J Wood Sci (2009) 55:230–235
DOI 10.1007/s10086-008-1021-1

NOTE

Irmanida Batubara · Tohru Mitsunaga · Hideo Ohashi

Screening antiacne potency of Indonesian medicinal plants: antibacterial, lipase inhibition, and antioxidant activities

Received: September 26, 2008 / Accepted: December 22, 2008 / Published online: February 28, 2009

Abstract Indonesian medicinal plants were screened as potential sources of antiacne agents. The screening methods were performed using antibacterial assay against *Propionibacterium acnes*, lipase inhibitor assay, and antioxidant assay. The results showed that from 40 plant materials extracted with methanol and 50% ethanol in water, *Caesalpinia sappan* was the best extract based on the combined activities: antibacterial (minimum inhibitory concentration 0.13 mg/ml; minimum bactericidal concentration 0.25 mg/ml), lipase inhibitory [50% inhibitory concentration (IC_{50}) 120.0 μg/ml], and antioxidative (IC_{50} 6.47 μg/ml). Another prospective extract is *Intsia palembanica* based on its lipase inhibitory activity (IC_{50} 4.1 μg/ml) and antioxidant activity (IC_{50} 3.87 μg/ml).

Key words Indonesian medicinal plants · *Propionibacterium acnes* · Lipase inhibitor · Antioxidant

Introduction

Nontimber forest products (NTFP) including medicinal plants originally from natural and planted forests have been widely promoted and sought after.[1] These natural products make a significant contribution to human health, not only in preventing disease but also in curing certain diseases. With a number of known species, it is predicted that there is still a huge number of species unexplored for NTFP and as a source of medicinal extracts.

I. Batubara
United Graduate School of Agricultural Science, Gifu University, Gifu 501-1193, Japan

T. Mitsunaga (✉) · H. Ohashi
Department of Applied Biological Science, Faculty of Applied Biological Sciences, Gifu University, 1-1 Yanagido, Gifu 501-1193, Japan
Tel. +81-58-293-2920; Fax +81-58-293-2920
e-mail: mitunaga@gifu-u.ac.jp

Part of this report was presented at the 58th Annual Meeting of the Japan Wood Research Society, Tsukuba, March 2008

Acne is a chronic inflammatory disease of multifactorial etiology.[2,3] It is common in adolescents; however, the overall rate appears to be on the rise, especially among adults. Acne is a distressing skin condition that can carry with it significant psychological problems. The most common pathways to acne include excess sebum production, hyperkeratinization of the hair follicle, oxidative stress, and the release of inflammatory mediators.[4,5]

The prevalent bacterium implicated in the clinical course of acne is *Propionibacterium acnes*, a gram-positive anaerobe that normally inhabits the skin and is implicated in the inflammatory phase of acne.[6] This bacterium plays a central role in the current concept of acne pathogenesis,[7] and appears to be the target of oral and topical antibiotic usage. The reduction in its numbers is a valid parameter for the therapeutic effectiveness of an antibiotic.[8]

Propionibacterium acnes secretes several proinflammatory products that play an important role in the development of inflammation. These include lipases, proteases, hyaluronidase, and chemotactic factors.[9] *Propionibacterium acnes* lipase is an important factor in the pathogenesis of acne because free fatty acids formed as a result of the effect of *P. acnes* lipase on sebaceous triglycerides induce severe inflammation.[10]

Recently it was reported that the most chronic medical conditions of acne are characterized by both oxidative stress and inflammation. It is likely that the blood levels of antioxidants are used up readily in those with acne because there is a greater demand to deal with free radicals.[4]

Compounds targeting acne, therefore, should be able to inhibit *P. acnes* growth, inhibit *P. acnes* lipase activity, and inhibit the oxidative stress. In other words, compounds or materials advocated for acne control should possess antibacterial, lipase inhibitor, and antioxidant activities.

Medicinal plants have been used in medicine for thousands of years. However, their efficacies proven with scientific methods, which can be employed to give a better understanding of their mechanisms of action, were only established in recent times. Natural substances such as glycyrrhizic acid, (±)-catechin, and kaempferol were reported as promising candidates for the treatment of acne due to

their strong inhibitory activity on GehA lipase.[11] The antioxidant effects of antioxidant-rich polyphenols such as green tea, turmeric, and berries were reported to have good activity in reducing the oxidative stress of acne patients.[4] In this study, the antimicrobial activity against *P. acnes*, inhibitory activity against *P. acnes* lipase, and antioxidant properties of some Indonesian plants were investigated.

Experimental

Plant materials

Twenty eight plant species used in this study were collected from Samarinda and Bogor in Indonesia. *Avicennia* sp., *Castanopsis javanica*, *Goniothalamus macrophyllus*, *Helminthostachys zeylanica*, *Hibiscus tiliaceus*, *Intsia palembanica*, *Koompassia malaccensis*, *Lepisanthes amoena*, *Litsea firma* Hook f. Dehaasia, *Melaleuca cajuputi*, *Rhizophora* sp., *Swietenia* sp., *Terminalia catappa*, *Usnea misaminensis*, *Vitex pubenscens*, and *Xylocarpus granatus* were collected from Samarinda, East Kalimantan, Indonesia. Identification and voucher specimens were collected at the Wood Anatomy Laboratory, Faculty of Forestry, Mulawarman University, East Kalimantan, Indonesia. Other species were collected from Bogor, Indonesia. The identification and voucher specimens were deposited in the Biopharmaca Research Center, Bogor Agricultural University, Bogor, Indonesia.

Preparation of plant extracts

All samples were dried and ground before being extracted with methanol and 50% (v/v) ethanol in water. Briefly, the dried and powdered plant materials were extracted with solvents (ratio of 1 g sample: 10 ml solvent) for 12 h three times. The extracts were filtered using Whatman filter paper (no. 1) and concentrated in vacuo at 30°C using a rotary evaporator. The extract yields were then calculated.

Antibacterial assay

The test organism used in this study was *Propionibacterium acnes* ATCC 6919. The medium consisted of GAM broth Nissui 0.5%, glucose 1.0% (Wako Japan), yeast extract 0.3% (Difco, France), nutrient broth 0.5% (Difco, France), and 0.2% Tween-80 (MP Biomedical, Japan). Sterilized medium (95 µl), sample [100 µl, serial concentration, diluted in dimethylsulfoxide (DMSO) 20%] or control (100 µl), and inoculum (5 µl) were added to each well of a 96-well plate.[12] The inoculum was prepared at the concentration of 10^{-2} CFU/ml. *Propionibacterium acnes* was incubated in the medium for 72 h under anaerobic conditions. Extract concentration at which there was no visually detectable bacterial growth was described as the minimum inhibitory concentration (MIC). Next, 10 µl of each medium with no visually detectable bacterial growth was inoculated in 100 µl of fresh medium. The concentration at which there was no bacterial growth after the second inoculation was described as the minimum bactericidal concentration (MBC). The negative control used was DMSO, while the positive controls were chloramphenicol (Wako, Japan), tetracycline (MP Biomedical, Japan), and isopropyl methylphenol (IPMP) (TCI, Japan). The antibacterial assay was conducted a minimum of three times, each at different times.

Preparation of crude lipase from *Propionibacterium acnes*

Propionibacterium acnes was cultured in medium (same as the medium in the antibacterial assay). The cell suspension was centrifuged at 900 *g* for 10 min and the precipitate was diluted in phosphate buffer saline (PBS) at pH 6.98. The bacteria in this solution were destroyed by microdestruction (TOMY Micro Smash MS-100) at 4000 rpm for 30 s and centrifuged at 5000 *g* for 60 s. The filtrate was collected and placed in a dialysis tube for 6 days. The dialyzate was freeze-dried and was used for successive experiments.

Propionibacterium acnes lipase inhibitory activity assay

Lipase inhibitory activity assay was conducted using the 2,3-dimercapto-1-propanol tributyrate (BALB) method.[13] Chloramphenicol, isopropyl methylphenol, and tetracycline were used as the positive controls.

Antioxidant assay

The antioxidant assay used in this study adopted a free-radical-scavenging activity using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) test. Samples were diluted in ethanol to make final concentrations of 1.67, 3.33, 6.67, 10.00, 13.33, 16.67, 33.33, 66.67, 100.00, 133.33, and 166.67 µg/ml. An aliquot of sample, 100 µl of 2-(*N*-morpholino)ethanesulfonic acid (MES) buffer pH 7.4, and 100 µl of DPPH solution (11.8 mg DPPH in 100 ml ethanol) were added to each well of a 96-well plate. After 30 min, the absorbance of the mixture was measured at 514 nm. The positive control was (+)-catechin (Tokyo Chemical, Japan) while ethanol was used as the blank. The inhibitory activity was calculated according to the following equation:

$$\text{Inhibition (\%)} = [1 - (A_{\text{sample}} - A_{\text{control}})/(A_{\text{blank}} - A_{\text{control}})] \times 100\%$$

where A_{sample} is the absorbance of the sample, A_{control} is the absorbance of (+)-catechin as control and A_{blank} is the absorbance of ethanol as the blank. Each sample concentration of the samples and positive control were tested in triplicate.

Statistical analysis

Data of lipase inhibitory and antioxidant activities were expressed as mean ± standard deviation (SD). Significant

difference between samples was assessed by one-way analysis of variance (ANOVA) followed by pairwise comparison of mean with the positive control using Tukey's multiple comparison test and $P = 0.05$ was considered as significant.

Results and discussion

Twenty eight Indonesian plants were collected for antiacne potency screening. The scientific, family, and local names of the samples as well as their common usage are presented in Table 1. Some samples are already used for skincare in Indonesia, but others are yet to be used. The samples can be divided into woody plants and nonwoody plants. The woody plants are mostly not used for skincare in Indonesia. Only *Caesalpinia sappan* has a lot of traditional usage including skincare, and is already widely known as a medicinal plant.[14]

The antiacne potency of Indonesian plants was analyzed based on antibacterial activity, lipase inhibitory activity, and antioxidant activity. The data are shown in Table 2. Based on antibacterial activity, about 35 out of 80 extracts used in this study were able to inhibit *Propionibacterium acnes* growth. The most effective extracts were *Caesalpinia sappan* methanol (MeOH) and 50% ethanol (EtOH) extracts (sample 3) and also *Goniothamalus macrophyllus* leaf MeOH extract (sample 7). The MIC values of these extracts were 0.13 mg/ml, which is the same as the MIC value of the positive control chloramphenicol. Other effective extracts were *Andrographis paniculata* MeOH extract (sample 1), *Curcuma xanthorrhiza* MeOH and 50% EtOH extracts (sample 6), *Goniothalamus macrophyllus* stem MeOH extract (sample 7), *Hibiscus tiliaceus* MeOH and 50% EtOH extracts (sample 11), *Psidium guajava* MeOH extract (sample 20), *Talinum* sp. MeOH extract (sample 23), and *Usnea misaminensis* MeOH and 50% EtOH extracts (sample 26). These effective extracts had MIC values lower than IPMP as the positive control (MIC 1 mg/ml).

Only 4 out of 80 extracts had an MBC lower than the MBC of IPMP. These were *C. sappan* (sample 3) MeOH and 50% EtOH extracts, *C. xanthorrhiza* (sample 6) 50% EtOH extract, and *P. guajava* (sample 20) MeOH extract. Based on combined antibacterial activities and MIC and MBC values, *C. sappan* MeOH and 50% EtOH extracts were the most effective.

The antimicrobial activity of *C. sappan* against intestinal bacteria was studied by Lim et al.[15] *Caesalpinia sappan* heartwood can inhibit the bacteria *Bifidobacterium bifidum*, *Clostridium perfringens*, *Escherichia coli*, and *Lactobacillus casei.* The active compound against *C. perfringens* and *L. casei* purified from *C. sappan* methanol extract is 5-hydroxy-

Table 1. Scientific, family, and local names and common usage of samples

Sample	Scientific name	Family name	Local name	Common usage in Indonesia	Reference
1	*Andrographis paniculata*	Acanthaceae	Sambiloto	Dysentery, cholera, hypertension, diabetes	14
2	*Avicennia* sp.	Verbenaceae	Api-api	Contraception	14
3	*Caesalpinia sappan*	Fabaceae	Secang	Dysentery, tuberculosis, skincare, rheumatism, cough	14
4	*Castanopsis javanica*	Lauraceae	Palele	–	–
5	*Curcuma longa*	Zingiberaceae	Kunyit	Itch relief, acne, small wounds, skin eruptions	14
6	*Curcuma xanthorrhiza*	Zingiberaceae	Temulawak	Fever, liver disorders, skincare	14
7	*Goniothalamus macrophyllus*	Annonaceae	Somputn	Face powder, skincare	14
8	*Guazuma ulmifolia*	Sterculiaceae	Jati belanda	Weight loss	14
9	*Gynura pseudochina*	Compositae	Daun dewa	Bruises, acne	17
10	*Helminthostachys zeylanica*	Ophioglossaceae	Akar telunjuk langit	Face powder, diabetes	14
11	*Hibiscus tiliaceus*	Malvaceae	Waru	Hypertension, fever, kidney disorders	14
12	*Intsia palembanica*	Fabaceae	Merbau	Impotence	14
13	*Koompassia malaccensis*	Fabaceae	Kempas	Anthelmintic	14
14	*Lepisanthes amoena*	Sapindaceae	Celekop	Acne, skincare, face powder	14
15	*Litsea* spp.	Lauraceae	Medang	Stomachache	14
16	*Melaleuca cajuputi*	Myrtaceae	Gelam	Itch relief	14
17	*Morinda citrifolia*	Rubitaceae	Mengkudu	Cough, tonsils, hypertension	14
18	*Phaleria papuana*	Thymelacaceae	Mahkota Dewa	–	–
19	*Piper vuscumentosa*	Piperaceae	Sirih merah	Diabetes	14
20	*Psidium guajava*	Myrtaceae	Jambu biji	Diarrhea	14
21	*Rhizophora* sp.	Rhyzoporaceae	Bakau	Diarrhea	14
22	*Switenia* sp.	Meliaceae	Mahoni	Malaria	14
23	*Talinum* sp.	Portulaceae	Kolesom	Tonic	14
24	*Terminalia catappa*	Combretaceae	Ketapang	Dysentery, small pox	14
25	*Tinospora tuberculata*	Merispermaceae	Brotowali	Fever, itch relief, skin fungus	14
26	*Usnea misaminensis*	Usneaceae	Kayu angin	Cough, sprue	14
27	*Vitex pubescens*	Verbenaceae	Laban	Fever	14
28	*Xylocarpus granatus*	Meliaceae	Boli	–	–

Table 2. Antiacne properties of plant extracts

Sample	Part of plant	Solvent	Yield (%)[a]	Antibacterial		Lipase inhibition[b]	Antioxidant[b]
				MIC (mg/ml)	MBC (mg/ml)	IC_{50} (µg/ml)	IC_{50} (µg/ml)
1	Herbs	MeOH	26.72	0.50	–[c]	238.1 ± 0.5 j	–[e]
		50% EtOH	10.22	1.00	2.00	–[d]	11.93 ± 0.10 fg
2	Stem	MeOH	5.04	–[c]	–	230.0 ± 1.1 ij	6.06 ± 1.10 bc
		50% EtOH	3.12	–	–	–	14.83 ± 1.80 gh
3	Stem	MeOH	8.63	0.13	0.25	150.0 ± 1.0 g	9.90 ± 1.51 ef
		50% EtOH	7.36	0.13	0.25	120.0 ± 1.7 f	6.47 ± 0.74 bcd
4	Stem	MeOH	5.34	–	–	227.0 ± 3.2 ij	16.89 ± 1.10 h
		50% EtOH	3.72	1.00	2.00	–	10.96 ± 1.20 ef
5	Rhizome	MeOH	21.09	–	–	80.1 ± 3.9 e	16.92 ± 0.08 h
		50% EtOH	7.45	–	–	19.3 ± 1.2 b	44.65 ± 0.11 lm
6	Rhizome	MeOH	18.30	0.50	2.00	274.5 ± 5.7 j	80.72 ± 0.21 v
		50% EtOH	5.32	0.50	0.50	n	100.22 ± 0.13 CD
7	Leaf	MeOH	5.86	0.13	1.00	120.0 ± 5.3 f	70.20 ± 0.16 t
		50% EtOH	5.15	–	–	–	45.96 ± 0.11 lm
	Stem	MeOH	7.62	0.50	1.00	431.3 ± 7.4 p	81.06 ± 0.13 v
		50% EtOH	5.62	–	–	301.6 ± 6.5 j	155.4 ± 0.14 H
	Bark	MeOH	7.62	1.00	–	–	96.20 ± 0.10 AB
		50% EtOH	4.66	1.00	–	–	77.53 ± 0.11 u
8	Leaf	MeOH	19.31	–	–	n	112.31 ± 0.13 E
		50% EtOH	7.57	1.00	1.00	n	57.92 ± 0.13 r
9	Leaf	MeOH	22.12	1.00	–	–	62.74 ± 0.10 s
		50% EtOH	14.5	–	–	420.0 ± 3.1 m	154.76 ± 0.18 H
	Rhizome	MeOH	5.80	–	–	n	131.37 ± 0.20 F
		50% EtOH	2.34	1.00	2.00	440.0 ± 7.5 n	90.54 ± 0.13 x
10	Flower	MeOH	16.00	1.00	2.00	n	93.09 ± 0.13 xyz
		50% EtOH	11.66	–	–	–	52.69 ± 0.20 opq
	Leaf	MeOH	28.21	1.00	2.00	–	–
		50% EtOH	20.17	–	–	–	–
	Root	MeOH	10.36	2.00	2.00	–	103.21 ± 0.14 CD
		50% EtOH	8.56	–	–	52.5 ± 1.8 d	51.26 ± 0.14 op
	Stem	MeOH	26.62	1.00	–	283.9 ± 7.7 j	72.61 ± 0.11 t
		50% EtOH	21.0	–	–	461.2 ± 1.6 o	150.29 ± 0.16 G
11	Stem	MeOH	6.23	0.25	1.00	–	80.33 ± 2.31 uv
		50% EtOH	4.66	0.50	2.00	–	155.91 ± 2.73 H
12	Stem	MeOH	16.72	–	–	4.1 ± 1.1 a	3.87 ± 0.52 ab
		50% EtOH	4.55	–	–	83.0 ± 0.7 e	6.63 ± 0.54 bcd
13	Stem	MeOH	1.92	2.00	–	–	9.51 ± 0.91 def
		50% EtOH	0.78	–	–	–	12.17 ± 1.73 fg
14	Stem	MeOH	12.35	1.00	–	151.7 ± 3.5 g	99.10 ± 0.17 BC
		50% EtOH	11.86	1.00	2.00	167.9 ± 5.8 h	50.00 ± 0.13 no
	Leaf	MeOH	23.17	–	–	–	17.25 ± 0.16 h
		50% EtOH	8.76	–	–	112.9 ± 5.8 f	9.76 ± 0.18 ef
15	Stem	MeOH	5.48	1.00	–	n	–
		50% EtOH	3.77	–	–	n	92.71 ± 2.11 xy
16	Stem	MeOH	1.20	–	–	n	58.41 ± 1.32 r
		50% EtOH	1.04	–	–	n	5.79 ± 1.13 abc
17	Fruit	MeOH	27.83	–	–	–	–
		50% EtOH	8.88	–	–	–	–
	Leaf	MeOH	13.12	–	–	–	–
		50% EtOH	7.52	2.00	–	–	–
18	Fruit	MeOH	27.0	–	–	–	47.01 ± 0.22 mn
		50% EtOH	7.52	–	–	487.4 ± 6.5 q	35.22 ± 0.09 k
	Leaf	MeOH	33.01	–	–	–	–
		50% EtOH	7.53	–	–	377.6 ± 6.1 i	147.61 ± 0.10 G
19	Leaf	MeOH	19.51	1.00	1.00	–	35.07 ± 0.15 k
		50% EtOH	5.67	2.00	–	n	17.04 ± 0.16 h
20	Leaf	MeOH	22.90	0.50	0.50	319.5 ± 4.9 k	16.71 ± 0.19 h
		50% EtOH	11.00	1.00	1.00	34.7 ± 4.8 c	11.60 ± 0.14 f
21	Stem	MeOH	19.67	–	–	31.0 ± 2.1 bc	5.90 ± 0.41 abc
		50% EtOH	7.56	–	–	476.0 ± 2.4 pq	9.87 ± 0.33 ef
22	Fruit	MeOH	9.77	1.00	–	–	–
		50% EtOH	7.47	2.00	–	–	–
	Stem	MeOH	5.93	–	–	84.0 ± 2.1 e	8.34 ± 0.92 cde
		50% EtOH	4.11	–	–	–	11.76 ± 0.81 fg
23	Leaf	MeOH	7.18	0.50	2.00	374.0 ± 5.5 i	53.91 ± 0.10 pq
		50% EtOH	4.01	2.00	2.00	–	53.72 ± 0.17 pq

Table 2. *Continued*

Sample	Part of plant	Solvent	Yield (%)[a]	Antibacterial		Lipase inhibition[b]	Antioxidant[b]
				MIC (mg/ml)	MBC (mg/ml)	IC_{50} (µg/ml)	IC_{50} (µg/ml)
24	Bark	MeOH	1.95	1.00	2.00	–	32.65 ± 0.84 k
		50% EtOH	1.29	1.00	2.00	–	43.42 ± 0.53 l
	Stem	MeOH	2.41	1.00	–	–	94.12 ± 0.71 yzA
		50% EtOH	1.72	2.00	2.00	–	85.46 ± 1.42 w
25	Stem	MeOH	24.58	2.00	–	–1	n
		50% EtOH	11.06	2.00	2.00	–	–
26	Lichen	MeOH	11.57	0.50	2.00	–	54.47 ± 2.11 q
		50% EtOH	8.50	0.50	2.00	n	–
27	Bark	MeOH	4.67	2.00	–	–	22.00 ± 0.90 i
		50% EtOH	3.77	1.00	1.00	–	29.36 ± 1.11 j
	Stem	MeOH	3.48	1.00	–	–	22.14 ± 1.42 i
		50% EtOH	2.81	1.00	–	n	29.17 ± 0.92 j
28	Stem	MeOH	8.80	–	–	n	23.75 ± 0.69 i
		50% EtOH	5.12	–	–	n	23.82 ± 1.28 i
29	Chloramphenicol			0.13	0.13	218.8 ± 2.8 i	
30	Isopropyl methylphenol			1.00	1.00	166.4 ± 2.5 h	
31	Tetracycline			0.03	0.03	471.3 ± 5.5 op	
32	(+)-Catechin						2.94 ± 0.03 a

MIC, Minimum inhibitory concentration; MBC, minimum bactericidal concentration; IC_{50}, concentration causing 50% inhibition; MEOH, methanol; EtOH, ethanol; n, no inhibition but acceleration observed

[a] Based on dried sample

[b] Data given as mean ± standard deviation of triplicate tests. Samples followed by the same letter are not significantly different according to Tukey's multiple comparison test at $P = 0.05$

[c] No inhibition activity at concentration 2 mg/ml

[d] Failed to achieve 50% inhibition at maximum concentration of 500 µg/ml

[e] Failed to achieve 50% inhibition at maximum concentration of 166.67 µg/ml

1,4-naphthoquinone. Another active compound, brazilin, from *C. sappan* that has antibacterial activity and has the potential to be developed into an antibiotic was reported by Xu and Lee.[16] Although the activity of *C. sappan* against some bacteria is known, its antibacterial potency against *P. acnes* has not yet been investigated.

As lipase inhibitors, 11 samples had better activities than the positive controls (chloramphenicol, tetracycline, and IPMP) (Table 2.). Five of the best extracts for lipase inhibitory activity were *Intsia palembanica* MeOH extract [sample 12; 50% inhibitory concentration (IC_{50}) 4.1 µg/ml], *Curcuma longa* 50% EtOH extract (sample 5; IC_{50} 19.3 µg/ml), *Rhizophora* sp. MeOH extract (sample 21; IC_{50} 31.0 µg/ml), *P. guajava* 50% EtOH extract (sample 20; IC_{50} 34.7 µg/ml), and *Helminthostachys zeylanica* root 50% EtOH extract (sample 10, IC_{50} 52.5 µg/ml). One sample, *Lepisanthes amoena* (sample 14) stem 50% EtOH extract (IC_{50} 167.9 µg/ml), had an activity not significantly different from the best positive control, IPMP (IC_{50} 166.4 µg/ml). Compared with catechin (IC_{50} 3.9×10^{-4} M or 113.1 µg/ml) and kaempferol (IC_{50} 2.3×10^{-4} M or 65.78 µg/ml) activity against lipase Geh A, some samples had stronger inhibition activities.[11]

For antioxidant activity, 11 samples had IC_{50} values lower than 10 µg/ml. Three of these samples, namely *Intsia palembanica* (sample 12) MeOH extract (IC_{50} 3.87 µg/ml), *Melaleuca cajuputi* (sample 16) 50% EtOH extract (IC_{50} 5.79 µg/ml), and *Rhizophora* sp. (sample 21) MeOH extract (IC_{50} 5.90 µg/ml), had IC_{50} values not significantly different from the positive control, (+)-catechin (IC_{50} 2.94 µg/ml). However, 13 samples at a concentration of 166.67 µg/ml could not inhibit the oxidation reaction of DPPH by 50%.

Based on the three activities, *C. sappan* extracts (methanol and 50% ethanol) have the highest potential as an antiacne agent. Among all samples, these extracts had the best antimicrobial activity, good inhibitory lipase activity, and good antioxidant activity. Another prospective sample is *I. palembanica*, which had good *P. acnes* lipase inhibitory and antioxidant activities. It is important that the active antiacne compounds from these species be isolated, purified, and identified, and our efforts to achieve these goals will be described in our next publication.

Conclusions

Of 28 plant species collected from Samarinda and Bogor in Indonesia, the samples that had the best antibacterial activity were *Caesalpinia sappan* MeOH and 50% EtOH extracts, and *Goniothalamus macrophyllus* stem MeOH extract. The sample that had the best lipase inhibitory and antioxidant activities was *Intsia palembanica* MeOH extract. Based on the three activities, *Caesalpinia sappan* extracts (methanol and 50% ethanol) have the best potential as an antiacne agent.

References

1. Ghimire SK, McKey D, Thomas YA (2005) Conservation of Himalayan medicinal plants: harvesting patterns and ecology of two threatened species, *Nardostachys grandiflora* DC. and *Neopicrorhiza scrophulariiflora* (Pennell) Hong. Biol Conserv 124:463–475

2. Brown SK, Shalita AR (1998) Acne vulgaris. Lancet 351:1871–1876
3. Toyoda M, Morohashi M (2001) Pathogens of acne. Med Electron Microsc 34:29–40
4. Katzman M, Logan AC (2007) Acne vulgaris: nutritional factors may be influencing psychological sequelae. Med Hypotheses 69:1080–1084
5. Nourin K, Ballard CJ (2006) Laser therapy for acne. Clin Dermatol 24:26–32
6. Strauss JS, Krowchuk DP, Leyden JJ, Lucky AW, Shalita AR, Siegfried EC, Thiboutot DM, Van Voorrhees AS, Beutner KA, Sieck CK, Bhushan R (2007) Guidelines of care for acne vulgaris management. J Am Acad Dermatol 56:651–663
7. Zane LT (2005) Introduction: welcome to the next generation of acne research. Semin Cutan Med Surg 24:65–66
8. Burkhart CG, Burkhart CN, Lehmann PF (1999) Acne: a review of immunologic and microbiologic factors. Postgrad Med J 75:328–331
9. Heymann WR (2006) Dialogue in dermatology: toll-like receptors in acne vulgaris. J Am Acad Dermatol 55:691–692
10. Higashi S (2003) Lipase inhibitors for the treatment of acne. J Mol Catal B Enzym 22:377–384
11. Falcocchio S, Ruiz C, Pastor FIJ, Saso L, Diaz P (2006) *Propionibacterium acnes* GehA lipase, an enzyme involved in acne development, can be successfully inhibited by defined natural substances. J Mol Catal B Enzym 40:132–137
12. Chomnawang MT, Surassmo S, Nukoolkarn VS, Gritsanapan W (2005) Antimicrobial effects of Thai medicinal plants against acne-inducing bacteria. J Ethnopharmacol 101:330–333
13. Furukawa I, Kurooka S, Arisue K, Kohda K, Hayashi C (1982) Assays of serum lipase by the "BALB-DTNB Method" mechanized for use with discrete and continuous-flow analyzer. Clin Chem 26:110–113
14. Sangat HM, Zuhud EAM, Damayanti EK (2000) Kamus Penyakit dan Tumbuhan Obat Indonesia [Etnofitomedika I] (in Indonesian). Yayasan Obor, Indonesia
15. Lim MY, Jeon JH, Jeong EY, Lee CH, Lee HS (2007) Antimicrobial activity of 5-hydroxy-1,4-naphtoquinone isolated from *Caesalpinia sappan* toward intestinal bacteria. Food Chem 100:1254–1258
16. Xu HX, Lee SF (2004) The antibacterial principle of *Caesalpinia sappan.* Phytother Res 18:647–651
17. Ng LT, Yap SF (2003) Gynura Cass. In: Lemmens RHMJ, Bunyapraphatsara N (eds) Plant resources of South East Asia No 12 (3). Medicinal and poisonous plants 3. Prosea Foundation, Bogor, Indonesia, pp 231–233