ANTI-QUORUM SENSING ACTIVITIES OF SELECTED SOIL BACTERIA AND CHINESE HERBS AND EFFICIENCY OF ELECTROTRANSFORMATION BY COSMID PLAFR1 VECTOR

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By

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February 2020

Chairman : Associate Professor Halimi Mohd Saud, PhD
Faculty : Agriculture

Chromobacterium violaceum is a pathogenic bacterium to human and distinctly characterized by the production of a purple pigment called violacein. They are commonly found in soil and water in tropical and subtropical areas. From this study, *C. violaceum* was found in 0-5 cm depth from the soil surface in Universiti Putra Malaysia golf course and football field with higher density after rainy day. *Chromobacterium violaceum* also show the characteristics of oligophile, resistant to chlorinated water and antimicrobial activity which allow growing in wider soil and water areas. In both methods (Interaction and Non-interaction), *C. violaceum* reached quorum level produced antibiotics and inhibited all the selected plant growth-promoting rhizobacteria (PGPR) which were (*Azospirillum brasilense* Sp7, *Rhizobium* UPMR1102 and *Bacillus sphaericus* UPMB10) but did not inhibit the selected PGPR in concentration below their quorum level. These incidences indicate the ubiquitous presence of *C. violaceum* in Malaysia soils. It would contaminate in the daily use of soil and has potential threats to agriculture sector. One of the bacteria (*Bacillus subtilis*) randomly isolated from soil was screened based on selective media HiCrome Bacillus Agar. *Bacillus subtilis* showed the capability of resistancy and anti-quorum sensing activity to *C. violaceum* wild type and mutant type CV026 by inhibiting the production of violacein and resistant to antibiotics produced by *C. violaceum*. However, screening the genes of interest by pCC1FOS fosmid vector found that none of the clones contained the characteristics desired from the *B. subtilis* and there were many factors causing the failure of screening in this research. Gene expression from heterologous in new host was facing many limitations and challenges in recent years. Traditional chinese herbs were proven of their anti-quorum sensing activities. Six selected traditional chinese herbs were screened for anti-quorum sensing activity by using *C. violaceum* as biomonitor. Two out of these herbs were found to exhibit anti-quorum sensing properties: *Lycium barbarum* and *Zingiber officinale*. Extracts

from *L. barbarum* has stronger anti-quorum sensing activity than *Z. officinale*. Colonies of *C. violaceum* treated with *L. barbarum* almost fully loss its purple pigment. The loss and lack of purple colour from the colonies of *C. violaceum* indicated that quorum sensing activity was inhibited by the herbal extraction. It was believed that these herbs contained a rich source of compounds to fight or control pathogenic bacteria and potentially a new therapeutic way to reduce the development of antibiotic resistance. In electrotransformation, a large size of cosmid vector was successfully transferred into the selected PGPR and *C. violaceum* by using electroporation. These methods were found to be more efficient by using lower field strength with longer pulse length. The cosmid vector from donor *E. coli* K12 MM294 was also a success by direct transferred to the recipients *A. brasilense* Sp7 and *C. violaceum* by electroduction.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

AKTIVITI ANTI-PENDERIAAN KUORUM DARI BAKTERIA TANAH DAN TUMBUHAN HERBA CINA YANG TERPILIH DAN KECEKAPAN ELEKTROTRANSFORMASI OLEH VEKTOR KOSMID PLAFR1

Oleh

LOKE WAI KEONG

Februari 2020

Pengerusi : Profesor Madya Halimi Mohd Saud, PhD
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Chromobacterium violaceum adalah bakteria patogenik kepada manusia dengan ciri-ciri penghasilan pigmen ungu yang dipanggil violacein. Ia berhabitat di dalam tanah dan air yang banyak dijumpai kawasan tropika dan sub-tropika. Dalam kajian ini, *C. violaceum* telah berjaya di asingkan dari kedalaman 0-5 cm dari permukaan tanah padang golf dan bola sepak Universiti Putra Malaysia. Ia juga menunjukan ciri-ciri seperti oligofil, rintangan terhadap air klorin dan aktiviti antimikrob membenarkannya tumbuh di kawasan tanah dan air yang lebih luas. Dalam kedua-dua kaedah (Interaksi dan Bukan interaksi), *C. violaceum* yang mencapai tahap kuorum menghasilkan antibiotik dan merencatkan semua rhizobakteria penggalak tumbesaran tumbuhan (PGPR) terpilih iaitu (*Azospirillum brasilense* Sp7, *Rhizobium* UPMR1102 and *Bacillus sphaericus* UPMB10) tetapi tidak merencatkannya apabila konsentrasi dibawah tahap kuorumnya. Ini menunjukan kewujudan *C. violaceum* di tanah Malaysia. Ia akan mencemarkan penggunaan tanah kita setiap hari dan berpotensi mengancam sektor pertanian. Salah satu bakteria (*Bacillus subtilis*) dapat diasingkan secara rawak dari tanah melalui kaedah selektif media HiCrome Bacillus Agar. *Bacillus subtilis* menunjukan keupayaan daya tahan dan aktiviti anti-penderiaan kuorum kepada *C. violaceum* jenis liar dan jenis mutan CV026 melalui perencatan produksi violacein dan rintangan terhadap antibiotik yg dihasilkan oleh *C. violaceum*. Walaubagaimanapun, saringan gen keperluan melalui vektor fosmid pCC1FOS didapati tiada klon mengandungi ciri-ciri yang diperlukan dari *B. subtilis* dan ia didapati banyak factor yang menyebabkan kegagalan saringan di dalam kajian ini. Gen ekspresi dari hos baru menhadapi banyak had dan cabaran dalam beberapa tahun kebelakangan ini. Herba tradisional cina terbukti mempunyai aktiviti anti-penderiaan kuorum. Enam herba tradisional cina terpilih diperiksa untuk aktiviti anti-penderiaan kuorum dengan menggunakan *C. violaceum* sebagai biomonitor. Dua daripada enam herba tradisional cina menunjukan ciri anti-

penderiaan kuorum iaitu *Lycium barbarum* dan *Zingiber officinale*. Pengekstrakan dari *L. barbarum* mempunyai aktiviti anti-penderiaan kuorum yang lebih kuat daripada *Z. officinale*. Koloni dari biomonitor *C. violaceum* dirawat dengan *L. barbarum* hampir sepenuhnya kehilangan pigmen ungunya. Kehilangan dan kekurangan warna ungu dari koloni *C. violaceum* menunjukkan aktiviti penderiaan kuorum dihalang oleh pengambilan ekstrak herba. Ia dipercayai mengandungi sumber yang kaya dengan sebatian untuk melawan atau mengawal bakteria patogen dan berpotensi sebagai cara terapi baru untuk mengurangkan perkembangan rintangan antibiotik. Dalam elektrotransformasi, vektor kosmid yang bersaiz besar berjaya dipindahkan ke dalam PGPR yang terpilih dan *C. violaceum* dengan menggunakan kaedah elektroporasi. Kaedah ini didapati mempunyai kecekapan yang lebih baik dengan menggunakan kekuatan medan yang lebih rendah dengan kepanjangan pulse elektrik yang lebih panjang. Vektor kosmid dari penderma *Escherichia coli* K12 MM294 juga berjaya secara terus memindah kepada penerima *Azospirillum brasilense* Sp7 dan *C. violaceum* oleh keadah elektroduksi.

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I certify that a Thesis Examination Committee has met on 18 February 2020 to conduct the final examination of Loke Wai Keong on his thesis entitled "Anti-Quorum Sensing Activities of Selected Soil Bacteria and Chinese Herbs and Efficiency of Electrotransformation by Cosmid pLAFR1 Vector" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
%	Percentage
°C	Degree Celsius
µm	Micrometer
mm	Milimeter
cm	Centimeter
g	Gram
µl	Microliter
ml	Mililiter
ms	Milisecond
kb	Kilobase
µF	Microfarad
Ω	Ohm
kV	Kilovolt
N	Normality
No.	Number
H_2SO_4	Sulfuric acid
NaOH	Sodium hydroxide

CHAPTER 1

INTRODUCTION

1.1 General

Chromobacterium violaceum is a Gram-negative pathogenic bacterium which can be found in most of the tropical country around the world mainly in stagnant water and soil (McGowan and Steinberg, 1995; Kothari *et al*., 2017; Marcia *et al*., 2017; Donny *et al*., 2018). The purple coloured *C. violaceum* was due to the production of violacein which is an antibiotic that is active against amoebae and trypanosomes (Forbes, 2002; Duran *et al*., 2007; Duran *et al*., 2016). Other antibiotics produced by *C. violaceum* were show on Table 1.1.

Table 1.1: Production of antibiotics by *Chromobacterium violaceum*

Antibiotic	**Active against**
Aerocyanidine	Gram-positive bacteria
3,6–dihydroxyin doxazene	Gram-negative bacteria
6–hydroxy–3–oxo–1,2–benzisoxazolin	Gram-negative bacteria
Aerocavin	Gram-negative and Gram-positive bacteria

(Source: Nelson and Carlos, 2001)

Chromobacterium violaceum also produce hydrogen cyanide (HCN) which was reported negatively affect the plant growth and development (Lambers, 1980; Alstrom *et al*., 1989; Schippers *et al*., 1990). The production of antibiotics and HCN from *C. violaceum* was related to the quorum sensing system. Quorum sensing is a bacteria communication system using signal molecules and receptors to control the gene expression (Miller and Bassler, 2001; Lee *et al*., 2013). This system also controls virulence factors, motility, biofilm formation and toxin production in most pathogenic bacteria including *C. violaceum* (Fuqua and Greenberg, 1998; De Kievit and Iglewski, 2000; Donabedian, 2003).

1.2 Statement of problem

The tropical weather in Malaysia offers a good environment for the growth of *C. violaceum.* The bacterium is commonly found in Malaysia soil. Soil is often contacted by people during their daily activities and also important in agriculture. However, the understanding of pathogenicity caused by *C. violaceum* was not fully discovered and the effects to the agriculture are still unknown especially to beneficial microbes and plantation crop. The quorum sensing that controlled the virulence factors and biofilm formation also causing danger to human livings where more than 80% of bacterial infections were caused by the formation of biofilm and also increase the resistance ability of bacteria against antibiotics after biofilm development (Costerton *et al*., 1999; Kothari *et al*., 2017).

Some of the characteristics found in soil-borne bacteria had the potential to overcome the problems caused by quorum sensing (Lee *et al*., 2002; Dong *et al*., 2004). These characters would be very useful if able to apply, transfer and combine into a single bacteria strain. Genetic engineering is considered one of the most promising ways to combine few useful characters from different strains of bacteria by inserted few interest genes into a single bacterium (Babu-Khan *et al*., 1995; Amarger, 2002). However, screening of the potential bacteria, genes of interest and efficient transformation methods were needed to increase the probability of success in developing genetically-modified bacteria.

1.3 Objectives of the study

The overall objective of this study was about to gain an understanding on anti-quorum sensing activities against *C. violaceum* and as a beginning plan for developing a genetically-modified bacteria through isolation, characterization and screening followed by genetic transformation that is related to anti-quorum sensing.
The specific objectives are:

1. To detect *Chromobacterium violaceum* from soil and determine the effects of *C. violaceum* on Gram-negative and Gram-positive bacteria from selected Plant Growth-Promoting Rhizobacteria (PGPR).
   - *C. violaceum* was chosen in this study because of the easy identification purple pigment on the colonies and antibiotics that able to kill both Gram-negative and Gram-positive bacteria which were controlled by quorum sensing system. This objective not only can determine the effectiveness of *C. violaceum* on selected Plant Growth-Promoting Rhizobacteria (PGPR) but those selected PGPR sensitive to *C. violaceum* can be used as a control for anti-QS and resistant ability screening in next objective.

2. To evaluate anti-QS and resistant ability against *C. violaceum* from soil bacteria.

- The bacteria showed anti-QS activity and resistant to *C. violaceum* have a great potential for developing genetically-modified bacteria by isolating the genes of interest that related to the abilities.

3. To detect the genes of interest related to inhibition of violacein production and resistant ability against *C. violaceum* from selected soil bacteria by using fosmid vector pCC1FOS.
   - Gene of interest is the most important source for developing genetically-modified bacteria. It is a must to isolate for genetic transformation and future research.

4. To investigate the effectiveness of electrotransformation and electroduction on selected (PGPR) and *C. violaceum* by using cosmid vector pLAFR1.
   - Parameters of electroporation like electric field strength (kV/cm) and pulse length (ms) very important to achieve optimum level during genetic transformation. The gene of interest can be transform into the new host efficiently.

5. To detect anti-QS activity against *C. violaceum* from selected chinese herbs.
   - Besides bacteria, herbs were reported to have anti-QS activities with potential interest for future study.

REFERENCES

Adeniji, A. A., Aremu, O. S. and Babalola, O. O. (2019). Selecting lipopeptide-producing, Fusarium-suppressing Bacillus spp.: Metabolomic and genomic probing of Bacillus velezensis NWUMFkBS10.5. *MicrobiologyOpen*. 8(6): e00742.

Adonizio, A. L., Downum, K., Bennett, B. C. and Mathee, K. (2006). Anti-quorum sensing activity of medicinal plants in southern Florida. *J. Ethnopharmacol*. 103**:** 427-435.

Ahmer, B. M., van Reeuwijk, J., Timmers, C. D., Valentine, P. J. and Heffron, F. F. (1998). *Salmonella* Typhimurium encodes an SdiA homolog, a putative quorum sensor of the LuxR family, that regulates genes on the virulence plasmid. *J. Bacteriol.* 180: 1185-1193.

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2002). Molecular Biology of the Cell. New York: *Garland Science*. p.35.

Aldridge, K. E., Valainis, G. T. and Sanders, C. V. (1988). Comparison of the in vitro activity of ciprofloxacin and 24 other antimicrobial agents against clinical strains of *Chromobacterium violaceum. Diagn Microbiol Infect Dis.* 10**:** 31–9.

Alippi, A. M. and Abrahamovich, E. (2019). HiCrome Bacillus agar for presumptive identification of Bacillus and related species isolated from honey samples. *Int. J. Food Microbiol*. 305: 108245 .

Al Khalifa, S. M., Al Khaldi, T., Alqahtani, M. M. and Al Ansari, A. M. (2015). “Two siblings with fatal Chromobacterium violaceum sepsis linked to drinking water,” BMJ Case Reports, vol. 2015.

Alstrom, S. and Burns, R.G. (1989). Cyanide production by rhizobacteria as a possible mechanism of plant growth inhibition. *Biol. Fertil. Soils*. 7: 232-238.

Amarger, N. (2002). Genetically modified bacteria in agriculture. *Biochimie*. 84(11): 1061-1072.

Andrew Preston (2003). Chapter 2 - Choosing a Cloning Vector. In Nicola Casali, Andrew Preston. E. coli Plasmid Vectors: Methods and Applications. Methods in Molecular Biology, Vol. 235. *Humana Press*. pp. 19–26

Annapurna, F., Reddy, S. V. R. and Leela, K. P. (1979). Fatal infection by *Chromobacterium violaceum*. *Ind J Med Sci*. 33: 8-10.

Ansari, S., Paudel, P., Gautam, K., Shrestha, S., Thapa, S., and Gautam, R. (2015). *Chromobacterium violaceum* isolated from a wound sepsis: a case study from Nepal. *Case Rep. Infect. Dis.* 2015:181946.

Aune, T. E. V. and Aachmann, F. L. (2010). Methodologies to increase the transformation efficiencies and the range of bacteria that can be transformed. *Appl Microbiol Biotechnol.* 85**:** 1301–1313.

Baker, S., Campbell, J. I., Stabler, R., Nguyen, H. V. M., To, D. S., Nguyen, D. V., *et al*. (2008). Fatal wound infection caused by *Chromobacterium violaceum* in Ho Chi Minh City, Vietnam. *J. Clin. Microbiol.* 46: 3853–3855.

Balaraman, L., Shanmugham, M., Sathyabhama, M. C. (2016). *Chromobacterium violaceum* causing catheter-related blood stream infection. *J Acad Clin Microbiol*. 18: 47-9.

Bandow, J. E., Brötz, H. and Hecker, M. (2002). *Bacillus subtilis* tolerance of moderate concentrations of rifampin involves the sigma(B)-dependent general and multiple stress response. *J. Bacteriol*. 184(2): 459–467

Banik, J. J. and Brady, S. F. (2010). Recent application of metagenomic approaches toward the discovery of antimicrobials and other bioactive small molecules. *Curr. Opin. Microbiol*. 13: 603–609.

Barry, P. (2011). Prescription Drug Side Effects. AARP. Retrieved from http://www.aarp.org/health/drugs-supplements/info-09-2011/prescription-drug-side-effects.html.

Bassler, B. L. (1999). How bacteria talk to each other: regulation of gene expression by quorum sensing. *Curr. Opin. Microbiol.* 2: 582-587.

Bassler, B. L. (2002). Small talk. Cell-to-cell communication in bacteria. *Cell.* 109: 421-424.

Bassler, B. L., Wright, M. and Silverman, M. R. (1994). Multiple signaling systems controlling expression of luminescence in *Vibrio harveyi* sequence and function of genes encoding a second sensory pathway. *Mol. Microbiol.* 13: 273-286.

Batista, J. H. and Silva Neto, J. F. (2017). “Chromobacterium violaceum pathogenicity: updates and insights from genome sequencing of novel Chromobacterium species,” *Front. Microbiol*. 8: 2213.

Bauer, W. D. and Robinson, J. B. (2002). Disruption of bacterial quorum sensing by other organisms. *Curr. Opin. Biotechnol.* 13: 234-237.

Beck, B. S. and Farrand, S. K. (1995). Capsular polysaccharide biosynthesis and pathogenicity in *Erwinia stewartii* require induction by an N-acyl homoserine lactone autoinducer. *J. Bacteriol*, 177: 5000–5008.

Becker, S., Soares, C. and Porto, L. M. (2009). Computational analysis suggests that virulence of *Chromobacterium violaceum* might be linked to biofilm formation and poly-NAG biosynthesis. *Genet. Mol. Biol*. 32(3): 640-644.

Biver, S., Portetelle, D. and Vandenbol, M. (2013). Characterization of a new oxidant-stable serine protease isolated by functional metagenomics. *Springerplus* 2:410.

Blosser, R. S. and Gray, K. M. (2000). Extraction of violacein from *Chromobacterium violaceum* provides a new quantitative bioassay for N-acyl homoserine lactone autoinducers. *J. Microbiol. Methods*. 40: 47–55.

Bollinger, N., Hassett, D. J., Iglewski, B. H., Costerton, J. W. and McDermott, T. R. (2001). Gene expression in *Pseudomonas aeruginosa*: evidence of iron override effects on quorum sensing and biofilm-specific gene regulation. *J. Bacteriol.* 183: 1990-1996.

Boone, D. R. *et al*. (2005) Bergey's manual of systematic bacteriology, Springer. 2(3): 824.

Brazilian National Genome Project Consortium. (2003). The complete genome sequence of Chromobacterium violaceum reveals remarkable and exploitable bacterial adaptability. *Proc Natl Acad Sci USA*. 100(20): 11660–11665.

Breah, L. and Michael, J. F. (2013). Exploiting Quorum Sensing To Confuse Bacterial Pathogens *Microbiol. Mol. Biol. Rev.* 77(1): 73–111.

Chan, K. G. *et al.* (2011). Characterization of N-acylhomoserine lactone-degrading bacteria associated with the *Zingiber officinale* (ginger) rhizosphere: co-existence of quorum quenching and quorum sensing in *Acinetobacter* and *Burkholderia*. *BMC Microbiol*. 11: 51.

Chang, H. C. *et al*. (2003). *Chromobacterium violaceum* bacteremia: a case report. *J Micriobiol Immunol Infect*. 36:141-144.

Chattopadhyay, A. *et al*. (2002). *Chromobacterium violaceum* Infection: A Rare But Frequently Fatal Disease. *J. Pediatr. Surg*. 37(1): 108-110.

Chen, X., Schauder, S., Potier, N., Van Dorsselaer, A., Pelczer, I., Bassler, B. L. and Hughson, F. M. (2002). Structural identification of a bacterial quorum-sensing signal containing boron. *Nature.* 415: 545-549.

Chevallier, A. (2016). *The Encyclopedia of Herba Medicine: A practical reference guide to more than 550 Herbs and Remedies for Common Ailments*. London, England: Dorling Kindersley.

Comella, N. and Grossman, A. D. (2005). Conservation of genes and processes controlled by the quorum response in bacteria: characterization

of genes controlled by the quorum-sensing transcription factor ComA in Bacillus subtilis. *Mol. Microbiol.* 57: 1159–1174.

Costerton, J. W., Lewandowski, Z., Caldwell, D. E., Korber, D. R. and Lappin S. H. M. (1995) Microbial biofilms. *Annu Rev Microbiol* 49: 711-745.

Costerton, J. W., Cheng, K. J., Geesey, G. G., Ladd, T. I., Nickel, J. C., Dasgupta, M. and Marrie, T. J. (1987). Bacterial biofilms in nature and disease. *Annu Rev Microbiol*, 41: 435-464.

Costerton, J. W., Stewart, P. S. and Greenberg, E. P. (1999). Bacteria biofilm, a common cause of persistent infection. *Science*. 284: 1318-1322

Costerton, J. W. (2007). The biofilm primer. Edited by Costerton WJ. Berlin Heidelberg: Springer-Verlag.

Craig, J. W., Chang, F. Y. and Brady, S. F. (2009). Natural products from environmental DNA hosted in *Ralstonia metallidurans*. *ACS Chem. Biol*. 4: 23–28.

Damalas, C., A. and Eleftherohorinos, I., G. (2011). "Pesticide Exposure, Safety Issues, and Risk Assessment Indicators". *Int. J. Environ. Res. Public Health*. 8(12): 1402–19.

Darmawan, G., Kusumawardhani, Y., Alisjahbana, B. and Fadjari, T. H. (2018). *Chromobacterium violaceum*: The Deadly Sepsis. Acta Medica Indonesiana, *Acta Med Indones*. 50: 80-81.

Das, M., Raythata, H. and Chatterjee, S. (2017). Bacterial Transformation: What? Why? How? and When?. *Annu. Res. Rev. Biol*. 16: 1-11.

David, P. C. and Nanette, J. P. (2012). Molecular Biology (2nd ed.). Academic Cell. p. 795.

Davies, D. G., Parsek, M. R., Pearson, J. P., Iglewski, B. H., Costerton, J. W. and Greenberg, E. P. (1998) The involvement of cell-to-cell signals in the development of a bacterial biofilm. *Science.* 280: 295-198.

De Kievit, T. R. and Iglewski, B. H. (2000). Bacterial quorum sensing in pathogenic relationships. *Infect. Immun*. 68: 4839-4849.

DeLisa, M. P., Valdes, J. J. and Bentley, W. E. (2001a). Mapping stress-induced changes in autoinducer AI-2 production in chemostat-cultivate *Escherchia coli* K-12. *J. Bacteriol.* 183: 2918-2928.

DeLisa, M. P., Wu, C. F., Wang, L., Valdes, J. J. and Bentley, W. E. (2001b). DNA microarray-based identification of genes controlled by autoinducer 2-stimulated quorum sensing in *Escherichia coli*. *J. Bacteriol.* 183: 5239-5247.

Donabedian, H. (2003). Quorum sensing and its relevance to infectious diseases. *J. Infect*. 46: 207–214.

Dong, Y. H., Wang, L. H., Xu, J. L., Zhang, H. B., Zhang, X. F., Zhang, L. H. (2001). Quenching quorum-sensing-dependent bacterial infection by an N-acyl homoserine lactonase. Nature 411: 813–817.

Dong, Y. H., Xu, J. L., Li, X. Z. and Zhang, L. H. (2000). AiiA, an enzyme that inactivates the acylhomoserine lactone quorum-sensing signal and attenuates the virulence of Erwinia carotovora. *Proc. Natl. Acad. Sci*. 97: 3526–3531.

Dong, Y. H., Gusti, A. R., Zhang, Q., Xu, J. L., Zhang, L. H. (2002). Identification of quorum-quenching N-acyl homoserine lactonases from *Bacillus* species. *Appl. Environ. Microbiol.* 68: 1754–1759.

Dong, Y. H., Zhang, X. F., Xu, J. L., Zhang, L. H. (2004). Insecticidal *Bacillus thuringiensis* silences *Erwinia carotovora* virulence by a new form of microbial antagonism, signal interference. *Appl. Environ. Microbiol*. 70: 954–960.

Duran, M., Ponezi, A. N., Faljoni-Alario, A., Teixeira, M. F., Justo, G. Z. and Duran, N. (2012). Potential applications of violacein: a microbial pigment. *Med Chem Res*. pp 21.

Duran, N., Justo, G. Z., Duran, M., Brocchi, M., Cordi, L., Tasic, L., et al. (2016). Advances in *Chromobacterium violaceum* and properties of violacein-its main secondary metabolite: a review. *Biotechnol. Adv.* 34: 1030–1045.

Dworkin, M. and Falkow, S. (2006). The Prokaryotes: Symbiotic associations, biotechnology, applied microbiology. Springer. 5: 737–746.

Eberhard, A., Burlingame, A. L., Kenyon, G. L., Nealson, K. H. and Openheimer, N. J. (1981). Structural identification of autoinducer of *Photobacterium fischeri* luciferase. *Biochemistry*. 20: 2444–2449.

Eberl, L. *et al.* (1996). Involvement of N-acyl-L-homoserine lactone autoinducers in controlling the multicellular behaviour of *Serratia liquefaciens*. *Mol. Microbiol.* 20: 127–136.

Epicentre. (2002). The CopyControl™ Fosmid Library Production Kit Generates More Complete and Unbiased (Blunt-End) Libraries of Stable, 40-Kb Genomic Clones. 9: 1-3.

Ergil, K. V., Kramer, E. J. and Ng, A. T. (2002). Chinese herbal medicines. *West J Med*. 176(4): 275–279.

Eynard, N. and Teissie, J., eds. (2000). Electrotransformation of Bacteria. Springer Lab Manuals. pp. 292.

Forbes, B. A., Daniel, F. S. and Alice, S. W. (2002). Diagnostic Microbiology: 11th Ed. Mosby. pp 423 – 434.

Fray, R. G. (2002). Altering plant-microbe interaction through artificially manipulating bacterial quorum sensing. *Annals of Botany.* 89: 245-253.

Friedman, A. M., Long, S. R., Brown, S. E., Buikema, W. J. and Ausubel, F. M. (1982). Construction of a broad host range cosmid cloning vector and its use in the genetic analysis of *Rhizobium* mutants. *Gene*. 18(3) 289-296.

Fuqua, C., Parsek, M. R. and Greenberg, E. P. (2001). Regulation of gene expression by cell-to-cell communication: acyl-homoserine lactone quorum sensing. *Annu. Rev. Genet*. 35: 439–468.

Fuqua, C. and Eberhard, A. (1999). *Cell–Cell Signalling in Bacteria* (eds.), ASM Press, Washington, pp. 211–230.

Fuqua, C. and Greenberg, E. P. (1998). Self perception in bacteria: quorum sensing with acylated homoserine lactones. *Curr. Opin. Microbiol*. 1: 183–189.

Givskov, M., DeNys, R., Manefield, M., Gram, L., Maximilien, R., Eberl, L., Molin, S., Steinberg, P. D. and Kjelleberg, S. (1996). Eukaryotic interference with homoserine lactone-mediated prokaryotic signaling. *J. Bacteriol.* 178: 6618-6622.

Glick, B. R. (1995). The enhancement of plant growth by free-living bacteria*. Can. J. Microbiol.* 41(2): 109–117.

Guazzaroni, M. E., Silva-Rocha, R. and Ward, R. (2015). Synthetic biology approaches to improve biocatalyst identification in metagenomic library screening. *Microb. Biotechnol.* 8: 52–64.

Hani, Z. A. (2017). Anti-quorum sensing natural compounds. *J Microscopy Ultrastruc*. 6(1): 1–1.

Hentzer, M. And Givskov, M. (2003). Pharmacological inhibition of quorum sensing for the treatment of chronic bacterial infections. *J. Clin. Invest.112*: 1300–1307.

Hoi, P. T. *et al*. (2006). *Chromobacterium violaceum* Infection. Br J Hosp Med (Lond). 67: 4.

Hradecna, Z., Wild, J. and Szybalski, W. (1998). Conditionally amplifiable inserts in pBAC vectors. *Microbial Comp Genom*. 3: 58.

Jang, C. W. and Magnuson, T. (2013). A Novel Selection Marker for Efficient DNA Cloning and Recombineering in E. coli. *PLoS ONE*. 8(2): e57075

Jitmuang, A. (2008). Human *Chromobacterium* violaceum infection in Southeast Asia: case reports and literature review. *Southeast Asian J Trop Med Public Health*. 39(3): 452-460.

Kalita, M., Bharadwaz, M., Dey, T., Gogoi, K., Dowarah, P., Unni, B .G., Ozah, D. and Saikia, I. (2015). Developing novel bacterial based bioformulation having PGPR properties for enhanced production of agricultural crops, *Indian J. Exp. Biol*, 53: 56-60.

Kanamaru, K., Tatsuno, I., Tobe T. and Sasakawa, C. (2000). SdiA, an *Escherichia coli* homologues of quorum–sensing regulators, controls the expression of virulence factors in enterohamemorrhagic *Escherichia coli* O157:H7. *Mol. Microbiol.* 38: 805-816.

Kaniyarakkal, V., Orvankundil, S., Lalitha, S. K., Thazhethekandi, R. and Thottathil, J. (2016). "Chromobacterium violaceum septicaemia and urinary tract infection: case reports from a tertiary care hospital in South India," *Case Reports in Infectious Diseases*. 2016: 4.

Khadanga, S., Karuna, T., Dugar, D. and Satapathy, S. P. (2017). "Chromobacterium violaceum-induced sepsis and multiorgan dysfunction, resembling melioidosis in an elderly diabetic patient: a case report with review of literature," *J Lab Physicians*. 9(4): 325–328.

Kim, J., Feng, Z., Bauer, J., Kallifidas, D., Calle, P. and Brady, S. (2010). Cloning large natural product gene clusters from the environment: piecing environmental DNA gene clusters back together with TAR. *Biopolymers.* 93: 833–844.

Kimura, N. (2014). Metagenomic approaches to understanding phylogenetic diversity in quorum sensing. *Virulence.* 5: 433–442.

Kloepper, J. W. and Schroth, M. N. (1978). Plant growth-promoting rhizobacteria on radishes. Proceedings of the 4th International Conference on Plant Pathogenic Bacteria. Angers, France: *Station de Pathologie Végétale et Phytobactériologie*, INRA. 2: 879–882.

Koh, C. L., Choon, K. S., Wai, F. Yin., Li, Y. T., Thiba, K., Yee, M. C. and Kok, G, C. (2013). Plant-Derived Natural Products as Sources of Anti-Quorum Sensing Compounds. *Sensors*. 13: 6217–28.

Kothari, V., Sharma, S. and Padia, D. (2017). "Recent research advances on Chromobacterium violaceum," *Asian Pac J Trop Med*. 10(8): 744–752.

Kotnik, T., Frey, W., Sack, M., Haberl, M. S., Peterka M. and Miklavčič, D. (2015). Electroporation-based applications in biotechnology. *Trends Biotechnol*. 233(8): 480-488.

Lambers, H. (1980). The physiological significance of cyanide-resistant respiration in higher plants. *Plant Cell Environ.* 3: 293-302.

Lai, P. B. S. *et al*. (2006). Fatal septicaemia from *Chromobacterium violaceum*: case reports and review of the literature. *Hong Kong Med J.* 12: 3.

Li, J. and Neubauer, P. (2014). *Escherichia coli* as a cell factory for heterologous production of nonribosomal peptides and polyketides. *New Biotechnol.* 31: 1–7.

Loke, W. K. and Halimi, M. S. (2010). Green Bean (Vigna radiata) Seedling Growth Inhibition by *Chromobacterium violaceum* under In-vitro Condition. *Malaysian J. Soil Sci*. 14: 95-99.

Luria, S. and Burrous, L. (1955). *Journal of Bacteriology*. 74: 461.

Madi, D. R., Vidyalakshmi, K., Ramapuram, J. and Shetty, A. K. (2015). "Successful treatment of Chromobacterium violaceum sepsis in a South Indian adult," *Am. J. Trop. Med. Hyg*. 93(5): 1066-1067.

Marino, M., Ramos, H. C., Hoffmann, T., Glaser, P. and Jahn, D. (2001). Modulation of anaerobic energy metabolism of Bacillus subtilis by arfM (ywiD). *J. Bacteriol*. 183(23): 6815–6821.

McGowan, Jr J. E. and Steinberg, J. P. (1995). Other gram negative bacilli, in Mandell GL, Bennett JE, Dolin R (eds)., Principles and Practice of Infectious Diseases (ed 4). New York, NY, *Churchill Livingstone*, pp 2106-2115.

McGowan, S., Sebaihia, M., Jones, S., Yu, B., Bainton, N., Chan, P. F., Bycroft, B., Stewart, G. S., Williams, P. and Salmond, G. P. (1995). Carbapenem antibiotic production in *Erwinia carotovora* is regulated by CarR, a homologue of the LuxR transcriptional activator**.** *Microbiology.* 141: 541-550.

McClean, K. H., Winson, M. K., Fish, L., Taylor, A., Chhabra, S. R., Camara, M., et al. (1997). Quorum sensing and *Chromobacterium violaceum*: exploitation of violacein production and inhibition for the detection of N-acyl homoserine lactones. *Microbiology.* 143: 3703–3711.

McLean, R. J., Pierson, L. S. and Fuqua, C. (2004). A simple screening protocol for the identification of quorum signal antagonists. *J. Microbiol. Methods*. 58, 351–360.

Miller, M. B. and Bassler, B. L. (2001). Quorum sensing in bacteria. *Ann. Rev. Microbiol.*, *55*: 165-199.

More, M. I., Finger, L. D., Stryker, J. L., Fuqua, C., Eberhard, A. and Winans S. C. (1996) Enzymatic synthesis of a quorum-sensing autoinducer through use of defined substrates. *Science.* 272: 1655-1658.

Musk, D. J. and Hergenrother, P. J. (2006). Chemical Countermeasures for the Control of Bacterial Biofilms: Effective Compounds and Promising Targets. *Curr. Med. Chem.* 13: 2163-2177.

Nasuno, E., Kimura, N., Fujita, M. J., Nakatsu, C. H., Kamagata, Y. and Hanada, S. (2012). Phylogenetically novel LuxI/LuxR-type quorum sensing systems isolated using a metagenomic approach. *Appl. Environ. Microbiol*. 78: 8067–8074.

Nelson, D. and Carlos, F. M. (2001). *Chromobacterium violaceum*: A Review of Pharmacological and Industrial Perspectives. *Crit. Rev. Microbiol*. 27(3): 201-222.

Nickoloff, J. A. (1995). Methods in Molecular Biology. Humana Press, Totowa, NJ. pp. 47.

Oger, P. and Farrand, S. K. (2002). Two opines control conjugal transfer of an *Agrobacterium* plasmid by regulating expression of separate copies of the quorumsensing activator gene *traR*. *J. Bacteriol.* 184: 1121-1131.

Pant, N. D., Sharma, M. and Khatiwada, S. (2015). "Asymptomatic bacteriuria caused by Chromobacterium violaceum in an immunocompetent adult," *Case Reports in Medicine*. 2015: 4.

Papenfort, K. and Bassler, B. (2016). Quorum sensing signal–response systems in Gram-negative bacteria. *Nat Rev Microbiol*. 14: 576–588.

Parajuli, N. P., Bhetwal, A., Ghimire, S. et al. (2016). "Bacteremia caused by a rare pathogen–Chromobacterium violaceum: a case report from Nepal," *Int. J. Gen. Med*. 9: 441–446.

Pearson, J. P., van Delden, C. and Iglewski, B. (1999). Active efflux and diffusion are involved in transport of *Pseudomonas aeruginosa* cell-to-cell signals. *J. Bacteriol.* 181: 1203-1210.

Pearson, J. P., Passador, L., Iglewski, B. H. and Greenberg, E. P. (1995). A second N-acylhomoserine lactone signal produced by *Pseudomonas aeruginosa*. *Proc. Natl. Acad. Sci. USA*. 92: 1490-1494.

Persson, T. *et al.* (2005). Rational design and synthesis of new quorum-sensing inhibitors derived from acylated homoserine lactones and natural products from garlic. *Org. Biomol. Chem.* 3(2):253-62.

Rashid, Z., Ali, U., Sulong, A. and Rahman, R. (2013). *Chromobacterium violaceum* infections; a series of case reports in a Malaysian tertiary hospital. *Internet J Infect Dis*. 11(1):1–6.

Rhea, G. A., Saida, B., Jennifer, R. K., Ajai, A. D. and Josephine R. C. (2018). Bacterial Quorum Sensing and Microbial Community Interactions. *mBio*. 9(3): e02331-17.

Reen, F., Gutiérrez-Barranquero, J., Dobson, A., Adams, C. and O'Gara, F. (2015). Emerging concepts promising new horizons for marine biodiscovery and synthetic biology. *Mar. Drugs.* 13: 294–2954.

Ren, D., Sims, J. J., and Wood, T. K. (2001). Inhibition of biofilm formation and swarming of *Escherichia coli* by (5Z)-4-bromo-5-(bromomethylene)-3-butyl-2(5H)-furanone. *Environmental Microbiology.* 3: 731-736.

Rocha, M. J., Harrington, C., Dobson, A. and O'Gara, F. (2014). Emerging strategies and integrated systems microbiology technologies for biodiscovery of marine bioactive compounds. *Mar. Drug.s.*12: 3516–3559.

Rols, M. P. and Teissie, J. (1998). Electropermeabilization of mammalian cells to macromolecules: control by pulse duration. *Biophys J. 75(*3): 1415-1423.

Sabree, Z. L., Rondon, M. R. and Handelsman, J. (2009). Metagenomics. In: Encyclopedia of Microbiology (Third Edition). *Academic Press*. pp 622-632.

Sambrook, J. and Russel, D. (2001). Molecular Cloning: A Laboratory Manual. Cold Spring Laboratory Press, Cold Spring Harbor NY, USA.

Schippers, B., Bakker, A., Bakker, P. and Peer, R. (1990). Beneficial and deleterious effects of HCN-producing pseudomonads on rhizosphere interactions. *Plant Soil.* 129: 75-83.

Schipper, C., Hornung, C., Bijtenhoorn, P., Quitschau, M., Grond, S. and Streit, W. R. (2009). Metagenome-derived clones encoding two novel lactonase family proteins involved in biofilm inhibition in *Pseudomonas aeruginosa*. *Appl. Environ. Microbiol*. 75: 224–233.

Serra, C. R., Earl, A. M., Barbosa, T. M., Kolter, R. and Henriques, A. O. (2014). Sporulation during growth in a gut isolate of *Bacillus subtilis*. *J. Bacteriol*. 196(23): 4184–4196.

Sigma-Aldrich. (2013). Product Information. 92325 BacillusChromoSelectAgar (Bacillus Chromo Select Agar - HiCrome™ Bacillus Agar –Bacillus HiCrome™ Agar). Sigma-Aldrich.com.

Shao, P. L., Hsueh, P. R., Hang, Y. C., Lu, C. Y., Lee, P. Y., Lee, C. H. *et al*. (2002). *Chromobacterium violaceum* infection in children: a case of fatal septicaemia with nasopharyngeal abscess and literature review*. Pediatr Infect Dis J*. 21: 707-709.

Siqueira, I. C. *et al*. (2005). *Chromobacterium violaceum* in Siblings, Brazil. *Emerging Infect. Dis*. 11: 9.

Slaughter, J. C. (1999). The naturally occurring furanones: formation and function from pheromone to food. *Biol Rev Camb Philos Soc.* 74: 259-276.

Smith, J. N., and Ahmer, B. M. M. (2003) Detection of other microbial species by Salmonella: Expression of SdiA regulon. *J. Bacteriol.* 185: 1357-1366.

Sneath, P. H. A., Whelan, J. P. F., Singh, R. B. *et al*. (1953). Fatal infection by *Chromobacterium violaceum*. *Lancet*. 2: 276-277.

Sperandio, V., Torres, A. G., and Kaper, J. B. (2002a) Quorum sensing *Escherichia coli* regulators B and C (QseBC): a novel two-component regulatory system involved in the regulation of flagella and motility by quorum sensing in *E. coli*. *Mol. Microbiol.* 43: 809-821.

Sperandio, V., Torres, A. G., Giron, J. A. and Kaper, J. B. (2001). Quorum sensing is a global regulatory mechanism in enterohemorrhagic *Escherichia coli* O157:H7. *J. Bacteriol.* 183: 5187-5197.

Srivastava, S. and Gera, C. 2006. Quorum-sensing: The Phenomenon of microbial communication. *Curr. Sci*. 90: 10-15.

Stauff, D. L. and Bassler, B.L. (2011). Quorum sensing in Chromobacterium violaceum: DNA recognition and gene regulation by the CviR receptor. *J Bacteriol*, 193(15): 3871-3878.

Stein, T. (2005). Bacillus subtilisantibiotics: structures, syntheses and specific functions. *Mol. Microbiol*. 56(4): 845–857.

Steinmoen, H., Knutsen, F. and Havarstein, L. S. (2002). Induction of natural competence in *Streptococcus pneumoniae* triggers lysis and DNA release from a subfraction of the cell population. *Proc. Natl. Acad. Sci. USA.* 99: 7681-7686.

Streit, W. R. and Schmitz, R. A. (2004). Metagenomics - the key to the uncultured microbes. *Curr. Opin. Microbiol*. 7: 492–498.

Suga, H. and Smith, K. M. (2003). Molecular mechanisms of bacterial quorum sensing as a new drug target. *Curr. Opin. Chem. Biol. 7*: 586–591.

Summers, D. K. and Withers, H. L. (1990). Electrotransfer: direct transfer of bacterial plasmid DNA by electroporation. *Nucleic Acids Res*. 18(8): 2192

Sun, J., Daniel, R., Wagner-Dobler, I. and Zeng, A. P. (2004). Is autoinducer-2 a universal signal for interspecies communication: A comparative genomic and phylogenetic analysis of the synthesis and signal transduction pathways. *BMC Evol. Biol*. 4: 36–46.

Swain, B., Otta, S., Sahu, K. K., Panda, K. and Rout, S. (2014). “Urinary tract infection by Chromobacterium violaceum,” *J. Clin. Diagnostic Res*. 8(8): 1-2.

Swift, S. *et al.* (1997). Quorum sensing in *Aeromonas hydrophila* and *Aeromonas salmonicida*: identification of the LuxRI homologues AhyRI and AsaRI and their cognate N-acylhomoserine lactone signal molecules. *J. Bacteriol*. 179: 5271–5281.

Szybalski, W., Wild, J. and Hradecná, Z. (2003). Method for converting single-copy BAC vectors to conditional high-copy pBAC/oriV vectors. *U.S. Patent Publ*. No. US-2003-0049665.

Taga, M. E. and Bassler, B. L. (2003). Chemical communication among bacteria. *Proc. Natl. Acad. Sci. USA.* 100: 14549-14554.

Taga, M. E., Miller, S. T. and Bassler, B. L. (2003). Lsr-mediated transport and processing of AI-2 in *Salmonella* Typhimurium. *Mol. Microbiol.* 50: 1411-1427.

Taylor, M., Radax, R., Steger, D. and Wagner, M. (2007). Sponge-associated microorganisms: evolution, ecology, and biotechnological potential. *Microbiol. Mol. Biol. Rev.* 71: 295–307.

Teissie, J., Golzio, M. and Rols, M. P. (2005). Mechanisms of cell membrane electropermeabilization: A minireview of our present knowledge. *Biochim. Biophys. Acta*. 1724(3): 270-280.

Teplitski, M., Robinson, J. B., and Bauer, W. D. (2000). Plants secrete substances that mimic bacterial N-acyl homoserine lactone signal activities and affect population density-dependent behaviors in associated bacteria. *Mol. Plant Microbe Interact.* 13: 637-648.

Ti, T. Y., Tan, W. C., Chong, A. P. *et al*. (1993). Nonfatal and fatal infections caused by *Chromobacterium violaceum*. *Clin Infect Dis.* 17: 505-507.

Uchiyama, T. and Miyazaki, K. (2009). Functional metagenomics for enzyme discovery: challenges to efficient screening. *Curr. Opin. Biotechnol*. 20: 616–622.

Ulrich, R. L. (2004). Quorum quenching: enzymatic disruption of N-acylhomoserine lactone-mediated bacterial communication in *Burkholderia thailandensis*. *Appl. Environ. Microbiol*. 70: 6173-6180.

Urdaci, M. C. and Pinchuk, I. (2004). Antimicrobial activity of Bacillusprobiotics. In: Ricca E, Henriques AO,Cutting SM, eds. Bacterial spore formers: probiotics and emerging applications. Norfolk UK: *Biosci. Horiz*. pp 171-182.

Vanbleu, E., Marchal, K. and Vanderleyden, J. (2004). Genetic and physical map of the pLAFR1 vector. *DNA seq*. 15(3): 225-227.

Vattem, D., Mihalik, K., Crixell, S. and Mclean, R. (2007). Dietary phytochemicals as quorum sensing inhibitors *Fitoterapia*, 78: 302-310.

Vincent, D. P., Meghana, C. G., Mohan, V. and Resmi, K. M. (2017). *Chromobacterium violaceum* causing community-acquired urinary tract infection. *Indian J Health Sci Biomed Res*. 10: 97-99.

Weaver, J. C. (2000). Electroporation of cells and tissues. *IEEE Trans Plasma Sci*. 28: 24–33.

Williams, P., Bainton, N. J., Swift, S., Chhabra, S. R., Winson, M. K., Stewart, G. S., Salmond, G. P. and Bycroft, B. W. (1992). Small molecule-mediated densitydependent control of gene expression in prokaryotes: bioluminescence and the biosynthesis of carbapenem antibiotics. *FEMS Microbiol. Lett.* 79: 161-167.

Winzer, K., Hardie, K. R., Burgess, N., Doherty, N., Kirke, D., Holden, M. T. G., Linforth, R., Cornell, K. A., Taylor, A. J., Hill, P. J., and Williams, P. (2002). LuxS: its role in central metabolism and the *in vitro* synthesis of 4-hydroxy-5-methyl-3(2H)-furanone. *Microbiology*. 148: 909-922.

Wooley, P.G. (1905). *Bacillus violaceous* manilae (a pathogenic organism). Bull Johns Hopkins Hosp. 16: 89.

Wu, N., Matand, K., Kebede, B., Acquaah, G. and Williams, S. (2010). Enhancing DNA electrotransformation effiency in *Escherichia coli* DH10B electrocompetent cells. *Electron J Biotechno*. 13: 11–19.

Zakry, F. A. A., Shamsuddin, Z. H., Khairuddin, A. R., Zakaria, Z. Z., Anuar, A. R. (2012). Inoculation of Bacillus sphaericus UPMB-10 to young oil palm and measurement of its uptake of fixed nitrogen using the ^{15}N isotope dilution technique*. Microbes Environ.* 27(3): 257–262*.*