REFERENCES

Amornchat, C., Krivaphan, V., and Triratana, T. The antibacterial activities of *Andrographis paniculata* crude extract on oral bacteria. J Thai Dent Assoc 41 (1991): 178-85.

Bennett, G.J., and Lee, H.H. Review article. Xanthones from *Guttiferae*. Phytochemistry 28 (1989): 967-98.

Brooks, G.F., Butel, G.S. and Morse, S.A. *Jawetz, Melnick,& Adellberg's.* Medical Microbiology. 23 ed. Singapore: McGraw-Hills Company, 2004.

Budavari, S., O'Neil, M.J., Smith, A., Heckelman, P.E., and Kinneary, J.F. Merk Index. Vol. 12. New Jersey: Merks Research Laboratory Division of Merk & Co, 1996.

Cai, L., and Wu, C.D. Compounds from *Syzygium aromaticum* possessing growth inhibitory activity against oral pathogens. J Nat Prod 59 (1996): 987-90.

Chairungsrilerd, N., Furukawa, K., Ohta, T., Nozoe, S., and Ohizumi, Y. Pharmacological properties of alpha-mangostin, a novel histamine H1 receptor antagonist. Eur J Pharmacol 314 (1996): 351-6.

Chen, S.X., Wan, M., and Loh, B.N. Active constituent against HIV-1 protease from *Garcinia mangostana*. Planta Med 62 (1996): 381-382.

Chynoweth, D.P. Microbial Growth Phase. Gainesville, Florida: University of Florida, 2004. Available from http://www.agen.ufl.edu/~chyn/age4660/lect/lect_09.

Ciancio, S.G. Antiseptics and antibiotics as chemotherapeutic agents for periodontitis management. Compend Contin Educ Dent 21 (2000): 59-62, 64, 66.

Cowan, M.M. Plant products as antimicrobial agents. Clin Microbiol Rev 12 (1999): 564-82.

Doan, N., Contreras, A., Flynn, J., Morrison, J. and Slots, J. Proficiencies of three anaerobic culture systems for recovering periodontal pathogenic bacteria. J Clin Microbiol 37 (1999): 171-4.

Dzink, J.L., and Socransky, S.S. Comparative in vitro activity of sanguinarine against oral microbial isolates. Antimicrob Agents Chemother 27 (1985): 663-665.

Fives-Taylor, P.M., Meyer, D.H., Mintz, K.P. and Brissette, C. Virulence factors of *Actinobacillus actinomycetemcomitans*. Periodontol 2000 20 (1999) :136-67.

Goldstein, E. J., Citron, D.M., Warren, Y., Merriam, C.V., Tyrrell, K. and Fernandez, H. In vitro activities of iodonium salts against oral and dental anaerobes. Antimicrob Agents Chemother 48 (2004): 2766-70.

Goodson, J.M., and Tanner, A. Antibiotic resistance of the subgingival microbiota following local tetracycline therapy. Oral Microbiol Immunol 7 (1992): 113-7.

Gopalakrishnan, G., Banumathi, B., and Suresh, G. Evaluation of the antifungal activity of natural xanthones from *Garcinia mangostana* and their synthetic derivatives. J Nat Prod 60 (1997): 519-24.

Greenstein, G., and Polson, A. The role of local drug delivery in the management of periodontal diseases: a comprehensive review. J Periodontol 69 (1998): 507-20.

Hannah, J.J., Johnson, J.D., and Kuftinec, M.M. Long-term clinical evaluation of toothpaste and oral rinse containing sanguinaria extract in controlling plaque, gingival inflammation, and sulcular bleeding during orthodontic treatment. Am J Orthod Dentofacial Orthop 96 (1989): 199-207.

Hiranras, P. Formulation of *Garcinia mangostana* Linn. extract buccal mucoadhesive film. Master's Thesis, Pharmacy, Faculty of Pharmaceutical Sciences, Chulalongkorn University, 2001.

Hirasawa, M., Shouji, N., Neta, T., Fukushima, K. and Takada, K. Three kinds of antibacterial substances from *Lentinus edodes* (Berk.) Sing. (Shiitake, an edible mushroom). Int J Antimicrob Agents 11 (1999): 151-7.

Hirasawa, M., Takada, K., Makimura, M. and Otake, S. Improvement of periodontal status by green tea catechin using a local delivery system: a clinical pilot study. J Periodontal Res 37 (2002): 433-8.

Holt, S.C., Kesavalu, L., Walker, S., and Genco, C.A. Virulence factors of *Porphyromonas gingivalis*. Periodontol 2000 20 (1999): 168-238.

Hwang, J.K., Chung, J.Y., Baek, N.I. and Park, J.H. Isopanduratin A from *Kaempferia pandurata* as an active antibacterial agent against cariogenic *Streptococcus mutans*. Int J Antimicrob Agents 23 (2004): 377-381.

Iinuma, M., Tosa, H., Tanaka, T., Asai, F., Kobayashi, Y., Shimano, R., et al. Antibacterial activity of xanthones from guttiferaeous plants against methicillin-resistant *Staphylococcus aureus*. J Pharm Pharmacol 48 (1996): 861-5.

Ingraham, J.L., and Ingraham, C.A. Introduction to Microbiology. A Case History Approach. 3 ed. California: Peter Marshall, 2004.

Jones, C.G. Chlorhexidine: is it still the gold standard?. Periodontol 2000 15 (1997): 55-62

Karnjanachotdamrong, P. Mangostin gel from *Garcinia mangostana* fruit. Senior Project, Pharmacy, Faculty of Pharmaceutical Science, Chulalongkorn University, 2000.

Kongchunmitkul, W. Preparation and evaluation of antibacterial activity of mangosteen rind extract throat spray. Master's Thesis, Pharmaceutical Technology, Faculty of Pharmaceutical Science, Chiangmai University, 2002.

Kusuma, K. A comparison study of the foot ulcer healing between dressing with mangostin cream and normal saline wet dressing in diabetic patient. Master's Thesis, Adult Nursing, Faculty of Nursing, Mahidol University, 2003.

Loesche, W.J. Oxygen sensitivity of various anaerobic bacteria. Appl Microbiol 18 (1969): 723-7.

Loesche, W.J. Role of *Streptococcus mutans* in human dental decay. Microbiol Rev 50 (1986): 353-80.

Mahabusarakam, W., Iriyachitra, P., and Taylor, W.C. Chemical constituents of *Garcinia mangostana*. J Nat Prod 50 (1987): 474-8.

Mahabusarakum, W., Phongpaichit, S., Jansakul, C., and Wiriyachitra, P. Screening of antibacterial activity of chemicals from *Garcinia mangostana*. Songkhla Nakkharin J 5 (1983): 337-9.

Mahabusarakum, W., Phongpaichit, S., and Wiriyachitra, P. Antibacterial activities of chemicals constituent from *Garcinia mangostana*. Linn. J Sci Soc Thailand 12 (1986): 239-242.

Meurman, J. H., Jousimies-Somer, H., Suomala, P., Alaluusua, S., Torkko, H. and Asikainen, S. Activity of amine-stannous fluoride combination and chlorhexidine against some aerobic and anaerobic oral bacteria. Oral Microbiol Immunol 4 (1989):117-9.

Mombelli, A., and Samaranayake, L.P. Topical and systemic antibiotics in the management of periodontal disease. Int Dent J 54 (2004): 3-14.

Moongkarndi, P., Kosem, N., Kaslungks, S., Luanratana, O., Pongpan, N., and Neungton, N. Antiproliferation, antioxidation and induction of apoptosis by *Garcinia mangostana* (mangosteen) on SKBR3 human brest cancer cell line. J Ethnopharm 90 (2004): 161-6.

Mueller, M., de la Pena, A. and Derendorf, H. Issues in pharmacokinetics and pharmacodynamics of anti-infective agents: kill curves versus MIC. Antimicrob Agents Chemother 48 (2004): 369-77

Murray, P.R. and Niles, A.C. Effect of incubation conditions on anaerobic susceptibility testing results. J Clin Microbiol 16 (1982): 1152-54.

Nakatani, K., Arakawa, T., Oosawa, K., Shimura, S., Atsumi, M., and Ohizumi, Y. Inhibitions of histamine release and prostaglandin E_2 synthesis by mangosteen, a Thai medicinal plant. Biol Pharm Bull 25 (2002b): 1137-41.

Nakatani, K., Arakawa, T., Yasuda, H., and Ohizumi, Y. Inhibition of cyclooxygenase and prostaglandin E_2 synthesis by gamma-mangostin, a xanthone derivative in mangosteen in C6 rat glioma cells. Biochem Pharmacol 63 (2002a): 73-9.

Olsen, I., Shah, H.N., and Gharbia, S.E. Taxonomy and biochemical characteristics of *Actinobacillus actinomycetemcomitans* and *Porphyromonas gingivalis*. Periodontol 2000 20 (1999): 14-52.

Overholser, CD.Jr. Longitudinal clinical studies with antimicrobial mouthrinses. J Clin Periodontol 15 (1988): 517-9.

Pfaller, M.A., Sheehan, D.J. and Rex, J.H. Determination of fungicidal activities against yeasts and molds: lessons learned from bactericidal testing and the need for standardization. Clin Microbiol Rev. 17 (2004): 268-80.

Prescott, L.M., Harley, J.P. and Klein, D.A. MICROBIOLOGY. 5 ed. Newyork : McGraw-Hill Companies, 2003.

Sapwarobol, S. Effects of xanthones extracted from rind of *Garcinia mangostana* in isolated rat hepatocytes. Master's Thesis, Pharmacology, Faculty of Pharmaceutical Science, Chulalongkorn University, 1997.

Seip, W.F., and Evans, G.L. Atmospheric analysis and redox potentials of culture media in the GasPak System. J Clin Microbiol 11 (1980): 226-33.

Sindermsuk, J., and Deekijsermphong, S. The antibacterial activities of crude extract from the fruit hull of *Garcinia Mangostana* on enteric pathogens and intestinal commensal. Bull Dept Med Serv 14 (1989): 421-26.

Somprasit, A., Sripiyarattanakul, K., Chuay-Yim, P., and Tanakittithum, P. Preliminary toxicological study of mangostin. Songklanakarin J Sci Technol 9 (1987): 51-7.

Suksamrarn, S., Suwannapoch, N., Phakhodee, W., Thanuhiranlert, J., Ratananukul, P., Chimnoi, N., et al. Antimycobacterial activity of prenylated xanthones from the fruits of *Garcinia mangostana*. Chem Pharm Bull (Tokyo) 51 (2003): 857-9.

Sundaram, B.M., Gopalakrishnan, C., Subramanian, S., Shankaranarayanan, D., and Kameswaran, L. Antimicrobial activities of *Garcinia mangostana*. Planta Med 48 (1983): 59-60.

Taweechaisupapong, S., Wongkham, S., Chareonsuk, S., Suparee, S., Srilalai, P., and Chaiyarak, S. Selective activity of *Streblus asper* on Mutans streptococci. J Ethnopharmacol 70 (2000): 73-9.

Talaro, K.P. and Taralo, A. Foundation in Microbiology international edition. 4 ed. Newyork: McGraw-Hill Companies, 2002.

Twetman, S. Antimicrobials in future caries control? A review with special reference to chlorhexidine treatment. Caries Res 383 (2004):223-9.

Williams. P., Ongsakul, M., Proudfoot, J., Croft, K., and Beilin, L. Mangostin inhibits the oxidative modification of human low density lipoprotein. Free Radic Res 23 (1995): 175-84.

Zambon, J.J. Periodontal diseases: microbial factors. Ann Periodontol 1 (1996): 879-925.

Zambon, J.J., and Kasprzak, S.A. The microbiology and histopathology of human root caries. Am J Dent 8 (1995): 323-8.

APPENDICES

APPENDIX A

PHOTOGRAPHS OF EXPERIMENTAL PROCEDURES

Figure 11. Photograph of mangosteen crude extract.

Figure 12. Photograph of a GasPak 100 system.

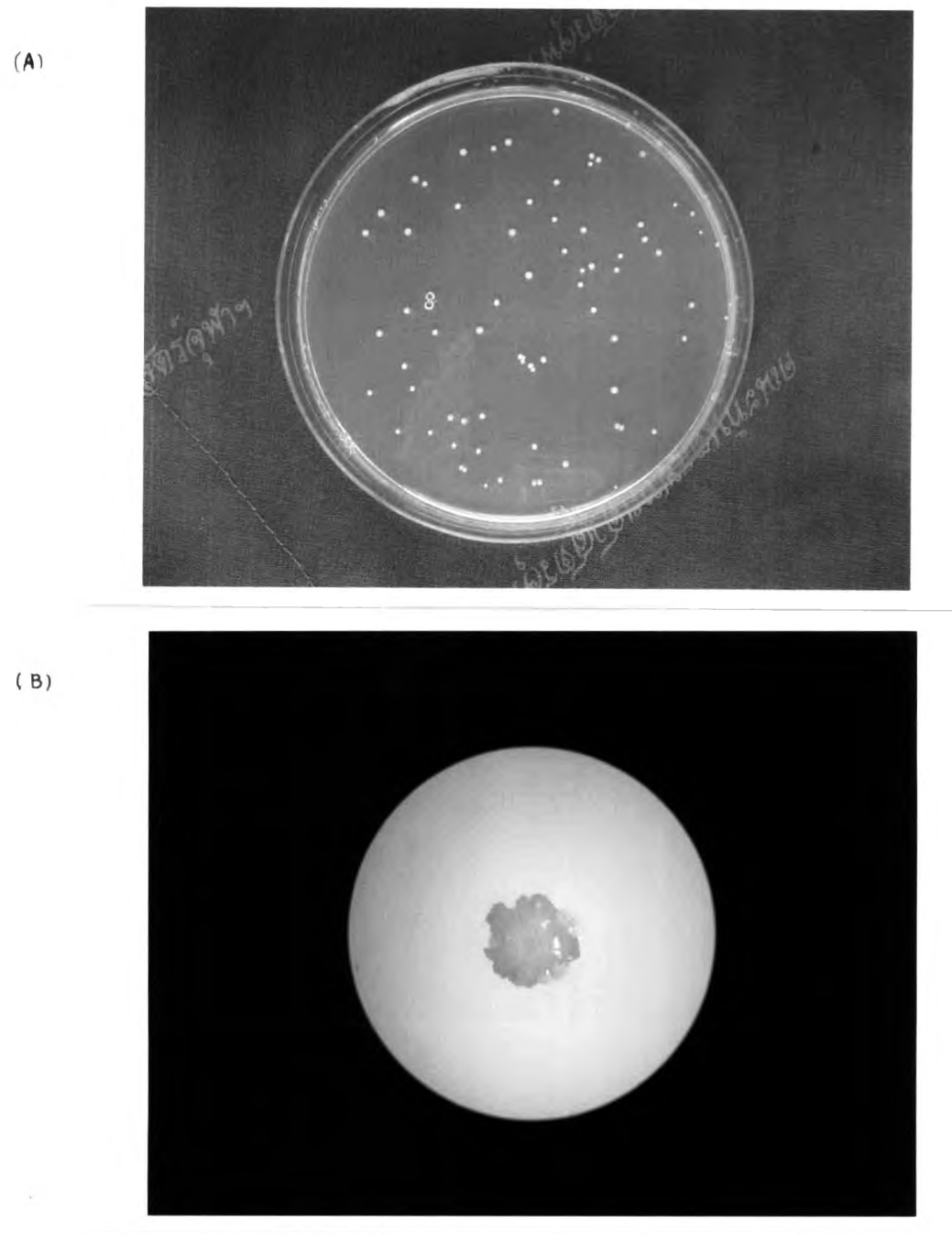

Figure 13. Colonies of *S. mutans* on trypticase soy agar.

(A) Countable bacterial colony on agar plate.

(B) *S. mutans* colony has yellowish-white color, irregular margin with rough and shiny surface. The photograph was inspected by stereoscope with a power of 40x.

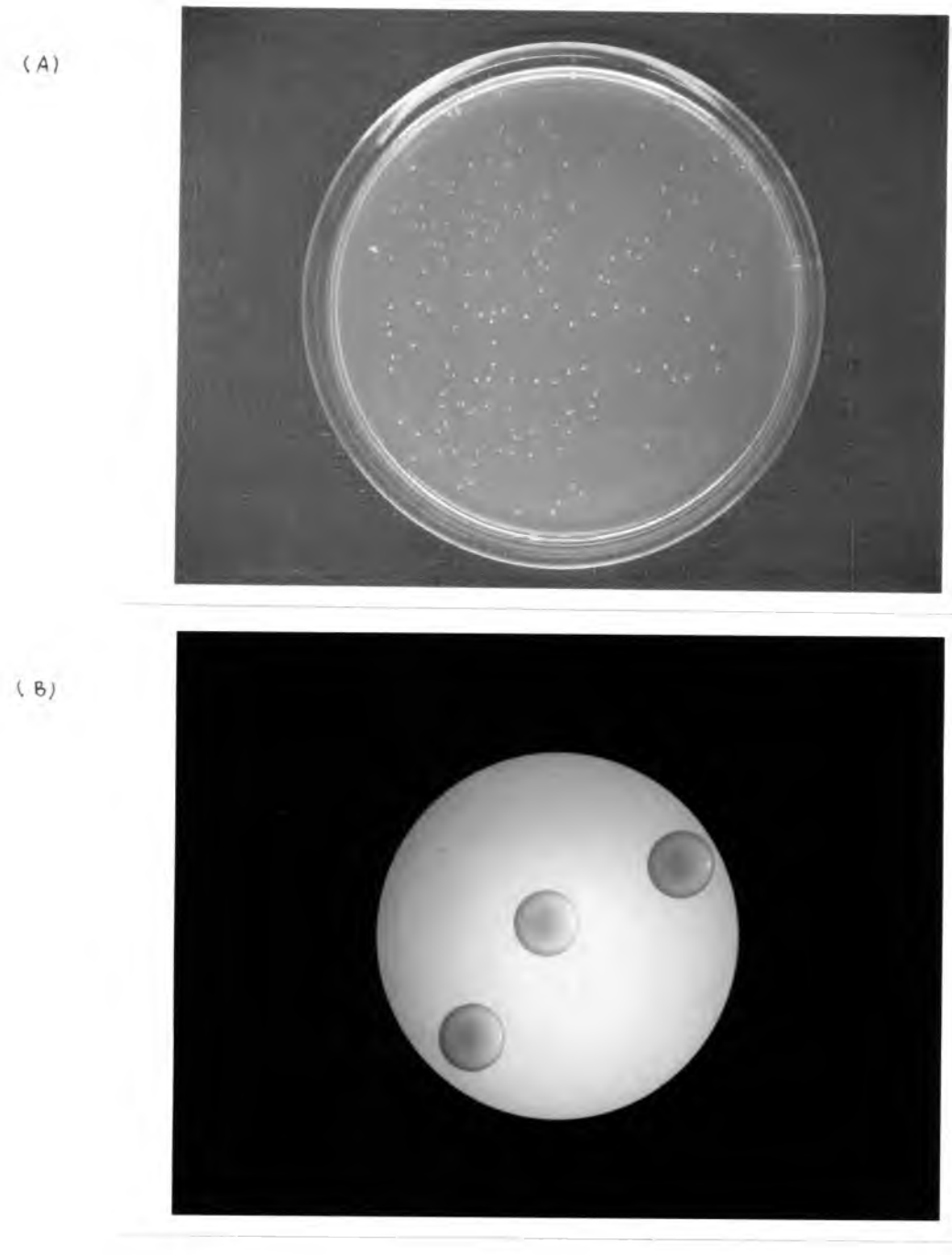

Figure 14. Colonies of *A. actinomycetemcomitans* on brain heart infusion agar.

(A) Countable bacterial colony on agar plate.

(B) *A. actinomycetemcomitans* colony has yellowish-white color, smooth colony with a star shapd inner colony. The photograph was inspected by stereoscope with a power of 40x.

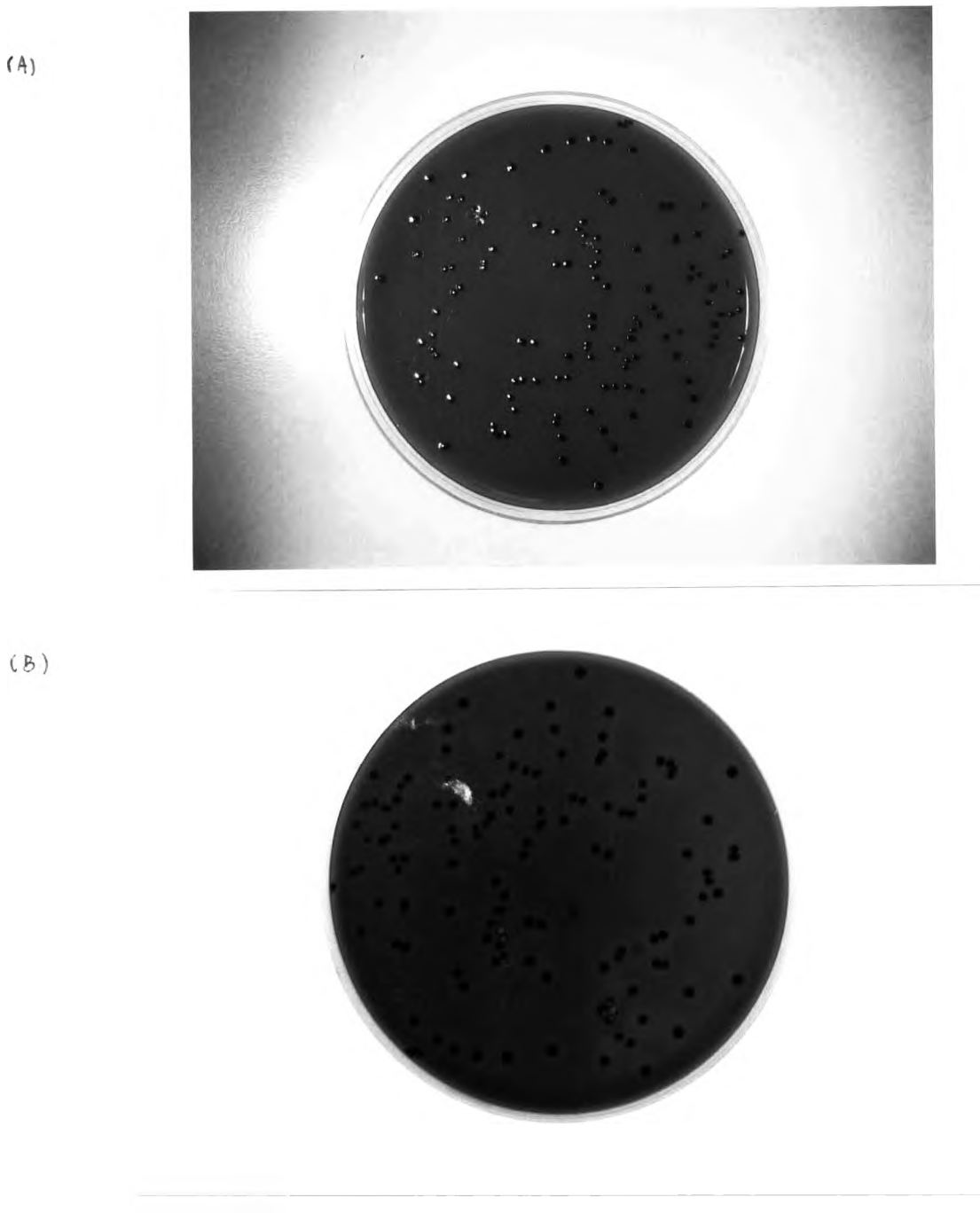

Figure 15. Colonies of *P. gingivalis* on brucella blood agar.

(A) Countable bacterial colony on agar plate. *P. gingivalis* has brown to black color, smooth and shiny surface.

(B) *P. gingivalis* shows complete hemolysis on blood agar.

APPENDIX B

TABLES OF EXPERIMENTAL RESULTS

Table 5. The growth pattern of *S. mutans* ATCC 25175 at varying time points after inoculated in the liquid media.

Time (Hour)	Absorbance at 600 nm	Number of viable bacteria (CFU/ml)	Log_{10} CFU/ml
0	0.022	1.71×10^6	6.233
1	0.035	2.07×10^6	6.316
2	0.061	1.84×10^7	7.265
3	0.122	2.04×10^8	8.310
4	0.220	1.60×10^9	9.203
5	0.480	1.0×10^9	9.000
6	0.652	2.95×10^{10}	10.470
7	0.790	9.25×10^{10}	10.966
8	0.788	1.03×10^9	9.013
9	0.748	3.5×10^7	7.544

Table 6. The growth pattern of *A. actinomycetemcomitans* at varying time points after inoculated in the liquid media.

Time (Hour)	Absorbance at 600 nm	Number of viable bacteria (CFU/ml)	Log_{10} CFU/ml
0	0.004	1.84×10^7	7.265
1	0.005	5.70×10^6	6.756
2	0.006	4.55×10^7	7.658
3	0.030	7.72×10^7	7.888
4	0.042	2.48×10^8	8.394
5	0.082	3.14×10^8	8.497
6	0.143	9.48×10^8	8.977
7	0.221	8.36×10^9	9.922
8	0.318	5.00×10^9	9.699
9	0.458	5.90×10^9	9.771

Table 7. Effect of DMSO on the growth of *S. mutans* ATCC 25175. Initial inoculum of bacteria is 6.87 x10^6 CFU/ml. Data are presented as means ± standard deviations.

DMSO concentration (g/L)	Log_{10} CFU/ml
0	9.55 ± 0.569
3.3	9.67 ± 0.197
6.6	9.28 ± 0.297

The differences in number of viable cells were analyzed by analysis of variance.
No significant differences in viable cell count (log_{10}CFU/ml) in the DMSO groups as compared to the broth control. ($P > 0.05$)

Table 8. Effect of DMSO on the growth of *P. gingivalis*. Initial inoculum of bacteria is 2.0 x10^8 CFU/ml. Data are presented as means ± standard deviations.

DMSO concentration (g/L)	Log_{10} CFU/ml
0	9.55 ± 0.008
3.3	9.63 ± 0.056
6.6	9.33 ± 0.163

The differences in number of viable cells were analyzed by Kruskal- Wallis test.
No significant differences in viable cell count (log_{10}CFU/ml) in the DMSO groups as compared to the broth control. ($P > 0.05$)

Table 9. Identifying MIC and MBC of mangosteen crude extract, chlorhexidine and DMSO against *A. actinomycetemcomitans*.

The table presented absorbance at 600 nm (OD.) and viable cell count (log_{10}CFU/ml) of broth containing mangosteen crude extract, chlorhexidine and DMSO.

The number of initial bacteria inoculum was 1.91×10^6 CFU/ml (=6.28 log_{10}CFU/ml).

Mangosteen conc. (μg/ml)	Conc. of DMSO (g/l)	OD. of blank	OD. of mangosteen crude extract	Log_{10}CFU/ml
640	26.4	1.994	> 3	8.48
320	13.2	1.136	1.171	ND
160	6.6	0.765	0.779	ND
80	3.3	0.342	0.535	ND
40	1.65	0.184	0.448	ND
Conc. of Chlorhexidine	-	OD. of blank	OD. of Chlorhexidine	Log_{10}CFU/ml
5	-	0	0	0
2.5	-	0	0	0
1.25	-	0	0	> 5
0.625	-	0	0.240	> 5
0.312	-	0	0.231	ND
Control	-	0.303	-	8.05

Table 10. Identifying MIC and MBC of mangosteen crude extract and chlorhexidine against *S. mutans* ATCC 25175.

The table presented absorbance at 600 nm(OD.) and viable cell count (log_{10}CFU/ml) of broth containing mangosteen crude extract or chlorhexidine.

The number of initial bacterial inoculum was 1.885×10^6 cfu/ml (=6.27 log_{10}CFU/ml).

Mangosteen conc. (μg/ml)	OD. of mangosteen crude extract	Log_{10} CFU/ml
5	0.013	0
2.5	0.015	0
1.25	0.018	0
0.625	0.016	0
0.312	0.820	ND
alpha-mangostin conc. (μg/ml)	OD. of alpha-mangostin	Log_{10} CFU/ml
5	0.004	0
2.5	0.002	0
1.25	0.002	0
0.625	0.001	0
0.312	0.451	> 5
Chlorhexidine conc. (μg/ml)	OD. of chlorhexidine	Log_{10} CFU/ml
5	0.000	0
2.5	0.018	0
1.25	0.006	0
0.625	0.005	0
0.312	0.014	0
0.156	0.886	ND
Control	1.015	8.04

Table 11. Identifying MIC and MBC of mangosteen crude extract and chlorhexidine against *S. mutans* $KPSK_2$.

The table presented absorbance at 600 nm(OD.) and viable cell count (log_{10}CFU/ml) of broth containing mangosteen crude extract or chlorhexidine.

The number of initial bacterial inoculum was 1.825×10^6 cfu/ml (=6.26 log_{10}CFU/ml).

Mangosteen conc. (μg/ml)	OD. of mangosteen crude extract	Log_{10}CFU/ml
5	0	0
2.5	0	0
1.25	0.002	0
0.625	0.009	> 5
0.312	0.765	ND
Chlorhexidine conc. (μg/ml)	OD. of chlorhexidine	Log_{10}CFU/ml
2.5	0	0
1.25	0	0
0.625	0.016	0
0.312	0.074	4.20
0.156	0.580	ND
Control	0.811	8.92

Table 12. Identifying MIC and MBC of mangosteen crude extract and chlorhexidine against *P. gingivalis* W 50.

The table presented absorbance at 600 nm(OD.) and viable cell count (log_{10}CFU/ml) of broth containing mangosteen crude extract and chlorhexidine.

Initial number of bacteria 1.589×10^{8} cfu/ml (=8.2 log_{10}CFU/ml).

Mangosteen conc. (μg/ml)	OD. of blank	OD. of mangosteen extract	Log_{10} CFU/ml
80	.081	.068	0
40	.044	.031	0
20	.031	.013	5.92
10	.026	.118	> 5
5	.010	1.300	ND
Chlorhexidine conc. (μg/ml)	OD. of blank	OD. of Chlorhexidine	Log_{10} CFU/ml
5	0	0	0
2.	0	0	0
1.25	0	.008	> 5
0.625	0	.031	ND
Control	1.889	-	9.18

Table 13. Time-kill kinetics of *S. mutans* ATCC 25175 when treated with mangosteen crude extract at 2x and 4x MBC compared to chlorhexidine at the same concentrations. The data are presented as $\log_{10}$ reduction in CFU/ml compared to the broth control at each time point (means ± standard deviations).

Time (minutes)	2xMBC (1.25 μg/ml)		4xMBC (2.5 μg/ml)	
	Mangosteen	Chlorhexidine	Mangosteen	Chlorhexidine
30	0.06 ± 0.030	0.05 ± 0.149	0.39 ± 0.203	0.20 ± 0.246
60	0.66 ± 0.356	0.20 ± 0.112	1.85 ± 0.643	0.31 ± 0.088
90	0.89 ± 0.267	0.32 ± 0.238	6.94 ± 0.292	0.47 ± 0.109

Table 14. Time-kill kinetics of *P. gingivalis* when treated with mangosteen crude extract at 2x and 4x MBC compared to chlorhexidine at the same concentrations. The data are presented as $\log_{10}$ reduction in CFU/ml compared to the broth control at each time point (means ± standard deviations).

Time (minutes)	2xMBC (80 μg/ml)		4xMBC (160 μg/ml)	
	Mangosteen	Chlorhexidine	Mangosteen	Chlorhexidine
5	0.28 ± 0.389	0.55 ± 0.341	1.20 ± 0.220	1.72 ± 0.699
15	1.74 ± 0.099	2.37 ± 0.975	6.71 ± 0.306	6.71 ± 0.306
30	6.91 ± 0.147	6.91 ± 0.147	6.91 ± 0.147	6.91 ± 0.147

BIOGRAPHY

Miss Piraporn Vichienroj was born on the third of February, 1977. She is a graduate of the Faculty of Dentistry, Chulalongkorn University since 2000. She worked at Sakaew Hospital from 2000 to 2002. She has studied in a Master degree program in Periodontology at Graduate School, Chulalongkorn University in 2002. Now she works in private hospital and private clinic.