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Research Article

ANTIBACTERIAL AND CYTOTOXIC POTENCIES OF STILBENE OLIGOMERS FROM STEM BARKS OF BAOTI (*DRYOBALANOPS LANCEOLATA*) GROWING IN KENDARI, INDONESIA

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ABSTRACT

Objective: The purpose of the research is to isolate and to identify compounds from stem barks of *Dryobalanops lanceolata* and to evaluate their activities toward bacteria and cancer cell lines.

Methods: Isolation of the compounds worked with chromatography methods including thin-layer chromatography, vacuum liquid chromatography, and radial chromatography. All compound structures were determined based on the spectroscopic evidence including ultraviolet (UV), Infrared, and one-dimension and two-dimension nuclear magnetic resonance spectra and comparison the spectroscopy data with related data from references. The biological properties of compounds are evaluated toward bacteria *Escherichia coli* ATCC 35219 and *Staphylococcus aureus* ATCC 25923 and human breast cancer cell lines T-47D as cytotoxic potency.

Results: Five stilbene oligomers have been isolated and identified from acetone extract of *D. lanceolata* stem barks namely balanocarpol (1), ε-viniferin (2), α-viniferin (3), vaticanol B (4), and hopeaphenol (5). The inhibition zone value (in mm) of ε-viniferin, balanocarpol, α-viniferin, hopeaphenol, and vaticanol B toward *E. coli* and *S. aureus* is 11±0.22 and 7±0.17, 9±0.17 and 13±0.12, 8±0.20 and 8±0.16, 6±0.16 and 8±0.11, and 5±0.12 and 4±0.14, respectively. Biological activity of the compounds against breast cancer cell lines T-47D (inhibitory concentration 50% in μM) for ε-viniferin, balanocarpol, α-viniferin, hopeaphenol, and vaticanol B is 34.13±0.15, 98.17±0.41, 84.79±0.24, 52.04±0.26, and 119.30±0.54, respectively.

Conclusions: ε-viniferin is the most active compound toward *E. coli* and human breast cancer cell lines T-47D. Biological activity against bacteria *S. aureus* indicated that balanocarpol is the most potential compound.

Keywords: Dipterocarpaceae, *Dryobalanops lanceolata,* Stilbenoids, Antibacterial, Cytotoxic.

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INTRODUCTION

Chemical and pharmacological study of traditional medicinal plants from Kendari,Indonesia has been conducted. The plants were Dipterocarpaceae [1-3], *Jatropha* [4-6], Annonaceae [7], *Pongamia* [8], *Imperata* [9], *Polygonum* [10,11], and *Dillenia* [12]. In continuing our study of both aspects, *Dryobalanops* genera (Dipterocarpaceae) is still interesting. *Dryobalanops* is a minor genus of Dipterocarpaceae and comprises 7 spesies. Conventionally, this plant used for stomachache and antioxidant [13]. The benefits showed that the chemical content and pharmacological aspects of *Dryobalanops* plants are very important.

Phytochemical studies of *Dryobalanops*, like other plants in Dipterocarpaceae such as *Dipterocarpus* [14] and *Hopea* [15], produced stilbene oligomers. Some *Dryobalanops* plants which have studied on chemical content are *D. aromatica,* resulted ε-viniferin, α-viniferin, laevifonol, ampelopsin E, malaysianol A, flexuasol A, vaticanol B, vaticanol C, diptoindonesin A, and bergenin [16,17]. *Dryobalanops beccarii* gave malaysianol D, malaysin A, ε-viniferin, diptoindonesin A, flexuasol A, vaticanol B, vaticanol C, bergenin, 4-O-galloylbergenin, scopoletin, 4-O-methylbalanophonin, methyl gallate, and gallic acid [18]. Cis- diptoindonesin B and trans-diptoindonesin B were isolated from Dryobalanops lanceolata [19]. Moreover, *D. lanceolata* from Malaysia yielded malaysianol B, hopeaphenol, stenophyllol, nepalensinol B, vaticanol B, vaticanol C, upunaphenol D and flexuosol A [20]. Pharmacological study showed that ε-viniferin is the most active compound against HL-60 cell lines [16] and vaticanol C is active toward A549 cell lines [18]. Upunaphenol D and flexuasol A displayed interisting potency toward bacteria *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Staphylococcus xylosus*, *Shigella flexneri*, *Salmonella typhimurium*, and *Escherichia coli* [17]. One of the Dipterocarpaceae plants which grow in Pohara Forest, Kendari is *D. lanceolata* or baoti (*Tolakinese* name).

D. lanceolata is one of seven spesies of *Dryobalanops* plants, and chemical and pharmacological aspects of *D. lanceolata* from Malaysia have been reported by Wibowo *et al*. [20]. This article reports isolation and structure determination of five stilbene oligomers from acetone extract of *D. lanceolata* stem barks from Kendari, Indonesia and their biological properties as antibacterial and anticancer. Three of five compounds from Kendari's *Dryobalanops* including balanocarpol, ε-viniferin, and α-viniferin are the first time reported from the plant. In addition, biological activities toward bacteria *E. coli* ATCC 35219, *S. aureus* ATCC 25923, and the cytotoxic property against human breast cancer cells T-47D have not been published yet.

METHODS

General procedures

Melting point (MP) of the isolated compounds was determined by "micro MP apparatus: Fisher John." The optical rotation established by polarimeter Perkin-Elmer 341 in MeOH. Ultraviolet (UV) and Infrared (IR) spectra were measured with cary varian 100 concentration and Perkin-Elmer Spectrum One FT-IR spectrophotometer, respectively. spectra of ^{1}H and ^{13}C nuclear magnetic resonance (NMR) were determined by spectrophotometer JEOL LTD ECP 400, operated at 400 MHz (^{1}H) and 100.53 MHz (^{13}C), used acetone-d_6 as solvent and TMS as internal standard. Separation and purification used thin-layer chromatography, vacuum liquid chromatography (VLC), and radial chromatography (RC).

Sample

Stem barks of *D. lanceolata* got from Pohara Forest, Kendari, Sulawesi Tenggara. The plant was identified by staffs of Herbarium Bogoriense, Bogor, Indonesia.

Extraction and isolation

Powder of stem barks of *D. lanceolata* (2.0 Kg) was extracted by acetone of 3×5 L for 3×24 hrs. The acetone extract was concentrated by rotary evaporator to get brown dark gum (116 g). All of acetone extract was fractionated by VLC using column with Φ 10 cm, adsorben: Si-gel (150 g) and mixture of ethyl acetate: N-hexane (30%: 100-100%: 0%, MeOH 100%) as eluent, produced 5 main fractions that are F1-F5 (3.0, 8.5, 11.0, 17.0, and 19.0 g). Separation of F2 (8.5 g) used VLC with column of Φ 10 cm, gave 5 fractions F21-F25 (0.4, 1.2, 1.8, 1.1, and 2.7 g). Purification of F22 using RC with eluent 10% MeOH-$CHCl_3$ yielded compound 1 (40 mg). Further separation of F24 employing the same procedure as F22 produced compound 2 (28 mg). Partition of F3 using VLC gave four fractions that are F31 (0.4 g), F32 (1.3 g), F33 (3.1 g), and F34 (3.1 g). Purification of F33 using VLC and RC yielded compound 3 (74 mg) and 4 (34 mg), respectively. Compound 5 (50 mg) came from separation and purification of F4 fraction which used the same method as purification of F33 fraction.

Biological activities evaluation

The antibacterial test was conducted by the agar dilution method using the general procedure outlined by Thakurta *et al*. [21]. The cultural concentration of bacteria was *E. coli*= 4.2×10^8 cfu/mL and *S. Aureus* = 3.2×10^7 cfu/mL. The cytotoxic property toward human breast cancer cell lines T-47D was evaluated using MTT assays methods about 1×10^4 cells/well [22].

RESULTS

Data of spectroscopy and physical properties of isolated compounds

Compound 1, a yellow powder, MP 180-183°C, $[\alpha]_D^{20}$-12° (C 0.1 MeOH). Spectra of UV (MeOH) λ_{maks} (log ε) 205 (5.03), 220 (4.96), 284 nm (4.38), (MeOH+ NaOH) λ_{maks} (log ε) 214 (5.40), 247 (4.99), 295 nm (4.49). IR spectra (KBr) υ_{maks} (cm^{-1}) 3366 (OH), 1613, 1512, 1451 (C=C aromatic), and 834 (para-disubstituted benzene). Spectra of ^{1}H NMR (Me_2CO-d_6, 400 MHz) and ^{13}C NMR (Me_2CO-d_6, 100 MHz) (Table 1).

Compound 2, a yellow powder, MP 172-176°C, $[\alpha]_D^{20}$ - 44° (C 0.1 MeOH). Spectra of UV (MeOH) λ_{maks} (log ε) 203 (5.05), 230 (4.87), 324 nm (4.57), (MeOH+ NaOH) λ_{maks} (log ε) 211 (5.52), 244 (5.06), 347 nm (4.84). Spectra of IR (KBr) υ_{maks} (cm^{-1}) 3393 (OH), 1606, 1513, 1443 (C=C aromatic), and 832 (para-disubstituted benzene). Spectra of ^{1}H NMR (Me_2CO-d_6, 400 MHz) δ_H (ppm) 7.14 (2H, d, J=8.4 Hz, H-2/6a), 6.77 (2H, d, J=8.4 Hz, H-3/5a), 5.38 (1H, d, J=6.6 Hz, H-7a), 4.35 (1H, d, J=6.6 Hz, H-8a), 6.23 (2H, d, J=2.2 Hz, H-10/14a), 6.20 (1H, br d, H-12a), 7.15 (2H, d, J=8.4 Hz, H-2/6b), 6.65 (2H, d, J=8.4 Hz, H-3/5b), 6.83 (1H, d, J=16.3 Hz, H-7b), 6.58 (1H, d, J=16.3 Hz, H-8b), 6.26 (1H, d, J=2.1 Hz, H-12b), and 6.64 (1H, d, J=2.1 Hz, H-14b).

Table 1: Biological activities of the isolated compounds

Compound(s)	Biological activities (mean±SD*)		
	Diameter of inhibition zone (mm)		IC_{50} (µM)
	E. coli	*S. aureus*	T-47D
Balanocarpol	9±0.17	13±0.12	98.17±0.41
ε-Viniferin	11±0.22	7±0.17	34.13±0.15
α-Viniferin	8±0.20	8±0.16	84.79±0.24
Vaticanol B	5±0.12	4±0.14	119.30±0.54
Hopeaphenol	6±0.16	8±0.11	52.04±0.26
Tetracycline (antibacterial standard)	14±0.14	19±0.12	-
Doxorubicine (anticancer standard)	-	-	2.35±0.08

*SD: Standard deviation, triplicates; diameter of Whatman paper=6 mm, (Balanocarpol) = (ε-viniferin) = (α-viniferin) = (vaticanol B) = (hopeaphenol) = 10000 µg/mL; control (teracyclin 30 µg/disc). For MTT assays, (sample) = 100 mg/mL, 50 mg/mL, 25 mg/mL, 12.5 mg/mL, 6.25 mg/mL, and 3.125 mg/mL

Compound 3, a pale brown powder, MP 222-224°C and $[\alpha]_D^{20}$ + 60° (C 0.1 MeOH). Spectra of UV (MeOH) λ_{maks} (log ε) 229 (4.57) and 286 nm (4.19). Spectra of UV (MeOH+NaOH) λ_{maks} (log ε) 251 (4.78), 295 nm (4.32), Spectra of IR (KBr) u_{maks} 3307 cm^{-1} (-OH), 1614, 1515, and 1486 cm^{-1} (C=C benzene), and 831 cm^{-1} (para-disubstituted benzene). Spectra of ^{1}H NMR (aseton-d_6, 400 MHz) δ ppm: 7,26 (2H, d, J=8.5 Hz, H-2/6b), 7.08 (2H, d, J=8.5 Hz, H-2/6c), 7.06 (2H, d, J=8.5 Hz, H-2/6a), 6.82 (2H, d, J=8.5 Hz, H-3/5c), 6.80 (2H, d, J=8.5 Hz, H-3/5b), 6.76 (1H, d, J=1.5 Hz, H-11b), 6.75 (2H, d, J=8.5 Hz, H-3/5a), 6.63 (1H, d, J=2.0 Hz, H-11c), 6.27 (1H, d, J=1.5 Hz, H-13b), 6.25 (1H, d, J=2.0 Hz, H-13a), 6.25 (1H, d, J= 2,0 Hz, H-13c), 6,10 (1H, br s, H-7a), 6,01 (1H, d, J=2,0 Hz, H-11a), 5,96 (1H, d, J=9.5 Hz, H-7b), 4.93 (1H, d, J=6.5 Hz, H-7c), 4.73 (1H, d, J=9.5 Hz, H-8b), 4.65 (1H, d, J=6.5 Hz, H-8c), 3.99 (1H, br s, H-8a), and OH (8.61; 8.57; 8.51; 8.43; 8.42; and 8.41 each s, 1H). Spectra of ^{13}C NMR (aseton-d_6, 100 MHz, APT) δ ppm: 161.6 (C-14a), 161.1 (C-14c), 160.8 (C-12c), 160.6 (C-14b), 159.3 (C-12a), 159.34 (C-12b), 158.3 (C-4c), 158.2 (C-4b), 157.8 (C-4a), 141.2 (C-10a), 138.7 (C-10c), 139.7 (C-10b), 132.5 (C-1c), 132.2 (C-1b), 132.0 (C-1a), 128.6 (C-2/6c), 128.15 (C-2/6b), 128.1 (C-2/6a), 120.9 (C-9b), 119.0 (C-9c), 118.8 (C-9a), 116.1 (C-3/5c), 116.1 (C-3/5 b), 115.7 (C-3/5a), 108.5 (C-11a), 106.2 (C-11b), 105.8 (C-11c), 98.0 (C-13a), 96.9 (C-13c), 96.6 (C-13b), 95.6 (C-7c), 90.0 (C-7b), 86.4 (C-7a), 55.6 (C-8c), 52.8 (C-8b), and 46.4 (C-8a).

Compound 4, a pale brown powder, MP 207-210°C, $[\alpha]_D^{20}$ - 35° (C 0.1 MeOH); UV (MeOH) λ_{maks} (log ε) 203 (5.09), 229 (4.89), 284 nm (4.19), absorption of UV (MeOH+NaOH) λ_{maks} (log ε) 207 (5.36), 247 (4.59), 286 nm (4.19), Spectra of IR (KBr) u_{maks} (cm^{-1}) 3370 (OH), 1614, 1514, and 1454 (benzene), and 832 (para-disubstituted benzene). Spectra of ^{1}H NMR (aseton-d_6, 400 MHz) δ ppm: 7.22 (2H, d, J=8.4 Hz, H-2/6a), 6,76 (2H, d, J=8.4 Hz, H-3/5a), 5,75 (1H, d, J=11.2 Hz, H-7a), 4.41 (1H, d, J=11.2 Hz, H-8a), 6.26 (1H, d, J=2.2 Hz, H-12a), 6.10 (1H, d, J=2.2 Hz, H-14a), 7.14 (2H, d, J=8.4 Hz, H-2/6b), 6.67 (2H, d, J=8.4 Hz, H-3/5b), 5.19 (1H, d, J=3.7 Hz, H-7b), 3.09 (1H, br d, H-8b), 6.03 (1H, br s, H-12b), 6.38 (2H, d, J=8.4 Hz, H-2/6c), 6.48 (2H, d, J=8.4Hz, H-3/5c), 4.08 (1H, t, J=10.5; 10.0 Hz, H-7c), 4.52 (1H, d, J=10.2 Hz, H-8c), 6.17 (1H, d, J=2.2 Hz, H-12c), 6.45 (1H, d, J=2.2 Hz, H-14c), 7.17 (2H, d, J=8.4 Hz, H-2/6d), 6.75 (2H, d, J=8.4 Hz, H-3/5d), 5.35 (1H, d, J=5.1 Hz, H-7d), 4.66 (1H, d, J=5.1Hz, H-8d), 6.08 (2H, br s, H-10/14d), 6.26 (1H, t, J=2.2 Hz, H-12d), Spectra of ^{13}C NMR (aseton-d_6, 100 MHz, APT) δ ppm: 161.8 (C-11c), 159.3 (C-11d), 159.5 (C-13c), 159.3 (C-13d), 158.9 (C-11b), 158.7 (C-4a), 158.1 (C-4d), 156.8 (C-13a), 156.4 (C-4c), 156.0 (C-4b), 155.8 (C-11a), 155.0 (C-13b), 148.1 (C-9d), 143.2 (C-9b), 141.9 (C-9a), 141.8 (C-9c), 134.7 (C-1d), 133.6 (C-1b), 131.5 (C-1c), 130.9 (C-1a), 130.8 (C-2/6b), 130.3 (C-2/6a), 129.3 (C-2/6c), 128.3 (C-2/6d), 124.6 (C-10a), 123.4 (C-10c), 122.3 (C-14b), 116.1 (C-3/5d), 116.08 (C-3/5a), 115.9 (C-3/5c), 115.8 (C-10b), 115.5 (C-3/5b), 107.6 (C-10/14d), 107.1 (C-14c), 105.8 (C-14a), 102.3 (C-12d), 101.7 (C-12a), 96.6 (C-12b), 95.8 (C-12c), 94.7 (C-7d), 90.5 (C-7a), 57.7 (C-8d), 57.6 (C-7c), 53.3 (C-8b), 49.3 (C-8c), 48.9 (C-8a), and 37.2 (C-7b).

Compound 5, a white powder, MP 160-164°C, $[\alpha]_D^{20}$ + 138° (C 0.1 MeOH); UV (MeOH) λ_{maks} (log ε) 203 (5.10), 230 (4.88), and 283 nm (4,23). Absorption of UV (MeOH+NaOH) λ_{maks} (log ε) 207 (5.27), 250 (4.51), 288 nm (3.94). Spectra of IR (KBr) u_{maks} (cm^{-1}) 3419 (OH), 2927 (CH aliphatic), 1614, 1512, and 1455 (benzene), and 834 (para-disubstituted benzene). Spectra of ^{1}H NMR (aseton-d_6, 400 MHz) δ ppm: 7.52 (2H, d, J=8.8, H-2/6a), 6.98 (2H, d, J=8.8, H-3/5a), 5.63 (1H, d, J=10.3, H-7a), 5.42 (1H, d, J=10.3, H-8a), 6.36 (1H, d, J=2.2, H-12a), 6.28 (1H, d, J=2.2, H-14a), 6.92 (2H, d, J=8.4, H-2/6b), 6.58 (2H, d, J=8.4, H-3/5b), 5.81 (1H, br s, H-7b), 3.96 (1H, s, H-8b), 5.75 (1H, d, J=2.1, H-12b), and 5.18 (1H, d, J=2.1, H-14b). Spectra of ^{13}C NMR (aseton-d_6, 100 MHz, APT) δ ppm: 133.8 (C-1a), 131.1 (C-2/6a), 116.9 (C-3/5a), 159.1 (C-4a), 94.6 (C-7a), 54.2 (C-8a), 141.1 (C-9a), 118.8 (C-10a),

160.6 (C-11a), 102.7 (C-12a), 158.2 (C-13a), 107.4 (C-14a), 138.2 (C-1b), 130.1 (C-2/6b), 114.9 (C-3/5b), 155.1 (C-4b), 44.1 (C-7b), 53.4 (C-8b), 142.2 (C-9b), 117.7 (C-10b), 159.1 (C-11b), 95.3 (C-12b), 156.9 (C-13b), and 110.2 (C-14b).

Biological activities data

The biological activities data of isolated compounds against bacteria and T-47D cancer cell lines are displayed in Table 1.

DISCUSSION

Stilbene monomer (resveratrol) comprises 14 carbon atoms and structure pattern C_6-C_2-C_6. The research has isolated and identified five stilbene oligomers from acetone extract of *D. lanceolata* stem barks. A total of 2 compounds have 28 carbon atoms or stilbene dimmers, a compound has 42 carbon atoms or stilbenes trimer, and two compounds have 56 carbon atoms or stilbene tetramer. The compound structures are displayed in the Fig. 1.

All isolated compounds are known compounds so the structures are determined by comparing the spectroscopic data of isolated compounds with similar data from references. For example, isolate 1, the spectrum data of ^{1}H NMR and ^{13}C NMR has a high similarity parameter with balanocarpol (1*) [23]. It can be concluded that compound 1 is balanocarpol as displayed in Table 2.

In the same way as structure determination of balanocarpol, the compounds 2, 3, 4, and 5 are ε-viniferin [24], α-viniferin [25], vaticanol B [26], and hopeaphenol [27], respectively. Refers to a previous study [20], three compounds were isolated from *D. lanceolata* from Kendari, namely, balanocarpol, ε-viniferin, and α-viniferin, not reported from Malaysia's *D. lanceolata*. These data complemented the diversity of *D. lanceolata*'s stilbene oligomers. Two compounds, vaticanol B and hopeaphenol, have been reported previously that thought to be characteristic of *D. lanceolata*.

According to biological activity data in Table 1, biological activity against bacteria indicated that ε-viniferin is the most active compounds toward *E. coli*, which followed by balanocarpol, α-viniferin, hopeaphenol, and vaticanol B. While the activity against *S. aureus*, balanocarpol is the most active compound followed by α-viniferin, hopeaphenol, ε-viniferin, and vaticanol B. ε-Viniferin and balanocarpol are stilbene dimers, consist of two unit stilbenes, means having a smaller molecular size than the others. It is estimated that activity of stilbene derivative against bacteria is influenced by the size of the molecule which can affect molecular penetration [28].

In general, stilbene derivatives have cytotoxic potency toward cancer cell lines not only from Dipterocarpaceae but also from Gnetaceae, for example, gnetin C and gnemonoside A, two stilbene dimers from *Gnetum gnemon* [29] or other phenolic compounds such as curcumin [30]. The cytotoxic properties against human breast cancer cell lines T-47D showed that all isolated compounds are less active than standard (doxorubicin). For isolated compounds, ε-viniferin is the most active compound, followed by hopeaphenol, α-viniferin, balanocarpol, and vaticanol B. ε-Viniferin has intact stilbene unit and all carbon atoms have orbital hybrid sp2. Consequently, ε-viniferin becomes richer phi electrons with the equitable electrons distribution from the ring B1 to B2 through electron delocalization. It will produce a more stable radical that can inhibit cancer cell growth [31]. Biological activity of hopeaphenol and α-viniferin against human breast cancer cell lines T-47D thought to be caused by the density of the compound [32]. Both of these compounds have a symmetrical plane in their structure. This causes the density of molecules into larger, like hopeaphenol, this compound has a small volume identical with stilbene dimer, but its molecular weight as a tetramer. Hopeaphenol as a tetramer has a molecular weight greater than two times the dimer, because there is a plane of symmetry in the structure hopeaphenol, the volume of hopeaphenol structure similar to the dimer. Consequently, hopeaphenol density becomes greater and more active compound against cancer cell lines. The sequence of cytotoxic properties of stilbene oligomers toward T-47D cell lines was identic to the sequence of the cytotoxic properties of the compounds against murine leukemia P-388 cells that are hopeaphenol (5.7±0.3 mM), α-viniferin (25.8±0.7 μM), balanocarpol (33.6±8.3 μM), and vaticanol B (56.8±2.3 μM) [1].

CONCLUSION

Five stilbene oligomers have been isolated and identified from the stem barks of *D. lanceolata*, namely, balanocarpol (1), ε-viniferin (2) (stilbene

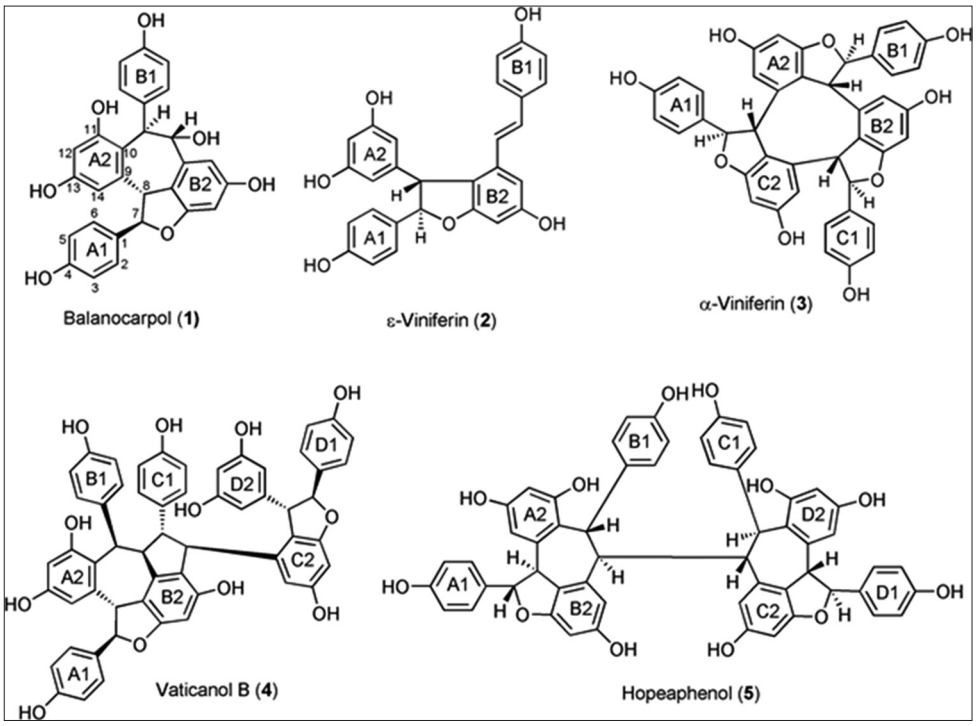

Fig. 1: Compound structures from *Dryobalanops lanceolata* stem barks (1 and 2) stilbene dimers, (3) stilbene trimer, and (4 and 5) stilbene tetramers

Table 2: Spectra of ^{1}H NMR of balanocarpol (1)

Number of component	δ_H (mult., J in Hz)		δ_C	
	1	**1***	**1**	**1***
1a	-	-	133.2	133.5
2 (6)a	7.48 (2H, d, 8.4)	7.50 (2H, d, 8.3)	131.3	131.5
3 (5)a	6.94 (2H, d. 8.4)	6.95 (2H, d, 8.3)	113.9	114.2
4a	-	-	155.5	155.8
7a	5.69 (1H, d, 9.5)	5.69 (1H, d, 9.3)	72.9	73.2
8a	5.15 (1H, d, 9.5)	5.16 (1H, br d, 9.3)	50.0	50.3
9a	-	-	140.6	140.8
10a	-	-	113.6	113.8
11a	-	-	159.5	159.7
12a	6.09 (1H, d, 2.2)	6.09 (1H, br s)	94.8	95.1
13a	-	-	158.9	159.2
14a	5.95 (1H, d, 2.2)	5.96 (1H, d, 2.3)	104.2	104.4
1b	-	-	133.4	133.7
2 (6)b	6.73 (2H, d, 8.4)	6.75 (2H, d, 8.3)	130.3	130.5
3 (5)b	6.41 (2H, d, 8.4)	6.42 (2H, d, 8.3)	116.2	116.4
4b	-	-	158.3	158.6
7b	4.89 (1H, br s)	4.90 (1H, br s)	52.1	52.3
8b	5.38 (1H, br s)	5.40 (1H, br s)	93.3	93.5
9b	-	-	142.6	142.8
10b	-	-	120.2	120.4
11b	-	-	157.2	157.4
12b	6.18 (1H, d, 2.2)	6.20 (1H, br s)	101.8	102.0
13b	-	-	156.5	156.9
14b	6.24 (1H, d. 2.2)	6.26 (1H, d, 2.0)	106.5	106.8
OH	4.41 (br d, 4.4)	4.36 (d, 4.4, C-8b)		
	8.65; 8.09; 8.06; 7.91; 7.81 (br s)	7.74 (br s, C-4a)		
		7.85 (br s, C-13b)		
		7.79 (br s, C-11a)		
		8.04 (br s, C-13a)		
		8.56 (br s, C-4b)		

Measured in acetone-d_6 (^{1}H, 400 MHz; ^{13}C NMR 100 MHz) *[23], NMR: Nuclear magnetic resonance

dimer), and α-viniferin (3) (stilbene trimer) and two stilbene tetramers that are vaticanol B (4) and hopeaphenol (5). ε-Viniferin was the most active compound against *E. coli* and balanocarpol was the most active substance toward *S. aureus*. Cytotoxic properties against human breast cancer cell lines T-47D indicated that ε-viniferin is the most active compound.

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