anurag et al. (2009)

n-hentricontanen, hexa-cosanol and *n*-octacosan (Suryawanshi et al., 2011).

The fruit contains asgaragine, tyrosine, undecane, tridecane, tetradecane, (e)-*β*-ocimene, α-thujene, α-pinene, β-pinene, α-terpinene, limonene, dendrolasine, dendrolasine α-ylangene, α-copaene, *β*- bourbonene, *β*-caryophyllene, α-trans bergamotene, aromadendrene, α-humulene, alloaromadendrene, 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 (Beerse et al., 2002), phenol,4-(2-aminopropyl)-, (+/-) (9.27%) and R-(2,2,3,3-2H4) butyrolactone (13.24%).

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

Phytochemical constitution of *F. auriculata*

Flavonols contents (kaempeferol, quercetin, myricetin) were identified by Sultana and Anwar (2008). Additionally, betulinic acid, lupeol, stigmasterol, bergapten, scopoletin, ß-sitosterol-3-*O*-ß-*D*-glucopyranoside, myricetin and quercetin-3-*O*-ß-*D*-glucopyranoside were isolated from the petroleum ether, $CHCl_3$ 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 $CHCl_3$, 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-Dglucopyranoside (Isoquercitrin), quercetin 3,7-*O*-α-L-dirhamnoside, quercetin 3-*O*-β-D-galactopyranosyl(1→6)-glucopyranoside and β-sitosterol-3-β-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,

Teixeira et al., 2006). 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*-setosterols and xanthotoxol (Gilani et al., 2008; Vaya and Mahmood, 2006). Latex contains caoutchouc, resin, albumin, cerin, sugar and malic acid, rennin, proteolytic enzymes, diastase, 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 politamide, 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*-cinnamate (Gewali et al., 1990), lupeol (Kamga et al., 2010; Chian and Ku, 2002), taraxar-14-ene (Kuo and Chaiang, 1999), ursolic acid (Kamga et al., 2010; Seebacher et al., 2003), ß-sitosterol (Xu et al., 2006), betulinic acid (Kamga et al., 2010; Simo et al., 2008), sitosterol 3-O-ß-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 protocathechuic acid (1.46 mg/ml) were the major compounds identified. Glycosides were not present in the leaf but present in the stem bark (Ebana 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). Benjaminamide: 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* (Ogungbamila et al., 1997).

A triterpene, conrauidienol, and dihydroflavonol, conrauiflavonol, along with *β*-amyrin acetate, betulinic acid, ursolic acid, 6*β*-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. platyphylla* revealed the presence of tannins, anthraquinones, flavornoid, 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. platyphylla* was higher than the *F. sycomorus* investigated, hence had better antibacterial activity in the leaf extracts of *F. platyphylla* 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 (Özçelik 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, terpenoid. In this study, it was found that EtOAc latex extract contains substances which have anticandidal 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.

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