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Anti-infective Activities of Secondary Metabolites from *Vitex pinnata*

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ABSTRACT

The phytochemical investigation of Vitex pinnata led to the isolation of a mixture of steroids β-sitosterol and stigmasterol (**1a and 1b**) and three known flavonoid identified as 5-hydroxy-3, 7, 4'-trimethoxyflavone (**2**), 5-hydroxy-7,4'-dimethoxy-flavone (**3**) and 5-hydroxy-3,3',4',7-tetramethoxyflavone (**4**). The structures of all isolated compounds were carried out by NMR and mass spectrometry. The isolated compounds were evaluated for their anti-infective activities against Trypanosoma brucei brucei and Mycobacterium marinum. Compound 1-4 showed moderate antitrypanosomal activity with MIC values of 6.25µg/ml, 19.0, 21.0 and 17.0µM, respectively while no activity observed on anti-mycobacterial. This study is the first to report the presence of three flavones and their antitrypanosomal activity from V. pinnata.

INTRODUCTION

Plants play a pivotal role in drug discovery by producing various types of bioactive compounds including anti-cancer (Pezzuto, 1997), anti-diabetic (Marles and Farnsworth, 1995), anti-inflammatory (Nam, 2006), antiviral (Mukhtar et al., 2008) and also anti-protozoan neglected diseases drugs (Schmidt et al., 2012). Vitex pinnata is a woody plant which can be found in primary, secondary forests and savannahs. This species is under the genus Vitex with the family Lamiaceae (formerly was under family Verbenaceae). It can be found in Southeast Asia like in Malaysia, Indonesia, Thailand, Cambodia and Philippines (de Kok, 2008). Traditionally the young leaves of V. pinnata are used by Malay communities for antipyretic treatment and bark is used to treat gastric ulcer (Corner, 1951). Other previous study described the leaves of V. pinnata were applied on cuts and wounds (Ong and Nordiana, 1999). Human African trypanosomiasis (HAT) or sleeping sickness is one of neglected tropical diseases listed by World Health Organisation (WHO) (WHO, 2013a). It is a fatal vector-borne parasitic disease provoked by Trypanosoma brucei rhodesiense (T. b. rhodesiense) or Trypanosoma brucei gambiense (T. b. gambiense) and transmitted by the tsetse fly (Glossina spp.). This infectious disease happens specifically only in rural areas of sub-Saharan Africa (Simarro et al., 2011). Only few drugs have been used to treat this disease and these include suramin, pentamidin, melarsoprol and eflornithine and the combination of nifurtomox/eflornithine. Most of the drugs are old, having been discovered in the 1940s and 1950s, and also have adverse effects on patients. For this reason, mining and developing new HAT drugs from natural products is still crucial and indispensable (Jacobs et al., 2011). Tuberculosis (TB) is an infectious disease and the pathogen responsible for TB is Mycobacterium tuberculosis. TB still remains as a public health disease and infected millions of people each year. According to WHO report, TB is a second leading cause death after the human immunodeficiency virus (HIV) and estimated nearly 8.6 million new TB cases and 1.3 million TB deaths will occur in 2012 (WHO, 2013b). Although TB is curable, however the rise of multidrug-resistance TB (MDR-TB) cases is very concerning which therefore require voluminous new anti MDR-TB drug candidates to be discovered to combat and eradicate this infectious diseases (WHO, 2013b). The present study reports the chemical investigation of extract from V. pinnata. Previous phytochemical study revealed the isolation of ecdysteroids, which are pinnatasterone, 20-hydroxyecdysone and turkesterone (Suksamrarn and Sommechai, 1993). Other study reported a new iridoid glucoside, pinnatoside and three known flavonoids namely viscioside, apigenin, and luteolin were isolated from the bark of V. pinnata (Ata et al., 2009). In this paper the isolation of secondary metabolites and its anti-infective activities against T. b. brucei and M. marinum of isolated compounds were described.

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MATERIALS AND METHODS

General Equipment and Experimental Procedures

The optical rotations of the compounds were measured on a 341 Polarimeter from PerkinElmer, Inc., USA. Analytical Thin Layer Chromatography (TLC) was performed on pre-coated TLC plates with normal silica gel 60 F254 and reverse phase TLC silica gel 60 RP-18 F254S (layer thickness 0.2 mm, Merck, Germany).

Plant material

Leaf parts of V. pinnata were collected from Marang Kuala Terengganu, situated approximately 500 kilometres northeast of Kuala Lumpur on the east coast of Peninsular Malaysia in September 2009. The plant was authenticated by Dr. Nashriyah Mat from Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin and voucher specimen was deposited (collection number VP 01).

Extraction and Isolation

The ground leaves of V. pinnata (1 kg) were extracted in a Soxhlet apparatus at 40°C by utilising three different solvents based on their polarity. The extraction was started with n-hexane followed by ethyl acetate then methanol with solvent volumes of 7.5 L each for 72 hours.

Later the extracts were concentrated in vacuo by using rotary evaporator (BUCHI Labortechnik AG, Switzerland) at 40ºC and the yield was 6.33g (n-hexane extract), 6.5g (ethyl acetate extract) and 5.2g (methanol extract). All dried extracts were stored at -20ºC freezer. Fractionation of the n-hexane extract (6.33g) was accomplished by using Medium Pressure Liquid Chromatography (MPLC).

Linear gradient elution was employed with hexane (A) and ethyl acetate (B) as solvents at a flow rate of 100ml/min. Pre-packed VersaPak silica cartridge (particle size 20-45 µm, diameter and length 40 x 150 mm) from Supelco was used in this run. 100% A was run for 5 min (isocratic) followed by 100% A to 100% B for 20 min (gradient) then with 100% B for the last 5 min (isocratic).

The run time was 30 min in total. For the first and last 5 min of the run, the fractions were collected for every 100 ml and followed by 50 ml volume fractions for 20 min resulting to 50 fractions. Fractions with similar TLC profiles were pooled together yielding 28 fractions. Fraction 12 contained a mixture of two compounds assigned as **1** (15mg).

Fraction 13 was further subjected to MPLC over a a pre-packed VersaPak silica cartridge (particle size 20–45 µm, diameter and length 23 x 53 mm) utilising an isocratic gradient system with 80% hexane and 20% ethyl acetate for 30 min at a flow rate of 20 ml/min. Fraction 13 afforded six sub-fractions and gave one pure compound **2** (20 mg). Fraction 16 afforded one major compound **3** (4 mg). Fraction 19 afforded the major compound **4** (130mg) by crystallisation after washing with mixtures of hexane and methanol.

NMR Instrumentation

One and two dimensional Nuclear Magnetic Resonance (NMR) experiments were measured in Strathclyde Institute of Pharmacy and Biomedical Sciences by using 400 MHz on an AS-400 JEOL NMR instrument (Tokyo, Japan). All isolated samples were dissolved in 650 µl of deuterated chloroform ($CDCl_3$).

HR-LCMS analysis

In High Resolution-Liquid Chromatography Mass Spectrometry (HR-LCMS) analysis, all samples were dissolved in MeOH HPLC grade to give final concentration of 1mg/ml. HR-LCMS analysis was carried out using a Accela 600 High Performance Liquid Chromatography (HPLC) pump with Accela autosampler and UV/Vis detector (Thermo Scientific, Bremen, Germany) and Orbitrap Exactive mass spectrometer (Thermo Fisher Scientific Inc, Hemel Hempstead UK). A reversed phase silica C18 HPLC column, 75.0 x 3.0 mm^2 (Hichrom Limited, UK) with particle size of 5 µm, pore size 100 ˚A was used. The approximate pressure was at 37 bar while the temperature was maintained at 22 ^{0}C. The mobile phase consisted of purified water (A) and acetonitrile (B) with 0.1 % formic acid in each solvent. The samples were eluted on a linear gradient of 90% A and 10% B to 100% B for 30 min and changed to isocratic mode for 5 min before decreasing back to 10% of B for 1 min. Then the column was re-equilibrated with 10% of B for 9 min before the next sample injection. The flow rate used in this method was 300µl/min and the injection volume was 10 µl.

GCMS Analysis

Sample (1 µl) was injected into the the Gas Chromatography Mass Spectrometry (GCMS) (Focus GC-DSQ2) system from Thermo Fisher Scientific (Bremen, Germany) using with 30 m long, 0.25 mm i.d., and 0.25 µm film thickness InertCap 1 MS capillary column from GL Sciences (Japan). The oven temperature was set at 80^{o}C for 1 minute and the temperature was increased at a rate of 15^o/min until it reached to 200^{o}C and was maintained for 15 min. Then the temperature was again increased at a rate of 5^{o}C/min until the final temperature of 320^{o}C (held for 10 min). The base temperature of the split/splitless (SSL) was 250^{o}C. The mode was splitless. The split flow was on at 15 mL/min. The splitless time was 1 minute. The carrier method was set to constant flow. The initial value was 1.50 mL/min and the initial time was 1 minute. The MS transfer line was maintained at a temperature of 320^{o}C. The source temperature of the DSQ II mass spectrometer was set to 250^{o}C. The mass range used was 50.0-800.0.

Anti-infective assays

The in vitro antitrypanosomal and antimycobacterial activities were examined according to the standard protocols previously published (Viegelmann et al., 2014).

RESULT AND DISCUSSION

The substance **1** was observed as a white powder. From the GCMS result, it showed two peaks at 19:23 and 19:53 minutes

with the molecular ion peaks at m/z 412.51 $[M]^+$ and 414.51 $[M]^+$, respectively. Online GCMS NIST library database suggested this fraction is a mixture of two compounds. GCMS spectrum at m/z 414.51 suggested the compound is *β*-sitosterol **1a**, with the molecular formula $C_{29}H_{50}O$ while at m/z 412.51 is stigmasterol **1b** with the molecular formula $C_{29}H_{48}O$. The HMQC spectrum was done to confirm the identity of the individual compounds in each of the mixture which were elucidated as *β*-sitosterol and stigmasterol by observing the specific signals at positions C-22 and C-23.

In the HMQC spectrum of stigmasterol the chemical shifts at positions C-22 and C-23 are 138.0 and 129.2 ppm, respectively which suggested an alkene group while in *β*-sitosterol, chemical shift signals at C-22 and C-23 were at 34.0 and 26.1 ppm, respectively for an alkyl group. Based on comparison to ^{13}C NMR data of **1a** and **1b** to the previous literatures (Alam et al., 1996; Mahato and Kundu, 1994) (Table 1) supported that compound **1a** and **1b** is a mixture of *β*-sitosterol and stigmasterol.

Table 1: ^{13}C NMR data of *β*-sitosterol (1a) and stigmasterol (1b) in Chloroform-d

Carbon	1a	*β*-sitosterol (Alam et al., 1996) in Chloroform-d	1b	Stigmasterol (Mahato and Kundu, 1994) in Chloroform-d
Position	δ_C	δ_C	δ_C	δ_C
1	37.4	37.3	37.1	37.3
2	31.9	31.9	31.6	31.7
3	71.8	71.9	71.8	71.9
4	42.3	42.3	41.5	42.3
5	140.3	140.8	140.3	140.8
6	121.7	121.8	121.7	121.8
7	31.7	31.7	31.7	32.1
8	32.0	32.0	32.0	32.0
9	50.1	50.2	50.1	50.2
10	36.5	36.6	36.7	36.6
11	21.1	21.2	20.8	21.2
12	39.6	39.8	39.6	39.8
13	42.3	42.4	42.3	42.4
14	56.7	56.8	56.7	56.8
15	24.3	24.4	24.3	24.4
16	28.6	28.3	28.6	28.3
17	55.9	56.1	55.9	56.1
18	11.6	11.9	11.6	11.9
19	19.4	19.5	19.2	19.1
20	36.2	36.2	40.1	40.6
21	18.8	18.9	20.5	20.0
22	34.0	34.0	138.0	138.4
23	26.1	26.2	129.2	129.2
24	45.8	46.0	51.1	51.3
25	29.2	29.2	32.0	34.0
26	19.8	19.9	19.0	18.9
27	19.0	19.1	21.2	21.3
28	23.1	23.1	25.4	25.5
29	12.0	12.1	12.0	12.1

Compound **2** was obtained as white needles, m.p. 427ºC. ESI-MS peak in the positive mode was found at m/z 329.1026 $[M+H]^+$ (base peak) which revealed a molecular weight of 328.32 g/mol and a molecular formula of C_{18} H_{16} O_6. Consequently, compound **2** had 11 degree of unsaturation. The ^1H NMR spectrum of **2** (Table 2) displayed a singlet signal at δ 12.65 due to the strongly hydrogen bonded phenolic hydroxyl moiety. The presence of two doublet signals at δ_H 6.44 (d, J=2) and δ 6.35 (d, J=2) were characteristic of two meta-related H-6 and H-8 as in a 5,7 disubstituted A-ring flavonoid. In the B ring system, two sets of symmetric proton doublet signals at δ 8.07 (2H, d, J=9) and 7.02 (2H, d, J=9) were detected for an AA' BB' system which indicated that C-4' was substituted. In addition, the ^1H NMR spectrum of this compound exhibited three singlets at δ_H 3.89, 3.87 and 3.85 showing the existence of three methoxyl groups. By comparing the data with previous literature (Rossi et al., 1997), the compound **2** was identified as 5-hydroxy-3, 7, 4'-trimethoxyflavone previously isolated from Aniba species. Compound **3** was obtained as white needles, m.p. 381ºC. The ESI-MS spectrum showed a molecular ion at negative mode with m/z 297.2434 $[M-H]^-$ suggested a molecular formula of $C_{19}H_{18}O_7$. The ^1H NMR spectrum (Table 2) showed of two methoxy signals at δ_H 3.88 and 3.89. One downfield singlet at δ_H 12.80 assigned to a phenolic hydroxyl group. The ^1H NMR spectrum of compound **3** was found to be similar to spectrum compound **2** except that compound **3** showed additional singlet peak at δ_H 6.58 suggested its position at C-3. In the A ring, AB system was assigned to two doublet protons (H-6 and H-8) at δ_H 6.37 and 6.48 with typical meta coupling constant of J= 2.2 Hz. In the B ring system, two sets of symmetric proton signals δ 7.84 (2H, d, J=9) and 7.01 (2H, d, J=9) were detected for an AA' BB' system which indicated that C-4' was substituted. The structure of **3** was identified as 5-hydroxy-7, 4'-dimethoxyflavone based on comparison to the previous published data (Kolak et al., 2009). Compound **4** was obtained as white crystalline needles, m.p. 473ºC. A molecular formula of $C_{19}H_{18}O_7$ was deduced by ESI-MS with molecular ion peak at m/z 359.1134 $[M+H]^+$ (base peak) with 11 degrees of unsaturation.

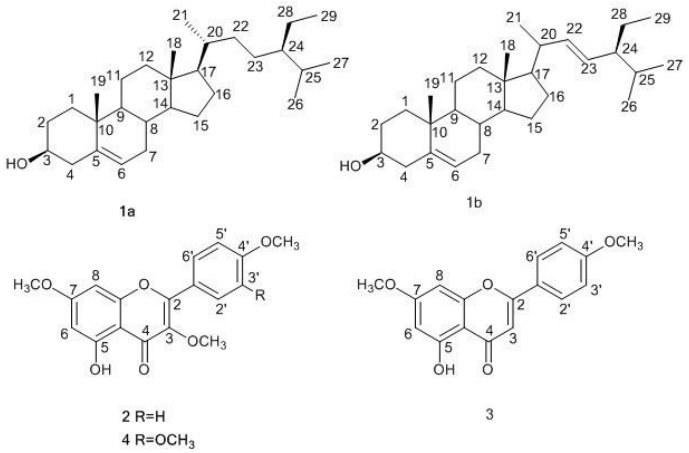

Fig. 1: Structures of isolated secondary metabolites from V. pinnata

The ^1H NMR spectrum (Table 3) showed four methoxy signals at δ_H 3.86, 3.88, 3.96 and 3.97. One downfield singlet at δ_H 12.64 was assigned to a phenolic hydroxyl group. In the A ring, AB system was assigned to two doublet protons (H-6 and H-8) at δ_H 6.36 and 6.45 with a typical meta coupling constant of J= 2.2 Hz.

Table 2: ^{13}C NMR data of 5-hydroxy-3, 7, 4'-trimethoxyflavone (2) and 5-hydroxy-7, 4'-dimethoxyflavone (3) in Chloroform-d.

Position	2	5-hydroxy-3, 7, 4'-trimethoxyflavone (Rossi et al., 1997) in Chloroform-d	3	5-hydroxy-7, 4'-dimethoxyflavone (Kolak et al., 2009) in Chloroform-d
	δ_H (J Hz)	δ_H (J Hz)	δ_H (J Hz)	δ_H (J Hz)
3			6.58, s	6.58, s
6	6.35, d (J=2)	6.33, d (J=2)	6.36, d (J=2.2)	6.37, d (J=2.4)
8	6.44, d (J=2)	6.43, d (J=2)	6.48, d (J=2.2)	6.48, d (J=2.4)
2' and 6'	8.07, d (J=9)	8.07, d (J=9)	7.84, d (J=9.0)	7.85, d (J=9.0)
3' and 5'	7.02, d (J=9)	7.0, d (J=9)	7.01, d (J=9.0)	7.02, d (J=9.0)
3-OCH_3	3.87,s	3.84, s	3.89, s	3.84, s
7-OCH_3	3.89, s	3.84, s	3.88, s	3.84, s
4'-OCH_3	3.85, s	3.84, s	12.80, s	12.80, s
5-OH	12.65, s	12.6, s		

Table 3: ^{13}C NMR data of 5-hydroxy-3,3',4',7-tetramethoxyflavone (4) in Chloroform-d.

Position	4	5-hydroxy-3,3',4',7-tetramethoxyflavone (Li et al., 2006) in DMSO-d_6
	δ_H (J Hz)	δ_H (J Hz)
6	6.36, d (J=2.2)	6.39, d (J=2.2)
8	6.45, d (J=2.2)	6.80. d (J=2.2)
2'	7.69, d (J=2.0)	7.67, d (J=2.0)
5'	6.99, d (J=8.9)	7.17, d (J=9.0)
6'	7.73, dd (J=8.9, 2.0)	7.74, dd (J=9.0, 2.0)
3- OCH_3	3.86, s	3.83, s
7- OCH_3	3.88, s	3.87, s
3'- OCH_3	3.96, s	3.87, s
4'- OCH_3	3.97, s	3.88, s
9-OH	12.64, s	12.62, s

Compound **1a** and **1b, 2, 3** and **4** showed moderate antitrypanosomal activity with MIC values of 6.25µg/ml, 19.0, 21.0 and 17.0µM. However no activity was observed in all isolated compounds against M. marinum (Table 4). Previous study reported that compound **4** was inactive against T. b. rhodesiense and T. cruzi (IC_{50} >80 µM) however showed adequate antileismanial activity against Leishmania donovani with IC_{50} value of 21.77 µM (Tasdemir et al., 2006).

Table 4: Summary of anti-infective activities of isolated compounds from V. pinnata.

Compounds	Antitrypanosomal activity against T. b. brucei, MIC (µM)	Anti-mycobacterial activity against M. marinum MIC (µM)
1	6.25µg/ml	>100
2	19.0 ± 3.5	>100
3	21.0 ± 4.1	>100
4	17.0 ± 2.3	>100
Suramin	0.11 ± 0.0	
Gentamycin		13.48 ± 0.0

Tumor necrosis factor-α (TNF-α) is a group of cytokines that involved systemic inflammatory reaction. Previous report describes the level of TNF-α was increased in the sera of bacterial, viral, and parasitic-infected patients including malaria and leishmaniasis (Barral-Netto et al., 1991; Scuderi et al., 1986; Shaffer et al., 1991).

The level of TNF-α in serum of T. b. gambiense-infected patient also corresponding with the disease severity (Okomo-Assoumou et al., 1995). Other finding also reported the level of TNF-α was high in patient with late-stage of T. b. gambiense infection and was declined dramatically after treatment with melarsoprol (Rhind et al., 1997). Traditionally, Malay community used leaves of V. pinnata to treat inflammation including fever and wounds (Burkill, 1966; Ong and Nordiana, 1999) and based from these evidences suggested the anti-inflammatory response in treating fever and wounds is possibly from compound **2**, **3** and **4** which exhibited moderate antitrypanosomal activity against T. b. brucei.

CONCLUSIONS

In conclusion, this finding reported that compound **2**, **3** and **4** were isolated efficiently for the first time from V. pinnata by using MPLC. In this study as well reported a moderate antitrypanosomal activity of these compounds against T. b. brucei for the first time.

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REFERENCES

Alam MS, Chopra N, Ali M, Niwa M. Oleanen and stigmasterol derivatives from Ambroma augusta. Phytochemistry, 1996; 41:1197-1200.

Ata A, Mbong N, Iverson CD, Samarasekera R. Minor chemical constituents of Vitex pinnata. Natural product communications, 2009; 4:1.

Barral-Netto M, Badaró R, Barral A, Almeida RP, Santos SB, Badaró F, Pedral-Sampaio D, Carvalho EM, Falcoff E, Falcoff R. Tumor Necrosis Factor (Cachectin) in Human Visceral Leishmaniasis. Journal of Infectious Diseases, 1991; 163:853-857.

Burkill IH. 1966. A Dictionary of the Economic Products of the Malay Peninsula. Ministry of Agriculture Co-operatives: Kuala Lumpur 2280.

Corner EJH. 1951. Wayside trees of Malaya. Singapore Govern: Singapore. de Kok R. The genus Vitex (Labiatae) in the flora Malesiana region, excluding New Guinea. Kew Bulletin, 2008; 63:17-40.

Jacobs RT, Nare B, Phillips MA. State of the art in African trypanosome drug discovery. Current topics in medicinal chemistry, 2011; 11:1255.

Kolak U, Hacibekıroğlu I, Öztürk M, Özgökçe F, Topçu G, Ulubelen A. Antioxidant and anticholinesterase constituents of Salvia poculata. Turkish Journal of Chemistry, 2009; 33.

Li S, Lo C-Y, Ho C-T. Hydroxylated polymethoxyflavones and methylated flavonoids in sweet orange (Citrus sinensis) peel. Journal of agricultural and food chemistry, 2006; 54:4176-4185.

Mahato SB, Kundu AP. 13C NMR Spectra of pentacyclic triterpenoids--a compilation and some salient features. Phytochemistry, 1994; 37:1517-1575.

Malan E, Roux DG. Flavonoids from Distemonanthus benthamianus Baillon. Methoxylated flavones and inter-relationships of benthamianin, a [2]benzopyrano[4,3-b][1]benzopyran. Journal of the Chemical Society, Perkin Transactions 1, 1979:2696-2703.

Marles RJ, Farnsworth NR. Antidiabetic plants and their active constituents. Phytomedicine, 1995; 2:137-189.

Mukhtar M, Arshad M, Ahmad M, Pomerantz RJ, Wigdahl B, Parveen Z. Antiviral potentials of medicinal plants. Virus Research, 2008; 131:111-120.

Nam N-H. Naturally occurring NF-κB inhibitors. Mini reviews in medicinal chemistry, 2006; 6:945-951.

Okomo-Assoumou MC, Daulouede S, Lemesre J-L, N'Zila-Mouanda A, Vincendeau P. Correlation of High Serum Levels of Tumor Necrosis Factor-α with Disease Severity in Human African trypanosomiasis. The American Journal of Tropical Medicine and Hygiene, 1995; 53:539-543.

Ong H, Nordiana M. Malay ethno-medico botany in Machang, Kelantan, Malaysia. Fitoterapia, 1999; 70:502-513.

Pezzuto JM. Plant-derived anticancer agents. Biochemical pharmacology, 1997; 53:121-133.

Rhind SG, Sabiston BH, Shek PN, Buguet A, Muanga G, Stanghellini A, Dumas M, Radomski MW. Effect of Melarsoprol Treatment on Circulating IL-10 and TNF-α Levels in Human African Trypanosomiasis. Clinical Immunology and Immunopathology, 1997; 83:185-189.

Rossi MH, Yoshida M, Soares Maia JG. 1997. Neolignans, styrylpyrones and flavonoids from an Aniba species. 1263-1269 p.

Schmidt T, Khalid S, Romanha A, Alves T, Biavatti M, Brun R, Da Costa F, De Castro S, Ferreira V, De Lacerda M. The potential of secondary metabolites from plants as drugs or leads against protozoan neglected diseases-Part II. Curr. Med. Chem, 2012; 19:2176-2228.

Scuderi P, Lam K, Ryan K, Petersen E, Sterling K, Finley P, Ray CG, Slymen D, Salmon S. Raised serum levels of tumour necrosis factor in parasitic infections. The Lancet, 1986; 328:1364-1365.

Shaffer N, Grau GE, Hedberg K, Davachi F, Lyamba B, Hightower AW, Breman JG, Nguyen-Dinh P. Tumor Necrosis Factor and Severe Malaria. Journal of Infectious Diseases, 1991; 163:96-101.

Simarro PP, Diarra A, Postigo JAR, Franco JR, Jannin JG. The human African trypanosomiasis control and surveillance programme of the World Health Organization 2000–2009: the way forward. PLoS neglected tropical diseases, 2011; 5:e1007.

Suksamrarn A, Sommechai C. Ecdysteroids from Vitex pinnata. Phytochemistry, 1993; 32:303-306.

Tasdemir D, Kaiser M, Brun R, Yardley V, Schmidt TJ, Tosun F, Rüedi P. Antitrypanosomal and antileishmanial activities of flavonoids and their analogues: in vitro, in vivo, structure-activity relationship, and quantitative structure-activity relationship studies. Antimicrobial agents and chemotherapy, 2006; 50:1352-1364.

Viegelmann C, Parker J, Ooi T, Clements C, Abbott G, Young L, Kennedy J, Dobson A, Edrada-Ebel R. Isolation and Identification of Antitrypanosomal and Antimycobacterial Active Steroids from the Sponge Haliclona simulans. Marine Drugs, 2014; 12:2937-2952.

WHO. 2013a. Sustaining the drive to overcome the global impact of neglected tropical diseases: second WHO report on neglected tropical diseases: summary.

WHO. 2013b. Global tuberculosis report 2013. World Health Organization: Geneva, Switzerland.

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