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ANTIMICROBIAL SCREENING OF THE ETHANOLIC LEAVES EXTRACT OF *FICUS CARICA* L. (*MORACEAE*) — AN ANCIENT FRUIT PLANT

In the present study, ethanolic extracts of Ficus carica L. leaves were tested for their antibacterial activity against Gram-negative bacteria Klebsiella pneumoniae (ATCC 700603), Pseudomonas aeruginosa (ATCC 27853), and Escherichia coli (ATCC 25922), Gram-positive bacteria Staphylococcus aureus (ATCC 25923), methicillin-resistant Staphylococcus aureus and Streptococcus pneumoniae (ATCC 49619) as well as fungus Candida albicans. The leaves of F. carica were collected in M.M. Gryshko National Botanical Garden (Kyiv, Ukraine). Antimicrobial activity was determined using the agar diffusion method. Crude extracts of Ficus carica leaves have shown a wide spectrum of antimicrobial activities. The ethanolic extract of F. carica leaves exhibited mild antimicrobial activity against the Gram-positive bacteria (10.4 mm of inhibition zone diameter for methicillin-resistant Staphylococcus aureus and 14.28 mm for Staphylococcus aureus), and the Gram-negative bacteria (13.25 mm for Escherichia coli). Klebsiella pneumoniae, Pseudomonas aeruginosa and Streptococcus pneumoniae appeared to be less sensitive to the extract, the inhibition zones were 9.75 mm, 8.69 mm and 8.56 mm, respectively. The antimicrobial activity of leaves extract is possibly could be explained by the presence of flavonoids, steroid, saponins and/or tannins. These plants have great medicinal potential for the therapy of infection. Further investigation is necessary to identify those bioactive compounds, which will be a platform for clinical applications.

These findings are important in order to evaluate the significance of collections of tropical plants maintained under glasshouse conditions at botanical gardens of Ukraine and to plan the conservation strategy by establishment of national collections of plants with valuable characteristics with the prospects of their use as sources of antimicrobial agents.

Key words: *Ficus carica*, leaf extracts, *Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, Streptococcus pneumoniae*, antimicrobial activity.

Introduction

The genus *Ficus*, comprising about 800 species of various life forms (trees, shrubs, and lianas) and life habits (terrestrials, epiphytes) in the family *Moraceae,* has a wide distribution and multiple uses in most tropical and subtropical regions throughout the world [6]. Some Ficus species are reported to be among the oldest human food sources.

The most widely cultivated *Ficus* species is *F. carica* or common fig. *F. carica* L. is typical Mediterranean fruit species, widely spread in near East, African, and South European countries, which is closely related both genetically and morphologically to number of wild *Ficus* which occur widely through the Mediterranean basin [45]. Plants of *F. carica* are xerophytes with interesting leaf structure, unique among Mediterranean trees [26]. Since ancient times fig fruits have provided a valuable food for people and animals in the Mediterranean region [40].

Fig (*F. carica* L.) is one of the most important fruit species of Mediterranean countries. Turkey is the major fig producer and exporter in the world with a total production of 270,830 t of figs (26 % of the world production [7].

Fossil evidence suggests that the common fig (*F. carica* L.) has been cultivated for over 11,000 years, possibly predating cereal grains, and thousands of cultivars of this species have been developed worldwide [24].

Domestication is though to have occurred in a number of regions within the Mediterranean basin starting in the Early Neolithic period [24]. From this region, cultivated figs spread worldwide throughout suitable climates — reaching England before 1548, China by 1550, Mexico in 1560 and finally the USA in 1769 (cit. by Morton (1987) [28]). While reproduction in the wild occurs due to pollination and the germination of viable seeds, under domestication *F. carica* varieties are a clone of female tree propagated vegetatively through cuttings. Some figs varieties require pollination for successful fruit set while other varieties may produce seedless fig fruits without pollination [45].

Figs, borne on small trees, are considered one of the classic fruits of the Mediterranean basin [40]. Domestication of *F. carica* was associated with a considerable increase in the size of the fruit (syconium) and its sugar content, as well as a characteristic shift to parthenocarpy or vegetative propagation [45].

F. carica is dispersed by birds and mammals and is an important food source for frugivorous animals in some areas [6].

It is deciduous or large shrub, growing to a height of 6.9—10.0 m, with smooth grey bark [34]. Its fragrant leaves are 12—25 cm long and 10—18 cm across, and deeply lobed with three or five lobes (Fig. 1).

The small orifice (ostiole) visible on the middle of the fruit (Fig. 2, 3) is a narrow passage, which allows the specialized fig wasp to enter the fruit and pollinate the flower, where after the fruit grows seeds [34].

F. carica has been traditionally used for its medicinal properties as metabolic, cardiovascular, respiratory, antispasmodic, and anti-inflammatory agents [25]. It was shown that various parts of the plant like bark, leaves, tender shoots, fruits, seeds, and latex of *F. carica* are medicinally important in different disorders [25, 34]. Leaves, fruits, and roots of *F. carica* are used in native medicinal system in different disorders such as gastrointestinal (colic, indigestion, loss of appetite,

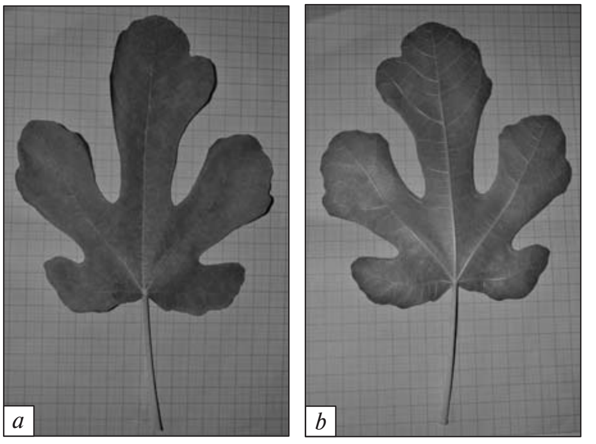
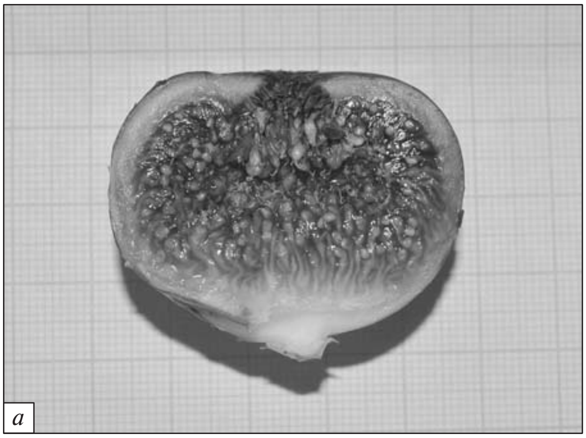


Fig. 1. Leaf morphology of *F. carica*: *a* — adaxial leaf surface; *b* — abaxial leaf surface

Fig. 2. An external view of *F. carica* syconium

and diarrhea), respiratory (sore throats, cough, and bronchial problems), inflammatory, and cardiovascular disorders [25].

Such various treated properties of *F. carica* can be explained by presence of compounds with antioxidative and antimicrobial activity. Indeed, phytochemical studies on *F. carica* revealed the presence of numerous bioactive compounds such as phenolic compounds, phytosterols, organic acids, anthocyanin composition, triterpenoids, coumarins, and volatile compounds such as hydrocarbons, aliphatic alcohols, and few other classes of secondary metabolites from different parts of *F. carica* [25]. The detection of ethanolic extract and latex of fig revealed the presence of flavonoids, terpenes and steroids, alkaloids, saponins and tan-



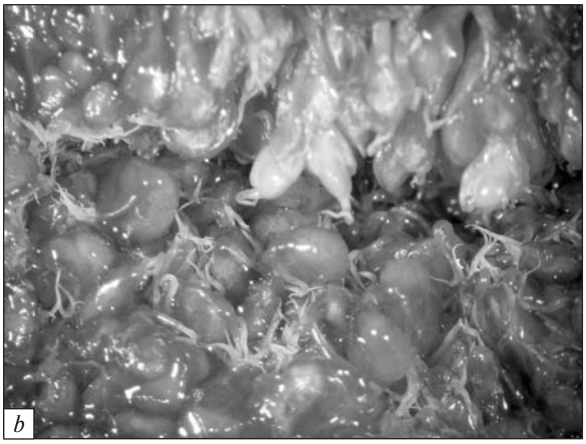


Fig. 3. The structure of *F. carica* syconium: *a* — an internal view of a longitudinal cross-section of the syconium; *b* — a close view of the female flowers enclosed in the syconium. The stereoscope image (b) was taken with Stemi 2000 C microscope (Carl Zeiss, Germany)

nins which possess diverse biological effect like antioxidant, anti-inflammatory and antibacterial activities [4].

Ficus carica has been reported to have anti-diabetic, hypoglycemic [8], hepatoprotective [15], antispasmodic [10], antipyretic [31], antibacterial [11], antifungal [19], antioxidant, anti-inflammatory, vulnerary, antitumor and antihelmintic [34] effects.

Fresh plant materials, crude extracts, and isolated components of *F. carica* have also shown a wide spectrum of antimicrobial activity [2, 18, 19, 21, 22]. Considering that other *Ficus* species have antimicrobial activity, the present investigation was undertaken to test the efficacy of ethanolic extract prepared from *F. carica* leaves against Gram-positive and Gram-negative bacteria as well as fungus *Candida albicans* to determine the possible use of this plant in preventing infections.

Material and methods

The leaves of *F. carica* were collected in M.M. Gryshko National Botanical Garden (Kyiv, Ukraine) during March, 2015. The whole collection of tropical and subtropical plants at M.M. Gryshko National Botanical Garden (including *Ficus* spp. plants) has the status of a National Heritage Collection of Ukraine. The collected leaves were brought into the laboratory for antimicrobial studies.

Preparation of plant extracts. Freshly leaves were washed, weighted, crushed, and homogenized in 96 % ethanol (in proportion 1:10) at room temperature. All extracts were then filtered and stored at 4 °C until use.

Bacterial test strain and growth conditions. Antimicrobial activity was determined using the agar diffusion method (Bauer et al., 1966). Gram-negative bacteria *Klebsiella pneumoniae* (ATCC 700603), *Pseudomonas aeruginosa* (ATCC 27853), and *Escherichia coli* (ATCC 25922), as well as Gram-positive bacteria *Staphylococcus aureus* (ATCC 25923), methicillin-resistant *Staphylococcus aureus* and *Streptococcus pneumoniae* (ATCC 49619) were used as test organisms. The cultivation medium was trypticase soy agar (Oxoid, UK), supplemented with 10% defibrinated sheep blood. Cultures were grown aerobically for 24 h at 37 °C. The cultures were later diluted with sterile solution of 0.9 % normal saline to approximate the density of 0.5 McFarland standard. The McFarland standard was prepared by inoculating colonies of the bacterial test strain in sterile saline and adjusting the cell density to the specified concentration.

Determination of antibacterial activity of plant extracts by the disk diffusion method. Antimicrobial activity was determined using the agar disk diffusion assay [1]. Culture of *S. aureus* was inoculated onto Mueller-Hinton (MH) agar plates. Sterile filter paper discs impregnated with 50 μL of extract dilutions were applied over each of the culture plates. Isolates of bacteria were then incubated at 37 °C for 24 h. The plates were then observed for the zone of inhibition produced by the antibacterial activity of various ethanolic extract obtained from leaves of *F. carica*. A negative control disc impregnated with 50 μL of sterile ethanol was used in each experiment. At the end of the period, the inhibition zones formed were measured in millimeters using the vernier. For each extract, 8 replicates were assayed. The plates were observed and photographs were taken. Zone diameters were determined and averaged. The fungal organism used for the present study was *Candida albicans*. The plates were incubated at 27 °C for 24 hrs. The plates were then observed for the zone of inhibition produced by the antifungal activity of *F. carica*. All statistical calculation was performed on separate data from each bacterial strains. The following zone diameter criteria were used to assign susceptibility or resistance of bacteria to the phytochemicals tested: Susceptible (S) ≥ 15 mm, Intermediate (I) — 11—14 mm, and Resistant (R) ≤ 10 mm [30].

Results and discussion

The results of screening study of antimicrobial activity of ethanolic extracts obtained from *F. carica* leaves are presented in Fig. 4 and 5.

Our results showed that the ethanolic extract of *F. carica* leaves exhibited mild antimicrobial activity against the Gram-positive bacteria (10.4 mm of inhibition zone diameter for methicillin-resistant *Staphylococcus aureus* and 14.28 mm for *Staphylococcus aureus*) (Fig. 4), and the Gram-negative bacteria (13.25 mm for *Escherichia coli*) (Fig. 5A). *Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Streptococcus pneumoniae* appeared to be less sensitive to the extract, the inhibition zones were 9.75 mm, 8.69 mm and 8.56 mm, respectively (Fig. 4).

The *in vitro* antimicrobial activity of ethanolic extract obtained from *F. carica* leaves could provide with potentially useful information for developing novel compounds with antibiotic properties. Indeed, *Ficus* species could be used as a possible way to treat diseases caused by multidrug-resistant bacteria [32]. The combination of the methanolic extract obtained from fig leaves with oxacillin or ampicillin has successfully been used for its synergistic effects against methicillin-resistant *S. aureus* (MRSA) [23]. The antimicrobial activity of *F. carica* extracts has been reported [2, 18, 21, 22]. The ethanolic leaf extract and latex of fig was effective against six bacterial strains, two Gram-positive (*S. aureus, Streptococcus pyogenes*) and four Gram-negative (*K. pneumonae, P. aeruginosa, Salmonella typhi, E. coli*), and three fungal strains (*Candida albicans, Fusarium oxysporum, Aspergillus niger*) [2]. The ethanolic extract of leaves exhibited strong activity against *S. aureus* and *S. typhi* (13 mm, 14 mm), and the fungi *F. oxysporum* (16 mm), whereas the latex showed higher activity against these bacteria (15 mm) for each of them, and the fungi *A. niger*

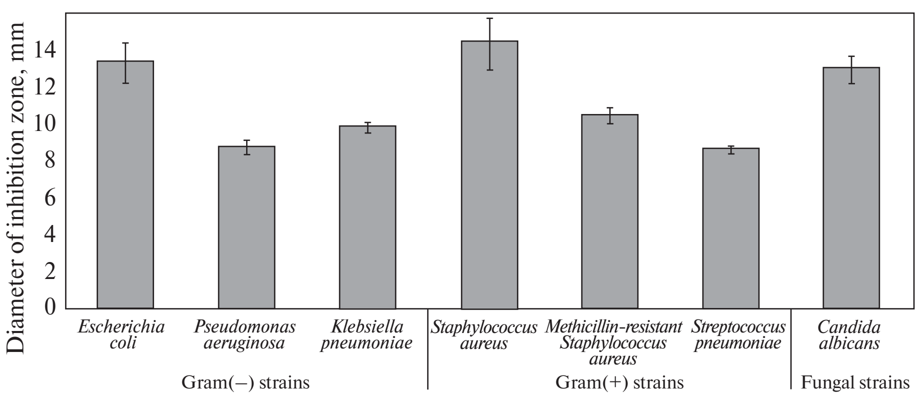


Fig. 4. Antimicrobial activity of ethanolic extract obtained from *F. carica* leaves against bacterial strains measured as inhibition zone diameter (M ± m), n = 8

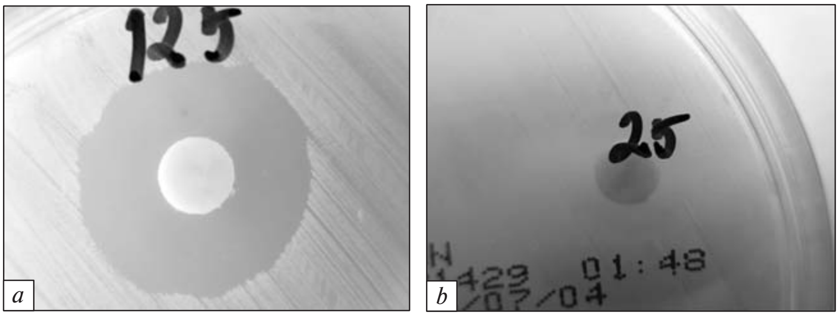


Fig. 5. Antimicrobial activity of ethanolic extract obtained from *F. carica* leaves against Gram-positive bacterial strain (*a — Staphylococcus aureus*) and Gram-negative bacterial strains (*b — Escherichia coli*) measured as inhibition zone diameter

(18 mm). *K. pneumonae* and *E. coli* seemed to be resistant to both extract which showed (8 mm, 9 mm) and (11 mm, 10 mm) with ethanolic extract and latex, respectively [2].

R. Jasmine and co-workers (2014) [11] have also evaluated two different extracts of *F. carica* against drug resistant human pathogens (*E. coli, P. aeruginosa, Streptococcus* spp., *Enterobacter* spp., *K. pneumoniae*, *S. typhi, S. paratyphi*). The ethanolic extract of *F. carica* showed good antimicrobial effect against the organisms than the methanolic extract. The zones of inhibition ranged from 3—11 mm, where the maximum activity of 15 mm was recorded against *Pseudomonas* spp. and 11 mm against *Salmonella* spp., suggesting the efficiency of the plant against drug resistant bacteria [11]. Hiba Hazim Hamid Al-Yousuf (2012) [17] have demonstrated that *F. carica* was effective against Gram-positive (*Bacillus subtilis, S. aureus, B. megaterium*) and Gram-negative bacterial strains (*P. aeruginosa, E. coli* and *Proteus vulgaris*). Methanolic extract of *F. carica* was more effective against *B. megaterium* among Gram-positive strains and *E. coli* among Gram-negative strains [17].

On the other hand, the methanolic extract of *F. carica* showed a strong antibacterial activity against oral bacteria. The combination effects of methanolic extract with ampicillin or gentamicin were synergistic against oral bacteria that showed that figs could act as a natural antibacterial agent (Jeong et al., 2009). L.A. Houda and co-workers [19] have evaluated methanolic, hexanoic, chloroformic and ethyl acetate extracts of *F. carica* latex against five bacteria species (*Enterococcus fecalis, Citobacter freundei, P. aeruginosa, E. coli* and *Proteus mirabilis*) and seven strains of fungi. The methanolic extract had no effect against bacteria except for *P. mirabilis* while the ethyl acetate extract had inhibition effect on the multiplication of five bacteria species. For the opportunist pathogenic yeasts, ethyl acetate and chlorophormic fractions showed a very strong inhibition (100 %); methanolic fraction had a total inhibition against *Candida albicans* (100 %) at a concentration of 500 μg/ml and a negative effect against *Cryptococcus neoformans*. *Microsporum canis* was strongly inhibited with methanolic extract (75 %) and totally with ethyl acetate extract at a concentration of 750 μg/ml. Hexanoic extract showed medium results [19].

The results from the present study agree well with those of I.R. Khaleel and co-workers [2] who found antimicrobial activity of ethanolic leaf extract and latex of *F. carica* against six bacterial strains, two Gram-positive (*S. aureus, Streptococcus pyogenes*) and four Gram-negative (*K. pneumonia, P. aeruginosa, Salmonella typhi, E. coli*), and three fungal strains (*C. albicans, Fusarium oxysporum, Aspergillus niger*). The results of these researchers showed that the ethanolic extract of *F. carica* leaves exhibited the strong activity against the Gram-positive bacteria (*S. aureus* — 13 mm in diameter of inhibition zone), and the Gram-negative bacteria (*S. typhi*, 14 mm), while it showed moderate activity against *S. pyogenes, P. aeruginosa* which recorded 12 mm and 11 mm, respectively. *K. pneu-*

moniae and *E. coli* appeared to be less sensitive to the extracts, the inhibition zone were 8 mm and 9 mm, respectively [3].

J.Wang and co-workers [39] have demonstrated that leaves water extract and ethanolic and hexane fractions from methanolic extracts have antiviral effect against human herpesvirus 1 (HSV-1). Extracts obtained from *F. carica* were possible candidates as herbal medicines for herpes virus, echovirus and adenovirus infectious diseases. *In vitro* antiviral potential activity of five extracts (methanolic, hexanic, ethyl acetate, hexane-ethyl acetate, and chloroformic) against herpes simplex type 1 (HSV-1), echovirus type 11 (ECV-11) and adenovirus (ADV) for adsorption and penetration, intracellular inhibition and virucidal activity, evaluating the capacity of the extracts to inhibit the replication of viruses was studied by Lazreg Aref and co-workers [21]. The hexanic and hexane-ethyl acetate extracts inhibited multiplication of viruses at concentrations of 78 μg/mL. Interestingly, that all extracts had no cytotoxic effect on Vero cells at all tested concentrations [21].

Moreover, the 80 % methanolic extract from the leaves of *F. carica* has been screened against *Mycobacterium tuberculosis* H37R and exhibited anti-tuberculosis activity with Minimal Inhibitory Concentration (MIC) value of 1600 μg/mL [16]. The leaf extract of *F. carica* showed the strongest nematicidal activity as 74.3, 96.2, and 98.4 % mortality, respectively, within 72 hrs [29]. The leaves acetone extracts of *F. carica* also showed antibacterial activity against plant pathogens, i.e. *Staphylococcus* species. The extract possessed antifungal activity against *Fusarium solani*, *F. lareritium, F. roseum, Daporuthe nonurai* and *Bipolaris leersiae* [37].

S. Hada et al. [18] also revealed that some phenolic compounds isolated from *F. carica* exhibit anticaries activity either due to growth inhibition against *Streptococcus mutans* or due to the inhibition of glucosyltransferases. The antibacterial effects may be related to the presence of flavonoids [18]. Indeed, phytochemical studies on *F. carica* revealed the presence of numerous bioactive compounds such as phenolic compounds, phytosterols, organic acids, anthocyanin composition, triterpenoids, coumarins, and volatile compounds such as hydrocarbons, aliphatic alcohols, and few other classes of secondary metabolites from different parts of *F. carica* [25]. A.P. Oliveira and co-workers [12] analyzed the metabolite profiling on the leaves, pulps and peels of two Portuguese white varieties of *F. carica*. All samples presented a similar phenolic profile composed by 3-o- and 5-o-caffeoylquinic acids, ferulic acid, quercetin-3-o-glucoside, quercetin-3-o-rutinoside, psoralen and bergapten. 3-o-caffeoylquinic acid and quercetin-3-o-glucoside are described for the first time in this species. Leaves' organic acids profile presented oxalic, citric, malic, quinic, shikimic and fumaric acids, while in pulps and peels quinic acid was absent [13]. Various volatile constituents of five Portuguese varieties of *F. carica* fruits (pulps and peels) have been isolated which include aldehydes: 3-methyl-butanal, 2-methyl-butanal, (E)-2-pentanal, hexanal, heptanal, octanal, and nonanal, alcohols: 1-penten-3-ol, 3-methylbutanol, benzyl alcohol, (E)-2-nonenol, and phenylethyl alcohol, ketone: 6-methyl-5-hepten-2-one, esters: methyl hexanoate, methyl salicylate, and ethyl salicylate, monoterpenes: limonene, menthol, α-pinene, β-pinene, linalool, eucalyptol, sesquiterpenes: α-cubenene, copaene, β-caryophyllene, τ-muurolene, τ-cadinene, and germacrene D, norisoprenoid: β-cyclocitral, and miscellaneous compounds: eugenol [12].

Organic acids, sugars, chlorogenic acid, catechin, epicatechin, kaempferol-3-o-glucoside, luteolin-8-C-glucoside, and total phenolic contents in the sun-dried and oven-dried figs were determined by A. Slatnar et al. [9]. Fruit from the *F. carica* contains numerous phenolics (ferulic, caffeoylquinic acid, and quercetin glycosides) and organic acids (malic, citric, fumaric, oxalic, quinic, shikimic, and chlorogenic acids) [20]. The fruit extract showed its efficacy in antioxidant, anti-inflammatory, anti-ulcerogenic, hepatoprotective, and gastroprotective activities [5]. Moreover, pentane extracts from the fig of *F. carica* contain numerous volatile compounds: benzyl aldehyde, benzyl alcohol, furanoid, linalool, pyranoid (trans), cinnamic aldehyde, indole, cinnamic alcohol, eugenol, and trans-caryophyllenes sesquiterpene: germacrene D, hydroxyl caryophyllene, angelicin, and bergapten [43].

Leaves were always the most effective part, which seems to be related with phenolics compounds content. The leaves of *F. carica* consist of various volatile compounds which are identified and distributed by distinct chemical classes, such as aldehydes: methyl-butanal, 2-methylbutanal, (E)-2-pentanal, hexanal, and (E)-2-hexanal, alcohols: 1-penten-3-ol, 3-methyl-1-butanol, 2-methylbutanol, heptanol, benzyl alcohol, (E)-2-nonen-1-ol, and phenylethyl alcohol, ketone: 3-pentanone, esters: methyl butanoate, methyl hexanoate, hexyl acetate, ethyl benzoate, and methyl salicylate, monoterpenes: limonene and menthol, sesquiterpenes: α-cubenene, α-guaiene, α-ylangene, copaene, β-bourbonene, β-elemene, α-gurjunene, β-caryophyllene, β-cubebene, aromadendrene, α-caryophyllene, τ-muurolene, τ-cadinene, α-muurolene, germacrene D, and (+)-ledene, norisoprenoid: β-cyclocitral, and miscellaneous compounds: psoralen [12]. Moreover, only the leaves possessed the capacity to scavenge superoxide radical [12].

In our study, the antibacterial activity of ethanolic extract of *F. carica* leaves is possibly linked to the presence of flavonoids, steroid, saponins and/or tannins. The high antimicrobial activity may perhaps due to leaves content of rutin, quercetin, luteolin, phenolic acids and phytosterols [35].

Antibacterial activity of tannins and saponins isolated from plant species are well documented [14]. The presence of flavonoids and polyphenols is the basis for the analgesic and anti-inflammatory activities of various parts of *F. carica* including the fruit, latex, bark, roots, and leaves [27, 33]. Fever may be a result of infection or a result of one of the sequels of tissue damage, inflammation, graft rejection, or other disease states [31]. Numerous researchers found that ethanolic extract of *F. carica* leaves possesses a significant antipyretic effect with comparable effects to that of paracetamol. In addition, the total phenolic content is significantly different among the different vegetal parts with the leaves reported to contain the highest levels [27]. The methanolic extract of the leaves has also been shown to exhibit the highest antioxidant potential [5]. Pharmacological and chemical studies have also demonstrated the antineoplastic or anti-inflammatory activity of both the crude extract and pure compounds [13].

The antimicrobial activity of purified flavonoids may result in susceptibility differences against species with different origins and background [41]. This could explain the difference in sensitivity to *F. carica* extract between *S. aureus*, *S. aureus* MRSA and *E. coli* used in this work and a previously tested other species of *Ficus* [42]. The highest antibacterial potential of *F. carica* could be explained by the amount of flavonoids present. However, the activity showed by ethanolic extract of *F. carica* may result from the interactions of different polyphenols. Most studies on the antimicrobial potential of polyphenols have focused on the inhibitory activity of individual components. We have shown that the interactions between various compounds can alter the antimicrobial effectiveness of the *F. carica* flavonoids against Gram-positive and Gram-negative bacteria and fungus *C. albicans*. The inhibitory effect of phenolics could be explained by absorption to cell membranes, interactions with enzymes, substrate and metal ion deprivation [36]. Direct interaction between the two compounds may result in changes of the structural conformation thus reducing the inhibitory activity. The antagonistic interaction observed with all combinations against *L. monocytogenes* may be the result of a number of mechanisms such as competition for target sites or inhibition of uptake by the cells [3]. On the other hand, the synergism observed between flavanone and phenolic acid against S. *aureus* and *S. enterica*, between flavanone and epicatechin against *S. enterica* and *S. aureus* and between phenolic acid and epicatechin against *S. aureus* could be because of their combined reaction with the cell membrane as a possible primary target site [38].

Conclusions

The obtained results indicated the therapeutic importance of *Ficus carica* leaves as an antimicrobial agent against some microbial infections, such as *Staphylococcus aureus, Pseudomonas aeruginosa*, *Klebsiella pneumoniae,* and *E. coli* as well as fungus *Candida albicans* which recognized as a global nosocomial problem.

Thus, *F. carica* has a great medicinal potential for the therapy of infections induced by Gram-positive and Gram-negative bacteria as well as fungi. Further investigation is necessary to identify those bioactive compounds, which will be a platform for clinical applications. However, further studies need to be performed to understand the precise mechanisms responsible for interactions between compounds in ethanolic extract of *F. carica* responsible for its antibacterial activity.

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АНТИМІКРОБНИЙ СКРИНІНГ ЕТАНОЛЬНОГО ЕКСТРАКТУ ЛИСТКІВ *FICUS CARICA* L. (*MORACEAE*) — ДАВНЬОЇ ПЛОДОВОЇ РОСЛИНИ

Досліджено антимікробну активність етанольного екстракту, отриманого з листків *F. carica* L., щодо грамнегативних (*Klebsiella pneumoniae* (ATCC 700603), *Pseudomonas aeruginosa* (ATCC 27853), *Escherichia coli* (ATCC 25922)) та грам-позитивних (*Staphylococcus aureus* (ATCC 25923), метицилін-резистентний штам *Staphylococcus aureus* та *Streptococcus pneumoniae* (ATCC 49619)) мікроорганізмів, а також мікроскопічного гриба *Candida albicans*. Листки були зібрані в Національному ботанічному саду імені М.М. Гришка (Київ, Україна). Антимікробну активність визначали за допомогою дискодифузійного методу. Неочищені екстракти листків *Ficus carica* виявили широкий спектр антимікробної активності. Зокрема для етанольного екстракту листків *F. carica* характерна помірна антибактеріальна активність щодо грам-позитивних (діаметр зони інгібування росту метицилін-резистентного штаму *Staphylococcus aureus* — 10,4 мм, *Staphylococcus aureus* — 14,28 мм) та грам-негативних бактерій (13,25 мм для *Escherichia coli*). *Klebsiella pneumoniae, Pseudomonas aeruginosa* та *Streptococcus pneumoniae* виявилися менш чутливими до дії екстракту — зона інгібування становила 9,75, 8,69 і 8,56 мм відповідно. Антимікробна активність екстрактів листків зумовлена, ймовірно, наявністю в екстрактах флавоноїдів, стероїдів, сапонінів та/або танінів. Отже, *F. carica* має значний потенціал для лікування інфекційних захворювань. Подальші дослідження потребують ідентифікації біологічно активних сполук, на основі яких будуть розроблені препарати для застосування у клінічній практиці.

Результати цього дослідження є важливими для оцінки значення оранжерейних колекцій рослин тропікогенних флор, у ботанічних садах України, а також для реалізації стратегії збереження рослин з цінними властивостями шляхом створення та підтримки національних колекцій рослин, які становлять значний інтерес для використання як джерела антимікробних засобів.

Ключові слова: *Ficus carica*, екстракти листків, *Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, Streptococcus pneumoniae,* антимікробна активність.

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АНТИМИКРОБНЫЙ СКРИНИНГ ЭТАНОЛЬНОГО ЭКСТРАКТА ЛИСТЬЕВ *FICUS CARICA* L. (*MORACEAE*) — ДРЕВНЕГО ПЛОДОВОГО РАСТЕНИЯ

Исследована антимикробная активность этанольного экстракта, полученного из листьев *F. carica L.*, в отношении грам-отрицательных (*Klebsiella pneumoniae* (ATCC 700603), *Pseudomonas aeruginosa* (ATCC 27853) и *Escherichia coli* (ATCC 25922)), грам-положительных (*Staphylococcus aureus* (ATCC 25923), метициллин-резистентный штамм *Staphylococcus aureus* и *Streptococcus pneumoniae* (ATCC 49619)) микроорганизмов, а также микроскопического гриба *Candida albicans*. Листья были собраны в Национальном ботаническом саду имени Н.Н. Гришко (г. Киев, Украина). Антимикробную активность определяли с помощью диско-диффузионного метода. Неочищенные экстракты листьев *Ficus carica* выявили широкий спектр антимикробной активности. В частности, для этанольного экстракта листьев *F. carica* характерна умеренная антибактериальная активность относительно грам-положительных (диаметр зоны ингибирования для метициллин-резистентного штамма *Staphylococcus aureus* — 10,4 мм и для *Staphylococcus aureus* — 14,28 мм) и грам-отрицательных микроорганизмов (13,25 мм для *Escherichia coli*). *Klebsiella pneumoniae, Pseudomonas aeruginosa* и *Streptococcus pneumoniae* оказались менее чувствительными к действию экстракта — зона ингибирования составляла 9,75, 8,69 и 8,56 мм соответственно. Антимикробная активность экстрактов листьев обусловлена, вероятно, содержанием в экстрактах флавоноидов, стероидов, сапонинов и/или таннинов. Таким образом, *F. carica* обладает мощным потенциалом для лечения инфекционных заболеваний. Дальнейшие исследования требуют идентификации биологически активных соединений, на основе которых будут разработаны препараты для применения в клинической практике.

Результаты этого исследования являются важными для оценки значения оранжерейных коллекций растений тропикогенных флор в ботанических садах Украины, а также для реализации стратегии сохранения биоразнообразия растений путем создания и поддержания национальных коллекций растений, представляющих значительный интерес с точки зрения их использования как источника антимикробных препаратов.

Ключевые слова: *Ficus carica*, экстракты листьев, *Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, Streptococcus pneumoniae*, антимикробная активность.