

HAIR GROWTH AND HAIR TANNING ACTIVITIES
OF MANGOSTEEN PERICARP WATER EXTRACT ON HAIR DERMAL
PAPILLA CELLS

TAN YING FANG

Universiti Teknologi Malaysia

HAIR GROWTH AND HAIR TANNING ACTIVITIES
OF MANGOSTEEN PERICARP WATER EXTRACT ON HAIR DERMAL
PAPILLA CELLS

TAN YING FANG

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Bioprocess)

Faculty of Chemical and Energy Engineering
Universiti Teknologi Malaysia

AUGUST 2016

To my beloved grandmum.

ACKNOWLEDGEMENTS

After an intensive period of two years, today is the day: writing this note of thanks is the finishing touch on my thesis. It has been a period of intense learning for me, not only in the scientific arena, but also on a personal level. Writing this thesis has had a big impact on me. Firstly, I am deeply grateful to my supervisor, Dr. Mariani Abdul Hamid for the giving me an opportunity to conduct my research and further my thesis at Institute of Bioproduct Development, Universiti Teknologi Malaysia. She gave me the freedom to explore on my own and at the same time the guidance to recover when my steps faltered. Furthermore, a big appreciation to my co-supervisor, Dr. Razauden Mohamed Zulkifli for his continuous encouragement, guidance and practical advice.

I would like to thank my seniors and lab mates, Helmi, YinShin and Atiqah from Nutritional Biochemical Lab, Faculty of Biomedical Engineering for their wonderful collaboration and were always willing to teach, guide and help me when i having any problems throughout the research study. In addition, i am also grateful to the lab staff at UTM, for their various forms of support during my research study. Furthermore, my friends, particularly, SukLin, Elaine and Kiew have helped me stay sane through these difficult years. Their support and care helped me overcome setbacks and stay focused on my graduate study. I would also like to thank them for their wise counsel and sympathetic ear.

Most importantly, none of this would have been possible without the love and patience of my family. My parents to whom this thesis is dedicated to, has been a constant source of love, concern, support and strength all these years. I would like to express my heart-felt gratitude to them and i warmly appreciate the generosity and understanding of them.

ABSTRACT

Hair graying represents the most common phenomena of human, and the number of men and women who suffer hair loss is increasing in accordance with changes in lifestyle and nutritional balance. Thus, it is important to develop new therapies to enhance hair growth activity as well as hair tanning. In this study, water extract of mangosteen pericarp was used to investigate its hair growth and tanning activities on hair dermal papilla cells. The mangosteen pericarp extract was found to contain 3.706 mg/ml protein, 0.519 mg/ml polysaccharide, 5.103 gallic acid equivalents mg/g total phenolic content and 1.503 quercetin equivalent mg/g total flavonoid content. Mangosteen pericarp extract showed high IC_{50} values in both 2,2-diphenyl-1-picrylhydrazyl and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) assays (4.142 mg/ml and 2.373 mg/ml, respectively). This indicated that mangosteen pericarp water extract has low antioxidant activity. The effect of mangosteen pericarp extract on the cellular mitochondrial activity, viability and cytotoxicity of hair dermal papilla cells were measured by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide and Sulforhodamine B assays. It was found that the highest concentration of the extract which did not affect the cell viability was 500 μ g/ml. For hair growth promoting activity, the degree of hair dermal papilla cells proliferation increased with increasing concentration of extract. By treated the cells with 500 μ g/ml of extract, cell proliferation significantly increased by 157.56%, compared to untreated control cells. The mangosteen pericarp extract was found to stimulate melanin synthesis and tyrosinase activity of dermal papilla cells in concentration-dependent manner, up to the highest concentration of 500 μ g/ml. The melanin synthesis was more than four-fold as compared to the untreated control group, indicating that this extract could be one of the melanogenic-stimulating agents. This study also showed that mangosteen pericarp extract was more potent and better in comparison with known effective melanogenic agents such as, α -melanocyte stimulating hormone and forskolin in inducing the melanogenic effects of dermal papilla cells. The overall results showed that mangosteen pericarp extract can potentially be used as a safe ingredient for the development of hair growth and hair tanning product.

ABSTRAK

Rambut beruban merupakan satu fenomena yang biasa dalam manusia, sementara bilangan lelaki dan wanita yang mengalami keguguran rambut semakin meningkat selaras dengan perubahan gaya hidup dan keseimbangan nutrisi/zat. Oleh itu, adalah amat penting untuk membangunkan terapi baru bagi meningkatkan aktiviti pertumbuhan rambut serta penghitaman rambut. Dalam kajian ini, ekstrak air kulit manggis digunakan untuk mengkaji aktiviti pertumbuhan rambut dan penghitaman rambut pada sel-sel kulit papilla rambut. Ekstrak kulit manggis didapati mengandungi 3.706 mg/ml protein, 0.519 mg/ml polisakarida, 5.103 setara asid gallic mg/g jumlah kandungan fenolik dan 1.503 setara quercetin mg/g jumlah kandungan flavonoid. Ekstrak kulit manggis menunjukkan nilai IC_{50} yang tinggi dalam kedua-dua eksperimen 2,2-diphenyl-1-picrylhydrazyl dan 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (4.142 mg/ml dan 2.373 mg/ml, masing-masing). Ini menunjukkan bahawa ekstrak kulit manggis berasaskan air mempunyai aktiviti antioksidan yang rendah. Kesan ekstrak kulit manggis ke atas aktiviti mitokondria sel, kebolehhidupan dan sitotoksiti sel papilla kulit rambut dikaji menggunakan eksperimen 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide dan Sulforhodamine B. Kepekatan tertinggi ekstrak yang tidak menjejaskan kebolehhidupan sel adalah 500 μ g/ml. Untuk aktiviti penggalakkan pertumbuhan rambut, tahap proliferasi kulit rambut sel papilla meningkat dengan peningkatan kepekatan ekstrak. Apabila dirawat dengan 500 μ g/ml ekstrak, perkembangan sel meningkat sebanyak 157.56%, berbanding dengan sel-sel kawalan yang tidak dirawat. Ekstrak kulit manggis didapati dapat merangsang sintesis melanin dan aktiviti tyrosinase pada sel-sel kulit papilla bergantung kepada kepekatan, sehingga kepekatan tertinggi 500 μ g/ml. Sintesis melatin didapati meningkat empat kali ganda lebih tinggi berbanding dengan sel-sel kawalan yang tidak dirawat. Keputusan keseluruhan menunjuk bahawa ekstrak kulit manggis boleh dijadikan sebagai alternatif bagi menggalakkan pertumbuhan rambut dan sebagai produk penghitaman rambut.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS	xv
	LIST OF ABBREVIATIONS	xvi
1	INTRODUCTION	1
	1.1 Research Background	1
	1.2 Problem Statement	3
	1.3 Objective of Research	4
	1.4 Scope of Research	5
	1.5 Hypothesis	5
	1.6 Significant of Study	6
2	LITERATURE REVIEW	7
	2.1 <i>Garcinia Mangostana</i> Linn.	7
	2.2 Uses of Mangosteen	8
	2.3 Phytochemicals of Mangosteen Pericarp	9

2.4	Hair Follicle Dermal Papilla Cells	11
2.5	Hair Growth Promoting Activity	14
2.5.1	Hair Loss	15
2.5.2	Mechanism of Hair Loss	18
2.5.3	Hair Loss Drug/Treatment in Market	19
2.5.3.1	Minoxidil	19
2.5.3.2	Finasteride	21
2.5.3.3	Hair Transplantation	21
2.5.4	Hair Growth Factors	22
2.5.5	Hair Growth Cycle	25
2.5.5.1	Anagen	26
2.5.5.2	Catagen	26
2.5.5.3	Telogen	26
2.6	Hair Melanogenesis Acitivity	27
2.6.1	Hair Graying	27
2.6.2	Melanin	31
2.6.3	Melanocytes	33
2.6.4	Tyrosinase	36
2.6.4.1	Tyrosinase-related protein	40
2.6.5	Melanogenesis	42
2.7	Natural Cosmetic Product and Chemical-Based Products	46
2.7.1	Comparison between Natural and Chemical-Based Products	46
2.7.2	Natural Hair Care Products	47
2.7.3	Chemical-Based Hair Care Products	51
3	METHODOLOGY	52
3.1	Materials	52
3.2	Flowchart of Research Project	53
3.3	Extraction of Mangosteen Pericarp	54

3.4	Chemical Component Analysis	54
3.4.1	Preparation of Standard Solution for HPLC	54
3.4.2	Preparation of Sample for HPLC	55
3.4.3	High Performance Liquid Chromatograph (HPLC) Analysis	55
3.5	Primary Metabolite Content Assay	56
3.5.1	Total Protein Estimation by Lowry's Method	56
3.5.2	Total Polysaccharide Estimation by Anthrone Method	57
3.6	Secondary Metabolite Content Assay	60
3.6.1	Total Phenolic Content (TPC) by Folin Ciocalteu Assay	60
3.6.2	Total Flavonic Content (TFC) by Aluminium Chloride Colorimetric Method	61
3.7	Evaluation of Antioxidant Activity	62
3.7.1	DPPH Radical Scavenging Activity	62
3.7.2	ABTS Radical Scavenging Activity	63
3.8	Hair Dermal Papilla Cell Culture	64
3.8.1	Maintenance of Stock Culture	64
3.8.2	Subculture of Human Follicle Dermal Papilla Cells	64
3.8.3	Cryopreservation of Cells	65
3.8.4	Recovery of Cells	66
3.9	α -MSH and Mangosteen Pericarp Extract Treatment	66
3.10	Cell Viability (MTT) Assay	68
3.11	Cell Cytotoxicity (SRB) Assay	69
3.12	Cell Proliferation (WST-1) Assay	70
3.13	Melanin Assay	71
3.13.1	Secreted Melanin Assay	71
3.13.2	Intracellular Melanin Assay	72
3.14	Intracellular Tyrosinase Activity Assay	73
3.15	Statistical analysis	74

4	RESULTS AND DISCUSSION	75
4.1	Yield of Mangsoteen Pericarp Extract	75
4.2	High Performance Liquid Chromatograph (HPLC) Analysis	76
4.3	Primary Metabolite Content	80
4.3.1	Estimation of Total Protein (Lowry's Method)	80
4.3.2	Estimation of Total Polysaccharide (Anthrone Method)	81
4.4	Secondary Metabolite Content	84
4.4.1	Total Phenolic Content (Folin Ciocalteu Assay)	85
4.4.2	Total Flavonic Content (Aluminium Chloride Colorimetric Method)	88
4.5	Antioxidant Activity	89
4.5.1	Free Radical Scavenging Activity by DPPH Assay	89
4.5.2	Free Radical Scavenging Activity by ABTS Assay	93
4.6	Relation between Phenolic Content, Antioxidant Activity and Tyrosinase Activity	96
4.7	Dermal Papilla Cell Culture	97
4.8	Cell Viability (MTT) Assay	99
4.9	Cell Cytotoxicity (SRB) Assay	103
4.10	Cell Proliferation (WST-1) Assay	106
4.11	Melanin Assay	109
4.11.1	Secreted Melanin Assay	109
4.11.2	Intracellular Melanin Assay	111
4.12	Intracellular Tyrosinase Activity Assay	114

5	CONCLUSION AND RECOMMENDATION	117
	5.1 Conclusion	117
	5.2 Recommendation	119
	REFERENCES	121

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	The causes of premature graying and its pathophysiology	30
2.2	Glossary of terms used in pigment cell biology	40
2.3	The botanicals useful for hair care	48
4.1	Primary metabolite concentration of mangosteen pericarp extract	82
4.2	Secondary metabolite concentration of mangosteen pericarp extract	85
4.3	The IC ₅₀ of DPPH scavenging activity of ascorbic acid, α -pherol and mangosteen pericarp extract	90
4.4	The IC ₅₀ of ABTS scavenging activity of trolox and mangosteen pericarp extract	94

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Mangosteen and mangosteen pericarp	11
2.2	Struture of hair follicle	13
2.3	Schematic illustration of the hair cycle	25
2.4	Tyrosinase catalyses the hydroxylation of tyrosine and the oxidation of DOPA to DOPA quinone	38
2.5	Details of tyrosine	39
2.6	Several signal pathways to regulate melanogenesis	43
2.7	Chemical struture of eumelanin and pheomelanin	44
2.8	Biosynthesis pathways for production of eumelanin and pheomelanin	45
3.1	Flowchart of research project	53
3.2	Flowchart of total protein estimation	57
3.3	Flowchart of total polysaccharide estimation	59
3.4	Flowchart of TPC assay	60
3.5	Flowchart of TFC assay	62
3.6	Flowchart of α -MSH and mangosteen pericarp extract treatment	67
3.7	Flowchart of MTT assay	68

3.8	Flowchart of SRB assay	69
3.9	Flowchart of WST-1 assay	70
3.10	Flowchart of secreted melanin assay	71
3.11	Flowchart of intracellular melanin assay	72
3.12	Flowchart of intracellular tyrosinase activity assay	73
4.1	The HPLC chromatograph for the α -mangostin standard which detected at wavelength 254 nm	79
4.2	The HPLC chromatograph for the mangosteen pericarp extract which detected at wavelength 254 nm	79
4.3	Morphology of dermal papilla cells observed under 10x magnification phase contrast microscope on day 2 until day 8 (70-80 % confluence of culture)	98
4.4	Cell viability of hair dermal papilla cells treated by mangosteen pericarp crude extract at different concentration ($\mu\text{g/ml}$)	100
4.5	Cell survival of hair dermal papilla cells treated by mangosteen pericarp crude extract at different concentration ($\mu\text{g/ml}$)	104
4.6	Cell proliferation of hair dermal papilla cells treated by mangosteen pericarp crude extract at different concentration ($\mu\text{g/ml}$)	107
4.7	Effect of mangosteen pericarp extract on melanin secretion of hair dermal papilla cells at different concentration ($\mu\text{g/ml}$)	110
4.8	Effect of mangosteen pericarp extract on melanin content of hair dermal papilla cells at different concentration ($\mu\text{g/ml}$)	112
4.9	Effect of mangosteen pericarp extract on total melanin (secreted and melanin content) of hair dermal papilla cells at different concentration ($\mu\text{g/ml}$)	113
4.10	Effect of mangosteen pericarp extract on intracellular tyrosinase activity of hair dermal papilla cells at different concentration ($\mu\text{g/ml}$)	115

LIST OF SYMBOLS

α	Alpha
β	Beta
$^{\circ}\text{C}$	Degree Celcius
γ	Gamma
%	Percentage

LIST OF ABBREVIATIONS

α -MSH	alpha-Melanocyte Stimulating Hormone
APC	Adenomatous Polyposis Coli
BSA	Bovine Serum Albumin
DMSO	Dimethyl Sulfoxide
DPPH	1,1-diphenyl-2-picrylhydrazyl
FBS	Fetal Bovine Serum
FDA	Food and Drug Administration
FK	Forskolin
GSK-3 β	Glycogen Synthase Kinase-3 β
g/L	Gram per liter
HPLC	High Performance Liquid Chromatography
HDPCs	Human Dermal Papilla Cells
IGF	Insulin-like Growth Factor
min	minutes
mg/mL	milligram per milliliter
mL	milliliter
mM	millimolar
MTT	3-(4,5-Dimethylthiazol-2-yl)-2,5-dipheynyl tetrazolium bromide
NaOH	Sodium Hydroxide
nm	nanometre
OD	Oxygen Demand
pH	Power of Hydrogen
SD	Standard Deviation
SRB	sulphorhodamine B
T ₃	Triiodothyronine

T ₄	Levorotatory thyroxine
TLC	Thin Layer Chromatography
TCA	Trichloroacetic acids
μg/mL	microgram per milliliter
μL	microliter
VEGF	Vascular Endothelial Growth Factor
WST-1	4-[3-(4-Idophenyl)-2-(4-nitrophenyl)-2H-5-tetrazolio]-1,3-benzene disulfonate

CHAPTER 1

INTRODUCTION

1.1 Research Background

In recent years, Global Beauty Market, also known as Cosmetics and Toiletries or Personal Care Products has grown by 4.5% a year on average Compound Annual Growth Rate (CAGR), with annual growth rates ranging from around 3% to 5.5%. This market has shown both its ability to achieve stable and continuous growth as well as its capacity for resilience in unfavorable economic conditions (Lopaciuk and Loboda, 2013). The Global Beauty Market is usually divided into five main business segments: skincare, haircare, color (make-up), fragrances and toiletries. These segments are complementary and through their diversity they are able to satisfy all consumers' needs and expectations with regard to cosmetics (Lopaciuk and Loboda, 2013). The global hair care market is characterized by nearly 10,000 launches per year, has become the dynamic nature of the market. Thus, the hair care market is growing robustly in both in the developed and the emerging markets and it leads to the global economic improvement and the consequent rise in disposable income among consumers. Geographically, Asia Pacific is the second largest market for cosmetics after Europe, expected to reach \$126.8 billion by 2020, registering a CAGR of 4.02%. The firm's analysts report Asia to be one of the most diverse and dynamic cosmetics markets in the world (Yeomans, 2015).

In the product category segment of the Asia-Pacific cosmetics market, skin and sun care, and hair care products are the most widely used product and hold a considerable percentage share (Kumar, 2015). Furthermore, demand for natural and organic cosmetic products is supplementing the growth of this market (Kumar, 2015). Those organic beauty products and natural cosmetics that manufactured in accordance with the fair-trade philosophy are becoming more and more visible in the global market. Consumer preferences towards the use of natural cosmetic products is increasing and forcing the manufacturers cosmetic and toiletries to change strategies according to their preferences (Lopaciuk and Loboda, 2013).

In a previous literature reported, it evidenced that graying hair may be contributed by massive oxidative stress via accumulation of hydrogen peroxide in the hair follicle. In this regard, previous studies by Hamid *et al.* (2012), which claimed the strong antioxidant activity and melanogenic effects of the mangosteen leaf extract has given an insight into the potential in development of gray hair prevention agent. In this study, the mangosteen leaf extract has stimulated the melanin production and tyrosinase activity on B16F1 melanoma cells in a dose-dependent manner and thus proposed that the extract can be used to treat disease of hypopigmentation and beneficial to the field of tanning cosmetic. However, there have been no reports specifically addressing the effects of the mangosteen pericarp extract on hair growth activity a hair tanning in hair dermal papilla cells. Furthermore, the use of chemicals and synthetic ingredients in hair growth and hair tanning product in the market has been reported associated with adverse consequences. Thus, it is of great importance to explore new natural ingredients for substitute the use of harmful chemicals in hair growth and hair tanning products.

Garcinia mangostana Linn., known as mangosteen, is a tropical fruit classified to the Guttiferae family (Zarena *et al.*, 2011). The pericarp of mangosteen has a long history of medicinal use in both Chinese and Ayurvedic medicine (Shibata *et al.*, 2013). People have used this waste pericarp as a traditional medicine for the treatment of abdominal pain, diarrhea, dysentery; heal the wound infection, suppuration and chronic ulcer (Zhou *et al.*, 2011), because it contains considerable

amounts of biologically active compounds that have been reported beneficial to human health, such as, xanthenes which have relatively strong antifungal and antibacterial activities (Obolskiy *et al.*, 2009); tannins that assure astringency to discourage infestation by insects, fungi, plant viruses, bacteria and animal predation (Akao *et al.*, 2008); anthocyanin like cyanidin-3-sophoroside which have high antioxidant properties (Chaovanalikit *et al.*, 2012); and phenols which exhibited strong pH-dependent bacteriostatic and bactericidal effects against Gram-positive bacteria (Palakawong *et al.*, 2013). This study was designed to investigate the effect of mangosteen pericarp extract on hair-growth promoting activity and hair tanning in hair dermal papilla cells.

1.2 Problem Statement

Hair loss is an emotionally distressing condition in humans and its major factors are genetic disorders (hypotrichosis), an increase in the induction of the telogen phase (telogen effluvium), genetic follicular miniaturization (androgenetic alopecia), an increase in telogenic depilation with detention of the follicle in early anagen (alopecia areata), and/or the elimination of the hair in anagen (anagenic effluvium) (Park *et al.*, 2012). Besides, hair graying, one of the most ordinary phenotype of human, is a common process of decreasing in the melanin content of hair follicles as individual aging. Other than the physiology of aging, there is also premature hair graying which the most commonly is from autosomal-dominant genetic inheritance or pathologic conditions (McDonough and Schwartz, 2012).

There are limited available treatment options for hair loss and hair graying and the aging impacts on the melanocyte system in hair follicle still an unknown. Furthermore, the use of chemicals and synthetic ingredients in hair growth and hair tanning product has been reported associated with adverse consequences. There are studies reported that hair products in market consists of many harmful chemicals, such as phthalates and parabens which associated with breast cancer; DEA

(Diethanolamine) and DEA compounds like, cocamide DEA and lauramide DEA, and related chemicals like MEA (Monoethanolamine), TEA (Triethanolamine) are hormone-disrupting chemicals that can react to form cancer-causing nitrosamines and research indicated a strong link to liver and kidney cancer; dibutyl phthalate (DBP) are toxic to reproduction and may interfere with hormone function; P-Phenylenediamine has potential to cause cancer and can be contaminated with heavy metals toxic to the brain; formaldehyde-releasing preservatives like methenamine and quaternium-15 which causes cancer; siloxanes like cyclomethicone and cyclotetrasiloxane can interfere with hormone function and damage the liver; and sodium lauryl sulfate and sodium laureth sulfate are one of the most toxic ingredients which exposures will cause eye damage, depression, diarrhea and many other ailments (Onge, 2012; Lipman, 2016). There are some natural ingredients used in hair treatment in market, such as jamaican castor oil, coconut oil, evening primrose oil, rosemary, aloe vera, lemongrass, horsetail and sage (Banks, 2014; Jackson, 2014). However, due to the lack of natural products, it is very important to develop new ingredients to enhance hair growth, to treat hair graying and to explore new natural ingredients for substitute the use of harmful chemicals in hair growth and hair tanning products. Previous studies showed that there is a strong melanogenesis activity on B16F1 melanoma cells using mangosteen leaf extract and it brings advantages to cure the disease of hypopigmentation and also tanning effect cosmetic field (Hamid *et al.*, 2012). Therefore, the use of the mangosteen pericarp water crude extract is believed can stimulate hair growth activity and hair tanning in hair dermal papilla cell.

1.3 Objective of Research

The objectives of the research were to investigate the hair growth and hair tanning activities of mangosteen pericarp extract on hair dermal papilla cells.

1.4 Scope of Research

The scopes of the research are:

- i. Extraction of mangosteen pericarp by using turbo extraction.
- ii. Investigate the primary and secondary metabolites contents of the mangosteen pericarp extract.
- iii. Investigate the antioxidant activity of mangosteen pericarp extract by DPPH assay and ABTS assay.
- iv. Investigate the viability and cytotoxicity effects of hair dermal papilla cells by using MTT assay and SRB assay.
- v. Investigate the promoting hair growth activity by WST-1 assay on hair dermal papilla cells.
- vi. Investigate the melanogenesis activity by measuring secreted melanin assay, intracellular melanin assay and intracellular tyrosinase activities of hair dermal papilla cells.

1.5 Hypothesis

The mangosteen pericarp water extract results in increment of cell proliferation and stimulate melanin synthesis which can promote hair growth and hair tanning activities on hair dermal papilla cells.

1.6 Significant of Study

This study was indicated that the mangosteen pericarp extract could be a new natural ingredient to substitute the use of harmful chemicals in the development of hair growth and hair tanning products. This has brought the advantage to cosmeceutical manufacturers who searching for new natural and safe plant based active ingredients, since the hair care and toiletries are the high demanding products in the cosmeceutical and pharmaceutical industries. Nowadays, cosmeceutical manufacturers are increasingly searching new products that was not harmful to the environment whilst their effectiveness remained comparable to the premium brand.

Other than that, the raw material used in this study was mangosteens, which are one of the local fruits in Malaysia which indirectly linked to the agriculture of the country. The agriculture's performance has brought the contribution to the country's economic development, since it is measured using information about harvests and the sale of raw materials, mainly crops and livestock. Furthermore, the increment of the demand of the mangosteen (raw materials) has generated the income to the local farmers, suppliers and industry and has contributed to impressive economic growth. In addition, this study also enhances the coordination effort among scientist, farmers, manufacturers, traders, and health care professionals and also regulatory authorities to drive the industry to a higher level of quality, safety and efficacy of native fruit products and thus economic return to the country. Thus, the most significant of this study can contribute to wealth creation, enhance quality of life and create a new industry.

REFERENCES

- Ahmat, N., Azmin, N. F. N., Ghani, N. A., Aris, S. R. S., Sidek, N. J., Abdullah, S. & Jasmani, H. 2010. Bioactive xanthenes from the pericarp of *Garcinia mangostana*. *Journal of Scientific Research*, 6(2): 123-127.
- Akao, Y., Nakagawa, Y., Iinuma, M. & Nozawa, Y. 2008. Anti-cancer effects of xanthenes from pericarps of mangosteen. *International Journal of Molecular Sciences*, 9: 355-370.
- Alam, N., Yoon, K. N., Lee, J. S., Cho, J. H. & Lee, T. S. 2012. Consequence of the antioxidant activities and tyrosinase inhibitory effects of various extracts from the fruiting bodies of *Pheurotus ferulae*. *Saudi Journal of Biological Sciences*, 19: 111-118.
- Analytical method. N.D. Retrieved from Ministry of the Environment website: <http://www.env.go.jp/en>
- Ancans, J., Tobin, D. J, Hoogduijn, M. J., Smit, N. P., Wakamatsu, K. & Thody, A. J. 2001. Melanosomal pH controls rate of melanogenesis, eumelanin/pheomelanin ratio and melanosome maturation in melanocytes and melanoma cells. *Experimental Cell Research*, 268: 26-35.
- Araujo, R., Fernandes, M., Paulo, A.C. & Gomes, A. 2010. Biology of human hair: know your hair to control it. *Advances in Biochemical Engineering/Biotechnology*, DOI: 10.1007/10_2010_88
- Arck, P.C., Overall, R., Spatz, K., Liezman, C., Handjiski, B., Klapp, B. F., Machin, M. A. B. & Peters, E. M. J. 2006. Towards a “free radical theory of graying”: melanocyte apoptosis in the aging human hair follicle is an indicator of oxidative stress induced tissue damage. *The Federation of American Societies for Experimental Biology Journal*, 20(9): 1567-1569.

- Baba, S. A. & Malik, S. A. 2015. Determination of total phenolic and flavonoid content, antimicrobial and antioxidant activity of a root extract of *Arisaema jacquemontii* Blume. *Journal of Taibah University of Science*, 9(4): 449-454.
- Banks, L. T. 2014. Natural herbs and ingredients that promote hair growth. Retrieved from The Clutch Magazine website: <http://www.clutchmagonline.com/2014/04/>
- Bak, S. S., Ahn, B. N., Kim, J. A., Shin, S. H., Kim, J. C., Kim, M. K., Sung, Y. K. & Kim, S. K. 2013. *Ecklonia cava* promotes hair growth. *Clinical and Experimental Dermatology*, 38: 904-910.
- Botchkareva, N. V., Botchkarev, V. A. & Gilchrist, B. A. 2003. Fate of melanocytes during development of the hair follicle pigmentary unit. *The Society for Investigate Dermatology*, 8(1): 76-79.
- Brummer, Y. & Cui, S. W. 2005. Food carbohydrates: Chemistry, physical properties, and applications. Taylor & Francis Group, LLC.
- Chan, C. F., Hwang, C. C., Lee, M. Y. & Lin, Y. S. 2014. Fermented broth in tyrosinase and melanogenesis inhibition. *Molecules*, 19: 13122-13135.
- Chaovanalikit, A., Mingmuang, A., Kitbunluewit, T., Choldumrongkool, N., Sondae, J. & Chupratum, S. 2012. Anthocyanin and total phenolic content of mangosteen and effect of processing on the quality of mangosteen products. *International Food Research Journal*, 19(3): 1047-1053.
- Chaverri, J. P., Rodriguez, N. C., Ibarra, M. O. & Rojas, J. M. P. 2008. Medicinal properties of mangosteen (*Garcinia mangostana*). *Food and Chemical Toxicology*, 46(10): 3227-3239.
- Chen, Q. S. 2009. Evaluate the effectiveness of the natural cosmetic product compare to chemical-based products. *International Journal of Chemistry*, 1(2): 57-59.
- Chin, Y. W. & Kinghorn, A. D. 2008. Structural characterization, biological effects, and synthetic studies on xanthenes from mangosteen (*Garcinia mangostana*), a popular botanical dietary supplement. *Mini Review Organic Chemistry*, 5(4): 355-364.
- Choi, S. J., Cho, A. R., Jo, S. J., Hwang, S. T., Kyu, H. K. & Oh, S. K. 2013. Effects of glucocorticoid on human dermal papilla cells in vitro. *Journal of Steroid Biochemistry and Molecular Biology*, 135: 24-29

- Chua, G. A., Bozzo, P. & Einarson, A. 2008. Safety of hair products during pregnancy: Personal use and occupational exposure. *Canadian Family Physician*, 54: 1386-1388.
- Cicatricial Alopecia Research Foundation. 2015. What is cicatricial alopecia or scarring alopecia? Retrieved from Cicatricial Alopecia Research Foundation website: <http://www.carfintl.org/>
- Cirimbei, M. & Vizireanu, C. 2014. Comparison of different solvents for isolation of antioxidant compounds of horseradish. Retrieved from The Analecta website: <http://www.analecta.hu>
- Commo, S., Gaillard, O. & Bernard, B. A. 2004. Human hair greying is linked to a specific depletion of hair follicle melanocytes affecting both the bulb and the outer root sheath. *British Journal of Dermatology*, 150(3): 435-443.
- Datta, K., Singh, A. T., Mukherjee, A., Bhat, B., Ramesh, B., Burman, A. C. 2009. *Eclipta alba* extract with potential for hair growth promoting activity. *Journal of Ethnopharmacology*, 124: 450-456.
- Devi, M. R. & Krishnakumari, S. 2015. Quantitative estimation of primary and secondary metabolites in hot aqueous extract of *Pleurotus sajor caju*. *Journal of Pharmacognosy and Phytochemistry*, 4(3): 198-202.
- Ding, L., Liu, B., Zhang, S. D., Hou, Q., Qi, L. L. & Zhou, Q. Y. 2011. Cytotoxicity, apoptosis-inducing effects and structure-activity relationships of four natural xanthenes from *Gentianopsis paludosa* Ma in HepG2 and HL-60 cells. *Natural Product Research*, 25(7): 669-683.
- Dinh, Q. Q. & Sinclair, R. 2007. Female pattern hair loss: Current treatment concepts. *Clinical Interventions in Aging*, 2(2): 189-199.
- Ekwall, B., Silano, V., Stamatii, A. P. & Zucco, F. 1990. Short-term toxicity tests for non-genotoxic effects. New York: Scope.
- Fatima, A., Alok, S., Agarwal, P., Singh, P. P. & Verma, A. 2013. Benefits of herbal extracts in cosmetics: A review. *International Journal of Pharmaceutical Sciences and Research*, 4(10): 3746-3760.
- Floegel, A., Kim, D. O., Chung, S. J., Koo, S. I. & Chun, O. K. 2011. Comparison of ABTS / DPPH assays to measure antioxidant capacity in popular antioxidant-rich US foods. *Journal of Food Composition and Analysis*, 24: 1043-1048.
- Folin, O. & Ciocalteu, V. 1927. On tyrosine and tryptophane determinations in proteins. *Journal of Biological Chemistry*, 73(2): 627-650.

- Franca, K., Rodrigues, T. S., Ledon, J., Savas, J. & Chacon, A. 2013. Comprehensive overview and treatment update on hair loss. *Journal of Cosmetics, Dermatological Sciences and Application*, 3: 1-8
- Francois, M. N., Dicko, A. & Soulimani, R. 2010. Chemical composition and biological activities of *Ficus capensis* leaves extracts. *Journal of Natural Products*, 3: 147-160.
- Gerhardt, P., Murray, R. G. E., Wood, W. A. & Krieg, N. R. 1994. Methods for general and molecular bacteriology. Washington, DC, ASM.
- Ghiani, S., Baroni, S., Burhio, D., Digilio, G., Fukuhara, M., Martino, P., Monda, K., Nervi, C., Kiyomine, A. & Aline, S. 2008. Characterization of human hair melanin and its degradation products by means of magnetic resonance techniques. *Magnetic Resonance in Chemistry*, 2008 (46): 471-479.
- Hamid, M. A., Sarmidi, M.R. & Chang, S. P. 2012. Mangosteen leaf extract increases melanogenesis in B16F1 melanoma cells by stimulating tyrosinase activity in vitro and by up-regulating tyrosinase gene expression. *International Journal of Molecule Medicine*, 29: 209-217.
- Han, J. H., Kwon, O. S., Chung, J. H., Cho, K. H., Eun, H. C. & Kim, K. H. 2004. Effect of minoxidil on proliferation and apoptosis in dermal papilla cells of human hair follicle. *Journal of Dermatological Science*, 34(2): 91-98.
- Hassan, A. W., Zulkifli, R. M., Basar, N., Ahmad, F. & Yunus, M. A. C. 2015. Antioxidant and tyrosinase inhibition activities of α -Mangostin and *Garcinia mangostana* Linn. pericarp extracts. *Journal of Applied Pharmaceutical Science*, 5(09): 037-040.
- Hassan, A. W., Ahmad, F., Zulkifli, R. M. & Yunus, M. A. C. 2015. Antioxidant and tyrosinase inhibition activities of *Eurycoma longifolia* and *Suietenia macrophylla*. *Journal of Applied Pharmaceutical Science*, 5(8): 006-010.
- Hassan, S. H. A., Fry, J. R. & Bakar, M. F. A. 2013. Phytochemicals content, antioxidant activity and acetylcholinesterase inhibition properties of indigenous *Garcinia parvifolia* fruit. *BioMed Research International*, 2013: 1-7.
- Hearing, V. J. 1999. Biochemical control of melanogenesis and melanosomal organization. *Journal of Investigative Dermatology Symposium Proceedings*, 4(1): 24-28.

- Huang, H. C., Hsieh, W. Y., Niu, Y. L. & Chang, T. M. 2012. Inhibition of melanogenesis and antioxidant properties of *Manolia gradiflora* L. flower extract. *BioMed Central*, 12: 72.
- Hussain, K., Ismail, Z., Sadikun, A. & Ibrahim, P. 2008. Analysis of proteins, polysaccharides, glycosaponins content of *Piper sarmentosum* Roxb. anti-TB evaluation for bio-enhancing / interaction effects of leaf extracts with Isoniazid (INH). *Natural Product Radiance*, 7(5): 402-408.
- Hwang, E. S. & Thi, N. D. 2014. Effects of extraction and processing methods on antioxidant compound contents and radical scavenging activities of Laver (*Porphyra tenera*). *Preventive Nutrition and Food Science*, 19(1): 40-48.
- Ideta, R., Soma, T., Tsunenaga, M. & Ifuku, O. 2002. Cultured human dermal papilla cells secrete a chemotactic factor for melanocytes. *Journal of Dermatological Science*, 28: 48-59.
- Jackson, K. C. 2014. Learn how to make hair thicker with these 7 natural ingredients that will ward off baldness for you and your guy. Retrieved from The Bustle website: <http://www.bustle.com/article/42639>
- Jahoda, C. A. B. & Oliver, R. F. 1984. Vibrissa dermal papilla cell aggregative behavior in vivo and in vitro. *Journal of Embryology and Experimental Morphology*, 79: 211-224.
- Ji, H. H., Oh, S. K., Jin, H.C., Kwang, H. C., Hee, C. E. & Kyu, H. K. 2004. Effect of minoxidil on proliferation and apoptosis in dermal papilla cells of human hair follicle. *Journal of Dermatological Science*, 34(2): 91-98.
- Jo, S. J., Paik, S. H., Choi, J. W., Lee, J. H., Cho, S. Y., Kim, K. H., Eun, H. C. & Kwan, O. S. 2012. Hair graying pattern depends on gender, onset age and smoking habits. *Acta Dermatovenereologica*, 92: 160-161.
- Jo, S. J., Shin, H. S., Paik, S. H., Na, S. J., Jin, Y. J., Park, W. S., Kim, S. N. & Kwan, O. S. 2013. Efficacy and safety of *Pueraria Lobata* extract in gray hair prevention: A randomized, double-blind, placebo-controlled study. *Korean Dermatological Association and Korea Society for Investigative Dermatology*, 25(2): 218-222.
- Junlatat, J. & Sripanidkulchai, B. 2014. Hair growth- promoting effect of *Canthamus tinctorius floret* extract. *Phytotherapy Research*, 28(7): 2013-1036.
- Kalita, P., Barman, T. K., Pal, T. K. & Kalita, R. 2013. Estimation of total flavonoids content (TFC) and antioxidant activities of methanolic whole plant extract of

- Biophytum sensitivum* Linn. *Journal of Drug Delivery & Therapeutics*, 3(4): 33-37.
- Kang, J. I., Kim, E. J., Kim, M. K., Jeon, Y. J., Kang, S. M., Koh, Y. S., Yoo, E. S. & Kang, H. K. 2013. The promoting effect of *Ishige sinicola* on hair growth. *Marine Drugs*, 11: 1783-1799.
- Kapoor, V. P. 2005. Herbal cosmetics for skin and hair care. *Natural Product Radiance*, 4(4): 306-314.
- Karim, A. A. & Azlan, A. 2012. Fruit pod extracts as a source of nutraceuticals and pharmaceuticals. *Molecules*, 17: 11931-11946.
- Kauser, S., Slominski, A., Wei, E. T. & Tobin, D. J. 2006. Modulation of the human hair follicle pigmentary unit by corticotropin-releasing hormone and urocortin peptides. *The FASEB Journal*, 20: 882-895.
- Koivikko, R., Loporen, J., Honkaren, T., Jormalainen, V. 2005. Content of soluble, cell-wall-bound and exuded phlorotannins in the brown alga *Fucus vesiculosus*, with implications on their ecological functions. *Journal of Chemical Ecology*, 31: 195-212.
- Kumar, P. 2015. Explore cosmetics in Asia-Pacific market research report for 2014 to 2020. Retrieved from the Consumer Market Research website: <http://www.whatech.com/market-research/consumer>
- Kim, D. O., Lee, K. W., Lee, H. J. & Lee, C. Y. 2002. Vitamin C equivalent antioxidant capacity (VCEAC) of phenolic phytochemicals. *Journal of Agricultural and Food Chemistry*, 50: 3713-3717.
- Kinghorn, A. D., Chai, H. B., Chung, K. S. & Keller, W. J. 2011. The classical drug discovery approach to defining bioactive constituents of botanicals. *Fitoterapia*, 82(1): 71-79.
- Li, X., Wang, Z., Wang, L., Walid, E. & Zhang, H. 2012. *In vitro* antioxidant and anti-proliferation activities of polysaccharides from various extracts of different mushrooms. *International Journal of Molecular Sciences*, 13: 5801-5817.
- Lipman, F. 2016. What chemicals should you look out for in your personal care products? Retrieved from The Voice of Sustainable Wellness website: <http://www.drfranklipman.com/>

- Liu, Y. B. & Nair, M. G. 2010. An efficient and economical MTT assay for determining the antioxidant activity of plant natural product extracts and pure compounds. *Journal of Natural Products*, 73(7): 1193-1195.
- Lopaciuk, A. & Loboda, M. 2013. Global beauty industry trends in the 21st century. *Active Citizenship by Knowledge Management & Innovation International Conference 2013*, 1079-1087.
- Lowry, O. H., Rosebrough, N. J., Farr, A. I. & Randall, J. L. 1951. Protein measurement with Folin phenol reagent. *Journal of Biological Chemistry*, 193: 265-275.
- Machmudah, S., Shiddiqi, Q. Y. A., Kharisma, A. D., Widiyastuti, Wahyudiono, Kanda, H., Winardi, S. & Goto, M. 2014. Subcritical water extraction of xanthone from mangosteen (*Garcinia Mangostana* Linn.) pericarp. *Journal Advanced Chemical Engineering*, 5(1): 117.
- Maisuthisakul, P. & Gordon, M. H. 2009. Antioxidant and tyrosinase inhibition activity of mango seed kernel by product. *Food Chemistry*, 117: 332-341.
- Manasathien, J. & Khanema, P. 2016. Antioxidant and cytotoxic activities of mangosteen (*Garcinia Mangostana*) pericarp extracts. *Suranaree Journal of Science and Technology*. Retrieved from <http://ird.sut.ac.th/e-journal/Journal/pdf/1503879.pdf>.
- Martinez, O. G., Bertos, E. D. L., Torrecillas, J. R., Ruiz, C., Milia, E., Lorenzo, M. L., Jimenez, B., Ortiz, A. S. & Rivas, A. 2016. Phenolic compounds in extra virgin olive oil stimulate human osteoblastic cell proliferation. *Plos One*, 11(3): e0150045.
- McDonough, P. H. & Schwartz, R. A. 2012. Premature Hair Graying. *Pediatric Dermatology*, 89: 161-165.
- Millar, S. E., Willent, K., Salinas, P. C., Roelink, H., Nusse, R., Sussman, D. J. & Barsh, G. S. 1999. WNT signaling in the control of hair growth and structure. *Development Biology*, 207: 133-149.
- Moongkarndi, P., Srisawat, C., Saetun, P., Jantaravinid, J., Peerapittayamongkol, C., Soi-ampornkul, R., Junnu, S., Sinchaikul, S., Chen, S. T., Charoensilp, P., Thongboobkerd, V. & Neungton, N. 2010. Protective effect of mangosteen extract againsts β -Amyloid-induced cytotoxicity oxidative stress and altered proteome in SK-N-SH cells. *Journal of Proteome Research*, 9: 2076-2086.

- Mosmann, T. 1983. Rapid colorimetric assay for cellular growth and survival: Application to proliferation and cytotoxicity assay. *Journal of Immunological Methods*, 65: 55-63.
- Murkute, A. V., Sahu, M. S., Mali, P. Y. & Rangari, V. D. 2010. Development and evaluation of formulations of microbial biotransformed extract of tobacco leaves for hair growth potential. *Pharmacognosy Research*, 2(5): 300-303.
- National Alopecia Areata Foundation. 2016. Clinical trials and research studies. Retrieved from N.A.A.F website: <http://www.naaf.org/>
- Neha, S., Manoj, K. P., Alok, S. & Jai, P. 2014. Indian medicinal plants: For hair care and cosmetics. *World Journal of Pharmaceutical Sciences*, 2(11): 1552-1556.
- Nishimura, E. K., Granter, S. R. & Fisher, D. E. 2005. Mechanism of hair graying: Incomplete melanocyte stem cell maintenance in the niche. *Science*, 307(5710): 720-724.
- Obolskiy, D., Pischel, I., Siriwatanametanon, N. & Heinrich, M. 2009. *Garcinia mangostana* L.: Phytochemical and pharmacological review. *Phytotherapy Research*, 23: 1047-1065.
- Ohno, R., Moroishi, N., Sugawa, H., Maejima, K., Saigusa, M., Yamanaka, M., Nagai, M., Yoshimura, M., Amakura, Y. & Nagai, R. 2015. Mangosteen pericarp extract inhibits the formation of pentosidine and ameliorates skin elasticity. *Journal of Clinical Biochemistry and Nutrition*, 57(1): 27-32.
- Onge, E. S. 2012. You have the right to know: 17 chemicals to avoid in cosmetic and personal care products. Retrieved from the Collective Evolution website: <http://www.collective-evolution.com/2012/04/10/>
- Ozsoy, N., Can, A., Yanardag, R. & Aker, N. 2008. Antioxidant activities of *Smilax excelsa* L. leaf extract. *Food Chemistry*, 110(3): 571-583.
- Palakawong, C., Sophanodora, P., Toivonen, P. & Delaquis, P. 2013. Optimized extraction and characterization of antimicrobial phenolic compounds from mangosteen (*Garcinia Mangostana* L.) cultivation and processing waste. *Journal of the Science of Food and Agriculture*, 93(15): 3792-3800.
- Park, H. Y., Kosmadaki, M., Yaar, M. & Gilchrest, B. A. 2009. Cellular mechanisms regulating human melanogenesis. *Cellular and Molecular Life Sciences*, 66: 1493-1506.

- Park, P. J., Moon, B. S., Lee, S. H., Kim, S. N., Kim, A. R., Kim, H. J., Park, W. S., Choi, K. Y., Cho, E. G. & Lee, T.R. 2012. Hair Growth-promoting effect of *Aconiti Ciliare Tuber* extract mediated by the activation of Wnt/ β -catenin signaling. *Life Sciences*, 91: 935-943.
- Pothitirat, W. & Gritsanapan, W, 2009. HPLC quantitative analysis method for the determination of α -Mangostin in mangosteen fruit rind extract. *Thai Journal of Agricultural Science*, 42(1): 7-12.
- Pothitirat, W., Chomnawang, M. T. & Gritsanapan, W. 2010. Anti-acne-inducing bacterial activity of mangosteen fruit rind extract. *Medical Principles and Practice*, 19: 281-286.
- Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M. & Evans, C. R. 1999. Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology and Medicine*, 26(9-10): 1231-1237.
- Rho, S. S., Park, S. J., Hwang, S. L., Lee, M. H., Kim, C. D., Lee, I. H., Chang, S. Y. & Pang, M. J. 2005. The hair growth promoting effect of *Asiasari radix* extract and its molecular regulation. *Journal of Dermatological Science*, 38: 89-97.
- Robia, C. B. B., Mitteregger, G., Aichinger, A., Egerbacher, M., Helmreich, M. & Bamberg, E. 2002. Primary cell culture and morphological characterization of canine dermal papilla cells and dermal fibroblasts. *Veterinary Dermatology*, 13: 1-6.
- Rogers, N. E. & Avram, M. R. 2008. Medical treatments for male and female pattern hair loss. *Journal of American Academy of Dermatology*, 59(4): 547-566.
- Roh, S. S., Kim, C. D., Lee, M. H., Hwang, S. L., Pang, M. J. & Yoon, Y. K. 2002. The hair growth promoting effect of *Sophora flavescens* extract and its molecular regulation. *Journal of Dermatological Science*, 30:43-49.
- Rosenthal, M. H., Kreider, J. W. & Shiman, R. 1973. Quantitative assay of melanin in melanoma cells in culture and in tumors. *Analytical Biochemistry*, 56(1): 91-99.
- Sasidharan, S., Chen, Y., Sararanan, D., Sundram, K. M. & Latha, L. Y. 2011. Extration, isolation and characterization of bioactive compounds from plants extracts. *African Journal of Traditional, Complementary and Alternative Medicines*, 8(1): 1-10.

- Sattayasai, J., Chaonapan, P., Arkaravichie, T., Soi-ampornkul, R., Junnu, S., Charoensilp, P., Samer, J., Jantaravinid, J., Masaratana, P., Suktitipat, B., Manissorn, J., Thongboonkerd, V., Neungton, N. & Moongkarndi, P. 2013. Protective effects of mangosteen extract on H₂O₂-induced cytotoxicity in SK-N-SH cells and scopolamine-induced memory impairment in mice. *Plos One*, 8(12): e85053.
- Schmid, D., Belser, E. & Zulli, F. 2007. Self-tanning based on stimulation of melanin biosynthesis. *Cosmetics & Toiletries Magazine*, 122(7): 55-62.
- Schouwey, K. & Beermann, F. 2008. The Notch pathway: hair graying and pigment cell homeostasis. *Histology and Histopathology*, 23: 609-619.
- Shan, T., Ma, Q., Guo, K., Liu, J., Li, W., Wang, F. & Wu, E. 2011. Xanthones from mangosteen extracts as natural chemopreventive agents: Potential anticancer drugs. *Current molecular Medicine*, 11(8): 666-677.
- Shibata, M. A., Matoba, Y., Tosa, H. & Linuma, M. 2013. Effects of mangosteen pericarp extracts against mammary cancer. *Alternative and Integrativemedicine*, 2: 8.
- Shivanand, P., Nilam, M. & Viral, D. 2010. Herbs play an important role in the field of cosmetics. *International Journal of PharmTech Research*, 2(1): 632-639.
- Slominski, A., Tobin, D. J., Shibahara, S. & Wortsman, J. 2004. Melanin pigmentation in mammalian skin and its hormonal regulation. *Physiological Reviews*, 84: 1155-1228.
- Slominski, A., Wortsman, J., Plonka, P. M., Schallreuter, K. U. & Paus, R. 2005. Hair follicle pigmentation. *Journal Investigate Dermatol*, 124: 13-21.
- Smets, F., Brabander, H. F. & Pottie, G. 1997. Enhancing the specificity of residue analysis for anabolic using HPLC clean up. *Journal of Food Safety and Food Quality*, 48: 25-48.
- Sulaiman, C. T. & Balachandran, I. 2012. Total phenolic and total flavonoids in selected indian medicinal plants. *Indian Journal of Pharmaceutical Sciences*, 74(3): 258-260.
- Sun, Y. N., Cui, L., Li, W., Yan, X. T., Yang, S. Y., Kang, J. I., Kang, H. K. & Kim, Y. H. 2013. Promotion effect of constituents from the root of *Polygonum multiflorum* on hair growth. *Bioorganic & Medicinal Chemistry Letters*, 23: 4801-4805.

- Suttirak, W. & Manurakchinakorn, S. 2014. In vitro antioxidant properties of mangosteen peel extract. *Journal of Food Science and Technology*, 51(12): 3546-3558.
- Tadtong, S., Viriyaroj, A., Vorarat, S., Nimkulrat, S. & Suksamararn, S. 2009. Antityrosinase and antibacterial activities of mangosteen pericarp extract. *Journal of Healthy Research*, 23(2): 99-102.
- Tobin, D. J. & Paus, R. 2001. Graying: gerontobiology of the hair follicle pigmentary unit. *Experimental Gerontology*, 36(1): 29-54.
- Tobin, D. J. 2008. Human hair pigmentation biological aspects. *International Journal of Cosmetic Science*, 30: 223-257.
- Toldra, F. & Nollet, L. M. L. (Eds.) 2013. Proteomics in foods: *Principles and Applications*. New York: Springer Science.
- Torrungruang, K. & Chutimaworapan, S. 2006. Effect of mangosteen pericarp extract on cell viability in human gingival fibroblasts. *Chulalongkorn University Dental Journal*, 29: 75-82.
- Trueb, R. M. 2002. Molecular mechanisms of androgenetic alopecia. *Experimental Gerontology*, 37: 981-990.
- Trueb, R. M. 2006. Pharmacologic interventions in aging hair. *Clinical Interventions in Aging*, 1(2): 121-129.
- Trueb, R. M. 2009. Oxidative stress in ageing of hair. *International Journal of Trichology*, 1(1): 6-14.
- Vinatoru, M. 2001. An overview of the ultrasonically assisted extraction of bioactive principles from herbs. *Ultrasonics Sonochemistry*, 8: 303-313.
- Whiting, D. A. 2008. Histology of the human hair follicle. *Hair Growth and Disorders*. Springer Berlin Heidelberg Publishing, 107-123.
- Widowati, W., Darsono, L., Suherman, J., Yellianty, Y. & Maesaroh, M. 2014. High performance liquid chromatography (HPLC) analysis, antioxidant, antiaggregation of mangosteen peel extract (*Garcinia mangostana* L.). *International Journal of Bioscience, Biochemistry and Bioformatics*, 4(6): 458-466.
- Wiechelman, K. J., Braun, R. D. & Fitzpatrick, J. D. 1988. Investigation of the bicinchoninic acid protein assay: Identification of the groups responsible for color formation. *Analysis Biochemistry*, 175: 231-237.

- Wittenauer, J., Falk, S., Weisz, U. S. & Carle, R. 2012. Characterisation and quantification of xanthenes from the aril and pericarp of mangosteens (*Garcinia mangostana* L.) and a mangosteen containing functional beverage by HPLC-DAD-MSⁿ. *Food Chemistry*, 134(1): 445-452.
- Yang, C. C. & Costsarelis, G. 2010. Review of hair follicle dermal cells. *Journal Dermatologic Science*, 57(1): 2.
- Yeomans, M. 2015. Asia's the second largest cosmetics market after Europe experts report. Retrieved from the Cosmetics Design Asia website: <http://www.cosmeticsdesign-asia.com>
- Yodhnu, S., Sirikatitham, A. & Wattanapiromsakul, C. 2009. Validation of LC for the determination of α -Mangostin in mangosteen peel extract: A tool for quality assessment of *Garcinia mangostana* L. *Journal of Chromatographic Science*, 47: 185-189.
- Yoo, B. Y., Shin, Y. H., Yoon, H. H., Seo, Y. K. & Park, J. K. 2010. Hair follicular cell/organ culture in tissue engineering and regenerative medicine. *Biochemical Engineering Journal*, 48: 323-331.
- Yoon, S. Y., Yoon, J. S., Jo, S. J., Shin, C. Y., Shin, J. Y., Kim, J. I., Kwon, O. S. & Kim, K. H. 2014. A role of placental growth factor in hair growth. *Journal of Dermatological Science*, 74(2): 125-134.
- Yoshimura, M., Ninomiya, K., Tagashira, Y., Maejima, K., Yoshida, T. & Amakura, Y. 2015. Polyphenolic constituents of the pericarp of mangosteen (*Garcinia Mangostana* L.) *Journal of Agricultural and Food Chemistry*, 63: 7670-7674
- Yoswathana, N. 2013. Accelerated extraction of xanthone from mangosteen pericarp using ultrasonic technique. *African Journal of Pharmacy and Pharmacology*, 7(6): 302-309.
- Zadernowski, R., Czaplicki, S. & Naczek, M. 2009. Phenolic acid profiles of mangosteen fruits (*Garcinia mangostana*). *Food Chemistry*, 112:685-689.
- Zarena, A. S. & Sankar, K. U. 2012. Phenolic acids, flavonoid profile and antioxidant activity in mangosteen (*Garcinia Mangostana* L.) pericarp. *Journal of Food Biochemistry*, 36: 627-633.
- Zarera, A. S. & Sankar, K.U. 2011. Xanthenes enriched extracts from mangosteen pericarp obtained by supercritical carbon dioxide process. *Separation and Purification Technology*, 80(1):172-178.

- Zhang, N. N., Park, D. K., & Park, H. J. 2013. Hair growth-promoting activity of hot water extract of *Thuja orientalis*. *BMC Complementary and Alternative Medicine*, 13:9.
- Zhang, Y. W., Sanjose, S. D., Bracci, P. M., Marton, L. M., Wang, R., Brennan, P., Hartge, P., Boffetta, P., Becker, N., Maynadie, M., Foretova, L., Cocco, P., Staines, A., Holford, T., Holly, E. A., Nieters, A., Benavente, Y., Bernstein, L., Zham, S. H. & Zhang, T. Z. 2008. Personal use of hair dye and the risk of certain subtypes of Non-Hodgkin Lymphoma. *American Journal of Epidemiology*, 167(11): 1321-1331.
- Zhou, H. C., Lin, Y. M., Wei, S. D. & Tam, N. F. Y. 2011. Structural diversity and antioxidant activity of condensed tannin fractionated from mangosteen pericarp. *Food Chemistry*, 129(4): 1710-1720.