Screening of in vitro antimicrobial activity of plants used in traditional Indonesian medicine

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ABSTRACT

Context: In many regions of Indonesia, there are numerous traditional herbal preparations for treatment of infectious diseases. However, their antimicrobial potential has been poorly studied by modern laboratory methods.

Objective: This study investigates in vitro antimicrobial activity of 49 ethanol extracts from 37 plant species used in Indonesian traditional medicine for treatment against Candida albicans, Enterococcus faecalis, Escherichia coli, Pseudomonas aeruginosa and Staphylococcus aureus.

Materials and methods: The plants were collected from the Biofarmacia collection garden, Bogor, Indonesia. The plant material was dried, finely grounded, extracted using ethanol, concentrated, and the dried residue was dissolved in 100% DMSO. Antimicrobial activity was determined in terms of a minimum inhibitory concentration (MIC) using a broth microdilution method in 96-well microplates.

Results: The extract of Orthosiphon aristatus (Blume) Miq. (Lamiaceae) leaf produced the strongest antimicrobial effect, inhibiting the growth of C. albicans (MIC 128 μg/mL), S. aureus (MIC 256 μg/mL), E. faecalis (MIC 256 μg/mL) and P. aeruginosa (MIC 256 μg/mL). The leaf extract of Woodfordia floribunda Salisb. (Lythraceae) also exhibited significant effect against C. albicans (MIC 128 μg/mL), S. aureus (MIC 256 μg/mL) and E. faecalis (MIC 256 μg/mL). Rotheca serrata (L.) Steane & Mabb. (Lamiaceae) leaf extract inhibited the growth of S. aureus (MIC 256 μg/mL) and C. albicans (MIC 256 μg/mL).

Discussion and conclusions: The leaf extract of O. aristatus and W. floribunda exhibited a significant anti-candidal effect. Therefore, both of these plants can serve as prospective source materials for the development of new anti-candidal agents.

Introduction

Despite tremendous progress in human medicine, communicable diseases remain a major public health problem (Cos et al. 2006). They are responsible for substantial morbidity and mortality, in particular in people living in low and middle-income countries, including Indonesia, where lower respiratory infections and tuberculosis are the leading causes of death (World Health Organization 2015a). Recently, the rapid emergence of resistant bacteria has occurred worldwide (Golkar et al. 2014; Wright 2014). This trend has been exacerbated in Indonesia by improper prescription, irrational use, and uncontrolled access to antibiotics (Abdulah 2012). As a result, infected patients are likely to have higher health expenditure, longer hospital stays, and require a second- or third-line drugs treatment that may be less effective, more toxic and more expensive (Farrell et al. 2005; Levy 2005).

In the last few years, medicinal plants have attracted the attention of pharmaceutical and scientific communities as sources of antimicrobial substances (Ginsburg and Deharo 2011). Phytochemical screening, based on ethnomedicinal data, is considered an effective approach for the discovery of new therapeutic agents (Savithramma et al. 2012). For instance, the invention of artemisinin from Artemisia annua L. (Compositae) in 1971 by Chinese scientists using data from ancient texts in traditional Chinese medicine (Tu 2011) has already saved millions of people from malarial infection (Bhatt et al. 2015). Currently, artemisinin-based combination therapy is recommended by the World Health Organization (WHO) for the treatment of this life-threatening disease and is being used worldwide (WHO 2015b). Since medicinal plants have demonstrated great efficacy as antimicrobial remedies in the past (Rahmatullah et al. 2012), they may also be a valuable reservoir for novel solutions for other microbial-related diseases.

Indonesia, while covering only 1.3% of the earth’s land surface, contains 10% of the global flowering plant species (Riswan and Yamada 2006). Until now, only one-third of the 6000 species used in Indonesian traditional medicine has been identified and provided with relatively complete data on their chemistry and biological properties (Zuhud 2009). Based on the richness of local phytocoenoses, most Indonesian people started using herbal medicines known as ‘jamu’ for treating diseases, maintaining health, and wellness centuries ago (Stevensen 1999). Although the first written records, namely ‘serat kawruh’ and ‘serat cennini’ date from the eighteenth century, the earliest evidence for this traditional medicinal system dates back to the eighth century, as it is illustrated by the image of a man grinding ‘kalpata’ leaf with other ingredients to make a mixture for a...
woman in a stone relief on the wall of Borobudur temple in Central Java (Riswan and Sangat 2002). Jamu medicines are usually prepared in form of infusions or decoctions by mixing different plant parts such as leaves, bark, roots and flowers. Species belonging to the family Zingiberaceae are the most frequently used jamu ingredients. For example, ‘jamu kunir asam’, which mainly consists of turmeric [Curcuma longa L., (Zingiberaceae)] and tamarind [Tamarindus indica L., (Fabaceae)], has been used to cure several diseases associated with pathogenic microorganisms such as diarrhea and dysentery (Beers 2001).

Despite numerous recent ethnobotanical inventories reporting the folk use of Indonesian medicinal plants for the treatment of infectious diseases (Grovenor et al. 1995; Zumsteg and Weckerle 2007; Roosita et al. 2008; Himmi et al. 2014; Silalahi et al. 2015; Sujawo et al. 2015), only a limited number of studies have assessed their antimicrobial potential. Although a review of the antimicrobial properties of Indonesian medicinal plants (Nugraha and Keller 2011) and other specific investigations targeting anti-acne (Batubara et al. 2009), anti-candidal (Kusuma et al. 2014), anti-biofilm (Pratiwi et al. 2015) and resistant isolates inhibition (Wikaningtyas and Sukandar 2016) have been carried out, to the best of our knowledge, a systematic screening for antimicrobial potentials following the standard methodological approaches remains limited. Thus, we decided to investigate the in vitro antimicrobial activity of plant species used in Indonesian traditional medicine for the treatment of infectious diseases against the panel of standard strains representing Gram-positive and Gram-negative bacteria as well as yeast.

**Materials and methods**

**Plant materials**

The plants were obtained from the Biopharmacca collection garden, Bogor Agricultural University (IPB) in Dramaga, Bogor (West Java Province, Indonesia) in July and August 2016. Specimens were authenticated by Ervizal Amir Muhammad Zuhud and deposited in the Herbarium of the Department of Forest Resources Conservation and Ecotourism, the Faculty of Forestry, IPB. The scientific names of the plant species were verified using online sources (The Plant List 2013). The selection of plant species was based on literature data on their traditional medicinal uses for the treatment of ailments caused by microbial agents (Ulung and Biofarmaka 2014). The botanical names, families, common names, voucher specimen numbers, traditional uses, and preparation of the tested parts are given in Table 1.

**Preparation of plant extract**

Plant materials were dried and finely ground into powder using an electric mill GM100 (Retsch, Haan, Germany). Each powdered sample (15 g) was extracted with 450 mL of 80% ethanol (Penta, Prague, Czech Republic) and placed on a rotary shaker (GFL3005, Burgwedel, Germany) for 24 h at room temperature. Ethanol has been chosen as a solvent because of its traditional use for in Jamu medicines (IP 2014). Extracts were subsequently filtered and concentrated in vacuo using a rotary vacuum evaporator R-200 (Buchi, Flawil, Switzerland) at 40 °C. Dried residues were dissolved in 100% dimethylsulphoxide (DMSO) to obtain extract stock solution at a concentration of 51.2 mg/mL, which was kept at −80 °C until tested. Dried residue yields (%) are shown in Table 1.

**Microorganisms and media**

In this study, four bacterial and one yeast strain were tested. The following American Type Culture Collection (ATCC) in the form of Culti-Loops standard strains were purchased from Oxoid (Basingstoke, UK): *Candida albicans* ATCC 10231, *Enterococcus faecalis* ATCC 29212, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853 and *Staphylococcus aureus* ATCC 29213. Microorganism cultures were maintained in Mueller-Hinton broth (MHB) (Oxoid, Basingstoke, UK) at 4 °C until use. MHB equilibrated with Tris-buffered saline (Sigma-Aldrich, Prague, Czech Republic) was used as the culture medium for *E. faecalis*, the MHB was enriched with 1% of glucose. For inoculum standardization, the turbidity of the microorganism suspension was adjusted to a 0.5 McFarland standard (1.5 × 10^8 CFU/mL) using a Densi-La-Meter II (Lachema, Brno, Czech Republic) spectrophotometric device.

**Minimum inhibitory concentration (MIC) assay**

MICs were determined by the broth microdilution method using 96-well microplates modified according to previous recommendations for the effective assessment of the antimicrobial potential of natural products (Clinical and Laboratory Standards Institute 2009; Cos et al. 2006). Assay microplate preparation and serial dilution were performed using the automated pipetting platform Freedom EVO 100 (Tecan, Mannedorf, Switzerland). Serial dilutions (100 μL) of each extract were distributed into the plate and diluted in the MHB making concentrations ranging from 4 to 512 μg/mL. Thereafter, the plates were inoculated with the respective microorganism suspension to make a final density 5 × 10^5 CFU/mL for bacteria and 1.5 × 10^4 CFU/mL for yeast, respectively. Plates were then incubated at 37 °C for 24 h (48 h for *C. albicans*). Microorganism growth was measured in terms of turbidity recorded at 405 nm (Cos et al. 2006) by a Cytation 3 microplate reader (BioTek, Winooski, VT). The MIC was expressed as the lowest concentration that showed ≥80% inhibition of microbial growth compared to an extract-free growth control. The antibiotics tetracycline and toconazolet (Sigma-Aldrich, Prague, Czech Republic) were dissolved in ethanol (Sigma-Aldrich, Prague, Czech Republic) and used as positive controls. The solvents used (DMSO and ethanol) did not inhibit bacterial growth at the concentrations tested (≤1%). Results reported in this study were expressed as the median/mode of MICs obtained from three independent experiments that were assayed in triplicate.

**Results**

In this study, a total of 49 ethanol extracts from 37 different Indonesian medicinal plant species belonging to 23 different families were investigated for their in vitro antimicrobial activity. The MIC values determined by means of the broth microdilution method are shown in Table 2. Results revealed that 21 plant extracts, namely: *Aerva sanguinolenta* (L.) Blume (Amaranthaceae), *Agathis macrophylla* (Lindl.) Mast. (Araucariaceae), *Aleurites moluccana* (L.) Willd. (Euphorbiaceae), *Amorphophallus muelleri* Blume (Araceae), *Bryophyllum pinnatum* (Lam.) Oken. (Crassulaceae), *Clerodendrum × spectiosum* Dombrain (Lamiaceae), *Curcuma mangga* Valeton & Zijp. (Zingiberaceae), *Eleutherine bulbosa* (Mill.) Urb. (Iridaceae), *Fibraurea tinctoria* Lour. (Acanthaceae), *Ixora paludosa* (Blume) Kurz (Rubiaceae), *Lagerstroemia speciosa* (L.) Pers. (Lythraceae),...
| Botany name [Family]    | Local name    | Voucher specimen | Traditional use                                                                 | Preparations (administrations) | Part used | Yield (%) |
|-------------------------|---------------|------------------|----------------------------------------------------------------------------------|---------------------------------|-----------|-----------|
| *Aerva sanguinolenta* (L.) Blume [Amaranthaceae] | Sambang colok | Ar-0017          | Vaginal infection                                                               | Decoction (I)                  | Leaf      | 24.12     |
| *Agathis macrophylla* (Lindl.) Mast. [Araucariaceae] | Agatis      | Ar-0001          | Oral disease, pharyngitis                                                      | Decoction (I)                  | Bark      | 20.57     |
| *Aleurites moluccanus* (L.) Willd. [Euphorbiaceae] | Kemiri       | Ar-0013          | Diarrhea                                                                        | Decoction (I)                  | Bark      | 12.83     |
| *Amomum compactum* Sol. ex Maton [Zingiberaceae] | Kapulaga     | Ar-0012          | Acne treatment, oral disease                                                   | Decoction (I)                  | Seed      | 6.85      |
| *Amorphophallus muelleri* Blume [Araceae] | Iles-iles    | Ar-0011          | Dyentery                                                                       | Decoction (I)                  | Tuber     | 6.77      |
| *Barleria prionitis* L. [Acanthaceae] | Landep       | Ar-0074          | Diarrhea, abscess, pharyngitis                                                  | Fresh (E), decoction (I)       | Leaf      | 31.87     |
| *Bryophyllum pinnatum* (Lam.) Oken. [Crassulaceae] | Sosor bebek  | Ar-0077          | Ear infection                                                                  | Decoction (I)                  | Leaf      | 25.22     |
| *Clerodendrum × speciosum* Dombrain [Lamiaceae] | Nona makan sirih | Ar-0020   | Dyentery                                                                       | Decoction (I)                  | Flower    | 18.05     |
| *Curcuma mangga* Valeton & Zijp. [Zingiberaceae] | Temu mangga | Ar-0069          | Liver disease, anti-malarial, anti-viral, parasites                              | Decoction (I)                  | Rhizome   | 19.04     |
| *Dracontia angustifolia* (Medik.) Roxb. [Asparagaceae] | Suji          | Ar-0080          | Dyentery                                                                       | Decoction (I)                  | Leaf      | 29.39     |
| *Eleutherine bulbosa* (Mill.) Urb. [Iridaceae] | Bawang dayak | Ar-0003          | Diarrhea, vaginismus                                                           | Fresh (I), decoction (I)       | Bulb      | 11.16     |
| *Evodia hortensis* J.R.Forst. & G.Forst. [Rutaceae] | Zodia         | Ar-0022          | Dermatophytosis                                                                | Decoction (I)                  | Leaf      | 25.55     |
| *Fibraurea tinctoria* Tour. [Acanthaceae] | Akar kuning  | Ar-0075          | Diarrhea, skin diseases                                                         | Decoction (I)                  | Leaf      | 26.89     |
| *Gardenia jasminioides* J. Ellis [Rubiaceae] | Kaca piring  | Ar-0079          | Diarrhea, dysentery, vaginal infection                                          | Decoction (I), Macerate (E)    | Leaf      | 25.02     |
| *Ipomoea quamoclit* L. [Convolvulaceae] | Rincik bumi  | Ar-0018          | Diarrhea                                                                       | Decoction (I)                  | Leaf      | 20.01     |
| *Ixora paludosa* (Blume) Kurz [Rubiaceae] | Asoka        | Ar-0002          | Diarrhea                                                                       | Decoction (I)                  | Bark      | 22.16     |
| *Lagenstroemia speciosa* (L.) Pers. [Lythraceae] | Bungur kecil | Ar-0005          | Dysentery, diapheria, diphteria, tuberculosis                                   | Decoction (I)                  | Leaf      | 25.55     |
| *Mussaenda frondosa* L. [Rubiaceae] | Bunga nusa indah | Ar-0004         | Acne treatment                                                                 | Decoction (I), fresh (E)       | Flower    | 21.59     |
| *Oldenlandia coromys* L. [Rubiaceae] | Rumput mutiara | Ar-0019        | Urinary tract infection, abscess                                                | Decoction (I)                  | Leaf      | 16.29     |
| *Orthosiphon aristatus* (Blume) Miq. [Lamiaceae] | Kumis kucing | Ar-0076          | Vaginal infection                                                               | Decoction (I)                  | Leaf      | 22.32     |
| *Paederia foetida* L. [Rubiaceae] | Daun kentut  | Ar-0007          | Dermatophytosis, ear infection                                                 | Decoction (I), fresh (E)       | Leaf      | 25.18     |
| *Phaleria macrocarpa* (Scheff.) Boerl. [Thymelaeaceae] | Mahkota dewa | Ar-0015          | Oral disease, pharyngitis, diapheria, diapheria                                | Decoction (I)                  | Fruit     | 28.08     |
| *Phyllanthus buxifolius* (Blume) Müll.Arg. [Euphorbiaceae] | Seligi       | Ar-0024          | Skin infection                                                                  | Decoction (I)                  | Leaf      | 20.52     |
| *Plantago major* L. [Plantaginaceae] | Daun sendok  | Ar-0008          | Dysentery                                                                       | Decoction (I)                  | Leaf      | 23.00     |
| *Plectranthus scutellarioides* (L.) R.Br. [Lamiaceae] | Iler         | Ar-0010          | Dysentery, tuberculosis                                                        | Decoction (I)                  | Leaf      | 17.76     |
| *Polyscias scutellaria* (Burm.f.) Fosberg [Araliaceae] | Mangkokan    | Ar-0016          | Dysentery                                                                       | Decoction (I), fresh (E)       | Leaf      | 30.96     |
| *Premna oblongifolia* Merr. [Menispermaceae] | Cincau hijau | Ar-0006          | Abscess, pharyngitis, pneumonia                                                | Decoction (I)                  | Leaf      | 14.83     |
| *Pyrosia pilosellodes* (L.) M.G. Price [Polyodiaceae] | Sisik naga   | Ar-0025          | Diapheria                                                                      | Decoction (I)                  | Leaf      | 5.02      |
| *Rotheca serrata* (L.) Steane & Mabb. [Lamiaceae] | Senggugu     | Ar-0021          | Dysentery                                                                       | Decoction (I)                  | Leaf      | 31.39     |
| *Salacca zalacca* (Gaertn.) Voss [Areaceae] | Salak        | Ar-0026          | Diapheria                                                                       | Fresh (E)                      | Fruit     | 77.89     |
| *Sericocalyx crispus* (L.) Bremerk. [Acanthaceae] | Keji beling  | Ar-0072          | Diapheria                                                                       | Decoction (I)                  | Leaf      | 19.35     |

(continued)
Orthosiphon aristatus (Blume) Miq. (Lamiaceae), Phaleria macrocarpa (Scheff.) Boerl. (Thymelaeaceae), Phyllanthus buxifolius (Blume) Müll.Arg. (Euphorbiaceae), Plectranthus scutellarioides (L.) R.Br. (Lamiaceae), Premna obtusa Merr. (Menispermaceae), Rotheca serrata Steane & Mabb. (Lamiaceae), Sericoclyx crispus Bremek. (Acanthaceae), Spermacoce neohispida Govaerts (Rubiaceae), Talinum paniculatum (Jacq.) Gaertn (Talinaceae) and Woodfordia floribunda Salisb. (Lythraceae), exhibited growth-inhibitory effect against at least one out of five microorganisms tested at a concentration ranging from 128 to 512 μg/mL.

Among 21 active plant extracts tested, the extract of O. aristatus leaf produced the strongest antimicrobial effect, inhibiting the growth of C. albicans and three bacteria (S. aureus, E. faecalis and P. aeruginosa) at MICs of 128 and 256 μg/mL, respectively. The leaf extract of W. floribunda also exhibited strong anti-fungal effect against C. albicans and moderate inhibition activity against two bacteria (S. aureus and E. faecalis) at respective MICs of 128 and 256 μg/mL. The bark extract of A. mollucanuss showed moderate inhibitory activity against S. aureus and E. faecalis (MIC 256 μg/mL). Extract from the rhizome parts of C. mangga exhibited moderate antimicrobial effect against S. aureus and C. albicans (MICs 256 μg/mL), and weak activity against E. faecalis (MIC 512 μg/mL). Extract from the rhizome parts of C. mangga exhibited moderate antimicrobial effect against S. aureus at MIC 256 μg/mL and weak activity against E. faecalis at 512 μg/mL. The leaf extract of R. serrata was found to be active against S. aureus (MIC 256 μg/mL) and C. albicans (MIC 512 μg/mL). The rest of the extracts were only found to be active at the highest concentration tested (MIC 512 μg/mL).

Generally, the susceptibility of Gram-positive bacteria and yeast were higher than Gram-negative bacteria. Only three plant extracts (O. aristatus, B. pinnatum and S. crispus) inhibited the growth of P. aeruginosa at an MIC of 512 μg/mL. None of the plant extracts tested in this study were found to inhibit the growth of E. coli.

**Discussion**

In this study, leaf extract of O. aristatus exhibited inhibitory activity against C. albicans, E. faecalis, S. aureus and P. aeruginosa. This is in correspondence with previously published results showing the antimicrobial effect of methanol and ethanol leaf extract of O. aristatus against S. aureus, P. aeruginosa (Ho et al. 2010; Vijayan et al. 2013) and C. albicans (Neharkar and Laware 2013), as determined by disk and agar diffusion methods. In addition, the essential oil of O. aristatus leaf has also been reported as exhibiting antifungal properties against several plant pathogens such as Botrytis cinerea, Colletotrichum capsici, Fusarium solani, Phytophthora capsici and Rhizoctonia solani (Hossain et al. 2008). Di et al. (2013) isolated several new diterpenoid compounds (orthoarins) from an ethanol aerial extract of O. aristatus. Many reports have extensively shown that diterpenoids exert significant antimicrobial effects (Veneziani et al. 2017). Olah et al. (2003) reported the presence of polyethoxylated flavonoids and caffeic acid derivatives, mainly rosmarinic acid in an ethanol leaf extract of O. aristatus. This compound has been known to possess antimicrobial activity against a broad spectrum of bacteria and yeasts (Gohari et al. 2010; Salawu et al. 2011). It can be assumed that these compounds may contribute to the broad-spectrum antimicrobial potential of O. aristatus found in the present study.

To the best of our knowledge, there are no previous studies reporting any antimicrobial effect for W. floribunda. However, the leaf extract of related species Woodfordia fruticosa has been reported to show inhibitory activity against methicillin-resistant S. aureus and the phytochemical screening of the n-butanol fraction of its leaf by GC–MS revealed the presence of secondary metabolites such as diethyl phthalate and thymol (Dubeys et al. 2014). Both of these compounds were previously described as exhibiting several antimicrobial properties (Mujeeb et al. 2014). Yoshida et al. (1990) reported the isolation and characterization of a hydrolysable tannin dimer, woodfordin C, from the methanol leaf extract of W. fruticosa. This compound has been reported as exhibiting antitumor and antimicrobial effects via the inhibition of DNA topoisomerase enzyme II which is important for DNA replication (Akiko et al. 1992; Mitscher 2005). As one of the chemo-taxonomic markers found in the Lythraceae family, it is assumable that the chemical compounds found in W. fruticosa may also contribute to the antimicrobial effect in W. floribunda. Nevertheless, it should be considered that incomplete data on the metabolite profiles of these plants limit the interpretation of any chemo-taxonomic markers as some species within the same genus might produce different compounds (Liu et al. 2017).

The rhizome extract of C. mangga exhibited moderate antimicrobial activity against S. aureus and E. faecalis in this study. Our results can be supported by findings of Renisheya et al. (2011) who determined an antimicrobial effect of ethanol extract of C. mangga against clinical isolates strains of S. aureus and P. aeruginosa via the disk diffusion technique. Philip et al. (2009) used agar, the diffusion method, and reported inhibitory effects of methanol, ethyl acetate, and hexane extracts of C. mangga rhizome on P. aeruginosa. The essential oil of C. mangga has also been reported effective against S. aureus and C. albicans using the disk diffusion technique (Kamazeri et al. 2012). In contrast, in our findings, we did not observe any inhibition of Gram-negative bacteria, probably due to the
In our study, the bark extract of *A. moluccanus* exhibited growth-inhibitory activity against *S. aureus*, *E. faecalis* and *C. albicans*. Our findings are in agreement with previously published research by Locher et al. (1995) who conducted antimicrobial testing using disk diffusion and reported an antimicrobial effect of *A. moluccanus* methanol bark extract on *S. aureus* and *P. aeruginosa*. Earlier work reported the isolation of bioactive compounds from the stem bark of *A. moluccanus* known as 3-acetyl aleuritolic acid and moluccanin which exhibited antibacterial effects (Alimboyoguen et al. 2014). Thus, above-mentioned compound could be responsible for the antimicrobial activity on *A. moluccanus* bark extract.

As previously reported by Rashid et al. (2013), the aqueous leaf extract of *R. serrata* demonstrated an inhibitory effect on *E. coli* in a disk diffusion assay. On the contrary, in this research, no inhibitory activity was observed on *E. coli* probably due to the difference in the solvent used. To the best of our knowledge, there are no previous studies reporting the antimicrobial effect of *R. serrata* leaf extract on *C. albicans* and *S. aureus*.

In general, certain differences between this research and other reports on the antimicrobial activity of plant species tested in this study could have been influenced by several factors. It is necessary to note that the chemical composition and antimicrobial activity of plant extracts can be significantly affected by the extraction techniques used, the type of solvent used (Dai and Mumper 2010), the methods of antimicrobial susceptibility testing, the different strains of microorganisms used, and the geographical origin of plant materials (Price and Morgan 2006).

### Table 2. Antimicrobial activity of ethanol extracts from Indonesian medicinal plants.

| Plant samples | Part used | Microorganisms/minimum inhibitory concentrations (μg/mL) |
|---------------|-----------|--------------------------------------------------------|
| *Aerva sanguinolenta* | Leaf | $512$ | $512$ | – | – | $512$ |
| *Agathis macrophylla* | Bark | $512$ | – | – | – | – |
| *Aleurites moluccanus* | Bark | $256$ | $512$ | – | – | $256$ |
| *Amomum compactum* | Seed | – | – | – | – | – |
| *Amorphophallus muelleri* | Tuber | – | – | – | – | – |
| *Barleria prionitis* | Stem | – | – | – | – | – |
| *Bryophyllum pinnatum* | Leaf | – | – | $512$ | – | – |
| *Clerodendrum × speciosum* | Flower | – | – | – | – | – |
| *Curcuma mangga* | Rhizome | $256$ | $512$ | – | – | – |
| *Dracaena angustifolia* | Bulb | – | – | – | – | $512$ |
| *Eleutherine bulbosa* | Leaf | – | – | – | – | $512$ |
| *Evodia hortensis* | Leaf | – | – | – | – | – |
| *Fibraurea tinctoria* | Leaf | – | $512$ | – | – | – |
| *Gardenia jasminoides* | Leaf | – | – | – | – | – |
| *Ipomoea quamoclit* | Leaf | – | – | – | – | – |
| *Ixora paludosa* | Leaf | $512$ | – | – | – | $512$ |
| *Lagerstroemia speciosa* | Leaf | $512$ | – | – | – | $512$ |
| *Mussaenda frondosa* | Flower | – | – | – | – | – |
| *Oldenlandia corymbosa* | Leaf | – | – | – | – | – |
| *Orthosiphon aristatus* | Leaf | $256$ | $256$ | $256$ | – | $128$ |
| *Paederia foetida* | Leaf | – | – | – | – | – |
| *Phaleria macrocarpa* | Leaf | – | – | $512$ | – | – |
| *Phyllanthus buxifolius* | Root | – | – | $512$ | – | – |
| *Plantago major* | Root | – | – | $512$ | – | – |
| *Plectranthus scutellarioides* | Leaf | – | – | – | – | – |
| *Polyscias scutellaria* | Leaf | – | – | – | – | – |
| *Premna oblongifolia* | Leaf | – | – | – | $512$ | – |
| *Pyrosis piloselloides* | Leaf | – | – | – | – | – |
| *Rotheca serrata* | Leaf | $256$ | – | – | – | $512$ |
| *Salacca zalacca* | Fruit | – | – | – | – | – |
| *Sericocalyx crispus* | Leaf | $512$ | $512$ | $512$ | – | $512$ |
| *Sida rhombifolia* | Leaf | – | – | – | – | $512$ |
| *Spermacoce neohispida* | Leaf | $512$ | – | – | – | – |
| *Stelechocarpus burahol* | Leaf | – | – | – | – | – |
| *Stemonitis paniculatum* | Leaf | $256$ | $256$ | – | – | $128$ |
| *Woodfordia floribunda* | Leaf | – | – | – | – | $0.25$ |

*Not active (MIC >512 μg/mL).

Tetracycline and tioconazole were used as positive controls for bacteria and yeast, respectively.
In summary, this study showed the in vitro antimicrobial activity of plants used in traditional Indonesian medicine for the treatment of diseases associated with pathogenic microorganisms. According to our results, leaf extract of \textit{O. aristasus} and \textit{W. floribunda} exhibited significant anti-candidal effects. Therefore, both of these plants could serve as source materials for the development of new anti-candidal agents. However, further phytochemical research focused on these species will be needed to isolate and characterize their antimicrobially effective constituents.

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