UNIVERSITI PUTRA MALAYSIA

ANTIBACTERIAL AND SPORICIDAL ACTIVITY OF Syzygium grande (Wight) Walp. AND Oenanthe javanica (Blume) DC. AGAINST Bacillus sp.

KHALED ABDUSALAM. B. A ATRASH

IB 2021 13

ANTIBACTERIAL AND SPORICIDAL ACTIVITY OF *Syzygium grande* (Wight) Walp. AND *Oenanthe javanica* (Blume) DC. AGAINST *Bacillus sp.*

By

KHALED ABDUSALAM. B. A ATRASH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

June 2020

© COPYRIGHT UPM

COPYRIGHT

All material contained within the thesis, including without limitation text, logos, icons, photographs, and all other artwork, is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia.

Copyright © Universiti Putra Malaysia

© COPYRIGHT UPM

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

ANTIBACTERIAL AND SPORICIDAL ACTIVITY OF *Syzygium grande* (Wight) Walp. AND *Oenanthe javanica* (Blume) DC. AGAINST *Bacillus sp.*

By

KHALED ABDUSALAM. B. A ATRASH

June 2020

Chairman : Professor Khozirah binti Shaari, PhD
Institute : Bioscience

The contamination of many products in the food industry has always been linked to spore-forming bacteria including *Bacillus* sp. which commonly found in different type of food raw materials. Although different approaches for managing bacterial endospore contamination is urgently needed in diverse industries and applications, natural products are seen as the alternative solution. Based on previous studies, both *Syzygium grande* and *Oenanthe javanica* have been reported to exhibit several biological properties including antibacterial and antifungal. Thus, the main aim of this study is evaluating antibacterial and sporicidal activities of *Syzygium grande* and *Oenanthe javanica* against vegetative cells and spores of *B. cereus* ATCC33019, *B. subtilis* ATCC6633, *B. megaterium* ATCC 14581 and *B. pumilus* ATCC 1488. A further objective is to isolate the bioactive compound(s).

In this study, the metabolomics analysis of the 70% methanol, methanol, ethyl acetate and hexane extracts from the both plant was performed and showed clear discrimination between the different solvent extracts due to presence of different classes of compounds. Twenty compounds of *S. grande* have been assigned, including amino acids, carbohydrate, triterpene, terpenoids, and organic compounds. Compounds responsible for the differentiation were identified by comparison of their ^{1}H-NMR chemical shifts. The PLS results indicated that many non-polar compounds from *S. grande* hexane extract included betulin, *β*-sitosterol, oleanolic acid, *β*-caryophyllene, acetic acid and 3-hydroxybutyric acid were strongly correlated to anti-Bacillus. While, eighteen compounds of *O. javanica* have been assigned, including amino acids, carbohydrate, an organic acid terpenoids, and organic compounds. The PLS results showed the different polar compounds included sugars, glycine, choline, proline, ellagic acid, and gallic acid from *O. javanica* methanol extract are the potential contributors for the antimicrobial activities. Various solvent fractions obtained from solvent partitioning of the methanolic extracts of *S. grande* and *O.*

© COPYRIGHT UPM

javanica were screened for antimicrobial and sporicidal activity against of target *Bacillus* species, respectively. The hexane fraction of both plant showed the highest antimicrobial and sporicidal activities against all *Bacillus* sp. The results showed that the growth of vegetative cells of all tested *Bacillus* species were inhibited by *S. grande* hexane fraction at 1.0% with MIC values ranged between 0.039 to 0.625 mg/mL. While, MBC values ranging between 0.312 to 1.25 mg/mL. *Bacillus* species was also inhibited by *O. javanica* hexane fraction with MIC between 0.078 to 0.625 mg/mL. While, MBC values between 0.625 to 2.5 mg/mL. From time-kill assays, 4×MIC and 8×MIC of the hexane fractions of *S. grande* and *O. javanica*, respectively, were found to kill 99.90% of *Bacillus* sp. after 2 to 4 h incubation. Hexane fraction of *S. grande* was found to completely eradicate all *Bacillus* spores at 1%, after 2 to 3h of incubation. Similarly, *O. javanica* hexane fraction completely eradicate of all *Bacillus* spores at 1% after 3 to 4h of incubation. From the GCMS analysis, a total of 33 and 29 compounds could be putatively identified in the *S. grande* and *O. javaneca* hexane fractions, respectively, which included hydrocarbons, fatty acid, diterpenoids and triterpenoids. Meanwhile, 18 compounds from *S. grande* and 21 compounds from *O. javanica* ethyl acetate fractions were putatively identified using LC-MS/MS analysis. Most of the compounds had antibacterial activities based on previously reported.

Isolation of bioactive constituents was then attempted on the active fractions using bioautographic assay and column chromatography. The hexane fraction of *S. grande* yielded *β*-sitosterol and ursolic acid, while lupeol was isolated from the hexane fraction of *O. javanica*. All compounds were found able to inhibit the growth of all the *Bacillus* species at 100 µg/mL. Both *β*-sitosterol and lupeol gave lowest MIC value (31.25 µg/mL) against *B. pumilus*, and gave equally low MIC values (31.25 to 62.5 µg/mL) against the other *Bacillus* species. Overall the MBC values ranged from 125 to 250 µg/mL. While, ursolic acid was slightly less bioactive, with MIC values of 62.5 to 250 µg/mL against the test organisms, while the MBC values ranged from 125 to 500 µg/mL. Finally, at concentrations 100 to 1000 µg/mL, the three compounds were investigated for their abilities to reduce the viability of *Bacillus* sp. spores. *β*-sitosterol was found to kill all *Bacillus* spores at 1000 µg/mL, after 2 to 3 h of incubation while, ursolic acid at same concentration was killed all *Bacillus* spores after 2 h of incubation. Similarly, lupeol at 1000 µg/mL, gave complete elimination of *Bacillus* spores after 1 or 2 h of incubation. In conclusion, *S. grande and O. javanica* hexane fractions and its compounds which isolated from these fractions exhibited antimicrobial and sporicidal activity against *Bacillus* species, thus it can be developed as anti-Bacillus agent.

© COPYRIGHT UPM

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

AKTIVITI ANTIBAKTERIA DAN SPORISID *Syzygium grande* (Wight) Walp. DAN *Oenanthe javanica* (Blume) DC. TERHADAP *Bacillus* sp.

Oleh

KHALED ABDUSALAM. B. A ATRASH

Jun 2020

Pengerusi : Profesor Khozirah binti Shaari, PhD
Institut : Biosains

Pencemaran pelbagai produk dalam industri makanan sering dikaitkan dengan bakteria pembentuk spora seperti *Bacillus* sp. yang kebiasaannya dijumpai dalam pelbagai jenis bahan mentah makanan. Walaupun pendekatan yang berbeza amat diperlukan dalam pelbagai industri dan aplikasi bagi menguruskan pencemaran endospora bakteria, produk semulajadi dilihat sebagai penyelesaian alternatif. Berdasarkan kajian-kajian sebelum ini, kedua-dua *Syzygium grande* dan *Oenanthe javanica* telah dilaporkan menunjukkan beberapa ciri biologi termasuk antibakteria dan antikulat. Oleh itu, matlamat utama kajian ini adalah untuk menilai aktiviti antibakteria dan aktiviti sporisidal *Syzygium grande* dan *Oenanthe javanica* terhadap sel-sel vegetatif dan spora *B. cereus* ATCC33019, *B. subtilis* ATCC6633, *B. megaterium* ATCC 14581 dan *B. pumilus* ATCC 1488. Selain itu, kajian ini juga bertujuan untuk mengasingkan sebatian-sebatian bioaktifnya.

Dalam kajian ini, analisis metabolomik 70% metanol, metanol, etil asetat dan ekstrak heksana dari kedua-dua tumbuhan tersebut telah dilakukan dan telah menunjukkan diskriminasi yang jelas antara ekstrak pelarut yang berbeza kerana terdapat kelas-kelas sebatian yang berlainan. Dua puluh sebatian dari *S. grande* telah dikenalpasti, termasuk asid amino, karbohidrat, triterpena, terpenoid, dan sebatian organik. Sebatian yang mempengaruhi pembezaan tersebut telah dikenalpasti berdasarkan perbandingan nilai anjakan kimia ^{1}H-NMR mereka. Hasil keputusan PLS menunjukkan sebatian tidak polar dari ekstrak heksana *S. grand* termasuk betulin, *β*-sitosterol, asid oleanolik, *β*-kariofailina, asid asetik dan asid 3-hidroksibutirik sangat berkait dengan anti-Bacillus. Manakala, lapan belas sebatian dari *O. javanica* telah dikenalpasti termasuk asid amino, karbohidrat, asid organik, dan sebatian organik. Hasil keputusan PLS menunjukkan sebatian polar yang berlainan termasuk gula, glisin, kolin, prolin, asid ellagik, dan asid gallik dari ekstrak metanol *O. javanica* adalah penyumbang yang berpotensi untuk aktiviti antimikrob. Pelbagai pecahan

© COPYRIGHT UPM

pelarut yang diperolehi daripada pembahagian pelarut ekstrak metanol *S. grande* dan *O. javanica* telah diuji untuk aktiviti antimikrob dan sporisid terhadap spesies *Bacillus* yang disasarkan. Pecahan heksana dari kedua-dua tumbuhan tersebut menunjukkan aktiviti antimikrob dan sporisidal yang tertinggi terhadap semua *Bacillus sp*. Hasil keputusan menunjukkan bahawa pertumbuhan sel-sel vegetatif dari semua spesis *Bacillus* yang diuji telah dihalang oleh pecahan heksana *S. grande* pada 1.0% dengan nilai MIC dalam linkungan antara 0.039 hingga 0.625 mg / mL. Manakala, nilai MBC adalah dalam linkungan antara 0.625 hingga 2.5 mg / mL. Dari ujian masa-pembunuhan, 4 × MIC dan 8 × MIC pecahan heksana *S. grande* dan *O. javanica*, masing-masing didapati membunuh 99.90% *Bacillus sp*. selepas inkubasi selama 2 hingga 4 jam. Pecahan heksana dari *S. grande* didapati benar-benar membasmi semua spora *Bacillus* pada 1%, selepas 2 hingga 3 jam inkubasi. Begitu juga, pecahan heksana *O. javanica* telah membasmi semua spora *Bacillus* pada 1% selepas 3 hingga 4 jam inkubasi. Daripada analisis GCMS, sejumlah 33 dan 29 sebatian telah dikenalpasti di dalam pecahan heksana *S. grande* dan *O. javaneca*, masing-masing, termasuk hidrokarbon, asid lemak, diterpenoid dan triterpenoid. Sementara itu, 18 sebatian dari *S. grande* dan 21 sebatian dari pecahan *O. javanica* etil asetat telah dikenalpasti dengan menggunakan analisis LC-MS / MS. Majoriti sebatian-sebatian tersebut mempunyai aktiviti antibakteria berdasarkan laporan yang dilaporkan sebelum ini.

Pengasingan sebatian bioaktif kemudiannya dilakukan pada pecahan yang aktif dengan menggunakan kromatografi assay dan kromatografi kolum. Pecahan heksana *S. grande* menghasilkan *β*-sitosterol dan asid ursolik, sementara lupeol diasingkan dari pecahan heksana *O. javanica*. Ketiga-tiga sebatian tersebut didapati mampu menghalang pertumbuhan semua spesies *Bacillus* pada 100 µg / mL. Kedua-dua *β*-sitosterol dan lupeol memberikan nilai MIC terendah (31.25 µg / mL) terhadap *B. pumilus*, dan memberikan nilai MIC sama rendah (31.25 hingga 62.5 µg / mL) berbanding spesies *Bacillus* yang lain. Secara keseluruhan, nilai MBC adalah dalam linkungan antara 125 hingga 250 µg / mL. Sementara itu, asid ursolik sedikit kurang bioaktif, dengan nilai MIC dalam linkungan antara 62.5 hingga 250 µg / mL terhadap semua organisma yang diuji, manakala nilai MBC adalah dalam linkungan antara 125 hingga 500 µg / mL. Akhir sekali, pada kepekatan antara 100 hingga 1000 µg / mL, ketiga-tiga sebatian telah diselidik untuk kebolehan mereka mengurangkan daya maju spora *Bacillus*. *β*-sitosterol didapati membunuh semua spora *Bacillus* pada 1000 µg / mL, selepas 2 hingga 3 jam inkubasi, manakala, asid ursolic pada kepekatan yang sama telah membunuh semua spora *Bacillus* selepas 2 jam inkubasi. Begitu juga, lupeol pada 1000 µg / mL memberikan penghapusan spora *Bacillus* yang lengkap selepas 1 atau 2 jam inkubasi. Kesimpulannya, pecahan heksana *S. grande* dan *O. javanica* dan sebatian-sebatian yang diasingkan daripada pecahan ini menunjukkan aktiviti antimikrob dan sporisidal terhadap species *Bacillus*, oleh itu ia boleh dibangunkan sebagai agen anti-Bacillus.

© COPYRIGHT UPM

ACKNOWLEDGEMENTS

First and foremost, all praises belong to Allah, the Lord of all the worlds. I am very grateful to the Almighty Allah, for guiding me to praise Him, which in itself requires more praise, Alhamdulillah. I thank the Almighty Allah the Omniscient and Omnipresent for His blessings and help to me throughout this wonderful journey of seeking knowledge.

I would like to express my sincere gratitude and appreciation to my supervisor, Professor Dr. Khozirah Shaari, for her guidance, advice, encouragement and above all, her confidence in me to complete this project. I also want to give my deep appreciation to my committee members.

Credit also goes to lab assistants from the Microbiology and phytochemical Laboratory of IBS including, Mr Salahaudin, Haji Azizul, Mrs Huda, and Mrs. Mazina Mohd, Mrs. Zurina Zainal and for their guidance in NMR works.

Everyone who's named above or not listed, but whose amity is important to me. They deserve my intensive and earnest gratitude for helping me throughout this period. I would like to thank the various members of our Research group with whom I had the opportunity to work with to mention few Dr. Soo Yee, Dr. Ahmed Mediani, and Nawal Bubaker. They provided a friendly and cooperative atmosphere at work and also useful feedback and insightful comments on my work.

I would especially like to thank my parents for everything and their continuous moral support as well as prayers all through my academic journey. My heartfelt thanks also go to my wife and my kids for their support and prayers. I want also to express my very sincere thankful and love to my wonderful brothers and my sisters for their support all the time.

© COPYRIGHT UPM

This thesis was submitted to the Senate of the 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:

Khozirah binti Shaari, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Yaya Rukayadi, PhD
Associate Professor
Faculty of Food sciences and Technology
Universiti Putra Malaysia
(Member)

Intan Safinar binti Ismail, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 09 September 2021

© COPYRIGHT UPM

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature: _____ Date: _____

Name and Matric No: Khaled Abdusalam. B. A Atrash, GS46034

© COPYRIGHT UPM

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Professor Dr. Khozirah binti Shaari

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Yaya Rukayadi

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Intan Safinar binti Ismail

© COPYRIGHT UPM

TABLE OF CONTENTS

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

LIST OF TABLES

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

LIST OF FIGURES

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

LIST OF APPENDICES

© COPYRIGHT UPM

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ATCC	American Type Culture Collection
Ca^{2+}	Calcium cation
Ca^{2+}-DPA	Calcium cation and dipicolinic acid chelate
CC	Column Chromatography
CD_3OD	Methanol-d4
$CDCl_3$	Deuterated Chloroform
CFU	Colony forming unit
CH_3OH-*d4*	Deuterated Methanol-d4
$CHCl_3$	Chloroform
CHX	Chlorhexidine
CLSI	Clinical and Laboratory Standards Institute
COSY	Correlations Spectroscopy
2D-NMR	Two-Dimensional Nuclear Magnetic Resonance Spectroscopy
DMSO	Dimethyl sulfoxide
DMSO-*d6*	Deuterated Dimethyl sulfoxide
EtOAc	Ethyl acetate
G	Gram
GC-MS	Gas Chromatography – Mass Spectrometry
1H-NMR	Proton Nuclear Magnetic Resonance Spectroscopy
H	Hour
Hex	Hexane
HMBC	Heteronuclear Multiple-bond Correlation
HSQC	Heteronuclear Single-quantum Correlation

© COPYRIGHT UPM

Hz	Hertz
IR	Infrared Spectroscopy
J	Coupling constant in Hz
LC-MS	Liquid Chromatography–Mass Spectrometry
m	Multiple
m.p.	Melting point
m/z	Mass per Charge
MBC	Minimum Bactericidal Concentration
MeOH	Methanol
MHA	Mueller Hinton agar
MHB	Mueller Hinton broth
mHz	MegaHertz
MIC	Minimum Inhibitory Concentration
Min	Minute
mL	Milliliter
mm	Millimeter
MS	Mass Spectrometry
MS/MS	Mass / Mass Spectrometry
MTT	3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyl tetrazolium bromide
n- BuOH	n-Butanol
NA	Nutrient agar
NaCl	Sodium chloride
NMR	Nuclear Magnetic Resonance
PBS	Phosphate Buffered Saline
PCA	Principal Component Analysis
PLS	Partial Least Squares

© COPYRIGHT UPM

Ppm	Part Per Million
ppm	Part per million
Rpm	Revolutions per minute
Rt	Retention Time
s	Singlet
Sp	Species
t	Triplet
TLC	Thin layer chromatography
WHO	world health organization
α	Alpha
β	Beta
δ	Chemical Shift in ppm
µg	Microgram
µL	Microliter

© COPYRIGHT UPM

CHAPTER 1

INTRODUCTION

1.1 Background

In the late 1700s, Nicolas Appert invented the appertization process, currently known as canning, to prolong food quality, shelf-life, in addition to prevent food spoilage over an extended period of time. Accordance with his conviction, the eradication of air was responsible for canned food stability. Subsequently, Cohn & Koch (1875) discovered spores for the first time, while Pasteur discovered spores-producing bacteria, causing food spoilage. Both these discoveries connected microbial activities with food spoilage and safety. Globally, these food spoilage microorganisms extensively affected a wide range of food, causing substantial food wastage and losses, even in the developed countries. According to Gustavsson *et al.* (2011), the annual losses of world food caused by different factors including spoilage microorganisms, can reach up to 40%.

Moreover, bacteria, yeast, as well as moulds are considered to be the common microorganisms causing substantial amount of food spoilage along with food products (Lianou *et al.*, 2016). As soon as these microorganisms get into food items, they will grow by consuming produce metabolites and nutrients, causing food spoilage accordingly (Parlapani *et al.*, 2017). The contaminated food products consumption causes foodborne illnesses, which is an important safety matter in public health (Azziz *et al.*, 2005; Kirk *et al.*, 2017). Moreover, microorganisms predominantly exist among natural surroundings, and hence, they could easily contaminate food through processing, slaughtering harvesting along with packaging (Hatab *et al.*, 2016). Thus,

microorganisms could persist in unfavourable circumstances including pasteurization, packaging, modified atmosphere packaging, vacuum, and low temperature (Dimitrijevi'c *et al.*, 2007; Provincial *et al.*, 2013; Saraiva *et al.*, 2016; Säde *et al.*, 2017). Apart from mold fungi, spoilage bacteria (*Bacillus* sp.) are also closely related to food spoilage. Once bacteria break down food, acids and other waste products are produced in the process. Moreover, the genus *Bacillus* could be defined as a group of rod-shaped, gram-positive, aerobic or anaerobic bacteria (Kim *et al.*, 2014), which are predominantly found in a variety of raw materials food (Opstal *et al.*, 2004). Therefore, these bacteria are potential causal agents for foodborne pathogenesis.

Bacillus sp. contaminate a variety of food and food products such as infant formula, new-born child cereal, cooked rice, dried milk, eggs, meat, flavours, pasta and noodles (Altayar & Sutherland, 2006; Kim *et al.*, 2013). Heat resistivity of *Bacillus* spores and its adaptability to different environments enable them to survive in foods that have gone through moderate cooking processes. It was reported that gaseous swelling and unpleasant odours in canned peas were mainly caused by the heat resistant spores'

© COPYRIGHT UPM

growth of the bacteria (Russell, 1990). It has been found that disease and spoilage are associated with thermally processed foods, as heat causes on killing the vegetative cells but permits the growth of spore-producing bacteria. Comparing to other food-borne pathogenic bacteria, spores have better endurance under usual food processing conditions, therefore, causing an immense problem for food industries. Thus, sterilizing food procedures, pharmaceutical, medical, and other products need to consider this significant level of resistance by bacterial spores. Several chemical compounds, such as glutaraldehyde, formaldehyde, chlorine-releasing agents, peroxygens, ethylene oxide, and ozone have been applied as sporicidal agents

(Russell, 1990). According to Lawrence & Palombo, (2009), these chemical compounds kills the spores through the inactivation of different phases of the germination process including the damage it causes to the bacterial DNA, and the irreversible disorder of the spore reliability. Although, glutaraldehyde shows great sporicidal activity, the pungent, rotten-like the chemical smell which makes it unacceptable to use in food products. Additionally, high concentrations and expansive contact time are considered necessary to observe significant log reductions in spore numbers (Lawrence and Palombo, 2009). Furthermore, the exposure to glutaraldehyde has also been associated with different health impacts such as skin, eyes and respiratory irritations (Ballantyne and Jordan, 2001). Similarly, formaldehyde can be utilized in both liquid and gaseous stages of the chemical. However, the rate of sporicidal effect of formaldehyde is significantly slower than glutaraldehyde (Lawrence & Palombo, 2009). Moreover, its utilization in food products has been banned by the United States Occupational Safety and Health Act because it was potentially found to be naturally carcinogenic (Lawrence & Palombo, 2009).)

In the same way, chlorine gas can be efficiently used as sporicide. However, its application could be harmful to human health (Lawrence & Palombo, 2009). Meanwhile, hydrogen peroxide is also beneficial in this context, however, chemicals are generally unstable, and its application requires high concentrations and extended contact time. Generally, spores are resistant to hydrogen peroxide, producing protective clumps and catalase to destroy them. On the other hand, ultraviolet (UV) light and microwave radiation are found to be effective in killing *Bacillus* spores. However, they are extremely risky to use within food industry (Lawrence & Palombo, 2009). Therefore, natural products are remarkably beneficial to help during the revelation and development of new sporicides. Although, the antimicrobial properties of various chemical compounds and essential oils derived of plants against vegetative cells have been largely reported and its utility for preservation purposes is also acknowledged, their further action against endospores have not been fully explored. Thus, there is a great potential to discover new sporicides from natural products.

A few studies have demonstrated that natural product compounds, for instance, oleuropein from olives suppresses the germination and succeeding growth of *B. cereus* spores (Tassou, 1993; Tassou *et al.*, 1991). Similarly, catechins from green tea (*Camellia sinensis*) displayed inhibition activity against both *Clostridium botulinum*

© COPYRIGHT UPM

and *C. butyricum* spores (Hara-Kudo *et al.*, 2005). Moreover, some cardamom essential oils, the tea plant, along with juniper leaves showed antibacterial activities against *B. subtilis* spores (Lawrence & Palombo, 2009). Extract of *Torilis japonica* can effectively suppress the germination of *B. subtilis* spores (Cho *et al.*, 2008) whilst fruit and leaf extracts of *Myristica fragrance* (nutmeg) plant has inhibited germination and succeeding growth of *B. cereus* spores (Rukayadi *et al.*, 2009).

Syzygium grande (*Wight*) which is known as "Jambu Laut or Sea apple" in Malaysia. It belongs to the Myrtaceae family, reportedly know to be rich in volatile oils and found to have both culinary and medicinal uses (Mohanan *et al.*, 2002). Meanwhile, *Oenanthe javanica DC*, vernacularly which is recognized as water dropwort or "selom", is a perennial aromatic herb of the Apiaceae family. The consumption of *O. javanica* as a traditional vegetable (*ulam*) and its use as food seasoning are widely practiced in Asian countries. For example, in Korea, a herb soup is consumed as a treatment for alcohol intoxication hangovers (Kim *et al.*, 2009). Both *S. grande* and *O. javanica* were reported to demonstrate numerous biological properties which includes the antioxidant, antibacterial and antifungal (Raja *et al.*, 2015; Ajam, 2014; Kwon *et al.* 2006; Shin, 2004; Narzary *et al.*, 2018).

The latter property indicated that both plants and their chemical constituents could be useful as antibacterial and/or antispore agents and it would be more interested to know more details about the antibacterial and sporicidal properties of these plants.

1.2 Problem Statements

Nowadays, the development of natural, plant-derived food sanitizers and food preservatives has been gaining more attention. This is due to the fact that synthetic chemicals could cause more harm than good when applied for human use, especially for food products. Certain plants contain phytochemical compounds which exhibit the antimicrobial activity that may be antibacterial, antifungal and/or antispore. Therefore, these plants can be used in food industry as a natural preservers or food sanitizers, providing potential alternatives to synthetic chemicals (Cho *et al.*, 2008). It is equally important to develop natural preservatives that are effective and efficient, not only to eradicate the microorganism, but also to reduce the regrowth possibility of the microorganism. Thus, identifying natural sporicidal agents that can minimize or totally eradicate the *Bacillus* sp. population, this is equally important and much needed by the food industry. Furthermore, realizing the great potential of natural products in yielding useful chemicals as possible alternatives to synthetic chemicals, the antibacterial and antispore properties of the two-essential oil-bearing plants have thus been investigated. Specifically, the plants antibacterial and antispore activities were investigated compared to vegetative cells along with spores of *B. cereus* ATCC33019, *B. subtilis* ATCC6633, *B. megaterium* ATCC 14581 in addition to *B. pumilus* ATCC 14884.

© COPYRIGHT UPM

1.3 Objectives of the Study

The specific objectives of the present study are:

1. To analyse metabolite variation of *S. grande* and *O. javanic* extracts prepared using different solvents and correlation with antimicrobial activities using ^{1}H NMR based metabolomics approach

2. To determine the effect of the methanolic extract and various solvent fractions of *S. grande* and *O. javanica* towards vegetative cells of *Bacillus* species.

3. To determine the effect of methanolic extract and various solvent fractions of *S. grande* and *O. javanica* towards spores of *Bacillus* species.

4. Identification the phytochemicals compounds in *S. grande* and *O. javanica* hexane and ethyl acetate fractions which had the highest antibacterial and sporicidal activity

5. To isolate and characterize the bioactive (antibacterial and antispore) chemical constituents of hexane fraction of *S. grande* and *O. javanica.*

© COPYRIGHT UPM

REFERENCES

Abas, F., Khatib, A., Shitan, M., Shaari, K., & Lajis, N. H. (2013). Comparison of partial least squares and artificial neural network for the prediction of antioxidant activity in extract of Pegaga (Centella) varieties from 1H nuclear magnetic resonance spectroscopy. *Food research international*, *54*(1), 852-860.

Abd-Alla, H. I., Shaaban, M., Shaaban, K. A., Abu-Gabal, N. S., Shalaby, N. M., & Laatsch, H. (2009). New bioactive compounds from Aloe hijazensis. *Natural product research*, *23*(11), 1035-1049.

Abdelgani, A. M., Rukayadi, Y., Shaari, K., & Safinar, I. (2018). Antibacterial and Sporicidal Activities of Methanolic *Sygygium polyanthum* L. Leaf Extract against Vegetative Cells and Spores of *Bacillus pumilus* and *Bacillus megaterium*. *Journal oF PurE and aPPliEd Microbiology*, *12*(3), 1047-1053

Abdul-Hamid, N. A., Abas, F., Ismail, I. S., Shaari, K., & Lajis, N. H. (2015). Influence of different drying treatments and extraction solvents on the metabolite profile and nitric oxide inhibitory activity of Ajwa dates. *Journal of food science*, *80*(11), H2603-H2611.

Abu-Reidah, I. M., Ali-Shtayeh, M. S., Jamous, R. M., Arráez-Román, D., & Segura-Carretero, A. (2015). HPLC–DAD–ESI-MS/MS screening of bioactive components from *Rhus coriaria* L.(Sumac) fruits. *Food chemistry*, *166*, 179-191.

Addgene. (2014). Creating bacterial glycerol stocks for long-term storage of plasmids. Retrieved 27 May 2015 from https: //www.addgene.org/ plasmidsprotocols/ create-glycerol-stocks/

Adhoni, S. A., Thimmappa, S. C., & Kaliwal, B. B. (2016). Phytochemical analysis and antimicrobial activity of Chorella vulgaris isolated from Unkal Lake. *Journal of Coastal Life Medicine*, *4*(5), 368-373.

Ahmed, Y., Sohrab, M. H., Al-Reza, S. M., Tareq, F. S., Hasan, C. M., & Sattar, M. (2010). Antimicrobial and cytotoxic constituents from leaves of Sapium baccatum. *Food and Chemical Toxicology*, *48*(2), 549-552.

Aisha, A. F., Abu-Salah, K. M., Alrokayan, S. A., Siddiqui, M. J., Ismail, Z., & Majid, A. M. (2012). *Syzygium aromaticum* extracts as good source of betulinic acid and potential anti-breast cancer. *Revista Brasileira de Farmacognosia*, *22*(2), 335-343.3.

Ajaiyeoba, E. O., Onocha, P. A., Nwozo, S. O., & Sama, W. (2003). Antimicrobial and cytotoxicity evaluation of *Buchholzia coriacea* stem bark. *Fitoterapia*, *74*(7-8), 706-709.

© COPYRIGHT UPM

Ajam, S. M. (2014). In vitro antimicrobial and antioxidant activity of aqueous and acetone extracts of *Syzygium grande* (Wight) Walp. leaves. *J. Gen. Environ. Res. Conserv*, *2*(2), 178-185.

Akhtar, M. J., Ahamed, M., Kumar, S., Siddiqui, H., Patil, G., Ashquin, M., & Ahmad, I. (2010). Nanotoxicity of pure silica mediated through oxidant generation rather than glutathione depletion in human lung epithelial cells. *Toxicology*, *276*(2), 95-102.

Alakolanga, A. G. A. W., Siriwardane, A. M. D. A., Kumar, N. S., Jayasinghe, L., Jaiswal, R., & Kuhnert, N. (2014). LC-MSn identification and characterization of the phenolic compounds from the fruits of *Flacourtia indica* (Burm. F.) Merr. and *Flacourtia inermis* Roxb. *Food Research International*, *62*, 388-396.

Alocilja, E. C., & Radke, S. M. (2003). Market analysis of biosensors for food safety. *Biosensors and Bioelectronics*, *18*(5-6), 841-846.

Alqadeeri, F., Rukayadi, Y., Abbas, F., & Shaari, K. (2019). Antibacterial and Antispore Activities of Isolated Compounds from Piper cubeba L. *Molecules*, *24*(17), 3095.

Altayar, M., & Sutherland, A. D. (2006). *Bacillus cereus* is common in the environment but emetic toxin producing isolates are rare. *Journal of applied microbiology*, *100*(1), 7-14.

Alwan, S., Soufi, H., Zreika, S., & Sukarieh, I. (2015). Micromeria barbata: antimicrobial and sporicidal activity against *Bacillus cereus*. *International Journal*, *5*(03), 2307-2083f.

Alzoreky, N. S., & Nakahara, K. (2003). Antibacterial activity of extracts from some edible plants commonly consumed in Asia. *International journal of food microbiology*, *80*(3), 223-230.

Atrih, A., Zöllner, P., Allmaier, G., Williamson, M. P., & Foster, S. J. (1998). Peptidoglycan structural dynamics during germination of *Bacillus subtilis* 168 endospores. *Journal of bacteriology*, *180*(17), 4603-4612.

Aureli, P., Fiorucci, G. C., Caroli, D., Marchiaro, G., Novara, O., Leone, L., & Salmaso, S. (2000). An outbreak of febrile gastroenteritis associated with corn contaminated by *Listeria monocytogenes*. *New England Journal of Medicine*, *342*(17), 1236-1241.

Awolola, G. V., Koorbanally, N. A., Chenia, H., Shode, F. O., & Baijnath, H. (2014). Antibacterial and anti-biofilm activity of flavonoids and triterpenes isolated from the extracts of *Ficus sansibarica* Warb. subsp. sansibarica (Moraceae) extracts. *African Journal of Traditional, Complementary and Alternative Medicines*, *11*(3), 124-131.

© COPYRIGHT UPM

Ayyanar, M., & Subash-Babu, P. (2012). *Syzygium cumini* (L.) Skeels: A review of its phytochemical constituents and traditional uses. *Asian Pacific journal of tropical biomedicine*, *2*(3), 240-246.

Aziz, N. H., Farag, S. E., Mousa, L. A., & Abo-Zaid, M. A. (1998). Comparative antibacterial and antifungal effects of some phenolic compounds. *Microbios*, *93*(374), 43-54.

Azziz-Baumgartner, E., Lindblade, K., Gieseker, K., Rogers, H. S., Kieszak, S., Njapau, H., Schleicher, R., McCoy, L, F., Misore, A., DeCock, K., Slutsker, L. & Rubin, C. (2005). Case–control study of an acute aflatoxicosis outbreak, Kenya, 2004. *Environmental health perspectives*, *113*(12), 1779- 1783.

Bai, J., Wu, Y., Wang, X., Liu, X., Zhong, K., Huang, Y., Chen, Y. & Gao, H. (2018). In vitro and in vivo characterization of the antibacterial activity and membrane damage mechanism of quinic acid against *Staphylococcus aureus*. *Journal of Food Safety*, *38*(1), e12416.

Bai, X., Park, I. B., Hwang, H. J., & Mah, J. H. (2015). The ability of S chisandra chinensis fruit to inhibit the growth of foodborne pathogenic bacteria and the viability and heat resistance of *Bacillus cereus* spores. *International journal of food science & technology*, *50*(10), 2193-2200.

Bajpai, V. K., Al-Reza, S. M., Choi, U. K., Lee, J. H., & Kang, S. C. (2009). Chemical composition, antibacterial and antioxidant activities of leaf essential oil and extracts of *Metasequioa glyptostroboides* Miki ex Hu. *Food and Chemical Toxicology*, *47*(8), 1876-1883.

Ballantyne, B., & Jordan, S. L. (2001). Toxicological, medical and industrial hygiene aspects of glutaraldehyde with particular reference to its biocidal use in cold sterilization procedures. *Journal of Applied Toxicology: An International Journal*, *21*(2), 131-151.

Barakat, K., & Saleh, M. (2016). Bioactive betulin produced by marine Paecilomyces WE3-F. *Journal of Applied Pharmaceutical Science*, *6*, 34-40.

Barker, G. C., Malakar, P. K., & Peck, M. W. (2005). Germination and growth from spores: variability and uncertainty in the assessment of food borne hazards. *International journal of food microbiology*, *100*(1-3), 67-76.

Baron, S. (1996). *Classification--Medical Microbiology*. University of Texas Medical Branch at Galveston.

Baydar, H., Sağdiç, O., Özkan, G., & Karadoğan, T. (2004). Antibacterial activity and composition of essential oils from Origanum, Thymbra and Satureja species with commercial importance in Turkey. *Food Control*. 15(3): 169-172.

Baydar, N. G., Özkan, G., & Sağdiç, O. (2004). Total phenolic contents and antibacterial activities of grape (Vitis vinifera L.) extracts. *Food Control*, *15*(5), 335-339.

© COPYRIGHT UPM

Belding, R. D., Blankenship, S. M., Young, E., & Leidy, R. B. (1998). Composition and variability of epicuticular waxes in apple cultivars. *Journal of the American Society for Horticultural Science*, *123*(3), 348-356.

Bhunia, A. (2007). *Foodborne microbial pathogens: mechanisms and pathogenesis*. Springer, New York, USA.

Biswas, S. M., & Chakraborty, N. (2013). Shedded Artocarpus leaves-good plant sources of natural squalene with potent antioxidant and antimicrobial activity-alternative to marine animals. *Journal of Natural Pharmaceuticals*, 4(1), 21-27.

Borges, A., Ferreira, C., Saavedra, M. J., & Simões, M. (2013). Antibacterial activity and mode of action of ferulic and gallic acids against pathogenic bacteria. *Microbial Drug Resistance*, *19*(4), 256-265.

Bottone, E. J. (2010). *Bacillus cereus*, a volatile human pathogen. *Clinical microbiology reviews*, *23*(2), 382-398.

Brock, T.D. and Madigan, M.T. 1991. *Biology of Microorganisms*, 6th ed. Prentice hall, New Jersey, USA.

Brul, S., van Beilen, J., Caspers, M., O'Brien, A., de Koster, C., Oomes, S., Smelt, J., Kort, R.andTer Beek, A. (2011). Challenges and advances in systems biology analysis of *Bacillus* spore physiology; molecular differences between an extreme heat resistant spore forming *Bacillus subtilis* food isolate and a laboratory strain. *Food Microbiology*. 28(2): 221-227.

Budzikiewicz, H., Wilson, J., & Djerassi, C. (1963). Mass spectrometry in structural and stereochemical problems. XXXII. 1 Pentacyclic triterpenes. *Journal of the American Chemical Society*, *85*(22), 3688-3699.

Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods a review. *International journal of food microbiology*, *94*(3), 223-253.

Bystrom, L. M., Lewis, B. A., Brown, D. L., Rodriguez, E., & Obendorf, R. L. (2008). Characterisation of phenolics by LC–UV/Vis, LC–MS/MS and sugars by GC in Melicoccus bijugatus Jacq.'Montgomery'fruits. *Food chemistry*, *111*(4), 1017-1024.

Cakir, A., Kordali, S., Kilic, H., & Kaya, E. (2005). Antifungal properties of essential oil and crude extracts of Hypericum linarioides Bosse. *Biochemical Systematics and Ecology*, *33*(3), 245-256.

Carson, C. F., Mee, B. J., & Riley, T. V. (2002). Mechanism of action of Melaleuca alternifolia (tea tree) oil on Staphylococcus aureus determined by time-kill, lysis, leakage, and salt tolerance assays and electron microscopy. *Antimicrobial agents and chemotherapy*, *46*(6), 1914-1920.

© COPYRIGHT UPM

CDC. Foodborne illness: frequently asked questions. Atlanta:(2005) Centers for Disease Control and Prevention.

Cetin-Karaca, H., & Newman, M. C. (2015). Antimicrobial efficacy of plant phenolic compounds against Salmonella and Escherichia Coli. *Food bioscience*, *11*, 8-16.

Ceuppens, S., Rajkovic, A., Heyndrickx, M., Tsilia, V., Van De Wiele, T., Boon, N., & Uyttendaele, M. (2011). Regulation of toxin production by *Bacillus cereus* and its food safety implications. *Critical reviews in microbiology*, *37*(3), 188-213.

Chan, E. W. C., Wong, S. K., & Chan, H. T. (2017). Ulam Herbs of Oenanthe javanica and Cosmos caudatus: an overview on their Medicinal Properties. *Journal of Natural Remedies*, *16*(4), 137-147.

Chao, C. Y., & Yin, M. C. (2009). Antibacterial effects of roselle calyx extracts and protocatechuic acid in ground beef and apple juice. *Foodborne Pathogens and Disease*, *6*(2), 201-206.

Chemburu, S., Wilkins, E., & Abdel-Hamid, I. (2005). Detection of pathogenic bacteria in food samples using highly-dispersed carbon particles. *Biosensors and Bioelectronics*, *21*(3), 491-499.

Cho, W. I., Choi, J. B., Lee, K., Chung, M. S., & Pyun, Y. R. (2008). Antimicrobial activity of torilin isolated from *Torilis japonica* fruit against *Bacillus subtilis*. *Journal of food science*, *73*(2), M37-M46.

Choma, I. M., & Grzelak, E. M. (2011). Bioautography detection in thin-layer chromatography. *Journal of Chromatography A*, *1218*(19), 2684-2691.

Chong, K. P., Rossall, S., & Atong, M. (2009). In vitro antimicrobial activity and fungitoxicity of syringic acid, caffeic acid and 4-hydroxybenzoic acid against Ganoderma boninense. *Journal of Agricultural Science*, *1*(2), 15.

Clements, L. D., Streips, U. N., & Miller, B. S. (2002). Differential proteomic analysis of *Bacillus subtilis* nitrate respiration and fermentation in defined medium. *Proteomics*, *2*(12), 1724-1734.

Clinical and Laboratory Standards Institute (CLSI).(2003). Reference method for dilution antimicrobial susceptibility tests for bacteria that grow aerobically.*Approved standard M7-A6*.National Committee for Clinical Laboratory Standards, Wayne, Pennsylvania, USA.

Cortezzo, D. E., Setlow, B., & Setlow, P. (2004). Analysis of the action of compounds that inhibit the germination of spores of Bacillus species. *Journal of Applied Microbiology*, *96*(4), 725-741.

Cos, P., Vlietinck, A. J., Berghe, D. V., & Maes, L. (2006). Anti-infective potential of natural products: how to develop a stronger in vitro 'proof-of- concept'.

© COPYRIGHT UPM

Journal of ethnopharmacology, *106*(3), 290-302.

Cowan, A. E., Olivastro, E. M., Koppel, D. E., Loshon, C. A., Setlow, B., & Setlow, P. (2004). Lipids in the inner membrane of dormant spores of *Bacillus* species are largely immobile. *Proceedings of the National Academy of Sciences*, *101*(20), 7733-7738.

Cox, S. D., Mann, C. M., Markham, J. L., Gustafson, J. E., Warmington, J. R., & Wyllie, S. G. (2001). Determining the antimicrobial actions of tea tree oil. *Molecules*, *6*(2), 87-91.

Dabiri, A., & Karbasizade, V. (2014). Evaluation of the Sporicidal Activity of Ethanol Extract of Arctium lappa Root against *Bacillus cereus*. *Zahedan Journal of Research in Medical Sciences*. 16(10): 47-49.

Dahham, S., Tabana, Y., Iqbal, M., Ahamed, M., Ezzat, M., Majid, A., & Majid, A. (2015). The anticancer, antioxidant and antimicrobial properties of the sesquiterpene β-caryophyllene from the essential oil of Aquilaria crassna. *Molecules*, *20*(7), 11808-11829.

De Bary, A (1884) Vergleichende Morphologie und Biologie der Pilze, Mycetozoen und Bakterien. Wilhelm Engelmann, Leipzig, Germany.

De Souza CE, da Silva AR, Rocha JE, Gomez MC, Rolóm M, Coronel C, da Costa JG, Netto ML, Rolim LA, Coutinho HD.. (2017). LC–MS characterization, anti- kinetoplastide and cytotoxic activities of natural products from Eugenia jambolana Lam. and Eugenia uniflora. *Asian Pacific Journal of Tropical Biomedicine*, *7*(9), 836-841.

Dimitrijević, S. I., Mihajlovski, K. R., Antonović, D. G., Milanović-Stevanović, M. R., & Mijin, D. Ž. (2007). A study of the synergistic antilisterial effects of a sub-lethal dose of lactic acid and essential oils from Thymus vulgaris L., Rosmarinus officinalis L. and Origanum vulgare L. *Food Chemistry*, *104*(2), 774-782.

Djipa, C. D., Delmée, M., & Quetin-Leclercq, J. (2000). Antimicrobial activity of bark extracts of *Syzygium jambos* (L.) Alston (Myrtaceae). *Journal of Ethnopharmacology*, *71*(1-2), 307-313.

Driks, A. (1999). *Bacillus subtilis* spore coat. *Microbiology and Molecular Biology Reviews*, 63(1), 1-20.

Driks, A. (2002). Maximum shields: the assembly and function of the bacterial spore coat. *Trends in microbiology*, *10*(6), 251-254.

Duc, L. H., Dong, T. C., Logan, N. A., Sutherland, A. D., Taylor, J., & Cutting, S. M. (2005). Cases of emesis associated with bacterial contamination of an infant breakfast cereal product. *International journal of food microbiology*, *102*(2), 245-251.

© COPYRIGHT UPM

Ek, S., Kartimo, H., Mattila, S., & Tolonen, A. (2006). Characterization of phenolic compounds from lingonberry (Vaccinium vitis-idaea). *Journal of agricultural and food chemistry*, *54*(26), 9834-9842.

Elisha, I. L., Botha, F. S., McGaw, L. J., & Eloff, J. N. (2017). The antibacterial activity of extracts of nine plant species with good activity against Escherichia coli against five other bacteria and cytotoxicity of extracts. *BMC complementary and alternative medicine*, *17*(1), 133.

Elsadig Karar, M. G., Quiet, L., Rezk, A., Jaiswal, R., Rehders, M., Ullrich, M. S., Brix, K., & Kuhnert, N. (2016). Phenolic profile and in vitro assessment of cytotoxicity and antibacterial activity of Ziziphus spina-christi leaf extracts. *Medicinal Chemistry*, 6(3), 143-156.

Erazo, S., Rocco, G., Zaldivar, M., Delporte, C., Backhouse, N., Castro, C., ... & Garcıía, R. (2008). Active metabolites from *Dunalia spinosa* resinous exudates. *Zeitschrift für Naturforschung C*, *63*(7-8), 492-496.

Eriksson, L., Johansson, E., Kettaneh-Wold, N., Trygg, J., Wikström, C., & Wold, S. (2006). *Multi-and megavariate data analysis* (Vol. 1, p. 1). Sweden: Umetrics.

Errington, J. (2003). Regulation of endospore formation in *Bacillus subtilis*. *Nature Reviews Microbiology*, *1*(2), 117.

Escandón, R. A., Del Campo, M., López-Solis, R., Obreque-Slier, E., & Toledo, H. (2016). Antibacterial effect of kaempferol and (−)-epicatechin on Helicobacter pylori. *European Food Research and Technology*, *242*(9), 1495-1502.

Fan, G., Luo, W. Z., Luo, S. H., Li, Y., Meng, X. L., Zhou, X. D., & Zhang, Y. (2014). Metabolic discrimination of *Swertia mussotii* and *Swertia chirayita* known as "Zangyinchen" in traditional Tibetan medicine by 1H NMR-based metabolomics. *Journal of pharmaceutical and biomedical analysis*, *98*, 364-370.

Fathoni, A., Saepudin, E., Cahyana, A. H., Rahayu, D. U. C., & Haib, J. (2017, July). Identification of nonvolatile compounds in clove (*Syzygium aromaticum*) from Manado. In *AIP Conference Proceedings* (Vol. 1862, No. 1, p. 030079). AIP Publishing.

Fernández-No, I.C., Böhme, K., Díaz-Bao, M., Cepeda, A., Barros-Velázquez, J. and Calo-Mata, P. (2013). Characterisation and profiling of *Bacillus subtilis*, *Bacillus cereus* and *Bacillus licheniformis* by MALDI-TOF mass fingerprinting. *Food Microbiology*. 33(2): 235-242.

Fiehn, O. (2001). Combining genomics, metabolome analysis, and biochemical modelling to understand metabolic networks. *International Journal of Genomics*. 2(3): 155-168.

Foster, S. J., & Johnstone, K. (1990). Pulling the trigger: the mechanism of bacterial spore germination. *Molecular microbiology*, *4*(1), 137-141.

© COPYRIGHT UPM

Fraige, K., Dametto, A. C., Zeraik, M. L., de Freitas, L., Saraiva, A. C., Medeiros, A. I., Gamboa, I. C., Cavalheiro J. A., Silva D. H. S., Lopes, N. P. & Bolzani, V. S. (2018). Dereplication by HPLC-DAD-ESI-MS/MS and Screening for Biological Activities of *Byrsonima* Species (Malpighiaceae). *Phytochemical analysis*, *29*(2), 196-204.

Friedman, M. (2014). Chemistry and multibeneficial bioactivities of carvacrol (4-isopropyl-2-methylphenol), a component of essential oils produced by aromatic plants and spices. *Journal of Agricultural and Food Chemistry*. 62(31): 7652-7670.

Galanakis, C. M. (2012). Recovery of high added-value components from food wastes: conventional, emerging technologies and commercialized applications. *Trends in Food Science & Technology*, *26*(2), 68-87.

Ghudhaib, K. K., Hanna, E. R., & Jawad, A. H. (2010). Effect of ellagic acid on some types of pathogenic bacteria. *Journal of Al-Nahrain University-Science*, *13*(2), 79-85.

Ghudhaib, K. K., Hanna, E. R., & Jawad, A. H. (2010). Effect of ellagic acid on some types of pathogenic bacteria. *Journal of Al-Nahrain University-Science*, *13*(2), 79-85.

Gnoatto, S. C., Dassonville-Klimpt, A., Da Nascimento, S., Galéra, P., Boumediene, K., Gosmann, G., Sonnet , P. & Moslemi, S. (2008). Evaluation of ursolic acid isolated from Ilex paraguariensis and derivatives on aromatase inhibition. *European journal of medicinal chemistry*, *43*(9), 1865-1877.

Gohlke, R. S. (1959). Time-of-flight mass spectrometry and gas-liquid partition chromatography. *Analytical Chemistry*, *31*(4), 535-541.

Gohlke, R. S., & McLafferty, F. W. (1993). Early gas chromatography/mass spectrometry. *Journal of the American Society for Mass Spectrometry*, *4*(5), 367-371.

Gottlieb, O.R.; Leao da- Silva, M. and Soares-Maia, J. G. (1972). Chemistry of brasilian Myrtaceae III. Eucaliptin from *Eugenia and Myrica* species alkaloids. *Phytochemistry*, 11: 1185.

Gould, G. W. (1977). Recent advances in the understanding of resistance and dormancy in bacterial spores. *Journal of Applied Bacteriology*, *42*(3), 297-309

Griffiths, M.W. 2010. Pathogens and toxins in foods: challenges and interventions. *ASM Press*, Washington, DC. pp. 1-19.

Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R., and Maybeck, A. (2011). *Global Food Losses and Food Waste: Extent, Causes.*

Hada, M., Hino, K., & Takeuchi, Y. (2001). Development of UV defense mechanisms during growth of spinach seedlings. *Plant and Cell Physiology*, *42*(7), 784-

© COPYRIGHT UPM

787.

Hall, R. D. (2006). Plant metabolomics: from holistic hope, to hype, to hot topic. *New phytologist*, *169*(3), 453-468.

Hamid, N. A. A., Mediani, A., Maulidiani, M., Abas, F., Park, Y. S., Leontowicz, H., Leontowiczd, M., Namiesnke, J. & Gorinstein, S. (2017). Characterization of metabolites in different kiwifruit varieties by NMR and fluorescence spectroscopy. *Journal of pharmaceutical and biomedical analysis*, *138*, 80-91.

Hara-Kudo, Y., Yamasaki, A., Sasaki, M., Okubo, T., Minai, Y., Haga, M., Kondo, K. & Sugita-Konishi, Y. (2005). Antibacterial action on pathogenic bacterial spore by green tea catechins. *Journal of the Science of Food and Agriculture*, *85*(14), 2354-2361.

Hashem, F. A., & Saleh, M. M. (1999). Antimicrobial components of some cruciferae plants (Diplotaxis harra Forsk. and Erucaria microcarpa Boiss.). Phytotherapy Research: *An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *13*(4), 329-332.

Hashim, N. H. N., Abas, F., Shaari, K., & Lajis, N. H. (2012). LC–DAD–ESIMS/MS characterization of antioxidant and anticholinesterase constituents present in the active fraction *from Persicaria hydropiper*. *LWT-Food Science and Technology*, *46*(2), 468-476.

Hatab, S., Athanasio, R., Holley, R., Rodas-Gonzalez, A., & Narvaez-Bravo, C. (2016). Survival and Reduction of Shiga Toxin-Producing *Escherichia coli* in a Fresh Cold-Pressed Juice Treated with Antimicrobial Plant Extracts. *Journal of food science*, *81*(8), M1987-M1995.

Hernández-Pérez, M., López-García, R. E., Rabanal, R. M., Darias, V., & Arias, A. (1994). Antimicrobial activity of *Visnea mocanera* leaf extracts. *Journal of ethnopharmacology*, *41*(1-2), 115-119.

Hill, R. A., Makin, H. L. J., Kirk, D. N., & Morphy, G. M. (1991). Dictionary of Steroids Chemical data, Structures and Bibliographics. *Chapman & Hall Ltd., London*.

Hites, R. A. (2016). Development of gas chromatographic mass spectrometry. *Analytical chemistry*, 88(14), 6955-6961.

Hofmann, T., Nebehaj, E., & Albert, L. (2016). Antioxidant properties and detailed polyphenol profiling of European hornbeam (*Carpinus betulus* L.) leaves by multiple antioxidant capacity assays and high-performance liquid chromatography/multistage electrospray mass spectrometry. *Industrial Crops and Products*, *87*, 340-349.

Horiuchi, K., Shiota, S., Hatano, T., Yoshida, T., Kuroda, T., & Tsuchiya, T. (2007). Antimicrobial activity of oleanolic acid from Salvia officinalis and related compounds on vancomycin-resistant enterococci (VRE). *Biological and*

© COPYRIGHT UPM

Pharmaceutical Bulletin, *30*(6), 1147-1149.

Hossain, M. B., Rai, D. K., Brunton, N. P., Martin-Diana, A. B., & Barry-Ryan, C. (2010). Characterization of phenolic composition in Lamiaceae spices by LC-ESI-MS/MS. *Journal of agricultural and food chemistry*, *58*(19), 10576-10581.

Huang, C. B., George, B., & Ebersole, J. L. (2010). Antimicrobial activity of n-6, n-7 and n-9 fatty acids and their esters for oral microorganisms. *Archives of oral biology*, *55*(8), 555-560.

Hvattum, E., & Ekeberg, D. (2003). Study of the collision-induced radical cleavage of flavonoid glycosides using negative electrospray ionization tandem quadrupole mass spectrometry. *Journal of Mass Spectrometry*, *38*(1), 43-49.

Hwang, S. J., Park, S. J., & Kim, J. D. (2013). Component analysis and antioxidant activity of *Oenanthe javanica* extracts. *Korean Journal of Food Science and Technology*, *45*(2), 227-234.

Indira, G. (2014). In vitro antifungal susceptibility testing of 5 antifungal agents against dermatophytic species by CLSI (M38-A) micro dilution method. *Clinical Microbial*, 3(3).

Ismail, A., Mohamed, M., Sulaiman, S. A., & Wan Ahmad, W. A. N. (2013). Autonomic nervous system mediates the hypotensive effects of aqueous and residual methanolic extracts of Syzygium polyanthum (Wight) Walp. var. polyanthum leaves in anaesthetized rats. *Evidence-Based Complementary and Alternative Medicine*, *2013*.

Jang, H. W., Lee, H. J., & Lee, K. G. (2005). Analysis and antioxidant activity of volatile extracts from plants commonly used in Korean foods. *Korean Journal of Food Science and Technology*, *37*(5), 723-729.

Jiménez, A., Meckes, M., Alvarez, V., Torres, J., & Parra, R. (2005). Secondary metabolites from *Chamaedora tepejilote* (Palmae) are active against *Mycobacterium tuberculosis*. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *19*(4), 320-322.

Jun, H., Kim, J., Bang, J., Kim, H., Beuchat, L. R., & Ryu, J. H. (2013). Combined effects of plant extracts in inhibiting the growth of *Bacillus cereus* in reconstituted infant rice cereal. *International journal of food microbiology*, *160*(3), 260-266.

Käferstein, F. K., Motarjemi, Y., & Bettcher, D. W. (1997). Foodborne disease control: a transnational challenge. *Emerging infectious diseases*, *3*(4), 503.

Klimpel KR, Arora N, Leppla SH. (1994): Anthrax toxin lethal factor contains a zinc metalloprotease consensus sequence which is required for lethal toxin activity. *Molecular Microbiol*.;13:1093.

© COPYRIGHT UPM

Karan, S. K., Mishra, S. K., Pal, D., & Mondal, A. (2012). Isolation of-sitosterol and evaluation of antidiabetic activity of Aristolochia indica in alloxan-induced diabetic mice with a reference to in-vitro antioxidant activity. *Journal of Medicinal Plants Research*, *6*(7), 1219-1223.

Karunanidhi, A., Thomas, R., Van Belkum, A., & Neela, V. (2012). In vitro antibacterial and antibiofilm activities of chlorogenic acid against clinical isolates of *Stenotrophomonas maltophilia* including the trimethoprim/sulfamethoxazole resistant strain. *BioMed research international*, *2013*.

Kaur, G. J., & Arora, D. S. (2009). Antibacterial and phytochemical screening of Anethum graveolens, Foeniculum vulgare and Trachyspermum ammi. *BMC complementary and alternative medicine*, *9*(1), 30.

Keat, N. B., Umar, R. U., Lajis, N. H., Chen, T. Y., Li, T. Y., Rahmani, M., & Sukari, M. A. (2010). Chemical constituents from two weed species of Spermacoce (Rubiaceae). *Malaysian Journal of Analytical Sciences*, *14*, 6-11.

Khanam, S., & Sultana, R. (2012). Isolation of β-sitosterol & stigmasterol as active immunomodulatory constituents from fruits of Solanum xanthocarpum (Solanaceae). *IJPSR*, *3*(4), 1057-60.

Khoo, L. W., Mediani, A., Zolkeflee, N. K. Z., Leong, S. W., Ismail, I. S., Khatib, A., Shaari, K. & Abas, F. (2015). Phytochemical diversity of *Clinacanthus nutans* extracts and their bioactivity correlations elucidated by NMR based metabolomics. *Phytochemistry Letters*, *14*, 123-133.

Kida, N., Mochizuki, Y., & Taguchi, F. (2004). An effective iodide formulation for killing *Bacillus* and *Geobacillus* spores over a wide temperature range. *Journal of applied microbiology*, *97*(2), 402-409.

Kim, B., Bang, J., Kim, H., Kim, Y., Kim, B. S., Beuchat, L. R., & Ryu, J. H. (2014). *Bacillus cereus* and *Bacillus thuringiensis* spores in Korean rice: prevalence and toxin production as affected by production area and degree of milling. *Food microbiology*, *42*, 89-94.

Kim, H. C., Chung, H. Y., Lee, S. Y., Chung, H. Y., Kim, Y. J., Baek, N. I., Kim, S. H., Choi, G. W., Kwon, B. M., Chung, I. S., Kim, D. K. & Park, M. H. (2005). Production of beta-sitosterol by Cell Suspension Culture of Chrysanthemum coronarium L. *Applied Biological Chemistry*, *48*(4), 425-430.

Kim, H. K., Choi, Y. H., & Verpoorte, R. (2006). Metabolomic analysis of Catharanthus roseus using NMR and principal component analysis. In *Plant Metabolomics* (pp. 261-276). Springer, Berlin, Heidelberg.

Kim, J. Y., Kim, K. H., Lee, Y. J., Lee, S. H., Park, J. C., & Nam, D. H. (2009). *Oenanthe javanica* extract accelerates ethanol metabolism in ethanol-treated animals. *BMB reports*, *42*(8), 482-485.

© COPYRIGHT UPM

Kim, S.A., Lee, M.K., Park, T.H. & Rhee, M.S. (2013). A combined intervention using fermented ethanol and supercritical carbon dioxide to control *Bacillus cereus* and *Bacillus subtilis* in rice. *Food Control*. 32(1): 93-98.

Kirk, M. D., Angulo, F. J., Havelaar, A. H., & Black, R. E. (2017). Diarrhoeal disease in children due to contaminated food. *Bulletin of the World Health Organization*, *95*(3), 233.

Klimpel, K. R., Arora, N., & Leppla, S. H. (1994). Anthrax toxin lethal factor contains a zinc metalloprotease consensus sequence which is required for lethal toxin activity. *Molecular microbiology*, *13*(6), 1093-1100.

Kongduang, D., Wungsintaweekul, J., & De-Eknamkul, W. (2008). Biosynthesis of *β*-sitosterol and stigmasterol proceeds exclusively via the mevalonate pathway in cell suspension cultures of Croton stellatopilosus. *Tetrahedron Letters*, *49*(25), 4067-4072.

Kramer, J. M., & Gilbert, R. J. (1989). *Bacillus cereus* and other *Bacillus* species. *Foodborne bacterial pathogens*, *19*, 21-70.

Kumar, A., Ilavarasan, R., Jayachandran, T., Deecaraman, M., Kumar, R. M., Aravindan, P., Padmanabhan, N. & Krishan, M. R. V. (2008). Anti-inflammatory activity of *Syzygium cumini* seed. *African Journal of Biotechnology*, *7*(8).

Kumar, S., Chandra, P., Bajpai, V., Singh, A., Srivastava, M., Mishra, D. K., & Kumar, B. (2015). Rapid qualitative and quantitative analysis of bioactive compounds from Phyllanthus amarus using LC/MS/MS techniques. *Industrial Crops and Products*, *69*, 143-152.

Kunst, F., Ogasawara, N., Moszer, I., Albertini, A. M., Alloni, G. O., Azevedo, V., ... & Borriss, R. (1997). The complete genome sequence of the gram-positive bacterium Bacillus subtilis. *Nature*, *390*(6657), 249.

Kwon, D., Yoon, S., Carter, O., Bailey, G. S., & Dashwood, R. H. (2006). Antioxidant and antigenotoxic activities of Angelica keiskei, *Oenanthe javanica* and *Brassica oleracea* in the *Salmonella* mutagenicity assay and in HCT116 human colon cancer cells. *Biofactors*, *26*(4), 231-244.

Lau, K. Y., Zainin, N. S., Abas, F., & Rukayadi, Y. (2014). Antibacterial and sporicidal activity of Eugenia polyantha Wight against *Bacillus cereus* and *Bacillus subtilis*. *International Journal of Current Microbiol and Applied. Sciences*, *3*(12), 499-510.

Lawal, U., Leong, S. W., Shaari, K., Ismail, I. S., Khatib, A., & Abas, F. (2017). α-Glucosidase Inhibitory and Antioxidant Activities of Different Ipomoea aquatica Cultivars and LC–MS/MS Profiling of the Active Cultivar. *Journal of Food Biochemistry*, *41*(2), e12303.

© COPYRIGHT UPM

Lawrence, H. A., & Palombo, E. A. (2009). Activity of essential oils against *Bacillus subtilis* spores. *Jornal of Microbiol and Biotechnol*, *19*(12), 1590-1595.

Lee, H. Y., Yoo, M. J., & Chung, H. J. (2001). Antibacterial activities in watercress (*Oenanthe javanica* DC) cultivated with different culture methods. *Journal of the Korean Society of Food Culture*, *16*(3), 243-249.

Lee, O. H., & Lee, B. Y. (2010). Antioxidant and antimicrobial activities of individual and combined phenolics in *Olea europaea* leaf extract. *Bioresource technology*, *101*(10), 3751-3754.

Leggett, H. C., Cornwallis, C. K., & West, S. A. (2012). Mechanisms of pathogenesis, infective dose and virulence in human parasites. *PLoS pathogens*, *8*(2), e1002512.

Lianou, A., Panagou, E. Z., & Nychas, G. J. (2016). Microbiological spoilage of foods and beverages. In *The stability and shelf life of food* (pp. 3-42). Woodhead Publishing.

Liu, K. S., Tsao, S. M., & Yin, M. C. (2005). In vitro antibacterial activity of roselle calyx and protocatechuic acid. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *19*(11), 942-945.

Liu, W. H., Hsu, C. C., & Yin, M. C. (2008). In vitro anti-Helicobacter pylori activity of diallyl sulphides and protocatechuic acid. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *22*(1), 53-57.

Logan N, De Vos P. 2009. Bergey"s Manual of Systematic Bacteriology. New York, NY: *Springer Science*.3: 21-128

Logan, N. A., & Halket, G. (2011). Developments in the taxonomy of aerobic, endospore-forming bacteria. In *Endospore-forming Soil Bacteria* (pp. 1-29). Springer, Berlin, Heidelberg.

Lou, Z., Wang, H., Zhu, S., Ma, C., & Wang, Z. (2011). Antibacterial activity and mechanism of action of chlorogenic acid. *Journal of food science*, *76*(6), M398-M403.

Lutz, G., Chavarría, M., Arias, M. L., & Mata-Segreda, J. F. (2006). Microbial degradation of palm (*Elaeis guineensis*) biodiesel. *Revista de biología tropical*, *54*(1), 59-63.

Lv, F., Liang, H., Yuan, Q., & Li, C. (2011). In vitro antimicrobial effects and mechanism of action of selected plant essential oil combinations against four food-related microorganisms. *Food Research International*, *44*(9), 3057-3064.

Ma, C. J., Lee, K. Y., Jeong, E. J., Kim, S. H., Park, J., Choi, Y. H., Kim, Y. C. & Sung, S. H. (2010). Persicarin from water dropwort (*Oenanthe javanica*)

© COPYRIGHT UPM

protects primary cultured rat cortical cells from glutamate-induced neurotoxicity. *Phytotherapy research*, *24*(6), 913-918.

Mahbub, K. R., Hoq, M. M., Ahmed, M. M., & Sarker, A. (2011). In vitro antibacterial activity of *Crescentia cujete* and *Moringa oleifera*. *Bangladesh Research Pubublications Journal*, *5*(4), 337-343.

Maloney, V. (2004). Plant metabolomics. *BioTeach Jornal*, *2*, 92-99.

Manoharan, K. P. (2006). Isolation, characterisation and/or evaluation of plant extracts for anticancer potential (Doctoral dissertation).

Manoharan, K. P., Song, F. J., Benny, T. K. H., & Yang, D. (2007). Triterpenoids from *Eugenia grandis*: structure elucidation by NMR spectroscopy. *Magnetic Resonance in Chemistry*, *45*(3), 279-281.

Maulidiani, H., Khatib, A., Shaari, K., Abas, F., Shitan, M., Kneer, R., Neto, V., & Lajis, N. H. (2012). Discrimination of three pegaga (*Centella*) varieties and determination of growth-lighting effects on metabolites content based on the chemometry of ^{1}H nuclear magnetic resonance spectroscopy. *Journal of Agricultural and Food Chemistry*. 60(1): 410-417.

Maulidiani, M., Mediani, A., Abas, F., Park, Y. S., Park, Y. K., Kim, Y. M., & Gorinstein, S. (2018). 1H NMR and antioxidant profiles of polar and non-polar extracts of persimmon (Diospyros kaki L.)–metabolomics study based on cultivars and origins. *Talanta*, *184*, 277-286.

Meador-Parton, J., & Popham, D. L. (2000). Structural Analysis of *Bacillus subtilis* spore Peptidoglycan during Sporulation. *Journal of bacteriology*, *182*(16), 4491-4499.

Mediani, A., Abas, F., Khatib, A., Tan, C. P., Ismail, I. S., Shaari, K., Ismail, A. & Lajis, N. H. (2015). Phytochemical and biological features of Phyllanthus niruri and Phyllanthus urinaria harvested at different growth stages revealed by 1H NMR-based metabolomics. *Industrial Crops and Products*, *77*, 602-613.

Mediani, A., Abas, F., Ping, T. C., Khatib, A., & Lajis, N. H. (2012). Influence of growth stage and season on the antioxidant constituents of Cosmos caudatus. *Plant foods for human nutrition*, *67*(4), 344-350.

Mena, P., Calani, L., Dall'Asta, C., Galaverna, G., García-Viguera, C., Bruni, R., & Del Rio, D. (2012). Rapid and comprehensive evaluation of (poly) phenolic compounds in pomegranate (Punica granatum L.) juice by UHPLC- MSn. *Molecules*, *17*(12), 14821-14840.

Misra, N. N., Rai, D. K., & Hossain, M. (2015). Analytical techniques for bioactives from seaweed. In *Seaweed Sustainability* (pp. 271-287). Academic Press.

Mohanan, N. and Sivadasan, M. (2002). Flora of Agasthyamala. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. pp. 265.

© COPYRIGHT UPM

Moir, A. (2006). How do spores germinate?. *Journal of applied microbiology*, *101*(3), 526-530.

Mokbel, M. S., & Hashinaga, F. (2005). Evaluation of the antimicrobial activity of extract from limitan (*Citrus grandis* Osbeck) fruit peel. *Pakistan Journal of Biological Sciences*. 8(8): 1090-1095.

Moreira, M. R., Ponce, A. G., Del Valle, C. E., & Roura, S. I. (2005). Inhibitory parameters of essential oils to reduce a foodborne pathogen. *LWT-Food Science and Technology*, *38*(5), 565-570.

Mostafa, A. A., Al-Askar, A. A., Almaary, K. S., Dawoud, T. M., Sholkamy, E. N., & Bakri, M. M. (2018). Antimicrobial activity of some plant extracts against bacterial strains causing food poisoning diseases. *Saudi journal of biological sciences*, *25*(2), 361-366.

Mrutyunjaya Rao, R., Ramakrishna, K., Suresh Babu, K., & Surya Kumar, M. V. (2017). Isolation of Ursolic Acid from Knoxia corymbosa. *Natural Products Chemistry & Research*, *5*(286), 2.

Muniandy, L., Mauris, E. N., Chandrasegaran, J., Khanam, Z., Ul, I., & Bhat, H. (2015). A Preliminary Study on Antimicrobial Activity of Leaf Methanolic Extract from *Eugenia polyantha*. J. Trop. Resour. Sustain. Sci. 3: 242-246.

Musa, W. J., Bialangi, N., Situmeang, B., & Silaban, S. (2018). Triterpenoid compound from metanol extract of mangrove leaves (Sonneratia alba) and anti-cholesterol activity test. *Journal Pendidikan Kimia*, *11*(1), 18-23.

Narzary, H., Islary, A., & Basumatary, S. (2018). Study of antimicrobial properties of six wild vegetables of medicinal value consumed by the Bodos of Assam, India. *Medicinal Plants-International Journal of Phytomedicines and Related Industries*, *10*(4), 363-368.

Negi, P. S. (2012). Plant extracts for the control of bacterial growth: Efficacy, stability and safety issues for food application. *International journal of food microbiology*, *156*(1), 7-17.

Newman, D. J., & Cragg, G. M. (2007). Natural products as sources of new drugs over the last 25 years. *Journal of natural products*, *70*(3), 461-477.

Nicholson, W. L. (2002). Roles of *Bacillus* endospores in the environment. *Cellular and Molecular Life Sciences CMLS*, *59*(3), 410-416.

Nicholson, W. L., Munakata, N., Horneck, G., Melosh, H. J., & Setlow, P. (2000). Resistance of Bacillus endospores to extreme terrestrial and extraterrestrial environments. *Microbiology and molecular biology reviews*, *64*(3), 548-572.

Nitiema, L. W., Savadogo, A., Simpore, J., Dianou, D., & Traore, A. S. (2012). In vitro antimicrobial activity of some phenolic compounds (coumarin and quercetin) against gastroenteritis bacterial strains. *International Journal of*

© COPYRIGHT UPM

Microbiological Research, *3*(3), 183-7.

Nonaka, G. I., AiKo, Y., Aritake, K., & Nishioka, I. (1992). Tannins and related compounds. CXIX. Samarangenins a and b, novel proanthocyanidins with doubly bonded structures, from *Syzygium samarangens* and *S. aqueum*. *Chemical and Pharmaceutical Bulletin*, *40*(10), 2671-2673.

Nonaka, G. I., Ishimaru, K., Watanabe, M., Nishioka, I., Yamauchi, T., & Wan, A. S. (1987). Tannins and Related Compounds. LI. Elucidation of the Stereochemistry of the Triphenoyl Moiety in Castalagin and Vescalagin, and Isolation of 1-O-Galloyl Castalagin from *Eugenia grandis*. *Chemical and pharmaceutical bulletin*, *35*(1), 217-220.

Nyiredy, S. (2000). Solid-liquid extraction strategy on the basis of solvent characterization. *Chromatographia*, *51*(1), S288-S296.

Odiba, J., Musa, A., Hassan, H., Yahay, S., & Okolo, E. (2014). Antimicrobial activity of isolated stigmast-5-en-3-β-ol (β-sitosterol) from honeybee propolis from North-Western, Nigeria. *International Journal of Pharma Sciences and Research*, *5*(12), 908-918.

Okusa, P. N., Penge, O., Devleeschouwer, M., & Duez, P. (2007). Direct and indirect antimicrobial effects and antioxidant activity of Cordia gilletii De Wild (Boraginaceae). *Journal of ethnopharmacology*, *112*(3), 476-481.

Oliveira, G. F. D., Furtado, N. A. J. C., Silva Filho, A. A. D., Martins, C. H. G., Bastos, J. K., & Cunha, W. R. (2007). Antimicrobial activity of *Syzygium cumini* (Myrtaceae) leaves extract. *Brazilian Journal of Microbiology*, *38*(2), 381-384.

Oreopoulou, V., & Tzia, C. (2007). Utilization of plant by-products for the recovery of proteins, dietary fibers, antioxidants, and colorants. In *Utilization of by-products and treatment of waste in the food industry* (pp. 209-232). Springer, Boston, MA.

Ozturk, S., & Ercisli, S. (2006). The chemical composition of essential oil and in vitro antibacterial activities of essential oil and methanol extract of *Ziziphora persica* Bunge. *Journal of ethnopharmacology*, *106*(3), 372-376.

Paidhungat, M., & Setlow, P. (2000). Role of Ger proteins in nutrient and nonnutrient triggering of spore germination in *Bacillus subtilis*. *Journal of Bacteriology*, *182*(9), 2513-2519.

Papp, N. (2004). Antimicrobial activity of extracts of five Hungarian Euphorbia species and some plant metabolits. *Acta Botanica Hungarica*, *46*(3-4), 363-371.

Park JC, Yu YB, Lee JH. (1993). Isolation of steroids and flavonoids from the herb of Oenanthe javanica DC. *Korean Journal of Pharmacognosy*. 24:244–6.

© COPYRIGHT UPM

Parlapani, F. F., Mallouchos, A., Haroutounian, S. A., & Boziaris, I. S. (2017). Volatile organic compounds of microbial and non-microbial origin produced on model fish substrate un-inoculated and inoculated with gilt-head sea bream spoilage bacteria. *LWT-Food Science and Technology*, *78*, 54-62.

Pateh U, Haruna AK, Garba M, Iliya I, Sule IM, Abubakar MS, Ambi AA (2009) Isolation of stigmasterol, β-sitoterol and 2hydroxyhexadecanoic acid methyl ester from the rhizomes of the *Stylochiton lancifolius* Pyer and Kotchy (Araceae).*Nigerian Journal of Pharmaceutical Sciences.*8 (1): 19-25.

Pattiram, P. D., Lasekan, O., Tan, C. P., & Zaidul, I. S. M. (2011). Identification of the aroma-active constituents of the essential oils of Water Dropwort (Oenanthe javanica) and'Kacip Fatimah'(Labisia pumila). *International Food Research Journal*, *18*(3).

Pejin, B., Savic, A., Sokovic, M., Glamoclija, J., Ciric, A., Nikolic, M., Radotic, M. & Mojovic, M. (2014). Further in vitro evaluation of antiradical and antimicrobial activities of phytol. *Natural product research*, *28*(6), 372-376.

Pellati, F., Orlandini, G., Pinetti, D., & Benvenuti, S. (2011). HPLC-DAD and HPLC-ESI-MS/MS methods for metabolite profiling of propolis extracts. *Journal of Pharmaceutical and Biomedical Analysis*, *55*(5), 934-948.

Pereira Beserra, F., Xue, M., Maia, G., Leite Rozza, A., Helena Pellizzon, C., & Jackson, C. (2018). Lupeol, a pentacyclic triterpene, promotes migration, wound closure, and contractile effect in vitro: possible involvement of PI3K/Akt and p38/ERK/MAPK pathways. *Molecules*, *23*(11), 2819.

Perez, R. M. (2003). Antiviral activity of compounds isolated from plants. *Pharmaceutical biology*, *41*(2), 107-157.

Pinto, E., Vale-Silva, L., Cavaleiro, C., & Salgueiro, L. (2009). Antifungal activity of the clove essential oil from *Syzygium aromaticum* on *Candida*, *Aspergillus* and *dermatophyte* species. *Journal of medical microbiology*, *58*(11), 1454-1462.

Pirhonen, T.I., Andersson, M.A., Ja¨a¨ skela¨inen, E.L., Salkinoja- Salonen, M.S., Honkanen-Buzalski, T. and Johansson, T.M.-L. (2005) Biochemical and toxic diversity of *Bacillus cereus* in a pasta and meat dish associated with a food-poisoning case. *Food Microbiol* 22, 87–91.

Prabhakaran, S., Gothandam, K. M., & Sivashanmugam, K. (2011). Phytochemical and antimicrobial properties of Syzygium cumini an ethanomedicinal plant of Javadhu hills. *Research in Pharmacy*, *1*(1), 22-32.

Prachayasittikul, S., Saraban, P., Cherdtrakulkiat, R., Ruchirawat, S., & Prachayasittikul, V. (2010). New bioactive triterpenoids and antimalarial activity of Diospyros rubra Lec. *Excli Journal*, *9*, 1.

Pramai, P., Hamid, N. A. A., Mediani, A., Maulidiani, M., Abas, F., & Jiamyangyuen, S. (2017). Metabolite profiling, antioxidant, and a-glucosidase

© COPYRIGHT UPM

inhibitory activities of germinated rice: nuclear-magnetic-resonance-based metabolomics study. *journal of food and drug analysis*, *30*(1), e1-1.

Prescott, L.M., Harley, J.P. and Klein, D.A. 1993. *Microbiology*. 3rd ed. Wm. C. Brown Publishers.

Priest, F. G. (1993). Systematics and ecology of Bacillus. *Bacillus subtilis and other gram-positive bacteria: Biochemistry, physiology, and molecular genetics*, 1-16.

Provincial, L., Guillén, E., Alonso, V., Gil, M., Roncalés, P., & Beltrán, J. A. (2013). Survival of Vibrio parahaemolyticus and Aeromonas hydrophila in sea bream (Sparus aurata) fillets packaged under enriched CO2 modified atmospheres. *International journal of food microbiology*, *166*(1), 141-147.

Ragasa, C. Y., Tsai, P. W., & Shen, C. C. (2009). Antimicrobial terpenoids from Erigeron sumatrensis. *NRCP Research Journal*, *10*(1), 27-32.

Rahman, H., Rahman, M., Islam, M., & Reza, S. (2011). The importance of forests to protect medicinal plants: a case study of Khadimnagar National Park, Bangladesh. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *7*(4), 283-294.

Rahmana, S. M. M., Muktaa, Z. A., & Hossainb, M. A. (2009). Isolation and characterization of β-sitosterol-D-glycoside from petroleum extract of the leaves of Ocimum sanctum L. *Asian Journal of Food and Agro-Industry*, *2*(1), 39-43.

Raja, S., Palanisami, E., Jothiramshekar, S. & Puthiyapurayil, S. (2015). Chemical Composition and Antimicrobial Activity of Leaf Essential Oil of *Syzygium grande* (Wight) Walp. *Journal of Essential Oil Bearing Plants*, 18:3, 642-646.

Raju, D., Waters, M., Setlow, P., & Sarker, M. R. (2006). Investigating the role of small, acid-soluble spore proteins (SASPs) in the resistance of Clostridium perfringens spores to heat. *BMC microbiology*, *6*(1), 50.

Ramamurthi, K. S., Clapham, K. R., & Losick, R. (2006). Peptide anchoring spore coat assembly to the outer forespore membrane in *Bacillus subtilis*. *Molecular microbiology*, *62*(6), 1547-1557.

Rhayour, K., Bouchikhi, T., Tantaoui-Elaraki, A., Sendide, K., & Remmal, A. (2003). The mechanism of bactericidal action of oregano and clove essential oils and of their phenolic major components on Escherichia coli and Bacillus subtilis. *Journal of essential oil research*, *15*(5), 356-362.

Rivero-Cruz, J. F., Sánchez-Nieto, S., Benítez, G., Casimiro, X., Ibarra-Alvarado, C., Rojas-Molina, A., & Rivero-Cruz, B. (2009). Antibacterial compounds isolated from *Byrsonima crassifolia*. *Rev Latinoamer Quím*, *37*(2), 155-163.

© COPYRIGHT UPM

Rosén, J., Gottfries, J., Muresan, S., Backlund, A., & Oprea, T. I. (2009). Novel chemical space exploration via natural products. *Journal of medicinal chemistry*, *52*(7), 1953-1962.

Rosenkvist, H., & Hansen, Å. (1995). Contamination profiles and characterisation of Bacillus species in wheat bread and raw materials for bread production. *International journal of food microbiology*, *26*(3), 353-363.

Rüger, H. J. (1989). Benthic studies of the northwest African upwelling region: psychrophilic and psychrotrophic bacterial communities from areas with different upwelling intensities. *Marine Ecology Progress Series*, *57*, 45-52.

Rukayadi, Y., Lau, K. Y., Zainin, N. S., Zakaria, M., & Abas, F. (2013). Screening antimicrobial activity of tropical edible medicinal plant extracts against five standard microorganisms for natural food preservative. *International Food Research Journal*, *20*(5), 2905.

Rukayadi, Y., Lee, K., Han, S., Kim, S., & Hwang, J. K. (2009). Antibacterial and sporicidal activity of macelignan isolated from nutmeg (Myristica fragrans Houtt.) against *Bacillus cereus*. *Food Science and Biotechnology*, *18*(5), 1301-1304.

Rukayadi, Y., Shim, J. S., & Hwang, J. K. (2008). Screening of Thai medicinal plants for anticandidal activity. *Mycoses*, *51*(4), 308-312.

Russell, A. D. (1990). Bacterial spores and chemical sporicidal agents. *Clinical microbiology reviews*, *3*(2), 99-119.

Säde, E., Penttinen, K., Björkroth, J., & Hultman, J. (2017). Exploring lot-to-lot variation in spoilage bacterial communities on commercial modified atmosphere packaged beef. *Food microbiology*, *62*, 147-152.

Şahin, F., Karaman, I., Güllüce, M., Öğütçü, H., Şengül, M., Adıgüzel, A.,Öztürk, S. & Kotan, R. (2003). Evaluation of antimicrobial activities of Satureja hortensis L. *Journal of ethnopharmacology*, *87*(1), 61-65.

Samoylenko, V., Jacob, M. R., Khan, S. I., Zhao, J., Tekwani, B. L., Midiwo, J. O., Walker, L. A. & Muhammad, I. (2009). Antimicrobial, antiparasitic and cytotoxic spermine alkaloids from Albizia schimperiana. *Natural product communications*, *4*(6), 1934578X0900400611.

Samy, M. N., Sugimoto, S., Matsunami, K., Otsuka, H., & Kamel, M. S. (2014). One new flavonoid xyloside and one new natural triterpene rhamnoside from the leaves of Syzygium grande. *Phytochemistry Letters*, *10*, 86-90.

Sanchez-Rabaneda, F., Juregui, O., Lamuela-Raventos, R. M., Viladomat, F., Bastida, J. & Codina, C. (2004). Qualitative analysis of phenolic compounds in apple pomace using liquid chromatography coupled to mass spectrometry in tandem mode. *Rapid Communications in Mass Spectrometry*. *RCM*. 18(5): 553- 563.

© COPYRIGHT UPM

Sandhu, A. K., & Gu, L. (2010). Antioxidant capacity, phenolic content, and profiling of phenolic compounds in the seeds, skin, and pulp of Vitis rotundifolia (muscadine grapes) as determined by HPLC-DAD-ESI-MS *Journal of agricultural and food chemistry*, *58*(8), 4681-4692.

Santos, F. J., & Galceran, M. T. (2003). Modern developments in gas chromatography–mass spectrometry-based environmental analysis. *Journal of Chromatography A*, *1000*(1-2), 125-151.

Saraiva, C., da Conceição Fontes, M., Patarata, L., Martins, C., Cadavez, V., & Gonzales-Barron, U. (2016). Modelling the fate of *Listeria monocytogenes* in beef meat stored at refrigeration temperatures under different packaging conditions. *Procedia Food Science*, *7*, 177-180.

Sarrıas, J. A., Valero, M., & Salmeron, M. C. (2003). Elimination of *Bacillus cereus* contamination in raw rice by electron beam irradiation. *Food Microbiology*, *20*(3), 327-332.

Sastry, V. M. V. S., & Rao, G. R. K. (1995). Dioctyl phthalate, and antibacterial compound from the marine brown alga—Sargassum wightii. *Journal of applied Phycology*, *7*(2), 185-186.

Sato, Y., Oketani, H., Singyouchi, K., OHTSUBO, T., KIHARA, M., SHIBATA, H., & HIGUTI, T. (1997). Extraction and purification of effective antimicrobial constituents of Terminalia chebula RETS. against methicillin-resistant Staphylococcus aureus. *Biological and Pharmaceutical Bulletin*, *20*(4), 401-404.

Sen, A., Dhavan, P., Shukla, K. K., Singh, S., & Tejovathi, G. (2012). Analysis of IR, NMR and antimicrobial activity of β-sitosterol isolated from Momordica charantia. *Science Secure Journal of Biotechnology*, *1*(1), 9-13.

Seo, W. H., & Baek, H. H. (2005). Identification of characteristic aroma-active compounds from water dropwort (*Oenanthe javanica* DC.). *Journal of agricultural and food chemistry*, *53*(17), 6766-6770.

Setlow, P. (2003). Spore germination. *Current opinion in microbiology*, *6*(6), 550-556.

Setlow, P. (2006). Spores of Bacillus subtilis: their resistance to and killing by radiation, heat and chemicals. *Journal of applied microbiology*, *101*(3), 514-525.

Setlow, P. (2007). I will survive: DNA protection in bacterial spores. *Trends in microbiology*, *15*(4), 172-180.

Shimbe, R. Y., Tor-Anyiin, T. A., Khan, M. E., & Anyam, J. V. (2016). β-Sitosterol from Hymenocardia acida root extract and its antimicrobial activity. *Journal of Chemical Society of Nigeria*, *41*(1).

© COPYRIGHT UPM

Shin, S. W. (2004). In vitro inhibitory activities of essential oils from Oenanthe javanica DC against Candida and Streptococcus species. *Natural Product Sciences*, *10*(6), 325-329.

Singh, D., Siew, Y., Chong, T., Yew, H., Ho, S., Lim, C., & Koh, H. (2019). Identification of phytoconstituents in Leea indica (Burm. F.) Merr. leaves by high performance liquid chromatography micro time-of- flight mass spectrometry. *Molecules*, *24*(4), 714.

Slepecky, R. A., & Hemphill, H. E. (2006). The genus Bacillus—nonmedical. *The Prokaryotes: Volume 4: Bacteria: Firmicutes, Cyanobacteria*, 530-562.

Slowing, K., Söllhuber, M., Carretero, E., & Villar, A. (1994). Flavonoid glycosides from Eugenia jambos. *Phytochemistry*, *37*(1), 255-258.

Sparkman, O. D., Penton, Z., & Kitson, F. G. (2011). *Gas chromatography and mass spectrometry: a practical guide*. Academic press.

Sticher, O. (2008). Natural product isolation. *Natural product reports*, *25*(3), 517-554.

Stragier, P., & Losick, R. (1996). Molecular genetics of sporulation in Bacillus subtilis. *Annual review of genetics*, *30*(1), 297-341.

Sturm, S., & Seger, C. (2012). Liquid chromatography–nuclear magnetic resonance coupling as alternative to liquid chromatography–mass spectrometry hyphenations: curious option or powerful and complementary routine tool?. *Journal of Chromatography A*, *1259*, 50-61.

Sudjaroen, Y., Hull, W. E., Erben, G., Würtele, G., Changbumrung, S., Ulrich, C. M., & Owen, R. W. (2012). Isolation and characterization of ellagitannins as the major polyphenolic components of Longan (Dimocarpus longan Lour) seeds. *Phytochemistry*, *77*, 226-237.

Sumono, A., & Sd, A. W. (2008). The use of bay leaf (Eugenia polyantha Wight) in dentistry. *Dental Journal (Majalah Kedokteran Gigi)*, *41*(3), 147-150.

Szakiel, A., Ruszkowski, D., Grudniak, A., Kurek, A., Wolska, K. I., Doligalska, M., & Janiszowska, W. (2008). Antibacterial and antiparasitic activity of oleanolic acid and its glycosides isolated from marigold (Calendula officinalis). *Planta Medica*, *74*(14), 1709-1715.

Taguri, T., Tanaka, T., & Kouno, I. (2004). Antimicrobial activity of 10 different plant polyphenols against bacteria causing food-borne disease. *Biological and Pharmaceutical Bulletin*, *27*(12), 1965-1969.

Tajkarimi, M. M., Ibrahim, S. A., & Cliver, D. O. (2010). Antimicrobial herb and spice compounds in food. *Food control*, *21*(9), 1199-1218.

Tan, I.S.and Ramamurthi, K.S. (2013). Spore formation in *Bacillus subtilis*.

© COPYRIGHT UPM

Environmental Microbiology Reports. 6(3): 212-225.

Tanko, Y., Mohammed, A., Okasha, M. A., Umah, A., & Magaji, R. (2008). Anti-nociceptive and anti-inflammatory activities of ethanol extract of *Syzygium aromaticum* flower bud in wistar rats and mice. *African Journal of Traditional, Complementary and Alternative Medicines*, *5*(2), 209-212.

Tassou, C. C., Nychas, G. J., & Board, R. G. (1991). Effect of phenolic compounds and oleuropein on the germination of *Bacillus cereus* T spores. *Biotechnology and applied biochemistry*, *13*(2), 231-237.

Tassou, C.C. (1993). Microbiology of olives with emphasis on the antimicrobial activity of phenolic compounds. Doctoral dissertation, University of Bath, United Kingdom.

Temitayo, A., Isaac, O., & Olugbengab, A. (2012). Structural and antimicrobial studies of coordination compounds of phenylalanine and glycine. *International Journal of Chemistry*, *4*(2), 49.

Tepe, B., Daferera, D., Sokmen, A., Sokmen, M., & Polissiou, M. (2005). Antimicrobial and antioxidant activities of the essential oil and various extracts of Salvia tomentosa Miller (Lamiaceae). *Food chemistry*, *90*(3), 333-340.

Tippayatum, P., & Chonhenchob, V. (2007). Antibacterial activities of thymol, eugenol and nisin against some food spoilage bacteria. *Agriculture and Natural Resources*, *41*(5), 319-323.

Todar (2004): The Genus Bacillus *In Online Textbook of Bacteriology. Science* , Vol. 304, p.1421.

Tor-Anyiin, T. A., Igoli, J. O., & Anyam, J. N. (2016). studies on dacryodes edulis iii: isolation and characterization of gallic acid from methanolic extract of raw (untreated) seeds of dacryodes edulis and its antimicrobial properties. *Journal of Chemical Society of Nigeria*, *41*(1).

Tuominen, A., & Sundman, T. (2013). Stability and oxidation products of hydrolysable tannins in basic conditions detected by HPLC/DAD–ESI/QTOF/MS. *Phytochemical Analysis*, *24*(5), 424-435.

Ultee, A., Bennik, M., & Moezelaar, R. (2002). The phenolic hydroxyl group of carvacrol is essential for action against the food-borne pathogen Bacillus cereus. *Applied and environmental microbiology*, *68*(4), 1561-1568.

Vambe, M., Naidoo, D., Aremu, A. O., Finnie, J. F., & Van Staden, J. (2019). Bioassay-guided purification, GC-MS characterization and quantification of phyto-components in an antibacterial extract of Searsia lancea leaves. *Natural Product Research*, 1-5.

Vandal, J., Abou-Zaid, M. M., Ferroni, G., & Leduc, L. G. (2015). Antimicrobial activity of natural products from the flora of Northern Ontario, Canada.

© COPYRIGHT UPM

Pharmaceutical biology, *53*(6), 800-806.

Vary, P. S., Biedendieck, R., Fuerch, T., Meinhardt, F., Rohde, M., Deckwer, W. D., & Jahn, D. (2007). *Bacillus megaterium*—from simple soil bacterium to industrial protein production host. *Applied microbiology and biotechnology*, *76*(5), 957-967.

Waites WM (1984) Antimicrobial Agents Acting on Bacterial-Spores. *Journal of Applied Bacteriology* 57(3):R6-R6.

Wal, A., Srivastava, R. S., Wal, P., Rai, A., & Sharma, S. (2015). Lupeol as a magical drug. *Pharmaceutical and biological evaluations*, *2*(5), 142-151.

Wang, S. T., Setlow, B., Conlon, E. M., Lyon, J. L., Imamura, D., Sato, T., Stelow, P., Losick, R. & Eichenberger, P. (2006). The forespore line of gene expression in *Bacillus subtilis*. *Journal of molecular biology*, *358*(1), 16-37.

Wang, W. N., Yang, X. B., Liu, H. Z., Huang, Z. M., & Wu, G. X. (2005). Effect of *Oenanthe javanica* flavone on human and duck hepatitis B virus infection *Acta Pharmacologica Sinica*, *26*(5), 587-592.

Watanabe, I., T. Yanai, S. Tamogami, M. Nakamura, and T. Habu. 1979. Volatile components of seri (*Oenanthe stolonifera DC*). *VII International Congress of Essential Oils*, October 7-11, 1977, Kyoto, Japan, p. 442-445.

World Health Organization. (2017). Diarrhoeal disease fact sheet. World Heal Organ Media Cent, 1-4.

Wolfender, J. L., Ndjoko, K., & Hostettmann, K. (2003). Liquid chromatography with ultraviolet absorbance–mass spectrometric detection and with nuclear magnetic resonance spectrometry: a powerful combination for the on-line structural investigation of plant metabolites. *Journal of chromatography A*, *1000*(1-2), 437-455.

Wolska, K. I., Grudniak, A. M., Fiecek, B., Kraczkiewicz-Dowjat, A., & Kurek, A. (2010). Antibacterial activity of oleanolic and ursolic acids and their derivatives. *Central European Journal of Biology*, *5*(5), 543-553.

Wu, H., Guo, J., Chen, S., Liu, X., Zhou, Y., Zhang, X., & Xu, X. (2013). Recent developments in qualitative and quantitative analysis of phytochemical constituents and their metabolites using liquid chromatography–mass spectrometry. *Journal of pharmaceutical and biomedical analysis*, *72*, 267-291.

Wu, V. C., Qiu, X., Benildo, G., Lin, C. S., & Pan, Y. (2009). Application of cranberry concentrate (Vaccinium macrocarpon) to control Escherichia coli O157: H7 in ground beef and its antimicrobial mechanism related to the downregulated slp, hdeA and cfa. *Food microbiology*, *26*(1), 32-38.

© COPYRIGHT UPM

Wu, Y., Jiang, X., Zhang, S., Dai, X., Liu, Y., Tan, H., Gao, L. & Xia, T. (2016).

Quantification of flavonol glycosides in Camellia sinensis by MRM mode of UPLC-QQQ-MS/MS. *Journal of Chromatography B*, *1017*, 10-17.

Yang, S. A., Jung, Y. S., Lee, S. J., Park, S. C., Kim, M. J., Lee, E. J., Byun, H. J., Jhee, K. H. & Lee, S. P. (2014). Hepatoprotective effects of fermented field water-dropwort (*Oenanthe javanica*) extract and its major constituents. *Food and Chemical Toxicology*, *67*, 154-160.

Young, S. B., & Setlow, P. (2003). Mechanisms of killing of *Bacillus subtilis* spores by hypochlorite and chlorine dioxide. *Journal of Applied Microbiology*, *95*(1), 54-67.

Zehl, M., Braunberger, C., Conrad, J., Crnogorac, M., Krasteva, S., Vogler, B., Beifuss, U. & Krenn, L. (2011). Identification and quantification of flavonoids and ellagic acid derivatives in therapeutically important Drosera species by LC–DAD, LC–NMR, NMR, and LC–MS. *Analytical and bioanalytical chemistry*, *400*(8), 2565-2576.

Zhang, Y., Liu, X., Wang, Y., Jiang, P., & Quek, S. (2016). Antibacterial activity and mechanism of cinnamon essential oil against Escherichia coli and Staphylococcus aureus. *Food Control*, *59*, 282-289.

Zhao, L., Zhang, H., Hao, T., & Li, S. (2015). In vitro antibacterial activities and mechanism of sugar fatty acid esters against five food-related bacteria. *Food chemistry*, *187*, 370-377.

© COPYRIGHT UPM