ANTIOXIDANT ACTIVITY, PHENOLICS, POLYPHENOLS AND FLAVONOIDS IN THE RHIZOMES AND LEAVES OF ZINGIBER OFFICINALE VAR. RUBRUM

ABDULLAHI MUHAMMAD

FRSB 2015 20

ANTIOXIDANT ACTIVITY, PHENOLICS, POLYPHENOLS AND FLAVONOIDS IN THE RHIZOMES AND LEAVES OF *ZINGIBER OFFICINALE VAR. RUBRUM*

By

ABDULLAHI MUHAMMAD

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the requirement for Degree of Master of Science

March 2015

DEDICATION

To my family
Mr. Muhammad Abdu and Aisha Muhammad
And all my siblings

Abstract of thesis submitted to the senate of Universiti Putra Malaysia in fulfillment of the requirement for the award of degree of Master of Science

ANTIOXIDANT ACTIVITY, PHENOLICS, POLYPHENOLS AND FLAVONOIDS IN THE RHIZOMES AND LEAVES OF *ZINGIBER OFFICINALE VAR. RUBRUM*

By

ABDULLAHI MUHAMMAD

March 2015

Chairperson: Mariani bnt Mansor, PhD

Faculty: Biotechnology and Biomolecular Sciences

Zingiber officinale var rubrum is a special cultivar of ginger that has distinctive genetic and phenotypic profiles. The use of synthetic antioxidants has been reported to have negative impacts on the consumers, this leads to tremendous increase in the interest for antioxidants from natural dietary sources especially for medicinal plants consumed as foods, beverages, condiments and spices like the ginger. Rhizomes and leaves of the ginger were exhaustively studied for their antioxidant activities (DPPH and FRAP), flavonoids, phenolics, polyphenols and primary metabolites contents. The effects of different growth stages and storage temperatures on the antioxidant activity and levels of phenolics, flavonoids and polyphenols were explored. Using the technique of HPLC, the flavonoid genistein was identified as one of the individual flavonoids in the plant. It was found that the rhizome extracts have the highest antioxidant activities of up to 57.55% DPPH and 20.27mg/g Trolox FRAP concentrations for the 70% methanol extracts. The flavonoid was found to be the most abundant compound among the three (phenolics, polyphenols and flavonoids) studied in the rhizomes whereas polyphenols were the most abundant in the leaves. The rhizomes have significant sugar content of up to 176µg/g Glucose FW and relatively lower protein content 48.50µg/gBSA FW. Storage temperature was found to significantly lead to the deterioration and degradation of phenolics, polyphenols, flavonoids and antioxidant activity. For example, FRAP and DPPH values of the control in the first week were 13.0mg/g Trolox DW and 58.82% respectively, these drastically fell to 7.23mg/g Trolox DW and 7.33% for the FRAP and DPPH respectively after storage at 70^0C for four weeks. Early vegetative stages of growth (8^{th} week after germination) were found to be richer in flavonoids, phenolics, polyphenols, 18.74mg/g Quercetin DW, 4.70mg/g GA DW, and 16.6mg/gGADW respectively. The antioxidant was also higher than the later stages (12^{th} and 16^{th} weeks). The plant has enormous antioxidant content, genistein is identified to be a constituent flavonoid in the rhizomes of *Z. officinale* younger plants have higher antioxidant activity

then older (for example, FRAP in the eighth and twelfth weeks were 16.70 and 14.45mg/gTrolox DW respectively while the DPPH percentage inhibitions were 56.80% and 50.05% for the eighth and twelfth weeks respectively) ones and also storage temperatures have so much effect on the total antioxidant.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KANDUNGAN ANTIOKSIDA, FENOLIK, POLIFENOL DAN FLAVONOID DALAM RIZOM DAN DAUN *ZINGIBER OFFICINALE VAR. RUBRUM*

Oleh

ABDULLAHI MUHAMMAD

Mac 2015

Penerusi: Mariani bnt Mansor, PhD

Fakulti: Bioteknologi dan Sains Biomolekul

Zingiber officinale var rubrum merupakan kultivar halia yang mempunyai profil genetik dan fenotipik tersendiri. Penggunaan antioksida sintetik dilaporkan mempunyai kesan negatif terhadap pengguna, ini membawa kepada peningkatan mendadak dalam kepentingan antioksida daripada sumber semula jadi pemakanan terutamanya tumbuhan ubatan yang digunakan sebagai makanan, minuman, bahan perasa dan rempah seperti halia. Rizom dan daun halia telah dikaji secara menyeluruh bagi aktiviti antioksida (DPPH dan FRAP), flavonoid, fenolik, polifenol dan kandungan metabolit primer. Kesan bagi peringkat pertumbuhan yang berbeza dan suhu penyimpanan terhadap aktiviti antioksida dan tahap fenolik, flavonoid dan polifenol dikaji. Dengan menggunakan teknik HPLC, flavonoid genistein telah dikenal pasti sebagai salah satu flavonoid yang terdapat di dalam tumbuhan tersebut. Ekstrak rizom mempunyai aktiviti antioksida yang tertinggi iaitu 57.55% DPPH dan 20.27mg / g Trolox FRAP bagi ekstrak methanol 70%. Flavonoid merupakan sebatian yang paling banyak terdapat di antara sebatian-sebatian (fenolik, polifenol dan flavonoid) yang dikaji dalam rizom manakala polifenol paling banyak terdapat dalam daun. Rizom mempunyai kandungan gula yang tinggi iaitu 176µg / g Glukosa FW dan kandungan protein yang agak rendah iaitu 48.50µg/ gBSA FW. Suhu penyimpanan mempunyai kesan yang ketara kepada pengurangan dan degradasi fenolik, polifenol, flavonoid dan aktiviti antioksida. Sebagai contoh, nilai kawalan bagi FRAP dan DPPH untuk minggu pertama masing-masing ialah 13.0mg / g Trolox DW dan 58.82%, nilai ini jatuh secara drastik masing-masing kepada 7.23mg / g Trolox DW dan 7.33% selepas empat minggu penyimpanan pada 70°C. Kandungan yang tinggi bagi flavonoid, fenolik, polifenol iaitu masing-masing 18.74mg / g Quercetin DW, 4.70mg / g GA DW, dan 16.6mg / gGADW dikesan pada peringkat awal pertumbuhan vegetatif (minggu ke-8 selepas percambahan). Antioksida juga lebih tinggi berbanding peringkat akhir (minggu ke-12 dan mingu ke-16). Halia mempunyai kandungan antioksida yang sangat banyak, genistein dikenalpasti sebagai flavonoid konstituen yang terdapat dalam rizom *Z. officinale*. Rizom daripada tumbuhan

muda mempunyai aktiviti antioksida yang lebih tinggi berbanding yang lebih tua (contohnya, FRAP dalam minggu kelapan dan kedua belas masing-masing masing-masing ialah 16.70 dan 14.45mg / gTrolox DW manakala peratusan perencatan DPPH masing-masing adalah 56.80% dan 50.05% untuk minggu kelapan dan kedua belas masing-masing) dan juga yang suhu penyimpanan mempunyai begitu banyak kesan ke atas jumlah antioksidan

ACKNOWLEDGEMENTS

My profound gratitude and sincere thanks go to almighty Allah for sparing my life and blessing me with all the opportunities in life. Sincere and heartfelt thanks go to my supervisors Prof. Dr. Maziah Mahmood and Dr. Syahida Ahmad for their unending motherly support and guide throughout my works and beyond. My sincere appreciations are always with my sponsors, Bayero University, Kano without whose efforts the whole journey might not be a successful one. I cannot finish without acknowledging the tremendous help and guide from all my lab members whom I can always count on for guidance, teaching and advises which immensely contributed to the success of this work.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Master of Science.
The members of the Supervisory Committee were as follows:

Maziah Mahmood, PhD
Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Chairperson)

Syahida Ahmad, PhD
Senior Lecturer
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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: ______________________

Signature: ______________________
Name of Member of Supervisory Committee: ______________________

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

^0C	Degree Celsius
µL	Micro liter
$AlCl_3$	Aluminum chloride
ANOVA	Analysis of Variance
BSA	Bovine serum albumin
CAT	Catalase
CD	Copalyl diphosphate
DPPH	1,1-Diphenyl-2-Picrylhydrazil
DW	Dry weight
FRAP	Ferric reducing antioxidant potential
GAE	Gallic acid equivalent
HCl	Hydrochloric acid
HIV	Human Immune Virus
HPLC	high performance liquid chromatography
L	Liter
Ml	milliliter
MPa	Mega Pascal
Na_2CO_3	Sodium carbonate
$NaNO_3$	Sodium Nitrite
NaOH	Sodium hydroxide
NO	Nitric Oxide
Nm	Nanometer
OH	Hydroxyl
POX	Proline Oxidase
RAPD	Random Amplified Polymorphic DNA
ROS	Reactive oxygen species
R_T	Retention time
SOD	Superoxide Desmutase
TPTZ	2,4,6-tri (2-pyridyl)-s-triazine
UV	Ultraviolet

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Ginger (*Zingiber officinale)* is a widely used spice, condiment for foods and beverages and medicinal plant for over 3000 years in Southeast Asian countries of India and China (Vermin and Parkanyi, 2005) It is thought to have originated from Indo-Malayan regions and then spread to other parts of the world through trading, including Africa, Asia Mediterranean and Pacific Islands (Kizhakkayil & Sasikumar, 2011). Ginger is a member of the genus Zingiber, in a family Zingiberacea There are roughly 1,200 species of Zingiberacea belonging to 18 genera world over, out of which 160 species from all the 18 genera are found to be dominant in Malaysian Peninsular (Holttum, 1950).

Medicinal plants are plants that possess therapeutic properties or exert beneficial pharmacological effect on animals. It has been established that the plants which naturally synthesize and accumulate secondary metabolites such as alkaloids, glycosides, tannins, phenols, volatile oils, flavonoids and vitamins possess medicinal properties. These medicinal plants which are often called traditional medicines need to be evaluated, given due recognition and develop as to improve their safety, efficacy, availability and wider application and low cost; [according to World Health Organisation (WHO) reports (Maydel, 1986)].

Surendran, et al, (2004) reported that there are four main cultivars of ginger in Malaysia, Halia Bara (red ginger), Halia Padi, Halia Betel (real ginger) and Halia Udang. (Surendran, et al., 2004). Different cultivars contain varied quantity of essential oils, the pungent compounds (6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol) and thus give a basis for classification and/or differentiation (Salmon et al., 2012)**.** Halia bara can out rightly be differentiated from other ginger types, through genetic and phenotypic studies .Using Phenotypic data, Halia Bara rhizome is reddish, smaller in size and has more pungent smell (Sivasothy et al., 2011). It has red petiole during early stages of growth and the base of its leaf shoot is also reddish. It was reported that using RAPD (Random Amplified Polymorphic DNA), the four main types of ginger found in Malaysia differ in three operon primers: OPA1, OPA8 and OPA20 (Ibrahim and Hussin, 2007). Chromatographic fingerprinting of gingers from five ginger producing countries (Malaysia, Vietnam, China, India and Thailand) was carried out to ascertain the alleged origin of ginger. Using the parameters, hierarchical cluster analysis, principal component analysis, linear discriminate analysis, the ginger profiles were grouped and separated into five (Yudthavorasit et al., 2014).

It has been reported that in Malaysia, *Zingiber officinale* is generally used in the treatment of ailments related to female diseases. These ailments include; post-natal symptoms after birth, and post-partum ailments (Ibrahim, and Hussin, 2007). *Zingiberacea* is also reported to be effective in enhancing blood circulation and the vicious contraction of the uterus during the postpartum (Jamal, et al., 2011). The most widely used methods for treatments with ginger in Malay culture include tonics, decoctions, and ointments. In the Malay folklore, Halia Bara is widely used in the treatments of joint pains, taken as juice and or applied topically as ointment made with vinegar (Ibrahim, and Hussin, 2007). It is also used in the treatment of arthritis (Jamal *et, al.*, 2011; Ramadan, et al., 2011)**.** For time immemorial, ginger has being used in the treatment of ailments like inflammation, rheumatic disorders, motion sickness, colds and gastrointestinal problems (Kimura, et al., 2005).

Antioxidants are substances or nutrients in the diets which have the capacity of preventing or slowing down the oxidative damage posed to the body by free radicals produced during normal cellular respiration and oxidations. Antioxidants act as "free radical scavengers" and hence prevent and repair damage caused by these free radicals. Many ailments are said to be caused and/or triggered by free radicals which include, diabetes, macular degeneration, heart diseases, and even cancers. Antioxidants may also strengthen immunity of the body against many diseases as such can prevent and lower the risk of cancers and many other infections (Brambilla et al., 2008). These free radicals, also called reactive oxygen species, singlet oxygen, hydrogen peroxide, superoxide anion, and hydroxyl radical are produced during normal metabolism and growth in the biological systems (Dragišić Maksimović et al., 2013). Antioxidants are molecules, ions or atoms that are capable of reversing the deterioration of cells caused by reactive oxygen species (ROS). ROS are known to be directly involved in reversing cell degeneration most especially in brain cells (Oboh et al., 2012). Most of the dietary plants that possess antioxidant capacities, have interestingly, demonstrated promising anti-inflammatory properties and thus prevention against oxidative damage (Conforti et al., 2009).

The interest in the studies of antioxidants has increased tremendously over the years due to the health benefits of the antioxidants. This leads to the explorations of several food and medicinal plants for their antioxidant activity. Synthetic antioxidant compound are often consumed for the antioxidant activity they display, but this often comes with side and adverse effects. This necessitates their replacements from naturally derived dietary sources.

1.2 General Objectives

The main aim of this research is to study the antioxidant properties, the secondary metabolites of the rhizomes and leaves of *Zingiber officinale var. rubrum* (*Halia Bara).*

1.3 Specific Objectives

1. To study the effects of different solvents on the extraction of antioxidant activity
2. To study the effects of storage temperatures on the degradation and stability of flavonoids, phenolics, polyphenols and their corresponding antioxidant capacities.
3. To study the flavonoids profiles of the rhizome extracts to determine the participatory flavonoids(s) in the antioxidant using RP-HPLC technique and to determine the primary metabolites profile of the plant.

1.4 Problem Statement

Antioxidants are found to protect the body against various diseases caused by reactive oxygen species (ROS) produced during cellular metabolism. Side and adverse effects through the use and consumptions of synthetic antioxidants lead to the need of their replacements from natural sources and most importantly from plants often consumed as foods, spices, condiments and as beverages (e.g ginger). This tremendous increase in interest and the need for antioxidant from natural sources warrant the study on foods and medicinal plants. This study will help explore the antioxidant properties of *Halia bara* and subsequently encourage or discourage the consumption of *Z. officinale* as an important source of antioxidant.

REFERENCES

Abraham, S. K., & Khandelwal, N. (2013). Ascorbic acid and dietary polyphenol combinations protect against genotoxic damage induced in mice by endogenous nitrosation. *Mutation Research*, *757*(2), 167–72.

Acosta-Estrada, B., Gutiérrez-Uribe, J., & Serna-Saldívar, S. O. (2014). Bound phenolics in foods, a review. *Food Chemistry*, *152*, 46–55.

Agati, G., Biricolti, S., Guidi, L., Ferrini, F., Fini, A., & Tattini, M. (2011). The biosynthesis of flavonoids is enhanced similarly by UV radiation and root zone salinity in *L. vulgare* leaves. *Journal of Plant Physiology*, *168*(3), 204–212.

Agati, G., Brunetti, C., Di Ferdinando, M., Ferrini, F., Pollastri, S., & Tattini, M. (2013). Functional roles of flavonoids in photoprotection: new evidence, lessons from the past. *Plant Physiology and Biochemistry ,72*, 35–45.

Ahmed, N., Konduru, N. K., Ahmad, S., & Owais, M. (2014). Synthesis of flavonoids based novel tetrahydropyran conjugates (Prins products) and their antiproliferative activity against human cancer cell lines. *European Journal of Medicinal Chemistry*, *75*, 233–46.

Ali, B. H., Blunden, G., Tanira, M. O., & Nemmar, A. (2008). Some phytochemical, pharmacological and toxicological properties of ginger *(Zingiber officinale Roscoe*): a review of recent research. *Food and Chemical Toxicology : An International Journal Published for the British Industrial Biological Research Association*, *46*(2), 409–20.

Alvarez-Ospina, H., Rivero Cruz, I., Duarte, G., Bye, R., & Mata, R. (2013). HPLC determination of the major active flavonoids and GC-MS analysis of volatile components of *Dysphania graveolens* (Amaranthaceae). *Phytochemical Analysis : PCA*, *24*(3), 248–54.

Amić, A., Marković, Z., Dimitrić Marković, J. M., Stepanić, V., Lučić, B., & Amić, D. (2014). Towards an improved prediction of the free radical scavenging potency of flavonoids: the significance of double PCET mechanisms. *Food Chemistry*, *152*, 578–85.

Annapareddy, P. (2012). Identifying and quantifying flavonoids in three medicinal Plants By Hplc. *International Journal of Innovative Research and Development*, *1*(8), 344–362.

Apetrei, I. M., & Apetrei, C. (2013). Voltammetric e-tongue for the quantification of total polyphenol content in olive oils. *Food Research International*, *54*(2), 2075–2082.

Apostolakis, A., Grigorakis, S., & Makris, D. P. (2014). Optimisation and comparative kinetics study of polyphenol extraction from live leaves (*Olea europaea*) using heated water/glycerol mixtures. *Separation and Purification Technology*, *128*, 89–95.

Araya, J. J., Zhang, H., Prisinzano, T. E., Mitscher, L. A., & Timmermann, B. N. (2011). Identification ofunprecedented purine-containing compounds, the zingerines, from ginger rhizomes (*Zingiber officinale Roscoe*) using a phase-trafficking approach. *Phytochemistry*, *72*(9), 935–941.

Arslan, M., Ashraf, M., & Shahbaz, M. (2012). Growth stage-based modulation in antioxidant defense system and proline accumulation in two hexaploid wheat (*Triticum aestivum L* .) cultivars differing in salinity tolerance. *Flora*, *207*(5), 388–397.

Babu, P. V. A., Liu, D., & Gilbert, E. R. (2013). Recent advances in understanding the anti-diabetic actions of dietary flavonoids. *The Journal of Nutritional Biochemistry*, *24*(11), 1777–89.

Baker, C. J., Mock, N. M., Whitaker, B. D., Hammond, R. W., Nemchinov, L., Roberts, D. P., & Aver'yanov, A. a. (2014). Characterization of apoplast phenolics: In vitro oxidation of acetosyringone results in a rapid and prolonged increase in the redox potential. *Physiological and Molecular Plant Pathology*, *86*, 57–63.

Balakrishnan, K. V. (2005). *Postharvest and Industrial Processing of Ginger, Ginger: the genus Zingiber*.

Ballus, C. A., Meinhart, A. D., de Souza Campos, F. A., da Silva, L. F. D. O., de Oliveira, A. F., & Godoy, H. T. (2014). A quantitative study on the phenolic compound, tocopherol and fatty acid contents of monovarietal virgin olive oils produced in the southeast region of Brazil. *Food Research International*, *62*, 74–83.

Bangoura, M. L., Nsor-Atindana, J., & Ming, Z. H. (2013). Solvent optimization extraction of antioxidants from foxtail millet species' insoluble fibers and their free radical scavenging properties. *Food Chemistry*, *141*(2), 736–744.

Barreca, D., Bisignano, C., Ginestra, G., Bisignano, G., Bellocco, E., Leuzzi, U., & Gattuso, G. (2013). Polymethoxylated, C- and O-glycosyl flavonoids in tangelo *(Citrus reticulata×Citrus paradisi*) juice and their influence on antioxidant properties. *Food Chemistry*, *141*(2), 1481–1488.

Bashan, Y., & De-Bashan, L. E. (2005). Fresh-weight measurements of roots provide inaccurate estimates of the effects of plant growth-promoting bacteria on root growth: A critical examination. *Soil Biology and Biochemistry*, *37*, 1795–1804.

Bhargava, S., Dhabhai, K., Batra, A., Sharma, A., & Malhotra, B. (2012). Zingiber Officinale : Chemical and phytochemical screening and evaluation of its antimicrobial activities. *Journal of Chemical and Pharmaceutical Research*, *4*(1), 360–364.

Bijak, M., Ponczek, M. B., & Nowak, P. (2014). Polyphenol compounds belonging to flavonoids inhibit activity of coagulation factor X. *International Journal of Biological Macromolecules*, *65*, 129–35.

Borges, G., Degeneve, A., Mullen, W., & Crozier, A. (2010). Identification of flavonoid and phenolic antioxidants in black currants, blueberries, raspberries, red currants, and cranberries. *Journal of Agricultural and Food Chemistry*, *58*(7), 3901–9.

Bourgaud, F., Gravot, a., Milesi, S., & Gontier, E. (2001). Production of plant secondary metabolites: a historical perspective. *Plant Science*, *161*(5), 839–851.

Boussetta, N., Lesaint, O., & Vorobiev, E. (2013). A study of mechanisms involved during the extraction of polyphenols from grape seeds by pulsed electrical discharges. *Innovative Food Science & Emerging Technologies*, *19*, 124–132.

Brambilla, D., Mancuso, C., Scuderi, M. R., Bosco, P., Cantarella, G., Lempereur, L. & Bernardini, R. (2008). The role of antioxidant supplement in immune system, neoplastic, and neurodegenerative disorders: a point of view for an assessment of the risk/benefit profile. *Nutrition Journal*, *7*, 29.

Cao, J., Xia, X., Dai, X., Wang, Q., & Xiao, J. (2014). Chemical composition and bioactivities of flavonoids-rich extract from Davallia cylindrica Ching. *Environmental Toxicology and Pharmacology*, *37*(2), 571–9.

Cardona, F., Andrés-Lacueva, C., Tulipani, S., Tinahones, F. J., & Queipo-Ortuño, M. I. (2013). Benefits of polyphenols on gut microbiota and implications in human health. *The Journal of Nutritional Biochemistry*, *24*(8), 1415–22.

Carrillo, L. C., Londoño-Londoño, J., & Gil, A. (2013). Comparison of polyphenol, methylxanthines and antioxidant activity in Theobroma cacao beans from different cocoa-growing areas in Colombia. *Food Research International*.

Casteele, K. Vande. (1993). Flavonoid biosynthesis in petals of Rhododendron simsii. *Phytochemistry*, *33*(6), 1419–1426.

Cerda, A., Martínez, M. E., Soto, C., Poirrier, P., Perez-Correa, J. R., Vergara-Salinas, J. R., & Zúñiga, M. E. (2013). The enhancement of antioxidant compounds extracted from Thymus vulgaris using enzymes and the effect of extracting solvent. *Food Chemistry*, *139*(1-4), 138–43.

Chahyadi, A., Hartati, R., Wirasutisna, K. R., & Elfahmi. (2014). Boesenbergia Pandurata Roxb., An Indonesian Medicinal Plant: Phytochemistry, Biological Activity, Plant Biotechnology. *Procedia Chemistry*, *13*, 13–37.

Chan, C. W., Deadman, B. J., Manley-Harris, M., Wilkins, A. L., Alber, D. G., & Harry, E. (2013). Analysis of the flavonoid component of bioactive New Zealand mānuka (Leptospermum scoparium) honey and the isolation, characterisation and synthesis of an unusual pyrrole. *Food Chemistry*, *141*(3), 1772–81.

Chan, E. W. C., Lim, Y. Y., Wong, L. F., Lianto, F. S., Wong, S. K., Lim, K. K. & Lim, T. Y. (2008). Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species. *Food Chemistry*, *109*, 477–483.

Chang, F. C., Wang, Y. N., Chen, P. J., & Ko, C. H. (2013). Factors affecting chelating extraction of Cr, Cu, and As from CCA-treated wood. *Journal of Environmental Management*, *122*, 42–46.

Chang, J. S., Wang, K. C., Yeh, C. F., Shieh, D. E., & Chiang, L. C. (2013). Fresh ginger (Zingiber officinale) has anti-viral activity against human respiratory syncytial virus in human respiratory tract cell lines. *Journal of Ethnopharmacology*, *145*(1), 146–51.

Chen, S., Zheng, Y., Fang, J., Liu, Y.-L., & Li, S.-H. (2013). Flavonoids in lotus (Nelumbo) leaves evaluated by HPLC–MSn at the germplasm level. *Food Research International*, *54*(1), 796–803.

Chen, Y. J., Liang, Z. T., Zhu, Y., Xie, G. Y., Tian, M., Zhao, Z. Z., & Qin, M. J. (2014). Tissue-specific metabolites profiling and quantitative analyses of flavonoids in the rhizome of Belamcanda chinensis by combining laser-microdissection with UHPLC-Q/TOF-MS and UHPLC–QqQ-MS. *Talanta*, *130*, 585–597.

Chen, Z., Ma, T., Huang, C., Zhang, L., Zhong, J., Han, J., … Li, J. (2014). Efficiency of transcellular transport and efflux of flavonoids with different glycosidic units from flavonoids of Litsea coreana L. in a MDCK epithelial cell monolayer model. *European Journal of Pharmaceutical Sciences : Official Journal of the European Federation for Pharmaceutical Sciences*, *53*, 69–76.

Cheng, V. J., Bekhit, A. E.-D. a., McConnell, M., Mros, S., & Zhao, J. (2012). Effect of extraction solvent, waste fraction and grape variety on the antimicrobial and antioxidant activities of extracts from wine residue from cool climate. *Food Chemistry*, *134*(1), 474–482.

Cheng, X.-L., Liu, Q., Peng, Y.-B., Qi, L.-W., & Li, P. (2011). Steamed ginger (Zingiber officinale): Changed chemical profile and increased anticancer potential. *Food Chemistry*, *129*(4), 1785–1792.

Cheynier, V., Comte, G., Davies, K. M., Lattanzio, V., & Martens, S. (2013). Plant phenolics: recent advances on their biosynthesis, genetics, and ecophysiology. *Plant Physiology and Biochemistry* ,*72*, 1–20.

Chiou, Y.-S., Wu, J.-C., Huang, Q., Shahidi, F., Wang, Y.-J., Ho, C.-T., & Pan, M.-H. (2014). Metabolic and colonic microbiota transformation may enhance the bioactivities of dietary polyphenols. *Journal of Functional Foods*, *7*(1), 3–25.

Cho, Y. Y., Oh, S., Oh, M. M., & Son, J. E. (2007). Estimation of individual leaf area, fresh weight, and dry weight of hydroponically grown cucumbers (*Cucumis sativus L.*) using leaf length, width, and SPAD value. *Scientia Horticulturae*, *111*, 330–334.

Chua, L. S. (2013). A review on plant-based rutin extraction methods and its pharmacological activities. *Journal of Ethnopharmacology*, *150*(3), 805–817.

Conforti, F., Sosa, S., Marrelli, M., Menichini, F., Statti, G. a., Uzunov, D. & Menichini, F. (2009). The protective ability of Mediterranean dietary plants against the oxidative damage: The role of radical oxygen species in inflammation and the polyphenol, flavonoid and sterol contents. *Food Chemistry*, *112*(3), 587–594.

Crupi, P., Pichierri, A., Basile, T., & Antonacci, D. (2013). Postharvest stilbenes and flavonoids enrichment of table grape cv Redglobe (*Vitis vinifera* L.) as affected by interactive UV-C exposure and storage conditions. *Food Chemistry*, *141*(2), 802–8.

Davies, Kevin M, Bradley, Marie J, Schwinn, Kathy E, Markham, Kenneth R, and P. E. (1993). Flavonoids Biosynthesis in flower petals of five lines of lisianthus (Eustoma grandiflorum Grise). *Plant Science, 9452*(93).

Deng, S.P. andTabatabai, M. A. (1994). Colorimetric determination of reducing. *Soil Biology & Biochemistry*, *26*(4), 473–477.

Díaz-García, M. C., Obón, J. M., Castellar, M. R., Collado, J., & Alacid, M. (2013). Quantification by UHPLC of total individual polyphenols in fruit juices. *Food Chemistry*, *138*(2-3), 938–49.

Ding, M., Leach, M., & Bradley, H. (2013). The effectiveness and safety of ginger for pregnancy-induced nausea and vomiting: a systematic review. *Women and Birth : Journal of the Australian College of Midwives*, *26*(1), 26–30.

Do, Q. D., Angkawijaya, A. E., Tran-Nguyen, P. L., Huynh, L. H., Soetaredjo, F. E., Ismadji, S., & Ju, Y.-H. (2014). Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica. *Journal of Food and Drug Analysis*, *22*(3), 296–302.

Dolores, M., Przygodzka, M., Ciesarova, Z., Kukurova, K., & Zielin, D. (2012). Changes in chemical composition and antioxidative properties of rye ginger cakes during their shelf-life. *Food Chemistry*, *135*, 2965–2973.

Dong, J., Zhang, M., Lu, L., Sun, L., & Xu, M. (2012). Nitric oxide fumigation stimulates flavonoid and phenolic accumulation and enhances antioxidant activity of mushroom. *Food Chemistry*, *135*(3), 1220–5.

Dörnenburg, H., & Knorr, D. (1995). Strategies for the improvement of secondary metabolite production in plant cell cultures. *Enzyme and Microbial Technology*, *17*(8), 674–684.

Dragišić Maksimović, J. J., Milivojević, J. M., Poledica, M. M., Nikolić, M. D., & Maksimović, V. M. (2013). Profiling antioxidant activity of two primocane fruiting red raspberry cultivars (*Autumn bliss and Polka*). *Journal of Food Composition and Analysis*, *31*(2), 173–179.

Du, H., Wu, J., Li, H., Zhong, P.-X., Xu, Y.-J., Li, C.-H., … Wang, L.-S. (2013). Polyphenols and triterpenes from Chaenomeles fruits: chemical analysis and antioxidant activities assessment. *Food Chemistry*, *141*(4), 4260–8.

Dueñas, M., Hernández, T., Estrella, I., & Fernández, D. (2009). Germination as a process to increase the polyphenol content and antioxidant activity of lupin seeds (*Lupinus angustifolius L.*). *Food Chemistry*, *117*(4), 599–607.

Ebrahimi, A., & Schluesener, H. (2012). Natural polyphenols against neurodegenerative disorders: potentials and pitfalls. *Ageing Research Reviews*, *11*(2), 329–45.

Eduarda, M., Silva, C., Guimarães, A. L., Oliveira, A. P. De, Araújo, C. D. S., Alves, J. & Almeida, S. (2012). HPLC-DAD analysis and antioxidant activity of Hymenaea martiana Hayne (Fabaceae). *Journal of Chemical Pharmaceutical Research*, *4*(2), 1160–1166.

Eichholz, I., Huyskens-Keil, S., Keller, A., Ulrich, D., Kroh, L. W., & Rohn, S. (2011). UV-B-induced changes of volatile metabolites and phenolic compounds in blueberries (*Vaccinium corymbosum L.*). *Food Chemistry*, *126*(1), 60–64.

Engida, A. M., Kasim, N. S., Tsigie, Y. A., Ismadji, S., Huynh, L. H., & Ju, Y.-H. (2013). Extraction, identification and quantitative HPLC analysis of flavonoids from sarang semut (*Myrmecodia pendan). Industrial Crops and Products*, *41*, 392–396.

Fanali, C., Dugo, L., & Rocco, A. (2013). Nano-liquid chromatography in nutraceutical analysis: determination of polyphenols in bee pollen. *Journal of Chromatography. A*, *1313*, 270–4.

Farràs, M., Valls, R. M., Fernández-Castillejo, S., Giralt, M., Solà, R., Subirana, I. & Fitó, M. (2013). Olive oil polyphenols enhance the expression of cholesterol efflux related genes in vivo in humans. A randomized controlled trial. *The Journal of Nutritional Biochemistry*, *24*(7), 1334–9.

Fernández-Castané, A., Fehér, T., Carbonell, P., Pauthenier, C., & Faulon, J.-L. (2014). Computer-aided design for metabolic engineering. *Journal of Biotechnology*.

Fernando, I. D. N. S., Abeysinghe, D. C., & Dharmadasa, R. M. (2013). Determination of phenolic contents and antioxidant capacity of different parts of Withania somnifera (L .) Dunal . from three different growth stages. *Industrial Crops & Products*, *50*, 537–539.

Fontana, A. R., & Bottini, R. (2014). High-throughput method based on quick, easy, cheap, effective, rugged and safe followed by liquid chromatography-multi-wavelength detection for the quantification of multiclass polyphenols in wines. *Journal of Chromatography A*. doi:10.1016/j.chroma.2014.03.044

Fortuna, T., Socha, R., Gałkowska, D., & Ro, J. (2014). Phenolic profile and antioxidant activity in selected seeds and sprouts. *Food Chemistry, 143*, 300–306.

Fu, Y., Chen, J., Li, Y.-J., Zheng, Y.-F., & Li, P. (2013). Antioxidant and anti-inflammatory activities of six flavonoids separated from licorice. *Food Chemistry*, *141*(2), 1063–71.

Geethalakshmi, R., Sakravarthi, C., Kritika, T., Arul Kirubakaran, M., & Sarada, D. V. L. (2013). Evaluation of antioxidant and wound healing potentials of *Sphaeranthus amaranthoides Burm*.f. *BioMed Research International*, *2013*, 607109.

Ghasemzadeh, A., Jaafar, H. Z. E., & Rahmat, A. (2010). Synthesis of phenolics and flavonoids in ginger (*Zingiber officinale Roscoe)* and their effects on photosynthesis rate. *International Journal of Molecular Sciences*, *11*(11), 4539–55.

Ghimeray, A. K., Sharma, P., Phoutaxay, P., Salitxay, T., Woo, S. H., Park, S. U., & Park, C. H. (2014). Far infrared irradiation alters total polyphenol, total flavonoid, antioxidant property and quercetin production in tartary buckwheat sprout powder. *Journal of Cereal Science, 59*(2), 167–172.

Gorelick, J., & Bernstein, N. (2014). *Elicitation : An Underutilized Tool in the Development of Medicinal Plants as a Source of Therapeutic Secondary Metabolites*. *Advances in Agronomy* (1st ed., Vol. 124). Elsevier Inc.

Grzanna, R., Lindmark, L., and Frondoza, C. G. (2005). Ginger-an herbal medicinal product with broad anti-inflammatory actions. *Journal of Medicinal Food, 8*, 125–132.

Gülçin, I., Bursal, E., Sehitoğlu, M. H., Bilsel, M., & Gören, A. C. (2010). Polyphenol contents and antioxidant activity of lyophilized aqueous extract of propolis from Erzurum, Turkey. *Food and Chemical Toxicology : An International Journal Published for the British Industrial Biological Research Association*, *48*(8-9), 2227–38.

Gupta, N., Sharma, S. K., Rana, J. C., & Chauhan, R. S. (2011). Expression of flavonoid biosynthesis genes vis-à-vis rutin content variation in different growth stages of *Fagopyrum species. Journal of Plant Physiology*, *168*(17), 2117–23.

Hakiman, M., & Maziah, M. (2009a). Non enzymatic and enzymatic antioxidant activities in aqueous extract of different *Ficus deltoidea accessions, 3*(3), 120–131.

Hakiman, M., & Maziah, M. (2009b). Non enzymatic and enzymatic antioxidant activities in aqueous extract of different Ficus deltoidea accessions. *Journal of Medicinal Plants Research, 3*(3), 120–131.

Han, L., Dong, B., Yang, X., Huang, C., Wang, X., & Wu, X. (2009). Effect of light on flavonoids biosynthesis in red rice rdh. *Agricultural Sciences in China*, *8*(6), 746–752.

Hernandez, Y., Lobo, M., & Gonzalez, M. (2009). Factors affecting sample extraction in the liquid chromatographic determination of organic acids in papaya and pineapple. *Food Chemistry*, *114*(2), 734–741.

Hessien, M., Donia, T., El-gendy, S., & Abou, M. (2013). Unfractionated green tea and ginger polyphenols induce apoptotic , cytotoxic and antioxidant effects in hepatoma cells. *Perspectives in Medicine*, *3*(3), 87–98.

Ho, S.-C., Chang, K.-S., & Lin, C.-C. (2013). Anti-neuroinflammatory capacity of fresh ginger is attributed mainly to 10-gingerol. *Food Chemistry*, *141*(3), 3183–91.

Holttum, R. E. (1950). *The Zingiberaceae of the Malay Peninsula, Gardens Bulletin., Singapore*.

Hori, Y., Miura, T., Hirai, Y., Fukumura, M., Nemoto, Y., Toriizuka, K., & Ida, Y. (2003). Pharmacognostic studies on ginger and related drugs--part 1: five sulfonated compounds from Zingiberis rhizome (Shokyo). *Phytochemistry*, *62*(4), 613–7.

Ibrahim, H. and Hussin, K. (2007). Cultivated ginger of peninsular Malaysia: Utilization profiles and micropropagation. *Gardens'Bulletin Singapore*, *59*, 71–88.

Imm, J., Zhang, G., Chan, L.-Y., Nitteranon, V., & Parkin, K. L. (2010). [6]-Dehydroshogaol, a minor component in ginger rhizome, exhibits quinone reductase inducing and anti-inflammatory activities that rival those of curcumin. *Food Research International*, *43*(8), 2208–2213.

Inbaraj, B. S., Lu, H., Kao, T. H., & Chen, B. H. (2010). Simultaneous determination of phenolic acids and flavonoids in Lycium barbarum Linnaeus by HPLC-DAD-ESI-MS. *Journal of Pharmaceutical and Biomedical Analysis*, *51*(3), 549–56.

Isengard, H.-D., & Heinze, P. (2003). Determination of total water and surface water in sugars. *Food Chemistry*, *82*(1), 169–172.

Jaiswal, A. K., & Abu-Ghannam, N. (2013). Degradation kinetic modelling of color, texture, polyphenols and antioxidant capacity of York cabbage after microwave processing. *Food Research International*, *53*(1), 125–133.

Jamal, J. A., Ghafar, Z. A., & Husain, K. (2011). Medicinal plants used for postnatal care in Malay traditional medicine in the peninsular Malaysia. *Pharmacognosy Journal*, *3*(24), 15–24.

Jara-Palacios, M. J., Hernanz, D., González-Manzano, S., Santos-Buelga, C., Escudero-Gilete, M. L., & Heredia, F. J. (2014). Detailed phenolic composition of white grape by-products by RRLC/MS and measurement of the antioxidant activity. *Talanta*, *125*, 51–57.

Jiang, H., Xie, Z., Koo, H. J., McLaughlin, S. P., Timmermann, B. N., & Gang, D. R. (2006). Metabolic profiling and phylogenetic analysis of medicinal Zingiber species: Tools for authentication of ginger *(Zingiber officinale Rosc)*. *Phytochemistry*, *67*(15), 1673–85.

Jittiwat, J., & Wattanathorn, J. (2012). Ginger pharmacopuncture improves cognitive impairment and oxidative stress following cerebral ischemia. *Journal of Acupuncture and Meridian Studies*, *5*(6), 295–300.

Jordán, M. J., Lax, V., Rota, M. C., Lorán, S., & Sotomayor, J. A. (2013). Effect of the phenological stage on the chemical composition , and antimicrobial and antioxidant properties of *Rosmarinus officinalis* L essential oil and its polyphenolic extract. *Industrial Crops & Products*, *48*, 144–152.

Kai, H., Obuchi, M., Yoshida, H., Watanabe, W., Tsutsumi, S., Park, Y. K., … Kurokawa, M. (2014). In vitro and in vivo anti-influenza virus activities of flavonoids and related compounds as components of Brazilian propolis (AF-08). *Journal of Functional Foods*, *8*, 214–223.

Kalailingam, P., Balasubramanian, K., Kannaian, B., Mohammed, A. K. N., Meenakshisundram, K., Tamilmani, E., & Kaliaperumal, R. (2013). Isolation and quantification of flavonoids from ethanol extract of Costus igneus rhizome (CiREE) and impact of CiREE on hypoglycaemic, electron microscopic studies of pancreas in streptozotocin (STZ)-induced diabetic rats. *Biomedicine and Preventive Nutrition*, *3*(3), 285–297.

Katayama, S., Kukita, T., Ishikawa, E., Nakashima, S., Masuda, S., Kanda, T., … Nakamura, S. (2013). Apple polyphenols suppress antigen presentation of ovalbumin by THP-1-derived dendritic cells. *Food Chemistry*, *138*(2-3), 757–61.

Katsube, T., Tsurunaga, Y., Sugiyama, M., Furuno, T., & Yamasaki, Y. (2009). Effect of air-drying temperature on antioxidant capacity and stability of polyphenolic compounds in mulberry (Morus alba L.) leaves. *Food Chemistry*, *113*(4), 964–969.

Kchaou, W., Abbès, F., Blecker, C., Attia, H., & Besbes, S. (2013). Effects of extraction solvents on phenolic contents and antioxidant activities of Tunisian date varieties (*Phoenix dactylifera L*.). *Industrial Crops and Products*, *45*, 262–269.

Kemperman, R. a., Gross, G., Mondot, S., Possemiers, S., Marzorati, M., Van de Wiele, T. & Vaughan, E. E. (2013). Impact of polyphenols from black tea and red wine/grape juice on a gut model microbiome. *Food Research International*, *53*(2), 659–669.

Khalaf, N. A., Shakya, A. K., Al-othman, A., El-agbar, Z., & Farah, H. (2008). Antioxidant Activity of Some Common Plants. *Turk J Biol*, *32*, 51–55.

Kim, B., Ku, C. S., Pham, T. X., Park, Y., Martin, D. a, Xie, L. &Bolling, B. W. (2013). *Aronia melanocarpa* (chokeberry) polyphenol-rich extract improves antioxidant function and reduces total plasma cholesterol in apolipoprotein E knockout mice. *Nutrition Research (New York, N.Y.)*, *33*(5), 406–13.

Kim, M. J., John, K. M. M., Choi, J. N., Lee, S., Kim, A. J., Kim, Y. M., & Lee, C. H. (2013). Changes in secondary metabolites of green tea during fermentation by *Aspergillus oryzae* and its effect on antioxidant potential. *Food Research International*, *53*(2), 670–677

Kimura, I., Pancho, L. R., and Tsuneki, H. (2005). *Pharmacology of Ginger, Ginger: the genus Zingiber*.

Kiokias, S., & Varzakas, T. (2014). Activity of flavonoids and β-carotene during the auto-oxidative deterioration of model food oil-in water emulsions. *Food Chemistry, 150*, 280–6.

Kizhakkayil, J., & Sasikumar, B. (2011). Diversity, characterization and utilization of ginger: a review. *Plant Genetic Resources*, *9*(03), 464–477.

Ko, M.-J., Cheigh, C.-I., & Chung, M.-S. (2014). Relationship analysis between flavonoids structure and subcritical water extraction (SWE). *Food Chemistry*, *143*, 147–55.

Koffi, E. N., Le Guernevé, C., Lozano, P. R., Meudec, E., Adjé, F. a., Bekro, Y.-A., & Lozano, Y. F. (2013). Polyphenol extraction and characterization of *Justicia secunda Vahl* leaves for traditional medicinal uses. *Industrial Crops and Products*, *49*, 682–689.

Kogawa, K., Kazuma, K., Kato, N., Noda, N., & Suzuki, M. (2007). Biosynthesis of malonylated flavonoid glycosides on the basis of malonyltransferase activity in the petals of *Clitoria ternatea*. *Journal of Plant Physiology*, *164*(7), 886–94.

Kołodziejczyk, K., Sójka, M., Abadias, M., Viñas, I., Guyot, S., & Baron, A. (2013). Polyphenol composition, antioxidant capacity, and antimicrobial activity of the extracts obtained from industrial sour cherry pomace. *Industrial Crops and Products*, *51*, 279–288.

Koyama, K., Ikeda, H., Poudel, P. R., & Goto-Yamamoto, N. (2012). Light quality affects flavonoid biosynthesis in young berries of Cabernet Sauvignon grape. *Phytochemistry*, *78*, 54–64.

Krajewski, S. S., & Narberhaus, F. (2014). Temperature-driven differential gene expression by RNA thermosensors. *Biochimica et Biophysica Acta*.

Kulevanova, S., Stefova, M., Panovska, T. K., & Stafilov, T. (2003). HPLC identification and determination of myricetin , quercetin , kaempferol and total flavonoids in herbal drugs. *Macedonian Pharmaceutical Bulletin*, *30*(2002), 25–30.

Lee, J. E., Kim, G.-S., Park, S., Kim, Y.-H., Kim, M.-B., Lee, W. S., … Shin, S. C. (2014). Determination of chokeberry (Aronia melanocarpa) polyphenol components using liquid chromatography-tandem mass spectrometry: Overall contribution to antioxidant activity. *Food Chemistry, 146*, 1–5.

Leifert, W. R., & Abeywardena, M. Y. (2008). Cardioprotective actions of grape polyphenols. *Nutrition Research (New York, N.Y.)*, *28*(11), 729–37.

Li, B. W., Andrews, K. W., & Pehrsson, P. R. (2002). Individual Sugars, Soluble, and Insoluble Dietary Fiber Contents of 70 High Consumption Foods. *Journal of Food Composition and Analysis*, *15*(6), 715–723

Li, T., Zhu, J., Guo, L., Shi, X., Liu, Y., & Yang, X. (2013). Differential effects of polyphenols-enriched extracts from hawthorn fruit peels and fleshes on cell cycle and apoptosis in human MCF-7 breast carcinoma cells. *Food Chemistry*, *141*(2), 1008–18.

Li, Y. L., Gan, G. P., Zhang, H. Z., Wu, H. Z., Li, C. L., Huang, Y. P., … Liu, J. W. (2007). A flavonoid glycoside isolated from Smilax china L. rhizome in vitro anticancer effects on human cancer cell lines. *Journal of Ethnopharmacology*, *113*(1), 115–124.

Li, Y.-W., Zhang, Y., Zhang, L., Li, X., Yu, J.-B., Zhang, H.-T., … Liu, H.-G. (2014). Protective effect of tea polyphenols on renal ischemia/reperfusion injury via suppressing the activation of TLR4/NF-κB p65 signal pathway. *Gene*, *542*(1), 46–51.

Liang, J., Li, F., Fang, Y., Yang, W., An, X., Zhao, L., … Hu, Q. (2014). Cytotoxicity and apoptotic effects of tea polyphenol-loaded chitosan nanoparticles on human hepatoma HepG2 cells. *Materials Science & Engineering. C, Materials for Biological Applications*, *36*, 7–13.

Liang, Y. H., Ye, M., Yang, W. Z., Qiao, X., Wang, Q., Yang, H. J., … Guo, D. A. (2011). Flavan-3-ols from the rhizomes of Drynaria fortunei. *Phytochemistry*, *72*(14-15), 1876–1882.

Lilamand, M., Kelaiditi, E., Guyonnet, S., Antonelli Incalzi, R., Raynaud-Simon, a, Vellas, B., & Cesari, M. (2014). Flavonoids and arterial stiffness: Promising perspectives. *Nutrition, Metabolism, and Cardiovascular Diseases : NMCD*, 1–7.

Lindholst, C. (2010). Long term stability of cannabis resin and cannabis extracts. *Australian Journal of Forensic Sciences*, *42*(January 2015), 181–190.

Liu, J.-Y., Yu, H.-S., Feng, B., Kang, L.-P., Pang, X., Xiong, C.-Q. &Ma, B.-P. (2013). Selective hydrolysis of flavonoid glycosides by Curvularia lunata. *Chinese Journal of Natural Medicines*, *11*(6), 684–9.

Liu, M., Li, X., Liu, Y., & Cao, B. (2013). Regulation of flavanone 3-hydroxylase gene involved in the flavonoid biosynthesis pathway in response to UV-B radiation and drought stress in the desert plant, Reaumuria soongorica. *Plant Physiology and Biochemistry*, *73*, 161–7.

Liu, N., Liu, W., Wang, D., Zhou, Y., Lin, X., Wang, X., & Li, S. (2013). Purification and partial characterization of polyphenol oxidase from the flower buds of Lonicera japonica Thunb. *Food Chemistry*, *138*(1), 478–83.

Liu, Q., Ha, W., Liu, Z., Xu, J., Tian, Y., Zhou, X., & Mu, X. (2014). 3-Hydroxybutanolide derivatives and flavonoid glucosides from Anoectochilus roxburghii. *Phytochemistry Letters*, *8*, 109–115.

Liu, S., Ju, J., & Xia, G. (2014). Identification of the flavonoid 3'-hydroxylase and flavonoid 3',5'-hydroxylase genes from Antarctic moss and their regulation during abiotic stress. *Gene*. doi:10.1016/j.gene.2014.03.026

Loginov, M., Boussetta, N., Lebovka, N., & Vorobiev, E. (2013). Separation of polyphenols and proteins from flaxseed hull extracts by coagulation and ultrafiltration. *Journal of Membrane Science*, *442*, 177–186.

López, J. M., Imperial, S., Valderrama, R., & Navarro, S. (1993). An improved Bradford protein assay for collagen proteins. *International Journal of Clinical Chemistry*, *220*(1), 91–100.

Lou, S.-N., Hsu, Y.-S., & Ho, C.-T. (2014). Flavonoid compositions and antioxidant activity of calamondin extracts prepared using different solvents. *Journal of Food and Drug Analysis*, (1), 2–7.

Lu, Y., Liu, Z., Wang, Z., & Wei, D. (2006). Quality evaluation of Platycladus orientalis (L.) Franco through simultaneous determination of four bioactive flavonoids by high-performance liquid chromatography. *Journal of Pharmaceutical and Biomedical Analysis*, *41*(4), 1186–90.

Lue, B.-M., Guo, Z., & Xu, X. (2010). Effect of room temperature ionic liquid structure on the enzymatic acylation of flavonoids. *Process Biochemistry*, *45*(8), 1375–1382.

Ma, D., Sun, D., Wang, C., Li, Y., & Guo, T. (2014). Expression of flavonoid biosynthesis genes and accumulation of flavonoid in wheat leaves in response to drought stress. *Plant Physiology and Biochemistry*, *80*, 60–66.

Ma, X., & Gang, D. R. (2006). Metabolic profiling of in vitro micropropagated and conventionally greenhouse grown ginger (*Zingiber officinale*). *Phytochemistry*, *67*, 2239–2255.

Maged, R., Nordin, N., & Abdulla, M. S. (2013). Anti-inflammatory effects of *Zingiber officinale roscoe* involve suppression of nitric oxide and prostaglandin E2 production. *Zanco Journal of Medical Sciences.*, *17*(1), 350–356.

Malik, S., Andrade, S. a. L., Sawaya, A. C. H. F., Bottcher, A., & Mazzafera, P. (2013). Root-zone temperature alters alkaloid synthesis and accumulation in *Catharanthus roseus and Nicotiana tabacum*. *Industrial Crops and Products*, *49*, 318–325.

Manochai, B., Paisooksantivatana, Y., Choi, H., & Hwa, J. (2010). Scientia Horticulturae Variation in DPPH scavenging activity and major volatile oil components of cassumunar ginger , *Zingiber montanum (Koenig)*, in response to water deficit and light intensity. *Scientia Horticulturae*, *126*(4), 462–466.

Marinova, D., Ribarova, F. and Atanassala, M. (2005). Total phenolics and flavonoids in Bulgarian fruits and vegetables. *J. Univ. Chem. Technol. Metallurgy*, *40*, 255–260.

Marinova, D., Ribarova, F., Atanassova, M. (2005). Total phenolics ans total flavonoids in Bulgarian fruits and vegetables. *Metallurgy*, *40*, 255–260.

Martens, S., Knott, J., Seitz, C. a., Janvari, L., Yu, S.-N., & Forkmann, G. (2003). Impact of biochemical pre-studies on specific metabolic engineering strategies of flavonoid biosynthesis in plant tissues. *Biochemical Engineering Journal*, *14*(3), 227–235.

Martens, S., Preuss, A., & Matern, U. (2010). Multifunctional flavonoid dioxygenases: flavonol and anthocyanin biosynthesis in Arabidopsis thaliana L. *Phytochemistry*, *71*(10), 1040–9.

Martín, S., González-Burgos, E., Carretero, M. E., & Gómez-Serranillos, M. P. (2011). Neuroprotective properties of Spanish red wine and its isolated polyphenols on astrocytes. *Food Chemistry*, *128*(1), 40–48.

Martins, N., Barros, L., Santos-Buelga, C., Henriques, M., Silva, S., & Ferreira, I. C. F. R. (2014). Decoction, infusion and hydroalcoholic extract of *Origanum vulgare* L.: Different performances regarding bioactivity and phenolic compounds. *Food Chemistry*, *158*, 73–80.

Mato, M., Onozaki, T., Ozeki, Y., Higeta, D., Itoh, Y., Yoshimoto, Y. & Shibata, M. (2000). Flavonoid biosynthesis in white-flowered Sim carnations (Dianthus caryophyllus). *Scientia Horticulturae*, *84*(3-4), 333–347.

Mattila, P., Astola, J., & Kumpulainen, J. (2000). Determination of flavonoids in plant material by HPLC with diode-array and electro-array detections. *Journal of Agricultural and Food Chemistry*, *48*(12), 5834–41.

Maydel, H. J. (1986). Trees and Shrubs of the Sahel, their characteristics and uses. In *Schriftenreihe der GTZ, Deutsche Gesellschaft fur Technische Zusammenarbit, German Federal Republic* (pp. 66–67).

Md Sarip, M. S., Morad, N. A., Mohamad Ali, N. A., Mohd Yusof, Y. A., & Che Yunus, M. A. (2014). The kinetics of extraction of the medicinal ginger bioactive compounds using hot compressed water. *Separation and Purification Technology*, *124*, 141–147.

Meenakshi, V. K., Gomathy, S., Senthamarai, S., Paripooranaselvi, M., Chamundeswari, K. P., & College, A. P. C. M. (2012). Analysis of vitamins by hplc and phenolic compounds , flavonoids by HPTLC in Microcosmus Exasperatus. *European Journal of Zoological Research*, *1*(4), 105–110.

Mekonnen, A., Kasim, N. S., Asteraye, Y., Ismadji, S., Huong, L., & Ju, Y. (2013). Extraction , identification and quantitative HPLC analysis of flavonoids from sarang semut (*Myrmecodia pendan*). *Industrial Crops & Products*, *41*, 392–396.

Mesomo, M. C., Corazza, M. L., Ndiaye, P. M., Dalla Santa, O. R., Cardozo, L., & Scheer, A. D. P. (2013). Supercritical CO_2 extracts and essential oil of ginger (*Zingiber officinale R.*): Chemical composition and antibacterial activity. *The Journal of Supercritical Fluids*, *80*, 44–49.

Mesomo, M. C., Paula, A. De, Perez, E., Ndiaye, P. M., & Corazza, M. L. (2012). The Journal of Supercritical Fluids Ginger (*Zingiber officinale R* .) extracts obtained using supercritical CO 2 and compressed propane : Kinetics and antioxidant activity evaluation. *The Journal of Supercritical Fluids*, *71*, 102–109.

Milenkovic, D., Jude, B., & Morand, C. (2013). miRNA as molecular target of polyphenols underlying their biological effects. *Free Radical Biology & Medicine*, *64*, 40–51.

Mishra, B. B., Gautam, S., & Sharma, A. (2013). Free phenolics and polyphenol oxidase (PPO): the factors affecting post-cut browning in eggplant (*Solanum melongena*). *Food Chemistry*, *139*(1-4), 105–14. doi:10.1016/j.foodchem.2013.01.074

Mohan, S., & Nandhakumar, L. (2014). Role of various flavonoids: Hypotheses on novel approach to treat diabetes. *Journal of Medical Hypotheses and Ideas*, *8*(1), 1–6.

Mukai, Y., Sun, Y., & Sato, S. (2013). Azuki bean polyphenols intake during lactation upregulate AMPK in male rat offspring exposed to fetal malnutrition. *Nutrition (Burbank, Los Angeles County, Calif.)*, *29*(1), 291–7.

Nagendra, K. L., Manasa, D., Srinivas, P., & Sowbhagya, H. B. (2013). Enzyme-assisted extraction of bioactive compounds from ginger (*Zingiber officinale Roscoe*). *Food Chemistry*, *139*(1-4), 509–514.

Nakamura, T., Coichev, N., & Moya, H. D. (2012). Modified CUPRAC spectrophotometric quantification of total polyphenol content in beer samples using Cu(II)/neocuproine complexes. *Journal of Food Composition and Analysis*, *28*(2), 126–134.

Nijveldt, R. . (2001). Flavonoids : a review of probable mechanism of action and potential applications. *American Journal of Clinical Nutrition*, *74*, 418–425.

O'Sullivan, a. M., O'Callaghan, Y. C., O'Grady, M. N., Hayes, M., Kerry, J. P., & O'Brien, N. M. (2013). The effect of solvents on the antioxidant activity in Caco-2 cells of Irish brown seaweed extracts prepared using accelerated solvent extraction (ASE®). *Journal of Functional Foods*, *5*(2), 940–948.

Oboh, G., Ademiluyi, A. O., & Akinyemi, A. J. (2012). Inhibition of acetylcholinesterase activities and some pro-oxidant induced lipid peroxidation in rat brain by two varieties of ginger (Zingiber officinale). *Experimental and Toxicologic Pathology : Official Journal of the Gesellschaft Für Toxikologische Pathologie*, *64*(4), 315–9.

Ochiai, R., Sugiura, Y., Shioya, Y., Otsuka, K., Katsuragi, Y., & Hashiguchi, T. (2014). Coffee polyphenols improve peripheral endothelial function after glucose loading in healthy male adults. *Nutrition Research (New York, N.Y.)*, *34*(2), 155–9.

Pająk, P., Socha, R., Gałkowska, D., Rożnowski, J., & Fortuna, T. (2014). Phenolic profile and antioxidant activity in selected seeds and sprouts. *Food Chemistry*, *143*, 300–6.

Palai, S.K. and Rout, G. R. (2007). Identification and genetic variation among eight varieties of ginger by using random amplified polymorphic DNA markers. *Plant Biotechnology*, *24*, 417–420.

Pawar, N., Pai, S., Nimbalkar, M., & Dixit, G. (2011). RP-HPLC analysis of phenolic antioxidant compound 6-gingerol from different ginger cultivars. *Food Chemistry*, *126*(3), 1330–1336.

Pérez-Jiménez, J., & Saura-Calixto, F. (2006). Effect of solvent and certain food constituents on different antioxidant capacity assays. *Food Research International*, *39*(7), 791–800.

Perla, V., Holm, D. G., & Jayanty, S. S. (2012). Effects of cooking methods on polyphenols, pigments and antioxidant activity in potato tubers. *LWT - Food Science and Technology*, *45*(2), 161–171.

Petchi, R., Vijaya, C., & Parasuraman, S. (2014). Antidiabetic activity of polyherbal formulation in streptozotocin - Nicotinamide induced diabetic wistar rats. *Journal of Traditional and Complementary Medicine*, *4*(2), 108.

Petersson, E. V., Rosén, J., Turner, C., Danielsson, R., & Hellenäs, K. E. (2006). Critical factors and pitfalls affecting the extraction of acrylamide from foods: An optimisation study. *Analytica Chimica Acta*, *557*(1-2), 287–295. doi:10.1016/j.aca.2005.10.014

Pfundstein, B., El Desouky, S. K., Hull, W. E., Haubner, R., Erben, G., & Owen, R. W. (2010). Polyphenolic compounds in the fruits of Egyptian medicinal plants (Terminalia bellerica, Terminalia chebula and Terminalia horrida): characterization, quantitation and determination of antioxidant capacities. *Phytochemistry*, *71*(10), 1132–48.

Płazek, A., Dubert, F., Kościelniak, J., Tatrzańska, M., Maciejewski, M., Gondek, K., & Zurek, G. (2014). Tolerance of Miscanthus×giganteus to salinity depends on initial weight of rhizomes as well as high accumulation of potassium and proline in leaves. *Industrial Crops and Products*, *52*, 278–285.

Pourcel, L., Routaboul, J. M., Cheynier, V., Lepiniec, L., & Debeaujon, I. (2007). Flavonoid oxidation in plants: from biochemical properties to physiological functions. *Trends in Plant Science*, *12*(1), 29–36.

Pria, Y. (1999). Estimation of Frankia growth using Bradford protein and INT reduction activity estimations : application to inoculum standardization. *FEMS Microbiology Letters*, *69*, 91–95.

Rainha, N., Koci, K., Varela, A., Lima, E., Baptista, J., & Fernandes-ferreira, M. (2013). Phytochemistry HPLC – UV – ESI-MS analysis of phenolic compounds and antioxidant properties of Hypericum undulatum shoot cultures and wild-growing plants. *Phytochemistry*, *86*, 83–91.

Rakić, S., Janković, S., Marčetić, M., Živković, D., & Kuzevski, J. (2014). The impact of storage on the primary and secondary metabolites, antioxidant activity and digestibility of oat grains *(Avena sativa*). *Journal of Functional Foods*, *7*, 373–380.

Ramadan, G., Al-Kahtani, M., and El-Sayed, W. (2011). Anti-inflammatory and Anti-oxidant Properties of *Curcuma longa* (Turmeric) Versus *Zingiber officinale* (Ginger) Rhizomes in Rat Adjuvant-Induced Arthritis. *Inflammation*, *34*(107), 291–301.

Razali, N., Mat-Junit, S., Abdul-Muthalib, A. F., Subramaniam, S., & Abdul-Aziz, A. (2012). Effects of various solvents on the extraction of antioxidant phenolics from the leaves, seeds, veins and skins of *Tamarindus indica* L. *Food Chemistry*, *131*(2), 441–448.

Reboredo-Rodríguez, P., Rey-Salgueiro, L., Regueiro, J., González-Barreiro, C., Cancho-Grande, B., & Simal-Gándara, J. (2014). Ultrasound-assisted emulsification-microextraction for the determination of phenolic compounds in olive oils. *Food Chemistry*, *150*, 128–36.

Redmile-Gordon, M. a, Armenise, E., White, R. P., Hirsch, P. R., & Goulding, K. W. T. (2013). A comparison of two colorimetric assays, based upon Lowry and Bradford techniques, to estimate total protein in soil extracts. *Soil Biology & Biochemistry*, *67*(100), 166–173.

Resende, F. A. da Silva Almeida, C. P., Vilegas, W., & Varanda, E. A. (2014). Differences in the hydroxylation pattern of flavonoids alter their chemoprotective effect against direct- and indirect-acting mutagens. *Food Chemistry*, *155*, 251–255.

Ribas-Agustí, A., Gratacós-Cubarsí, M., Sárraga, C., Guàrdia, M. D., García-Regueiro, J.-A., & Castellari, M. (2014). Stability of phenolic compounds in dry fermented sausages added with cocoa and grape seed extracts. *LWT - Food Science and Technology*, *57*(1), 329–336.

Richard, T., Papastamoulis, Y., Waffo-Teguo, P. & Monti, J.-P. (2013). 3D NMR structure of a complex between the amyloid beta peptide (1-40) and the polyphenol ε-viniferin glucoside: implications in Alzheimer's disease. *Biochimica et Biophysica Acta*, *1830*(11), 5068–5074.

Rocío Teruel, M., Garrido, M. D., Espinosa, M. C., & Linares, M. B. (2015). Effect of different format-solvent rosemary extracts (*Rosmarinus officinalis*) on frozen chicken nuggets quality. *Food Chemistry*, *172*(5957), 40–46.

Rodríguez, Ó., Santacatalina, J. V., Simal, S., Garcia-Perez, J. V., Femenia, A., & Rosselló, C. (2014). Influence of power ultrasound application on drying kinetics of apple and its antioxidant and microstructural properties. *Journal of Food Engineering*, *129*, 21–29.

Roriz, C. L., Barros, L., Carvalho, A. M., Santos-Buelga, C., & Ferreira, I. C. F. R. (2014). Pterospartum tridentatum, Gomphrena globosa and *Cymbopogon citratus:* A phytochemical study focused on antioxidant compounds. *Food Research International*, *62*, 684–693.

Salmon, C. N. A., Bailey-Shaw, Y. A., Hibbert, S., Green, C., Smith, A. M., & Williams, L. a. D. (2012). Characterisation of cultivars of Jamaican ginger (*Zingiber officinale Roscoe*) by HPTLC and HPLC. *Food Chemistry*, *131*(4), 1517–1522.

Santos, C. N. S., Koffas, M., & Stephanopoulos, G. (2011). Optimization of a heterologous pathway for the production of flavonoids from glucose. *Metabolic Engineering*, *13*(4), 392–400.

Saravanan, S., Arunachalam, K., & Parimelazhagan, T. (2014). Antioxidant, analgesic, anti-inflammatory and antipyretic effects of polyphenols from *Passiflora subpeltata* leaves – A promising species of Passiflora. *Industrial Crops and Products*, *54*, 272–280.

Sarkis, J. R., Michel, I., Tessaro, I. C., & Marczak, L. D. F. (2014). Optimization of phenolics extraction from sesame seed cake. *Separation and Purification Technology*, *122*, 506–514.

Schinella, G., Mosca, S., Cienfuegos-Jovellanos, E., Pasamar, M. Á., Muguerza, B., Ramón, D., & Ríos, J. L. (2010). Antioxidant properties of polyphenol-rich cocoa products industrially processed. *Food Research International*, *43*(6), 1614–1623.

Sekmen, A. H., Turkan, I., Tanyolac, Z. O., Ozfidan, C., & Dinc, A. (2012). Different antioxidant defense responses to salt stress during germination and vegetative stages of endemic halophyte Gypsophila oblanceolata Bark . *Environmental and Experimental Botany*, *77*, 63–76.

Shanmugam, K. R., Mallikarjuna, K., Kesireddy, N., & Sathyavelu Reddy, K. (2011). Neuroprotective effect of ginger on anti-oxidant enzymes in streptozotocin-induced diabetic rats. *Food and Chemical Toxicology : An International Journal Published for the British Industrial Biological Research Association*, *49*(4), 893–7.

Shao, Y., Xu, F., Sun, X., Bao, J., & Beta, T. (2014). Phenolic acids , anthocyanins , and antioxidant capacity in rice (Oryza sativa L .) grains at four stages of development after flowering. *Food Chemistry*, *143*, 90–96.

Shu, P., Hong, J.-L., Wu, G., Yu, B.-Y., & Qin, M.-J. (2010). Analysis of flavonoids and phenolic acids in Iris tectorum by HPLC-DAD-ESI-MSn. *Chinese Journal of Natural Medicines*, *8*(3), 202–207.

Silva, S. D., Feliciano, R. P., Boas, L. V, & Bronze, M. R. (2014). Application of FTIR-ATR to Moscatel dessert wines for prediction of total phenolic and flavonoid contents and antioxidant capacity. *Food Chemistry*, *150*, 489–93.

Simirgiotis, M. J., & Schmeda-Hirschmann, G. (2010). Determination of phenolic composition and antioxidant activity in fruits, rhizomes and leaves of the white strawberry (Fragaria chiloensis spp. chiloensis form chiloensis) using HPLC-DAD-ESI-MS and free radical quenching techniques. *Journal of Food Composition and Analysis*, *23*(6), 545–553.

Sivasothy, Y., Chong, W. K., Hamid, A., Eldeen, I. M., Sulaiman, S. F., & Awang, K. (2011). Essential oils of Zingiber officinale var. rubrum Theilade and their antibacterial activities. *Food Chemistry*, *124*(2), 514–517.

Sommella, E., Pepe, G., Pagano, F., Carlo, G., Manfra, M., Calabrese, G. & Lucano, A. (2013). UHPLC profiling and effects on LPS-stimulated J774A . 1 macrophages of flavonoids from bergamot (Citrus bergamia) juice , an underestimated waste product with high anti-inflammatory potential. *Journal of Functional Foods*, *7*, 641–649.

Somogyi, T., & Iriving, C. I. (1944). for Examination of the Nelson-Somogyi Method the Determination of Reducing. *Analytical Chemistry*, *15*, 373–381.

Sousa, A., Ferreira, I. C. F. R., Barros, L., Bento, A., & Pereira, J. A. (2008). Effect of solvent and extraction temperatures on the antioxidant potential of traditional stoned table olives 'alcaparras'. *LWT - Food Science and Technology*, *41*(4), 739–745.

Strehl, R., Schumacher, K., de Vries, U., & Minuth, W. W. (2002). Proliferating cells versus differentiated cells in tissue engineering. *Tissue Engineering*, *8*(1), 37–42.

Süntar, I., Akkol, E. K., Senol, F. S., Keles, H., & Orhan, I. E. (2011). Investigating wound healing, tyrosinase inhibitory and antioxidant activities of the ethanol extracts of Salvia cryptantha and Salvia cyanescens using in vivo and in vitro experimental models. *Journal of Ethnopharmacology*, *135*(1), 71–7.

Surendran, E., Ravindran, P., and Remadevi, R. (2004). *Properties and Medicinal Uses of Ginger, in Ginger*, CRC Press,India

Taleon, V., Dykes, L., Rooney, W. L., & Rooney, L. W. (2014). Environmental effect on flavonoid concentrations and profiles of red and lemon-yellow sorghum grains. *Journal of Food Composition and Analysis*.

Tao, Y., Zhang, Z., & Sun, D.-W. (2014). Kinetic modeling of ultrasound-assisted extraction of phenolic compounds from grape marc: Influence of acoustic energy density and temperature. *Ultrasonics Sonochemistry*, *21*(4), 1461–9.

Teh, S.-S., & Birch, E. J. (2014). Effect of ultrasonic treatment on the polyphenol content and antioxidant capacity of extract from defatted hemp, flax and canola seed cakes. *Ultrasonics Sonochemistry*, *21*(1), 346–53.

Teles, S., Alberto, J., Muniz, L., Oliveira, D., Malheiro, R., Lucchese, A. M., & Silva, F. (2014). Lippia origanoides H . B . K . essential oil production , composition , and antioxidant activity under organic and mineral fertilization : Effect of harvest moment. *Industrial Crops & Products*, *60*, 217–225.

Tenore, G. C., Campiglia, P., Ritieni, A., & Novellino, E. (2013). In vitro bioaccessibility, bioavailability and plasma protein interaction of polyphenols from Annurca apple (M. pumila Miller cv Annurca). *Food Chemistry*, *141*(4), 3519–24.

Ti, H., Li, Q., Zhang, R., Zhang, M., Deng, Y., Wei, Z. & Zhang, Y. (2014). Free and bound phenolic profiles and antioxidant activity of milled fractions of different indica rice varieties cultivated in southern China. *Food Chemistry*, *159*, 166–174.

Tkáˇ, J., Petruš, L., & Hrabárová, E. (2000). Determination of total sugars in lignocellulose hydrolysate by a mediated Gluconobacter oxydans biosensor. *Analytica Chimica Acta*, *420*, 1–7.

Tlili, N., Mejri, H., Yahia, Y., Saadaoui, E., Rejeb, S., & Khaldi, A. (2014). Phytochemicals and antioxidant activities of *Rhus tripartitum* (Ucria) fruits depending on locality and different stages of maturity. *Food Chemistry*, *160*, 98–103.

Trantas, E., Panopoulos, N., & Ververidis, F. (2009). Metabolic engineering of the complete pathway leading to heterologous biosynthesis of various flavonoids and stilbenoids in Saccharomyces cerevisiae. *Metabolic Engineering*, *11*(6), 355–66.

Tresserra-Rimbau, A., Medina-Remón, A., Pérez-Jiménez, J., Martínez-González, M. A., Covas, M. I., Corella, D. & Lamuela-Raventós, R. M. (2013). Dietary intake and major food sources of polyphenols in a Spanish population at high cardiovascular risk: the PREDIMED study. *Nutrition, Metabolism, and Cardiovascular Diseases* , *23*(10), 953–9.

Tsukakoshi, Y., Naito, S., Ishida, N., & Yasui, A. (2009). Variation in moisture , total sugar , and carotene content of Japanese carrots : Use in sample size determination. *Journal of Food Composition and Analysis*, *22*, 373–380.

Tulio, A. Z., Jablonski, J. E., Jackson, L. S., Chang, C., Edirisinghe, I., & Burton-Freeman, B. (2014). Phenolic composition, antioxidant properties, and endothelial cell function of red and white cranberry fruits. *Food Chemistry*, *157*, 540–52.

Vermin, G. and Parkanyi, C. (2005). Chemistry of ginger, ginger the genus. *Zingiber*, *41*(87).

Vetrani, C., Rivellese, A. a., Annuzzi, G., Mattila, I., Meudec, E., Hyötyläinen, T. & Aura, A.-M. (2014). Phenolic metabolites as compliance biomarker for polyphenol intake in a randomized controlled human intervention. *Food Research International*, 1–6.

Vijendra Kumar, N., Murthy, P. S., Manjunatha, J. R., & Bettadaiah, B. K. (2014). Synthesis and quorum sensing inhibitory activity of key phenolic compounds of ginger and their derivatives. *Food Chemistry*, *159*, 451–457.

Vilano, D., Fernandez-Pachon, M.S., Moya, M.L., Toronscoso, A.M., Garcia-Parilla, M. C. (2007). Radical Scavenging ability of phenolics compounds towards DPPH free radical. *Talanta*, *71*, 230–235.

Walter, G. and Niehaus, J. (1989). Versicolorin Synthesis by Aspergillus parasiticus : Temperature and Zinc ’ Regulation by. *Experimental Mycology*, *26*, 20–26.

Wang, Y., Gao, L., Shan, Y., Liu, Y., Tian, Y., & Xia, T. (2012). Influence of shade on flavonoid biosynthesis in tea (*Camellia sinensis (L.) O. Kuntze*). *Scientia Horticulturae*, *141*, 7–16.

Wanyo, P., Meeso, N., & Siriamornpun, S. (2014). Effects of different treatments on the antioxidant properties and phenolic compounds of rice bran and rice husk. *Food Chemistry*, *157*, 457–63.

Wei, Q.-Y., Ma, J.-P., Cai, Y.-J., Yang, L., & Liu, Z.-L. (2005). Cytotoxic and apoptotic activities of diarylheptanoids and gingerol-related compounds from the rhizome of Chinese ginger. *Journal of Ethnopharmacology*, *102*(2), 177–84.

Wei, Y., Peng, A.-Y., Wang, B., Ma, L., Peng, G., Du, Y., & Tang, J. (2014). Synthesis and biological evaluation of phosphorylated flavonoids as potent and selective inhibitors of cholesterol esterase. *European Journal of Medicinal Chemistry*, *74*, 751–8.

Wen, L., Wu, D., Jiang, Y., Prasad, K. N., Lin, S., Jiang, G. & Yang, B. (2014). Identification of flavonoids in litchi (Litchi chinensis Sonn.) leaf and evaluation of anticancer activities. *Journal of Functional Foods*, *6*, 555–563.

Whiting, A. (1979). Stages in the biosynthesis of [6] -gingero1 in Zingiber offinale. *J.C.S. Chemical Communication*, (1152), 1151–1153.

Wilczyńska, A. (2014). Effect of filtration on colour, antioxidant activity and total phenolics of honey. *LWT - Food Science and Technology*, *57*(2), 767–774.

Wojdyło, A., Teleszko, M., & Oszmiański, J. (2014). Antioxidant property and storage stability of quince juice phenolic compounds. *Food Chemistry*, *152*, 261–70.

Wu, Z., Li, H., Yang, Y., Zhan, Y., & Tu, D. (2013). Variation in the components and antioxidant activity of *Citrus medica L . var . sarcodactylis* essential oils at different stages of maturity. *Industrial Crops & Products*, *46*, 311–316.

Xi, J., Xue, Y., Xu, Y., & Shen, Y. (2013). Artificial neural network modeling and optimization of ultrahigh pressure extraction of green tea polyphenols. *Food Chemistry*, *141*(1), 320–326.

Xiao-li, H., Fang, C., Ying-bo, Z., & Hong-zhe, T. (2011). Determination of five flavonoids in honeys by HPLC-ESI-MS/MS. In *Proceedings of 2011 International Conference on Electronic & Mechanical Engineering and Information Technology* (pp. 1773–1776). Ieee.

Xu, C., Yagiz, Y., Borejsza-Wysocki, W., Lu, J., Gu, L., Ramírez-Rodrigues, M. M., & Marshall, M. R. (2014). Enzyme release of phenolics from muscadine grape (Vitis rotundifolia Michx.) skins and seeds. *Food Chemistry*, *157*, 20–9.

Yan, S., Li, L., He, L., Liang, L., & Li, X. (2013). Maturity and cooling rate affects browning, polyphenol oxidase activity and gene expression of 'Yali' pears during storage. *Postharvest Biology and Technology*, *85*, 39–44.

Yang, Z.-F., Bai, L.-P., Huang, W.-B., Li, X.-Z., Zhao, S.-S., Zhong, N.-S., & Jiang, Z.-H. (2014). Comparison of in vitro antiviral activity of tea polyphenols against influenza A and B viruses and structure-activity relationship analysis. *Fitoterapia*, *93*, 47–53.

Yao, L., Jiang, Y., Datta, N., Singanusong, R., & Liu, X. (2004). HPLC analyses of flavanols and phenolic acids in the fresh young shoots of tea (*Camellia sinensis*) grown in Australia, *84*, 253–263.

Yeh, H., Chuang, C., Chen, H., Wan, C., Chen, T., & Lin, L. (2014). Bioactive components analysis of two various gingers (*Zingiber of fi cinale Roscoe*) and antioxidant effect of ginger extracts. *LWT - Food Science and Technology*, *55*(1), 329–334.

Yoo, H., Chae, H.-S., Kim, Y.-M., Kang, M., Ryu, K. H., Ahn, H. C. & Kim, J. (2014). Flavonoids and arylbenzofurans from the rhizomes and roots of Sophora tonkinensis with IL-6 production inhibitory activity. *Bioorganic & Medicinal Chemistry Letters*, *24*(24), 5644–5647.

Yosr, Z., Hnia, C., Rim, T., & Mohamed, B. (2013). Changes in essential oil composition and phenolic fraction in *Rosmarinus officinalis L . var . typicus Batt* . organs during growth and incidence on the antioxidant activity. *Industrial Crops & Products*, *43*, 412–419.

Yu, J., Ahmedna, M., & Goktepe, I. (2005). Effects of processing methods and extraction solvents on concentration and antioxidant activity of peanut skin phenolics. *Food Chemistry*, *90*(1-2), 199–206.

Yu, Y., Xu, Y., Wu, J., Xiao, G., Fu, M., & Zhang, Y. (2014). Effect of ultra-high pressure homogenisation processing on phenolic compounds, antioxidant capacity and anti-glucosidase of mulberry juice. *Food Chemistry*, *153*, 114–20.

Yudthavorasit, S., Wongravee, K., & Leepipatpiboon, N. (2014). Characteristic fingerprint based on gingerol derivative analysis for discrimination of ginger (*Zingiber officinale*) according to geographical origin using HPLC-DAD combined with chemometrics. *Food Chemistry*, *158*, 101–111.

Yusoff, A., Kumara, N. T. R. N., Lim, A., Ekanayake, P., & Tennakoon, K. U. (2014). Impacts of temperature on the stability of tropical plant pigments as sensitizers for dye sensitized solar cells. *Journal of Biophysics*, *2014*. doi:10.1155/2014/739514

Zachariah, T. J. (2008). *Ginger In: Chemistry of Spices. Parthasarathy, VA, Chempakam, B., Zachariah, TJ (Ed), CAB International, Oxfordshire, UK, pp. 70-96.*

Zaidi, J. H., Qureshi, I. H., Arif, M., and Fatima, I. (1992). *Trace Element Analysis of Food Spices by Inaa, International Journal of Environmental Analytical Chemistry 48, 33-40. 111*. (Vol. 48).

Zhang, H.-F., Zhang, X., Yang, X.-H., Qiu, N.-X., Wang, Y., & Wang, Z, Z. (2013). Microwave assisted extraction of flavonoids from cultivated *Epimedium sagittatum:* Extraction yield and mechanism, antioxidant activity and chemical composition. *Industrial Crops and Products, 50*, 857–865.

Zhang, L., Tu, Z., Yuan, T., Wang, H., Fu, Z., Wen, Q., & Wang, X. (2014). Solvent optimization, antioxidant activity, and chemical characterization of extracts from Artemisia selengnesis Turcz. *Industrial Crops and Products, 56*, 223–230.

Zhang, X., Chen, F., & Wang, M. (2013). Impacts of selected dietary polyphenols on caramelization in model systems. *Food Chemistry*, *141*(4), 3451–8.

Zucca, P., Sanjust, E., Loi, M., Sollai, F., Ballero, M., Pintus, M., & Rescigno, A. (2013). Isolation and characterization of polyphenol oxidase from Sardinian poisonous and non-poisonous chemotypes of Ferula communis (L.). *Phytochemistry*, *90*, 16–24.

Zujko, M. E., Witkowska, a M., Waśkiewicz, a, & Sygnowska, E. (2012). Estimation of dietary intake and patterns of polyphenol consumption in Polish adult population. *Advances in Medical Sciences*, *57*(2), 375–84.

LIST OF PUBLICATIONS

Conference Proceedings

1. **Abdullahi Muhammad**, Maziah Mahmood and Syahida Ahmad. *Zingiberacea officinale var rubrum (*halia bara): In vitro antioxidant, flavonoids profiling, Effects of temperature and growth stages on the synthesis of total antioxidants activity. Malaysian society of molecular biology and biotechnology conference 2014. Monash University Malaysia,

2. Abdullahi Muhammad, Maziah Mahmood and Syahida Ahmad. In vitro antioxidant and flavonoids profiling of *Zingiberacea officinale var. rubrum* ***(halia** bara).* International Conference on Advances in Plant Biochemistry and Biotechnology (APBB), 2014.

3. Abdullahi Muhammad, Maziah Mahmood and Syahida Ahmad. Antioxidant, Phenolics, Polyphenols and Flavonoids Contents in *Zingiber Officinale* Var. *Rubrum* Rhizomes and Leaves. 22nd Biotech Colloquim 2014

Publications

1. **Abdullahi Muhammad**, Maziah Mahmood and Syahida Ahmad. Effects of growth stages and storage temperatures on the total antioxidants activity of *Zingiber officinale var. rubrum.* Pakistan Journal of Pharmaceutical Sciences. Submitted

2. **Abdullahi Muhammad**, Maziah Mahmood and Syahida Ahmad. In vitro antioxidant, total flavonoids, phenolics and polyphenols of *Zingiber officinale* var. *rubrum* leaf and rhizome extracts. *Food Chemistry.* Submitted

UNIVERSITI PUTRA MALAYSIA

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : ________________

TITLE OF THESIS / PROJECT REPORT :
Antioxidant Activity, Phenolics, Polyphenols and Flavonoids in the Rhizomes and Leaves of Zingiber Officinale var. Rubrum.

NAME OF STUDENT : Abdullahi Muhammad

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	CONFIDENTIAL	(Contain confidential information under Official Secret Act 1972).
☐	RESTRICTED	(Contains restricted information as specified by the organization/institution where research was done).
☐	OPEN ACCESS	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐	PATENT	Embargo from ____________ (date) until ____________ (date)

Approved by:

____________________	____________________
(Signature of Student)	(Signature of Chairman of Supervisory Committee)
New IC No/ Passport No.:	Name:
Date :	Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]